NUREG/IA-0130
CAMP002

International Agreement Report

Assessment of RELAP5/MOD3.1 With the LSTF SB-SG-06 Experiment Simulating a Steam Generator Tube Rupture Transient

Prepared by
Kwang Won Seul, Young Seok Bang, Sukho Lee, Hho Jung Kim

Korea Institute of Nuclear Safety
P.O. Box 16, Daeduck Danji
Taejon, 305-600 Korea

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

September 1996

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

AVAILABILITY NOTICE

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 2120 L Street, NW., Lower Level, Washington, DC 20555-0001
2. The Superintendent of Documents, U.S. Government Printing Office, P. O. Box 37082, Washington, DC 20402-9328
3. The National Technical Information Service, Springfield, VA 22161-0002

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC bulletins, circulars, information notices, inspection and investigation notices; licensee event reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the Government Printing Office: formal NRC staff and contractor reports, NRC-sponsored conference proceedings, international agreement reports, grantee reports, and NRC booklets and brochures. Also available are regulatory guides, NRC regulations in the *Code of Federal Regulations,* and *Nuclear Regulatory Commission Issuances*.

Documents available from the National Technical Information Service include NUREG-series reports and technical reports prepared by other Federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, and transactions. *Federal Register* notices, Federal and State legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free, to the extent of supply, upon written request to the Office of Administration, Distribution and Mail Services Section, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, Two White Flint North, 11545 Rockville Pike, Rockville, MD 20852-2738, for use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.

NUREG/IA-0130
CAMP002

International Agreement Report

Assessment of RELAP5/MOD3.1 With the LSTF SB-SG-06 Experiment Simulating a Steam Generator Tube Rupture Transient

Prepared by
Kwang Won Seul, Young Seok Bang, Sukho Lee, Hho Jung Kim

Korea Institute of Nuclear Safety
P.O. Box 16, Daeduck Danji
Taejon, 305-600 Korea

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

September 1996

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Assessment of RELAP5/MOD3.1 with the LSTF SB-SG-06 Experiment Simulating a Steam Generator Tube Rupture (SGTR) Transient

Abstract

The objective of the present work is to identify the predictability of RELAP5/MOD3.1 regarding thermal-hydraulic behavior during a steam generator tube rupture (SGTR). To evaluate the computed results, LSTF SB-SG-06 test data simulating the SGTR that occurred at the Mihama Unit 2 in 1991 are used. Also, some sensitivity studies of the code change in RELAP5, the break simulation model, and the break valve discharge coefficient are performed. The calculation results indicate that the RELAP5/MOD3.1 code predicted well the sequence of events and the major phenomena during the transient, such as the asymmetric loop behavior, reactor coolant system (RCS) cooldown and heat transfer by natural circulation, the primary and secondary system depressurization by the pressurizer auxiliary spray and the steam dump using the intact loop steam generator (SG) relief valve, and so on. However, there are some differences from the experimental data in the number of the relief valve cycling in the affected SG, and the flow regime of the hot leg with the pressurizer, and the break flow rates. Finally, the calculation also indicates that the coolant in the core could remain in a subcooled state as a result of the heat transfer caused by the natural circulation flow even if the reactor coolant pumps (RCPs) turned off and that the affected SG could be properly isolated to minimize the radiological release after the SGTR.

Contents

List of Tables

List of Figures

Acknowledgements

This report was performed under the sponsorship of Korea Ministry of Science and Technology (MOST). Dr. Yong Gyu LIM, President of the Korea Institute of Nuclear Safety (KINS), contributed significantly to the administration of the project. Authors express an appreciation to him. And authors also appreciate to Dr. Kukita (JAERI) who provided a presentation materials on LSTF experiment, and to Mr. Donald E. Solberg (USNRC) who is a CAMP project manager.

Executive Summary

The RELAP5 code has been developed as one of the best-estimate codes. The code is based on a non-homogeneous and non-equilibrium model for one dimensional, two-phase flow. Recently, the RELAP5/MOD3 code development program has been initiated to develop a code version suitable for the analysis of all transient and postulated accidents in PWR systems

The objective of present work is to evaluate the predictability of the RELAP5/ MOD3.1 on major thermal-hydraulic behavior during the Steam Generator Tube Rupture (SGTR) accident. Such a transient behavior includes following phenomena; the asymmetric loop behavior, the RCS cooldown and heat transfer by the natural circulation, system depressurization, and so on. To do this, the calculation results are assessed and compared with the LSTF SB-SG-06 test data simulating the single SGTR accident occurred at Mihama Unit 2 in 1991. Also, some sensitivity studies are performed on items which may have influence on the prediction of the transient behavior; RELAP5 code version, break simulation model and break valve discharge coefficients. Finally, from these analysis results, the capability of core recovery and contaminated coolant isolation following the SGTR accident are discussed briefly.

The LSTF is large scale facility which is a 1/48 volumetrical scale of PWR and also the LSTF test data agreed well with the transient behavior observed in Mihama Unit 2 power plant. Thus, it is expected that the RELAP5/MOD3.1 can give reliable calculation results to applicable to real plant if the present calculation predicts well the LSTF test data. Comparing the present calculation results with the the SB-SG-06 test data, overall transient behavior predicted by using RELAP5/MOD3.1 was in a good agreement with the experiment and the following conclusions were obtained.

1) The RELAP5/MOD3.1 predicted well the sequence of events and the major phenomena during the transient, such as the asymmetric loop behavior, the RCS cooldown and heat transfer by the natural circulation, primary and secondary system depressurization by the pressurizer auxiliary spray and the steam dump using the intact loop SG relief valve, and so on. However, there were differences in some items, such

as the number of the relief valve cycling in the affected SG, the flow regime of the hot leg with the pressurizer and the break flow rates.

2) The RELAP5/MOD3.1 overestimated the number of the RV cycling in the isolated SG. In the experiment, the pressurization rate in the affected SG steam dome was determined as a result of the condensation and compression of the steam by the ascending SG water level rather than the vaporization. However, the code may not properly predict this type of the wall and steam-water interface condensation phenomena. The frequent RV opening had influence on the break flow rate and caused the overestimated break flow rate. Hence, to obtain the accurate transient behavior including the break flow rate, it may be necessary to improve the model on the wall and steam-water interface condensation under superheated situation in the RELAP5/MOD3.1.

3) The results of sensitivity studies shows that, in the early phase of the transient, the results using the RELAP5/MOD3.1 agreed better with the experiment than that of the MOD3.0 code. Also the break flow rate was sensitive to the break simulation model and the break valve discharge coefficient. Especially, the break nozzle model based on the LSTF test configuration provided better agreement with the experiment than the break valve model. Also, in case simulating the SG U-tube rupture as the break valves, the discharge coefficient, C_d of the break valves had strong influence on the break flow rate.

I. Introduction

A Steam Generator Tube Rupture (SGTR) Accident is initiated from the break of the barrier between the Reactor Coolant System (RCS) and the secondary Main Steam System (MSS), which results from the failure of Steam Generator (SG) U-tube. In general, the degradation of the SG U-tube integrity is caused due to the vibration, corrosion and crack for the long plant operation. Because the occurrence probability of the SG U-tube rupture is relatively higher than the RCS piping, the issue on the degradation of SG U-tube integrity has been studied as one of the Unresolved Safety Issues (USIs) by the USNRC for a long time [1].

In the view point of radiological release, the integrity of the barrier between the RCS and the secondary MSS is very significant. Such a SGTR accident could provide the direct release path of contaminated coolant to the environment. Also SGTR accident induces a rather complex phenomena on the plant responses, such as the asymmetric loop behavior, RCS cooldown using natural circulation in intact loop, depressurization of each system and energy transfer between primary and secondary systems. As a consequence, it is necessary that an operator understand precisely the plant behavior during the accident and some actions to minimize the radiological consequences be prepared. Almost all the reports analyzing the SGTR accident clearly show that there are the substantial operator involvements required to mitigate the consequence of the events. Such operator actions may include the isolation of the affected SG to contain the contaminated coolant, the pressurizer power operated relief valve (PORV) open or auxiliary spray actuation to depressurize the primary pressure, the atmospheric steam dump in intact SG, high pressure safety injection (HPSI) pumps termination, reactor coolant pumps (RCPs) restart, and so on.

On February 9, 1991, a single tube in steam generator was ruptured in Mihama Unit 2 in Japan. The Mihama Unit 2 has been operated since 1972, and its nuclear steam supply system design was supplied by Westinghouse with Model 44 steam generator. The cause of the tube rupture was reported as the incorrect insertion of anti-vibration bars, which could not protect the tube from the fatigue by fluid elastic vibration. The Japan Atomic Energy Research Institute (JAERI) carried out the integral simulation experiments on the SGTR incident that occurred at the Mihama Unit 2 power station. The experiment was conducted at the Large Scale Test Facility (LSTF) of the ROSA-IV Program [2,3]. The objective of the experiment was to provide the detailed thermal-hydraulic experimental data, that supplement the plant records, to be used for in-depth evaluation of the SGTR incident and for validation of computer-code. The experimental results indicated that the sequence of events and the behavior of system parameters agree well with Mihama Unit 2 records, and confirmed that there is a large margin in the core cooling capability during the SGTR incident.

The objective of present work is to evaluate the predictability of the RELAP5/ MOD3.1[4] on major thermal-hydraulic behavior during the SGTR accident. Such a transient behavior includes following phenomena; the asymmetric loop behavior, the RCS cooldown and heat transfer by the natural circulation, primary and secondary system depressurization by the pressurizer auxiliary spray and the steam dump using the relief valve, and so on. To do this, the calculation results are assessed and compared with the LSTF SB-SG-06 test data simulating the single SGTR accident occurred at Mihama Unit 2. As mentioned above, the LSTF test data agreed well with the transient behavior observed in Mihama Unit 2 nuclear power plant. Also, the LSTF is large scale facility which is a 1/48 volumetrical scale of PWR. Thus, it is expected that the RELAP5/MOD3.1 can give reliable calculation results to applicable to real plant if the present calculation predicts well the LSTF test data. Also, in present work, some sensitivity studies will be performed on items which may have influence on the prediction of the transient behavior, such as RELAP5 code version and break simulation model. Finally, from these analysis results, the capability of core recovery and contaminated coolant isolation following the SGTR accident will be briefly discussed.

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 a experimental data in Chapter IV. In particular, the discussion involves an assessment of the major phenomena during SGTR accident. The code predictability and run statistics are also described in this chapter. The conclusions obtained through the present study are summarized in Chapter V. Finally, the RELAP5/MOD3.1 input deck for steady state run and transient run are attatched as an Appendix A and B, respectively.

II. Experimental Facility, Conditions and Procedures

II.1 Facility Description

The LSTF is a 1/48 volumetrically scaled model of a Westinghouse type 3423 MWt four loop PWR[2]. The LSTF has the same elevations as the reference PWR to simulate the natural circulation phenomena and large loop pipes to simulate the two-phase regimes and major phenomena in an actual plant. Figure 1 shows the flow diagram of the LSTF. The facility was designed to be operated at the same pressures and temperatures as the reference PWR.

The LSTF facility simulates the major components of the PWR primary system (for example, pressure vessel, pressurizer, SGs, RCPs, etc.) and the reactor protection system (for example, emergency core cooling system, auxiliary feedwater system, etc.) that have an impact on the plant behavior during the operational transients. Equipment controls allow the test operators to either follow procedures defined in standard plant manual or follow variations of standard procedures. Other systems, such as the secondary and various auxiliary systems, are capable of achieving pretest steady-state conditions and simulating the primary to secondary interactions. These systems include feedwater, condensate and steam systems together with component service systems such as the cooling water, water purification etc.

The fuel assembly dimensions, i.e. the fuel rod and the guide thimble diameter, pitch and length, and the ratio of the number of fuel rods to the number of guide thimbles were designed to be the same as the 17 x 17 fuel assembly of the reference PWR to preserve the heat transfer characteristics of the core. The total number of rod which was scaled by 1/48, is 1064 for the electrically heated and 104 for the unheated rods. The most important design scaling compromise is the 10 MW maximum core power limitation, 14% of the scaled reference PWR rated power. The steady-state condition is therefore restricted to a core mass flow rate that is 14% of the scaled value, to simulate the reference PWR temperature distribution in the primary loop.

The four primary loops of the reference PWR were represented by two equal-volume loops. The hot 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.

II.2 Experimental Conditions and Procedures

The experiment (SB-SG-06 test simulated an accident with SG single tube rupture) was initiated by opening a break valve nearly at the same RCS pressure and temperature as in Mihama Unit 2. The reactor trip signal and safety injection signal were sent automatically at the same RCS setpoint pressures as in Mihama Unit 2. Then, the HPSI systems were actuated and the HPSI flow was directed to the cold legs and vessel upper plenum. The damaged SG was isolated at 12 minutes after reactor trip. At the same time, depressurization of intact SG secondary side was initiated. Such a depressurization was terminated according to the Mihama Unit 2 Emergency Operating Procedure (EOP). Subsequently, the atmospheric relief valve (RV) on the damaged SG opened and closed automatically.

In order to stop the break flow by reducing the primary pressure, the pressurizer PORVs were tried to open in the real plant, but it failed to open. Thus the pressurizer auxiliary spray was used instead of the PORV. The pressurizer auxiliary spray was actuated 44 minutes after reactor trip to depressurize the RCS. The HPSI pumps were turned off after the pressurizer water level recovered. The pressuirzer auxiliary spray was turned off after the RCS pressure equilibrated with the damaged SG pressure. Finally, the RCP in intact loop was restarted at 65 minutes after reactor trip. The experiment was ended when the RCS conditions were stabilized. The overall event sequences of the SGTR transient can be shown in Table 3.

The measurement systems were developed and installed to measure the various thermal hydraulic phenomena associated with the experiment. Installed locations and measuring range for all instruments and data acquisition system in LSTF were in detail described in reference 2. In particular, the estimated accuracy of the experimental data used in this study was presented with the origin of the measured data in Table 4. /.

III. Code and Modeling

III.1 Code Description

The RELAP5 code has been developed as one of the best-estimate codes. The code is based on a non-homogeneous and non-equilibrium model for one dimensional, two-phase system that is solved by a fast, partially implicit numerical scheme to permit economical evaluation of system transients. Recently, the RELAP5/MOD3 code development program has been initiated to develop a code version suitable for the analysis of all transient and postulated accidents in PWR systems including both large and small break LOCAs as well as the full range of operational transient. Although the emphasis of the RELAP5/MOD3 development is on large break LOCA, improvements to existing code models, based on the results of assessments against operational transient test data, are also being made. In this code assessment on the SGTR transient, the unmodified released code version, RELAP5/MOD3.1 and MOD 3.0 are used.

III.2 Modeling Description

The nodalization used to simulate the LSTF facility of the ROSA-IV program with the RELAP5 code is represented in Figure 2. The model is based on 177 volumes connected by 186 junction and 166 heat structures composed of 947 mesh points for averaged U-tube model case. In the reactor 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. In the schematization of the upper part of the LSTF downcomer (volumes 100 and 104), care was taken to correctly simulate the steady-state mass flow rates in the connection with the hot legs (bypasses), the upper plenum (unintentional leak path) and the upper head (spray nozzles) to obtain the requested values, i.e. 0.1 %, 0.085 % and 0.3 % of the core inlet flow rate, respectively. The core is modeled by one channel arranged in 6 hydraulic volumes, in which only one series of heat structures is adopted to simulate the fuel assembly (i.e. a flat radial core power profile is assumed). The reason for this choice resides in the attempt to perform the simplest modeling of the LSTF facility as possible. A pipe connection (volume 156) between the upper head and the upper plenum of the pressure vessel is introduced in the scheme to simulate the guide thimble channel path existing in the facility.

The two loops of the LSTF system are represented by the intact-loop (volumes 200 to 299) and the broken-loop (volumes 400 to 499) in an almost symmetrical way. In fact, each of the two loops presents the hot leg, the SG inlet and outlet plena, the SG U-tube channel, the loop seal, the reactor coolant pump, the cold leg. In addition, the pressurizer is connected to the intact-loop hot leg by means of the surge line element. In the volumes representing the pressurizer vessel, an additional heat structure is introduced to simulate the effects of the proportional and back-up heaters. But the pressurizer heaters are not used in this case of SGTR transient. The two SG secondary sides (volumes 300 to 399 and 500 to 599) are simulated using an identical schematization. They can be subdivided into the downcomer, the boiling section, the steam separator and the steam dome. The steam and feedwater lines are simulated by using Time Dependent Junctions with imposed flow rates. The relief and safety valves are also connected to the SG steam dome using valve components in which the operational setpoints and conditions are specified to be the same as the experiment.

The U-tube break models are examined for two cases as shown in Figure 3. Case 1 is to simulate the double-ended break as a single-ended break nozzle based on the LSTF SB-SG-06 test configuration. Figure 4 shows the break line arrangement in LSTF. The break nozzle is a straight, cylindrical pipe of 6.2 mm in inner diameter and 1.8 m in length. Such a nozzle is to simulate the scaled break area and length as well as the pressure drop along the ruptured tube. In this report, this break nozzle modelling case, i.e., Case 1 will be regarded as a base case calculation. Case 2 is to simulate the U-tube rupture as two break valves between a single broken U-tube channel and secondary SG. The valve junction diameter is 6.2 mm and the single broken U-tube size is 19.6 mm in inner diameter as in LSTF experiment. The remaining SG U-tubes are modeled as an averaged single U-tube.

IV. Analysis Results and Discussion

IV.1 Analysis Conditions

As a base calculation, the released code version without modification, RELAP5/ MOD3.1 is used to identify the code predictability on the thermal-hydraulic behavior during the SGTR accident. Table 1 represents the comparison of initial conditions between the LSTF SB-SG-06 test and the calculation. The calculated values were obtained from the steady state run. It is indicated that the major calculated parameters of the primary and secondary coolant systems agree well with the measured values in LSTF SB-SG-06 test.

Table 2 represents the setpoints and conditions used in calculation. These conditions are based on the specified operational setpoints and conditions of the experiment. However, the experimental information was not enough to accurately simulate the transient behavior. Thus, some control logics such as timing of termination of HPSI into upper plenum were modelled in accordance with the experimental results. The calculation was attempted up to 5000 seconds when the operator's recovery procedure is initiated as in experiment.

Table 3 represents the major sequence of the events during the SGTR transient. The major events are composed of the reactor trip, auxiliary feedwater actuation, high pressure safety injection (HPSI), affected SG isolation (MSIV close) and intact SG depressurization (RV open), RV cycling in affected SG, pressurizer auxiliary spray actuation, and so on. Two calculations depending on the break simulation model were performed and the table is showing the similar sequence of the events. As a base calculation, the computed results of the Case 1, which based on the LSTF SB-SG-06 test configuration, are compared with experimental data and are in detail discussed in following section. The experimental data compared in this study were obtained by digitizing curves of the figures in open literatures [5,6]. The origin of the experimental data including the estimated accuracy and the corresponding calculated parameters are listed in Table 4.

Also, in these base and sensitity calculations, 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. Hence there are no deviations from the user guidelines described in RELAP5/MOD3 code manual volume V.

IV.2 Analysis Results

1. RCS Pressure Response

Figure 5 shows the primary system pressure behavior during the SGTR transient. After the initiation of single SG U-tube rupture, the pressurizer pressure and water level decrease monotonically because the amount of break flow to SG secondary side is larger than the coolant supplied by the charging pumps. The reactor scram occurs when the RCS pressure reaches 13.42 MPa. After that, the pressure and water level continue to decrease. The pressurizer water level behavior will be discussed later (Figure 11). Following the continuous decrease of the RCS pressure, the pressure reaches to the setpoint of the safety injection signal and the RCP trip. The high pressure safety injection (HPSI) into cold legs and upper plenum of the reactor vessel begin to deliver at 98 seconds and 300 seconds after the safety injection signal, respectively. The RCPs coastdown at 80 seconds after the reactor scram. The pressurizer is emptied completely at about 335 seconds.

The HPSI water continues to inject into primary side in order to recover the core inventory, while break flow enters secondary side through the break nozzle. The pressurizer auxiliary spray system instead of the pressurizer relief valves, is used to increase a depressurization rate at 2660 seconds after the reactor scram and the pressurizer water level is recovered from 3000 seconds. The HPSI systems are terminated after the pressurizer water level is recovered. When the RCS pressure becomes identical to the broken loop SG pressure, the pressurizer auxiliary spray is turned off. Finally, the RCP in intact loop is restarted about 4000 seconds after reactor scram, and the experiment and calculation are terminated at 5000 seconds when the primary system conditions are stabilized. The overall transient response of the calculated primary pressure agrees well with the LSTF SB-SG-06 test data.

2. Secondary Pressure Response

Figure 6 represents the secondary pressure behavior during the SGTR transient. The broken loop SG is isolated by closing the main steam isolation valve (MSIV) at 722 seconds after reactor scram and simultaneously the intact loop SG is depressurized by the latched open of the SG relief valve (RV). Such actions are to contain the contaminated coolant in the affected SG and to maintain the heat removal from primary to secondary through the intact SG, respectively. The pressure of broken loop SG increases due to the primary coolant inflow with high enthalpy and is controlled by opening and closing the SG RV. The break flow rate entered into the secondary side can be shown in Figure 17. Consequently the general trend of the calculated secondary pressure is analogous to the experiment. However, there exists the difference in the number of the RV cycling of broken loop SG. The RV was opened once in experiment, while it was opened several times in calculation. The difference will be discussed in detail in section IV.3.

3. Thermal Response

Figure 7 represents fluid temperatures at inlet, mid section and outlet of reactor vessel core. The RCS saturation temperature is also plotted in the figure. Figure 8 shows fluid temperatures on the broken loop SG secondary side. From this figures, it is found that there exists the sufficient subcooled margin in the primary side and the superheated steam in the broken loop secondary side during the SGTR transient. The RCS fluid temperatures decrease rapidly after the reactor scram. However, the core outlet fluid temperature increases slightly after RCPs trip, which is due to reduction of the heat transfer between primary side and secondary side.

The RCS fluid temperatures continue to decrease gradually by the atmospheric steam dump and feedwater in the secondary side and the HPSI cold water in the primary side. This explains that the core heat is removed by the natural circulation in the intact loop. Thus, the subcooled margin of RCS coolant becomes larger sufficiently to prevent the core voiding. They decrease rapidly at about 4300 seconds because of the forced convection caused from restart of the intact loop RCP. Figures 9 and 10 are the hot leg fluid temperatures in intact loop and broken loop, respectively. The similar trends to the RCS fluid temperature are found. The overall transient responses of the calculated fluid temperatures agree well with the experimental data. However, in the early phase of the transient, there exists the bump in the experiment, while it is not seen in the calculation. The bump occurs when the hot water and steam in the pressurizer is penetrated into the hot leg after emptying of pressurizer at about 400 seconds.

4. Water Level Behavior

Figure 11 shows that the pressurizer is emptied completely at about 335 seconds and the water level is recovered from about 3000 seconds. The calculation result agrees well with the experiment. Figure 12 shows the SG water levels behavior in broken and intact loop SGs. After MSIV closure of the broken loop SG, the water level increases gradually by the primary coolant inflow through the break nozzle. The calculated water level increases with the similar rate as that in experimental data, however, the value of water level is slightly higher than that of experimental data. Such a calculation result is because the SG inventory is controlled to remain a reference water level up to main feedwater trip. Supposed that a detailed experimental information on the main feedwater and main steam flow rate will be given, this difference is expected to be reduced. The water level in intact loop SG rapidly decreases due to the atmospheric steam dump. However, to keep the heat removal from the primary side by the natural circulation, the SG inventory continues to be made up by the auxiliary feedwater system. The feedwater supply can be shown in Figure 19.

5. Loop Mass Flow Behavior

Figures 13 and 14 show the loop mass flow rates in the intact and broken loop, respectively. Although the mass flow in broken loop reduces to approximately zero after the RCP trip, the natural circulation flow through the intact loop is maintained more than 5 kg/sec, which is large enough to keep the core coolant subcooled. It is shown that the heat removal from primary side to secondary side is remained by the natural circulation during SGTR transient. The intact loop mass flow increases rapidly at about 4000 seconds after reactor scram by restarting the RCP to stabilize the RCS conditions. Consequently, the calculation predicts well the experimental behavior.

Figures 15 and 16 show the HPSI flow rates into cold legs and core upper plenum, respectively. In general, the HPSI flow rate is depending on the RCS pressure. Thus the curves representing HPSI flow rate as a function of RCS pressure were used in calculation. As shown in Figure 15, the measured HPSI flow rate into core upper plenum has somewhat uncertainty, especially in the starting point and termination point. However, the overall hehavior of the HPSI flow rate agrees well with the experimental data.

6. Break Flow Behavior

Figure 17 shows the break flow rate through the break nozzle during the SGTR transient. The break flow rate is influenced by the pressure difference between primary and secondary systems. Initially the pressure difference is very large, thus the critical flow is formed immediately after break initiation, and the break flow rate gradually decreases as reduction of the pressure difference. After the HPSI system actuation, the break flow rate again increases slightly depending on the RCS pressure. When the RV in the broken loop SG is opened, the break inflow from the primary side is increased instantaneously by the SG pressure drop. This rapid increase of the break flow rate appears several times periodically (due to RV cycling) in the calculation. After the RCS depressurization using the pressurizer auxiliary spray at about 2900 seconds, the pressures of both systems are nearly identical and the break flow rate becomes much smaller. This figure shows the RV cycling has strong influence on the break mass flow. The integrated break flow was calculated 3177 kg during the transient, which is larger than the measured value of 2600 kg approximately. Table 5 shows the comparison of the integrated total mass flow during transient and Figure 18 shows the integrated break flow and HPSI flow. Consequently, it is found that the frequent RV opening results in the large amount of the break mass flow. The sensitivity study on the break simulation model will be discussed in following section.

7. Others

Figures 19 and 20 show the calculated main and auxiliary feedwater flow rate into the secondary side. The main feedwater stops at about 280 seconds in both loops, while to ensure the secondary side inventory, the auxiliary feedwater continues to be supplied to the intact loop secondary side. Figure 21 shows the calculated mass flow rate of the pressurizer auxiliary spray to depressurize the RCS. Figure 22 shows the atmospheric steam dump mass flow rate in the intact loop secondary side through the latched open RV to keep the heat removal between primary and secondary side.

Comparing the present calculation results with the experimental data, it was found that the RELAP5/MOD3.1 code predicts well the single SGTR transient behavior and the timing of sequence of events. Also, it was found that the coolant in the core could remains as subcooled state by the heat transfer, which resulted from the natural circulation flow even during RCPs turned off, and the affected SG could be properly isolated to minimize the radiological release following the SGTR accident.

IV.3 Code Predictability

As discussed in the above section, the comparison between the available LSTF SB-SG-06 test data and the calculation results, indicates that the RELAP5/MOD3.1 code yields in general agreeable results for SGTR transient. However, there exist differences in some parameters from the experiment as follows.

Figure 6 shows the behavior of the SG secondary pressure for both intact loop and broken loop sides. The general trend agrees well with the experiment. However, the number of the relief valve opening in the broken loop SG is overestimated; several times in calculation, while once in experiment (three times in Mihama Unit 2). This difference may come from the insufficient nodalization and/or the modelling on the heat transfer in the secondary side. However, the code model on wall and steam-water interface condensation can be considered as one of the reason for the difference if the current modelling is reasonable one. As shown in Figures 8 and 10, the steam in the broken loop SG steam dome is superheated after about 1000 seconds and the break flow entered from the primary system is subcooled. Also, since the SG water temperature becomes higher than the break flow (or hot leg) temperature, the heat transfer across the U-tube wall is reversed from secondary side to primary side. Figure 23 shows the reversed heat flux across the U-tube walls in the affected SG. Hence, one can conclude that the pressurization of affected SG mainly occurs as a result of compression of the steam phase by the ascending SG water level rather than the vaporization in SG. In the experiment, the pressure increasing rate was reduced by condensation on the wall and steam-water interface, but in the calculation, it was not predicted appropriately. Figure 24 shows the calculated heat flux across the SG steam dome wall. The experimental data relevant to the parameter was not available. However, the heat flux from the steam dome to environment, after 1000 seconds, may be not enough to reduce the pressure increasing rate to the experimental value. Those overprediction of pressure increasing rate is considered as a reason for the frequent RV opening/closing. Such a frequent RV opening, which results in the larger pressure difference between primary and secondary systems, had influence on the break flow rate and caused the overestimated break flow rate. Thus, to obtain the accurate secondary pressure behavior including the break flow rate, it may be necessary to improve the model on the wall and steam-water interface condensation under superheated steam situation in the RELAP5/MOD3.1 code.

In the experiment, as shown in Figure 9, the fluid temperature "bumps" appeared at the top of the hot leg to which the pressurizer was connected. It is a temporal increase of the fluid temperature only at the top of the hot leg. Most hot leg water remains subcooled. This phenomena occurred, after emptying of the pressurizer, when the hot water and steam in the pressurizer are penetrated into the hot leg where the subcooled water is flowing toward the SG. In addition, the experiment indicated that the slight stratified two-phase flow with small void fraction was observed at the top of the hot leg. However, the calculated hot leg bulk fluid temperature was just slightly increased and the "bumps" was not observed as shown in Figure 9. Also, the flow regime in the intact loop hot leg was predicted as a bubbly flow, which has the very small void fraction less than 0.1. This discrepancy may be caused from the difference in measured location and the code limitation to calculate the temperature stratification in one dimensional model. The experimental data were measured at the top of the hot leg, while in analysis, the bulk temperature of the hot leg was computed. In fact, the averaged bulk fluid temperature measured in experiment may be lower than that of Figure 9. Figures 25 and 26 show that the pressurizer steam is penetrated into the hot leg through surge line around 400 seconds and the void is formed in the hot leg in the calculation.

IV.4 Sensitivity Study

Sensitivity study was performed on some items which may influence on the prediction of transient behavior, such as the primary pressure, the break flow rate, etc. The chosen items are the RELAP5 code version (MOD3.0 vs MOD3.1), the break simulation model as described in section III.2 and the break valve discharge coefficient, C_d for the break valve model case (from 0.15 to 0.2).

Figure 27 shows the comparison of the primary pressures which were calculated using RELAP5/MOD3.0 and RELAP5/MOD3.1, respectively. Although the pressure behavior for both cases after the HPSI was almost identical, the MOD3.1 predicted better the pressure trend in the early phase of the transient than the MOD3.0. The MOD3.1 was known to improve some deficiencies and errors from the MOD3.0 for following items; condensation model, spherical accumulator model, boron transport model and error corrections such as undamped flow oscillations in stagnant crossflow junctions, etc.[7] Although, from this calculation, it couldn't clearly find out the improved point of the code, the present calculation results indicated that the MOD3.1 was improved, especially in capability to predict the thermal-hydraulic behavior around the reactor trip.

Figure 28 shows the comparison of break flow rates calculated using the two different break simulation models. In the early phase, the break flow rates for the both cases were nearly identical, but, after the HPSI, the break flow rate for the Case 2 was larger than that for the Case 1. As mentioned previously, the rapid increase of the break flow for the Case 1 was caused by the RV cycling in broken loop SG. However, even though the RV cycling also occurred in the Case 2, the rapid increase of the break flow rate was not occurred. It indicated that the critical flow was formed at the break valves in Case 2, that is, the break flow behavior was determined from the primary pressure instead of the pressure difference between primary and secondary systems. Consequently, it is found that the Case 1 simulating the double ended SG tube rupture as the break nozzle, based on the LSTF SB-SG-06 test configuration, agreed better with the experimental data than the Case 2 with break valve model. Therefore, it is found that the break nozzle model is more realistic, though the number of the RV opening was overestimated.

Figure 29 shows the comparison of the break flow rates calculated with a variation of discharge coefficient, C_d from 0.15 to 0.2, for the Case 2 modelling. As described above section, the critical flow was formed at the break valves in this case. The break flow rate from RCS to secondary side increased with increasing discharge coefficient. Especially, in case of C_d=0.15, the break flow rate after the reactor trip was nearly identical to the experiment. However, the break flow rate before the reactor trip was lower than that of experiment, and consequently the reactor trip time was delayed 200 seconds approximately. Therefore this case was not in good agreement with the experiment in the early phase of the transient. Table 5 describes the total break flow, total HPSI flow and total discharged steam flow throughout the transient. It can be stated that the total break and total HPSI flows increase with increasing C_d. In addition, the break flow and HPSI flow for the Case 1 were overestimated. As discussed above, the overestimated total break flow was caused by the frequent opening of the RV in the isolated SG, which results in the larger pressure difference between primary side and secondary side. Although the experimental data has somewhat its uncertainty range, Table 5 shows that the total discharged steam flow through the RV was predicted quite high. Because of this increased break flow, the total HPSI flow integrated during transient was also overestimated.

IV.5 Run Statistics

The main computer used in the present calculation was a DEC workstation 5000/240 with UNIX operating system. Figure 30 presents a plot of the required CPU time for the two cases during the SGTR transient. It is shown that Case 1 was required about ten times larger CPU time than that of Case 2. It may be because the Case 1 has another minor flow path between primary and secondary systems, which consists of some volumes and junctions. Figure 31 shows Courant time step and advanced time step size with respect to a real transient time. The time step size was reduced down to about 0.01 second.

The Case 1 transient run using RELAP5/MOD3.1 was terminated at 5000 seconds, and the required CPU time was 114,737 seconds including 11.6 seconds for input processing. The attempted advancement was 291,357 time steps. Therefore, the grind time can be calculated as follows,

CPU time	CPU = 114,737 - 11.6 = 114,725.4 sec
Number of time step	DT = 291,357
Number of Volume	C = 177
Transient Real Time	RT = 5000 sec
Grind Time	GT = CPUx1000/(CxDT) = 2.2246 CPU msec/vol/step

V. Conclusions

The RELAP5/MOD3.1 was assessed using the LSTF SB-SG-06 test simulating the SGTR incident which occurred at the Mihama Unit 2 in 1991. To evaluate the code predictability on major thermal-hydraulic behavior, the calculation results are assessed and compared with the experimental data. LSTF is large scale facility of PWR, thus, it is expected that the RELAP5/MOD3.1 can give reliable calculation results to applicable to real plant if the present calculation predicts well the LSTF test data. Overall RELAP5/MOD3.1 calculation provided a good agreement with the SB-SG-06 test data for the SGTR transient and the following conclusions were obtained.

1) The RELAP5/MOD3.1 predicted well the transient behavior during the SGTR accident, such as the primary and secondary pressures, the temperatures of the core and hot legs, the break flow rate, HPSI flow rates, the pressurizer and SG water level, and so on. The calculation results also predicted well the sequence of events and the major phenomena during the transient, such as the asymmetric loop behavior, the RCS cooldown and heat transfer by the natural circulation, primary and secondary system depressurization by the pressurizer auxiliary spray and the steam dump using the intact loop SG relief valve, and so on. However, there were differences in some items when compared to the applicable test data. Those items are the number of the relief valve cycling in the affected SG, the flow regime of the hot leg with the pressurizer and the break flow rates.

2) The RELAP5/MOD3.1 overestimated the number of the RV cycling in the isolated SG. In the experiment, the pressurization rate in the affected SG steam dome was determined as a result of the condensation and compression of the steam by the ascending SG water level rather than the vaporization. However, the code may not properly predict this type of the wall and steam-water interface condensation phenomena. The frequent RV opening had influence on the break flow rate and caused the overestimated break flow rate. Hence, to obtain the accurate transient behavior including the break flow rate, it may be necessary to improve the model on the wall

and steam-water interface condensation under superheated situation in the RELAP5/ MOD3.1.

3) The sensitivity study was performed on the RELAP5 code version, the break simulation model and the break valve discharge coefficient. In the early phase of the transient, the results using the RELAP5/MOD3.1 agreed better with the experiment than that of the MOD3.0 code. Also the break flow rate was sensitive to the break simulation model and the break valve discharge coefficient. Especially, the break nozzle model based on the LSTF test configuration provided better agreement with the experiment than the break valve model. Also, in case simulating the SG U-tube rupture as the break valves, the discharge coefficient, C_d of the break valves had strong influence on the break flow rate.

4) Finally, the analysis results indicated that the core coolant remained subcooled state by the heat transfer resulted from the natural circulation flow even during RCPs turned off, and the affected SG could be properly isolated to minimize the radiological release following the SGTR accident.

References

[1] USNRC,"A Prioritization of Generic Safety Issues", NUREG-0933, September 1993.

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

[3] Y.Anoda, H.Nakamura, T.Wadanabe, M.Hirano and Y.Kukida,"Steam Generator Tube Rupture Simulations", International Conference on New Trends in Nuclear System Thermohydraulics, Pisa, Italy, May 30 - June 2, 1994.

[4] EG&G,"RELAP5 Input Data Requirements, Appendix A to RELAP5/MOD3 Code Manual", January 1990.

[5] Y.Kukida, et al.,"Integral Simulation Experiments on the Mihama Unit 2 Steam Generator Tube Rupture (SGTR) Incident with Use of the ROSA-IV/LSTF", the material presented by JAERI at KINS/KAERI, March 10-11, 1992.

[6] M.Hirano,et al.,"Analyses of SGTR Event at Mihama-2", Presented at KINS/INS Meeting, March 10-11, 1992.

[7] Gray E. Wilson,"Proposed CAMP Protocols", Presented at the second CAMP Meeting, Tractebel, Belgium, May 1993.

Table 1 Comparison of Initial Conditions

Parameters	LSTF SB-SG-06 Measured		RELAP5/MOD3.1 Case 1		RELAP5/MOD3.1 Case 2	
Primary Coolant System	(Intact : Broken)		(Intact : Broken)		(Intact : Broken)	
Hot leg temperature (K)	587.4	585.9	586.02	586.02	586.0	586.0
Cold leg temperature (K)	560.5	560.0	560.85	560.76	560.74	560.72
Loop mass flow rate (kg/s)	34.65	33.84	36.580	35.478	36.579	35.480
Core mass flow rate (kg/s)	-		71.707		71.708	
Pump speed (rad/s)	128.3	124.3	128.3	124.3	128.3	124.3
Core power (MW)	10		10		10	
Pressurizer						
Pzr. pressure (MPa)	15.38		15.380		15.380	
Pzr. water level (m)	2.64		2.680		2.679	
Pzr. temperature (K)	-		616.28		616.28	
Secondary Coolant System						
SG steamdome pres.(MPa)	6.89	6.89	6.858	6.860	6.857	6.860
SG steam dome temp.(K)	-		557.56	557.58	557.55	557.57
SG steam flow rate (kg/s)	2.68	2.58	2.799	2.722	2.741	2.673
Main feed flow rate (kg/s)	-		2.7447	2.6701	2.7692	2.7244
SG downcomer water level (m)	9.22	9.19	9.251	9.273	9.251	9.271

* Case 1 : averaged U-tube model (regarded as Base Case)
* Case 2 : single broken U-tube and averaged U-tube model

Table 2 Setpoints and Conditions used in RELAP5/MOD3.1 Calculation

Events	Setpoints and Conditions
-Tube Break	-Break valve open at t=0
-Reactor Trip	$-P_{Pzr} < 13.42$ MPa -Experimental core power decay curve
-Main Feedwater Trip	$-P_{Pzr} < 12.97$ MPa
-Safety Injection Signal (SI)	$-P_{Pzr} < 12.87$ MPa
-Pump Coastdown	-Experimental coastdown curve
-IL RCP Restarted	-Rx Trip+3979s
-HPSI Flow rate	-Experimental pressure vs. flow rate curve
-HPSI into Cold legs	-Safety injection from SI+98s, plus charging
-HPSI into Core Upper Plenum	-Safety injection from SI+300s
-HPSI Turned off (stop)	-Pzr water level recovered - HPSI-CL: $L_{Pzr} > 1.0$ m - HPSI-UP: SI+2900s - Charging: no termination(0.265kg/s)
-Accumulator Injection	-Not used
-LPSI System	-Not used
-Aux. Feedwater Start	-BL: hot water: 1.14kg/s for 81s from SI+37s cold water: none -IL: hot water: 1.5kg/s for 200s from SI+37s cold water: 1.0kg/s from SI+237s until $L_{IL-SG}>12.85$ m
-Affected SG Isolation	-BL-MSIV close from Rx Trip+722s
-Intact SG Depressurization	-IL-RV open from Rx Trip+722s
-Intact SG Depres. Termination	-IL-RV close if ($T_{IL-hotleg}< 531.4$ K)
-Affected SG RV Cycling	-6.4 MPa $< P_{BL-SGdome}<$ 7.3 MPa
-SG Safety Valves Cycling	-7.69 MPa $< P_{BL-SGdome}<$ 8.68 MPa
-Pzr. Aux. Spray Flow rate	-0.1 kg/s
-Pzr. Aux. Spray Start	-Rx Trip+2666s
-Pzr. Aux. Spray Turned off	$-P_{Pzr} = P_{IL-SGdome}$

Table 3 Event Sequences of SGTR Transient

Major Events (unit : second)	LSTF SB-SG-06	RELAP5/MOD3.1 (Case 1)	(Case 2)
- Tube Break	0	0	0
- Reactor Trip	266	251	246
- Main Feedwater Trip	300	280	280
- Safety Injection Signal	305	289	287
- Pzr. Empty	331	335	335
- Pump Coastdown	348	331	326
- Aux. Feedwater Start	342	326	324
- HPSI into Cold legs	403	387	385
- HPSI into Core Upper Plenum	605	589	587
- Affected SG Isolated(MSIV close)	988	973	971
- Intact SG Depressurized(RV open)	988	973	971
- Intact SG Depressurization Terminated (RV close)	1751	1744	1740
- Affected SG RV Opened	2635(once)	cycling	cycling
- Pzr. Aux. Spray Start	2932	2917	2915
- HPSI Turned off (stop)	3390	3390	3390
- Pzr. Aux. Spray Turned off	3617	3527	3742
- Intact Loop RCP Restarted	4245	4230	4225
- Termination	5000	5000	5000

* Case 1 : break nozzle model based on SB-SG-06 test configuration (regarded as Base Case)

* Case 2 : break valve model with single averaged and broken U-tube

Table 4 Lists of Measured Data and Corresponding Calculated Parameters

Items	Origin of Measured Data	Full Scale Accuracy*	Calculated Parameters
-Primary pressure	Ref. 3 & 5	0.32 FS	p-610010000
-Secondary pressure	Ref. 3 & 5	0.32 FS	p-516010000, p-316010000
-Core inlet temperature	not used	-	tempf-120010000
-Core mid temperature	Ref. 5	0.616 FS	tempf-124030000
-Core outlet temperature	not used	-	tempf-128010000
-RCS saturation temperature	Ref. 3 & 5	0.777 FS	sattemp-200010000
-Steam dome steam temperature	unavailable	-	tempg-516010000
-SG saturation temperature	unavailable	-	sattemp-516010000
-SG water temperature	unavailable	-	tempf-504040000
-Intact loop hot leg temperature	Ref. 5	0.616 FS	tempf-206010000
-Broken loop hot leg temperature	Ref. 5	0.616 FS	tempf-406010000
-Pzr water level	Ref. 5	0.32 FS	cntrlvar 610
-SG water level	Ref. 3	0.32 FS	cntrlvar 312, 512
-Intact loop mass flow rate	Ref. 5	1.12 FS	mflowj-206020000
-Broken loop mass flow rate	Ref. 5	1.12 FS	mflowj-406020000
-HPSI-up mass flow rate	Ref. 5	1.62 FS	mflowj-722000000
-HPSI-cold legs mass flow rate	Ref. 5	1.62 FS	cntrlvar 922
-Break mass flow rate	Ref. 5	1.12 FS	cntrlvar 916
-Integrated break & HPSI flow	unavailable	-	cntrlvar 915, 921
-Intact SG feedwater flow rate	unavailable	-	cntrlvar 917
-Broken SG feedwater flow rate	unavailable	-	cntrlvar 918
-Pzr aux spray mass flow rate	unavailable	-	mflowj-612000000
-Steam dump flow rate	unavailable	-	mflowj-369000000
-Heat flux on U-tube wall	unavailable	-	htrnr-420100101
-Heat flux on steam dome wall	unavailable	-	htrnr-500300400
-Flow rate in Pzr surge line	unavailable	-	mflowj-206040000
-Void fraction in Pzr surge line	unavailable	-	voidg-600030000

* Detailed Information was described in Ref. 2

Table 5 Comparison of Integrated Total Mass Flows during Transient

Mass Flows (unit : kg)	LSTF SB-SG-06	Case 1	Case 2 (RELAB5/MOD3.1) Cd=0.15	Cd=0.18	Cd=0.20
- Total break flow into secondary side	about 2600	3177	3212	3482	3765
- Total HPSI flow into RCS (up/cl)	about 2900 (1000/1900)	3497 (1216/2281)	3535	3947 (1373/2574)	4248
- Discharged steam flow through MSL	about 1200	1277	-	1185	-
- Discharged steam flow through RV	about 20	133	-	153	-
- Aux. Feedwater flow into SG	about 500	669	-	605	-

* Case 1 : break nozzle model based on SB-SG-06 test configuration
* Case 2 : break valve model with single averaged and broken U-tube

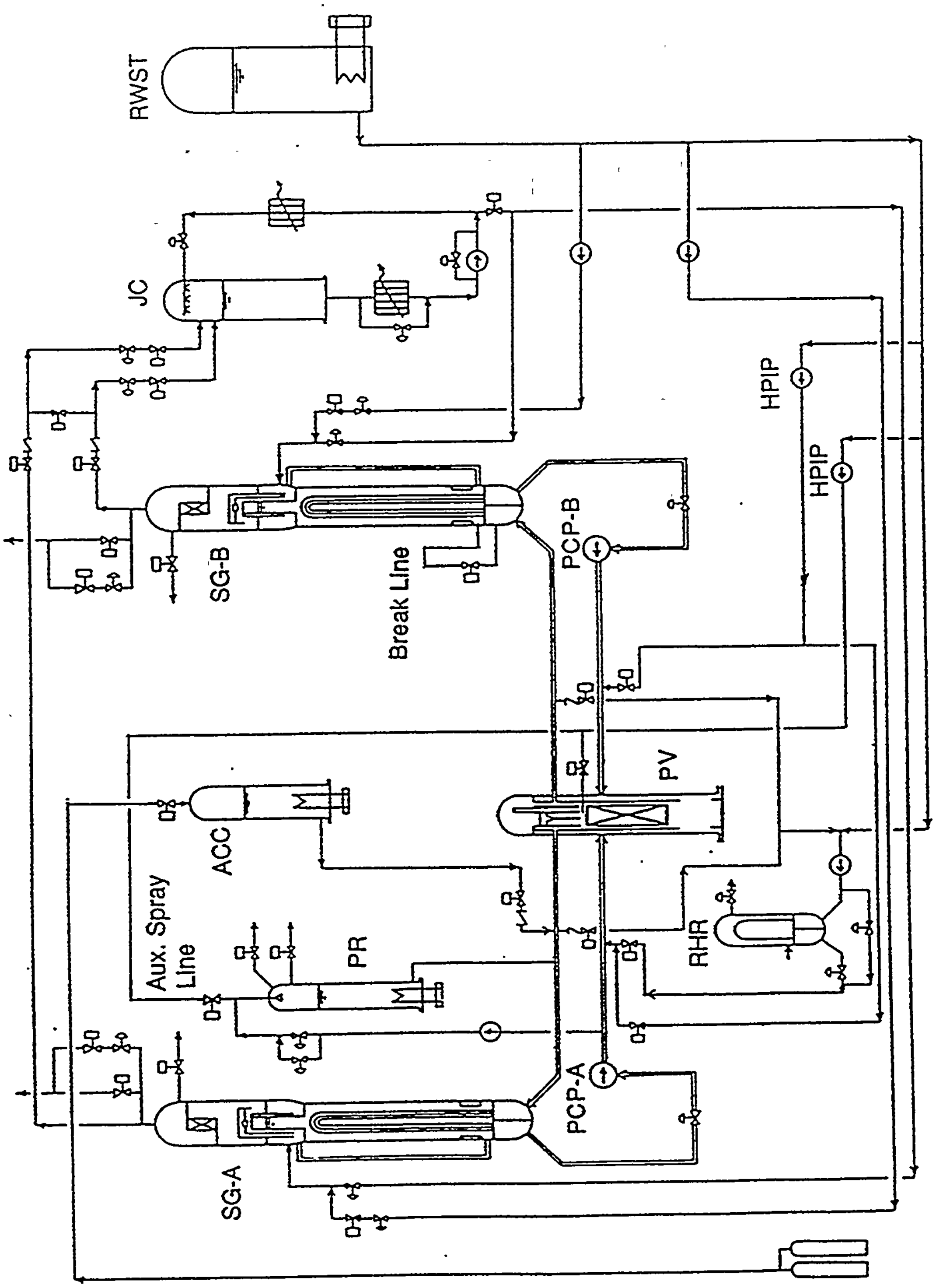


Figure 1 ROSA-IV LSTF Flow Diagram

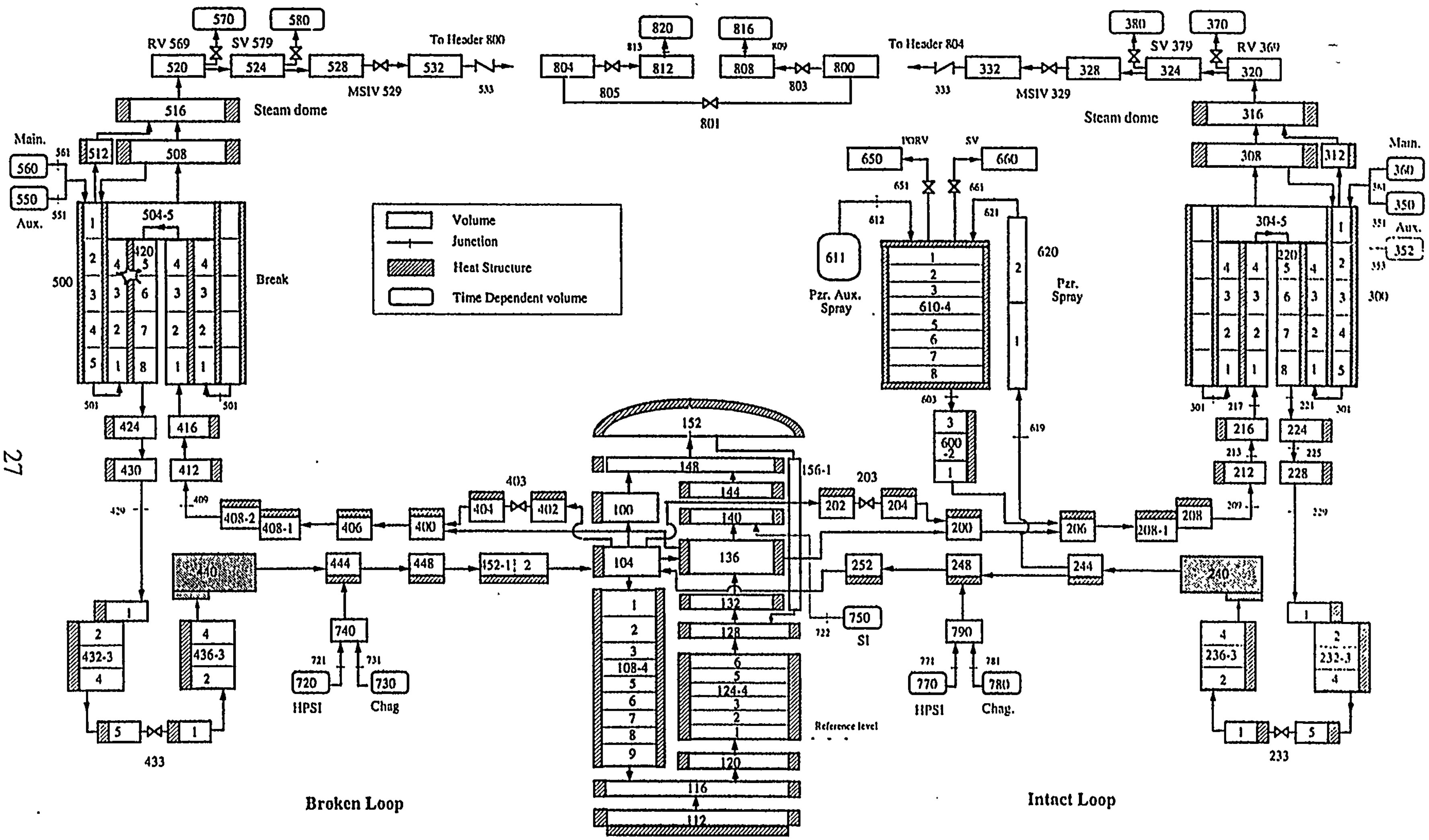
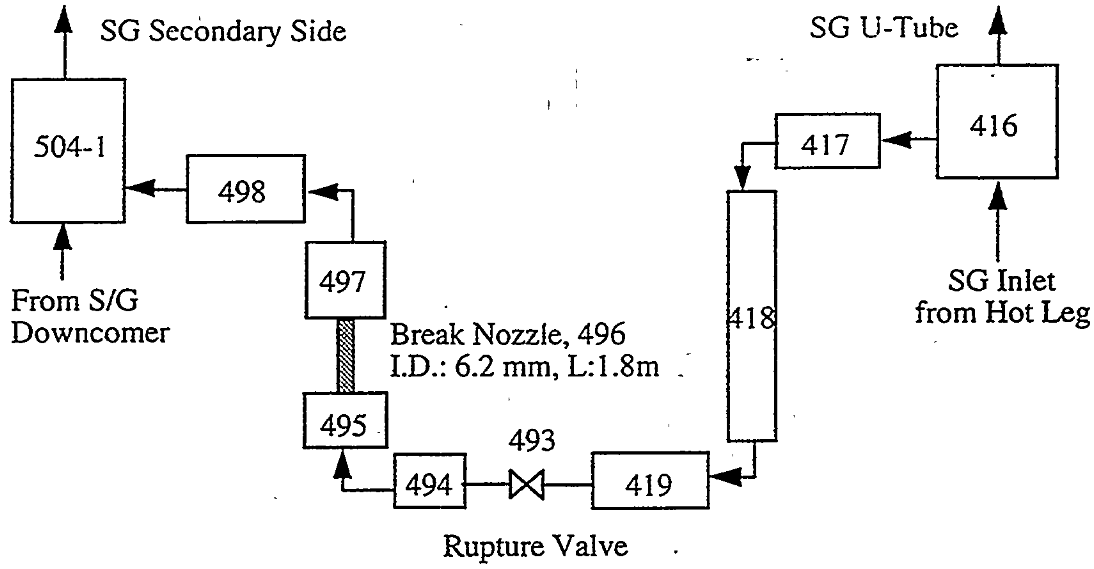


Figure 2 RELAP5 Nodalization of ROSA-IV LSTF for SGTR Transient Assessment

(1) Case 1 (Base Case): Break Nozzle Model Based on Facility Configuration



(2) Case 2 : Break Valve Model with Single Averaged and Broken U-Tube

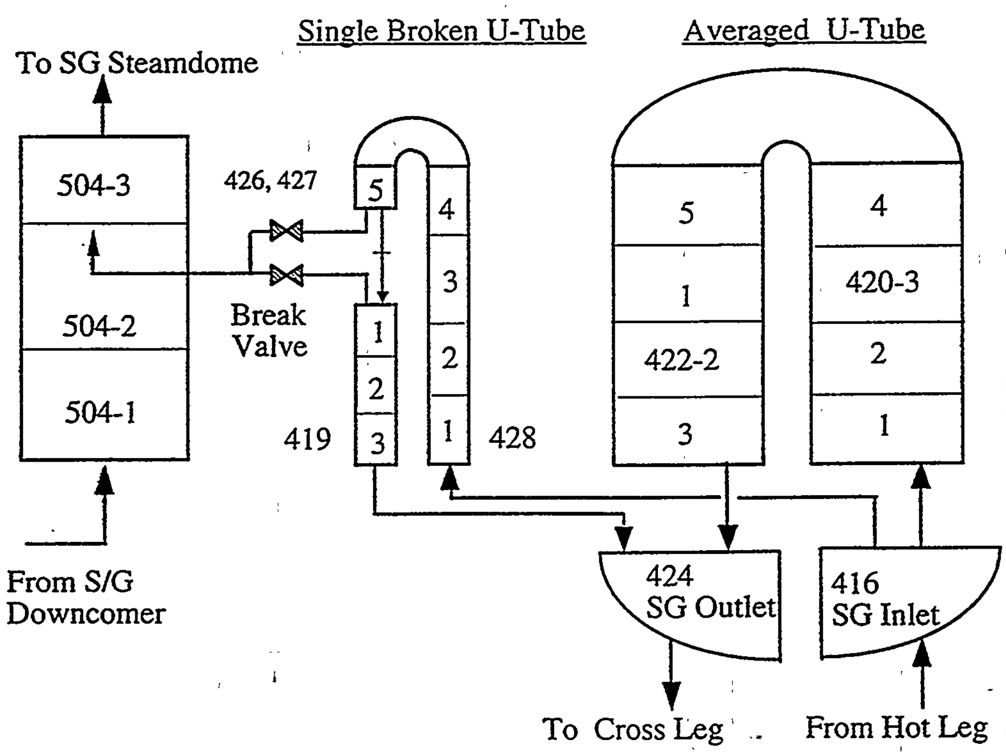


Figure 3 Break Simulation and Nodalization

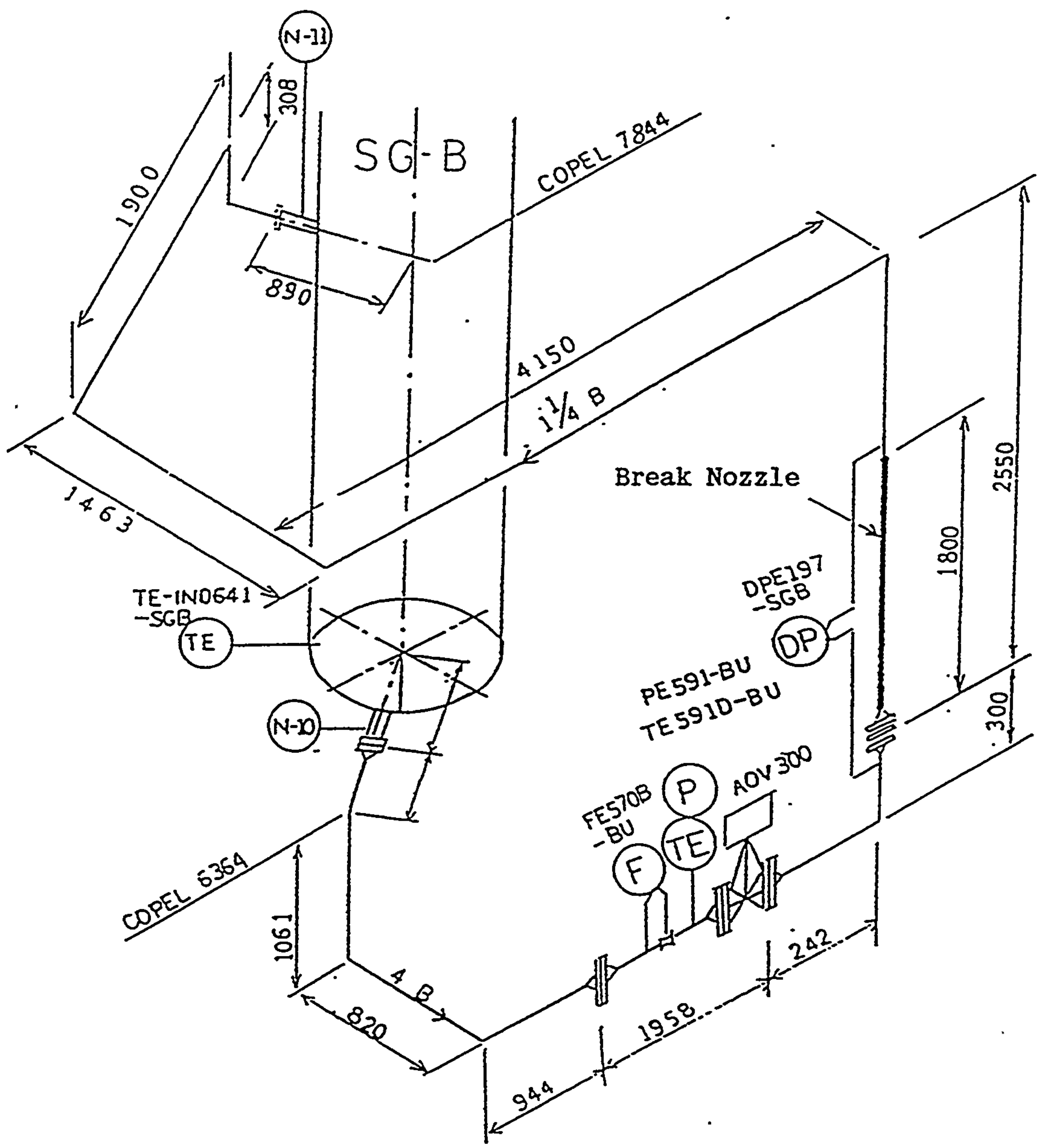


Figure 4 Break Line Configuration in LSTF SB-SG-06 Test

Figure 5 Comparison of Primary Pressure between Experiment and Calculation

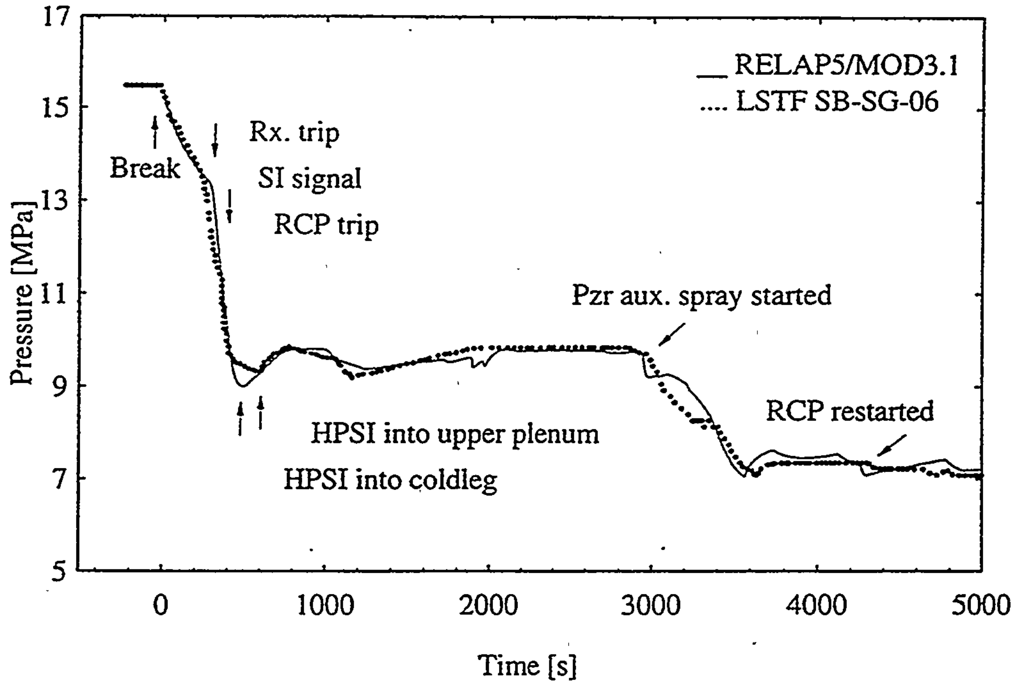


Figure 6 Comparison of Secondary Pressures between Experiment and Calculation

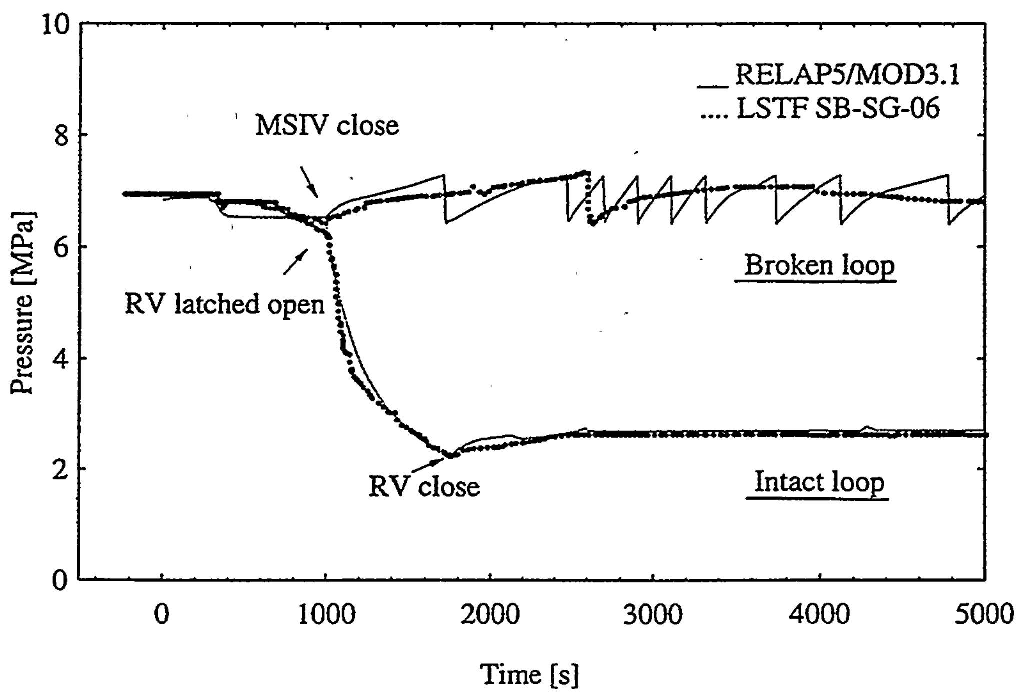


Figure 7 Comparison of Core Fluid Temperatures

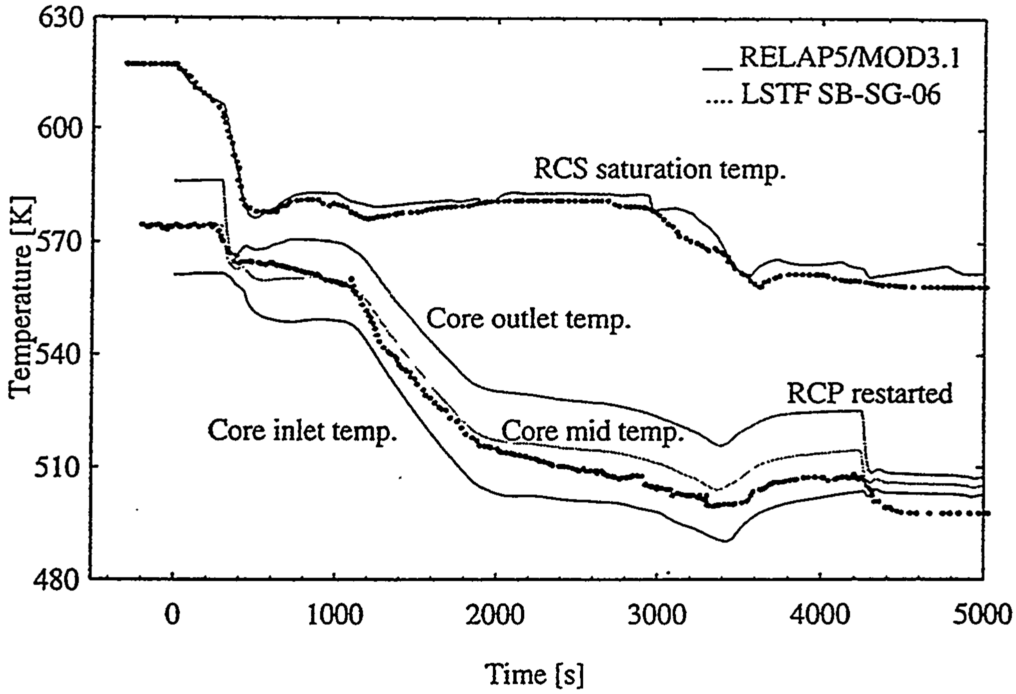


Figure 8 Comparison of Broken Loop Secondary Side Fluid Temperatures

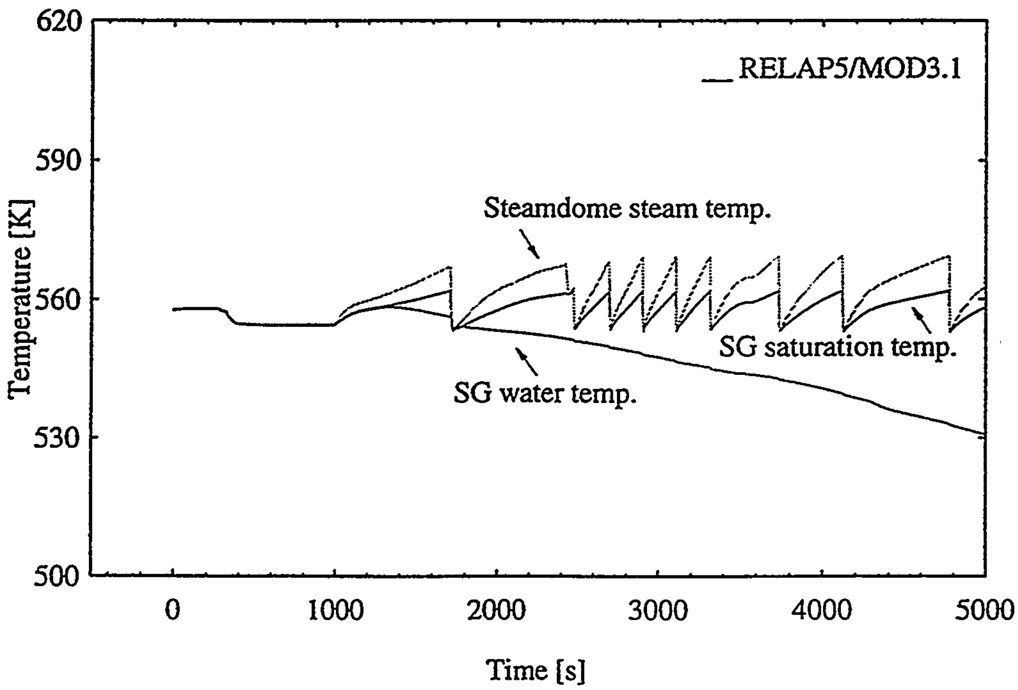


Figure 9 Comparison of Intact Loop Hot leg Temperature

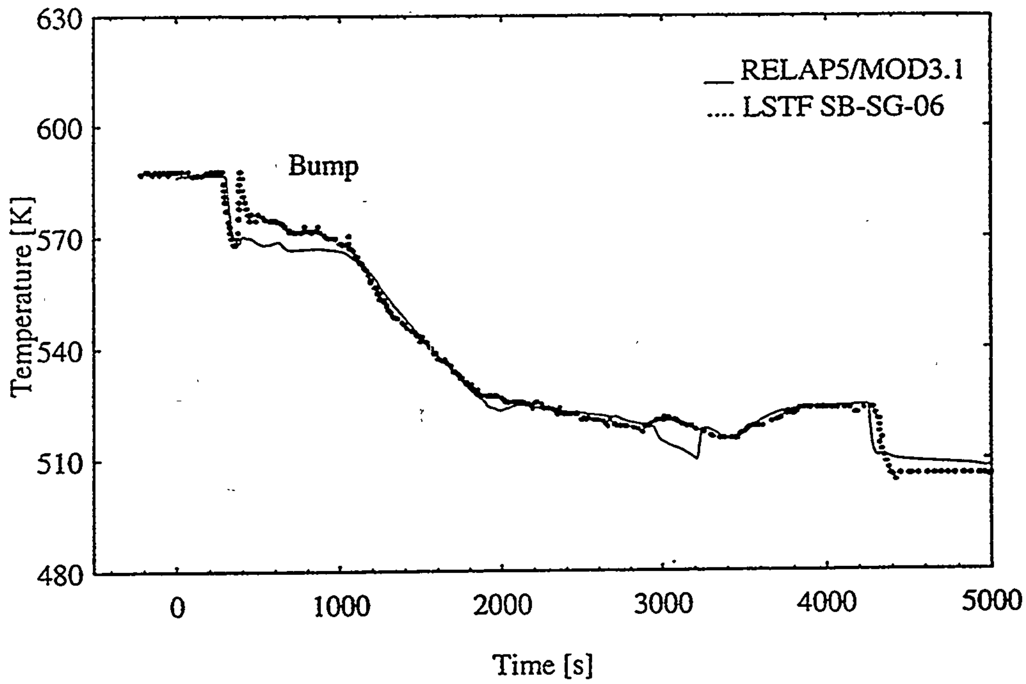


Figure 10 Comparison of Broken Loop Hot leg Temperature

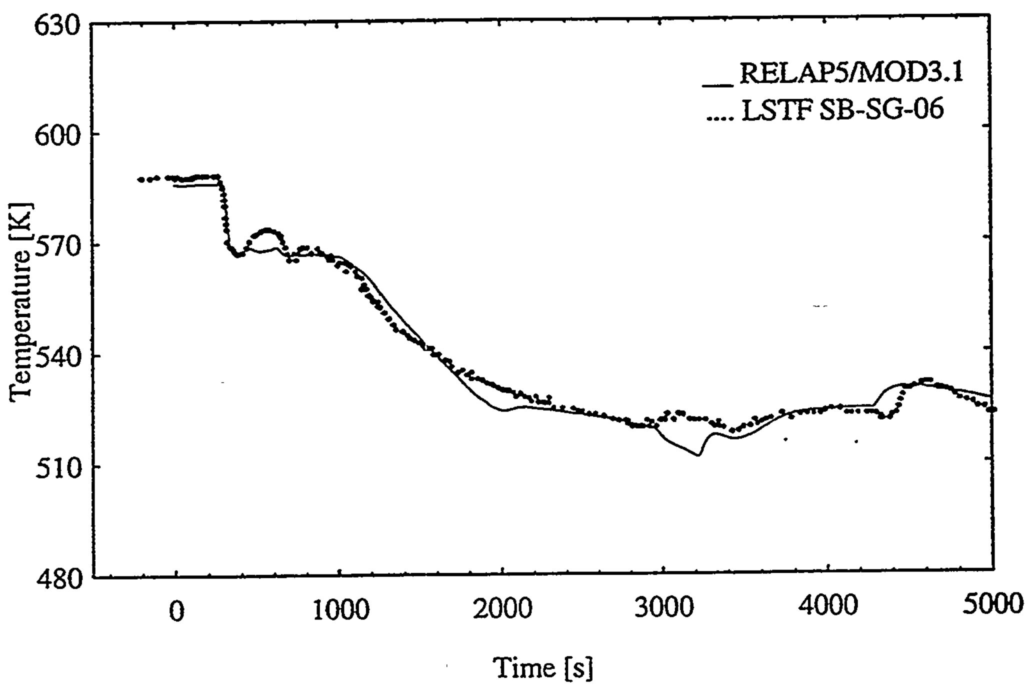


Figure 11 Comparison of Pressurizer Water Level

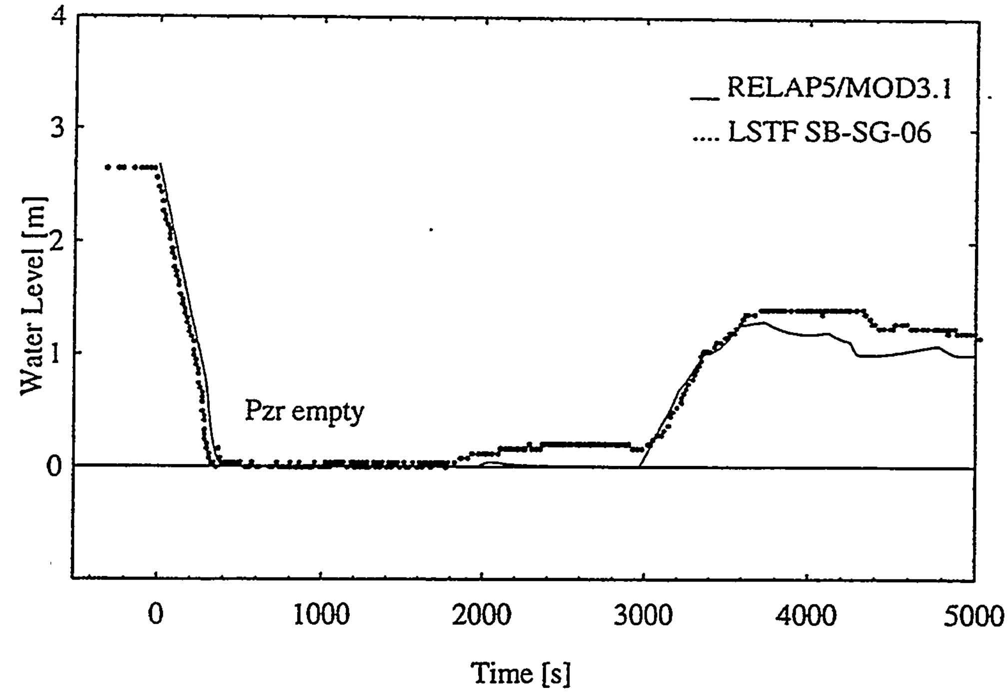


Figure 12 Comparison of SG Water Levels

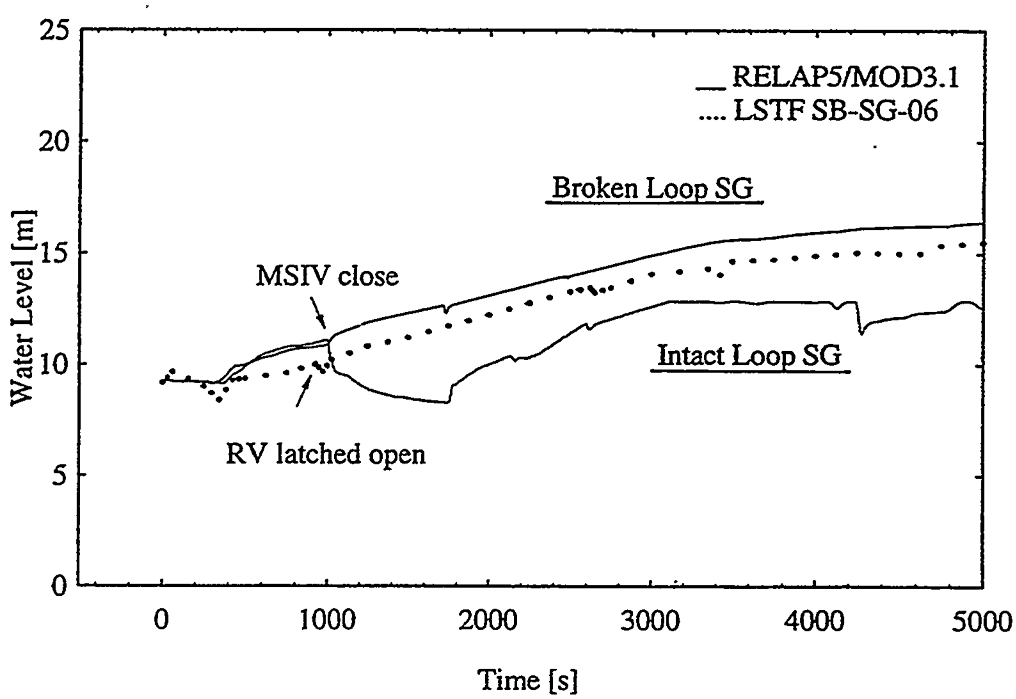


Figure 13 Comparison of Intact Loop Mass Flow rate

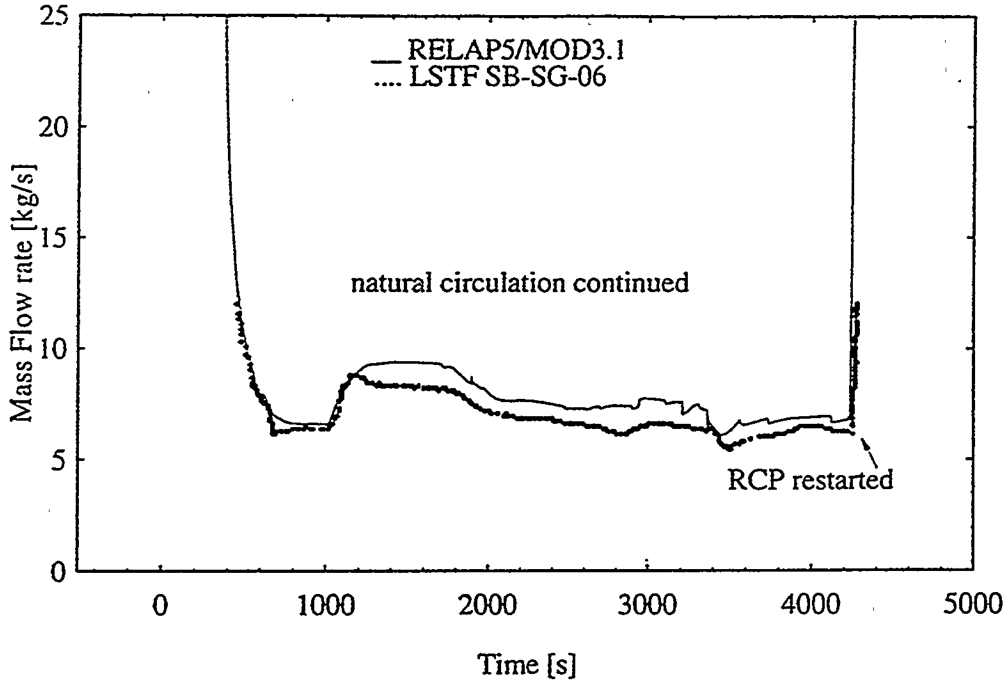


Figure 14 Comparison of Broken Loop Mass Flow rate

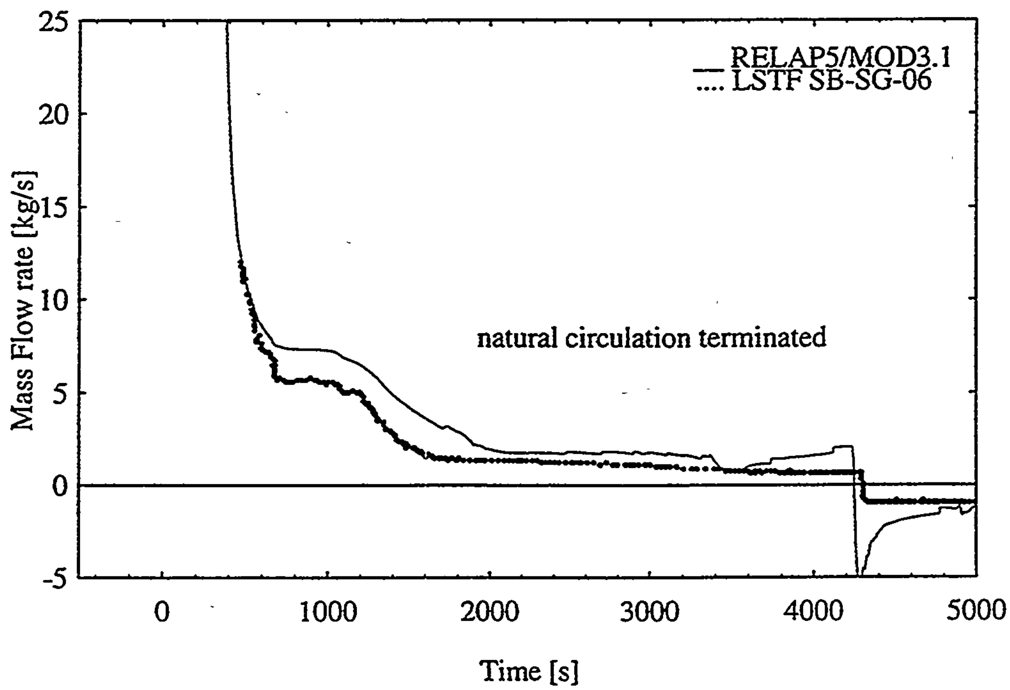


Figure 15 Comparison of HPSI-core upper plenum Mass Flow rate

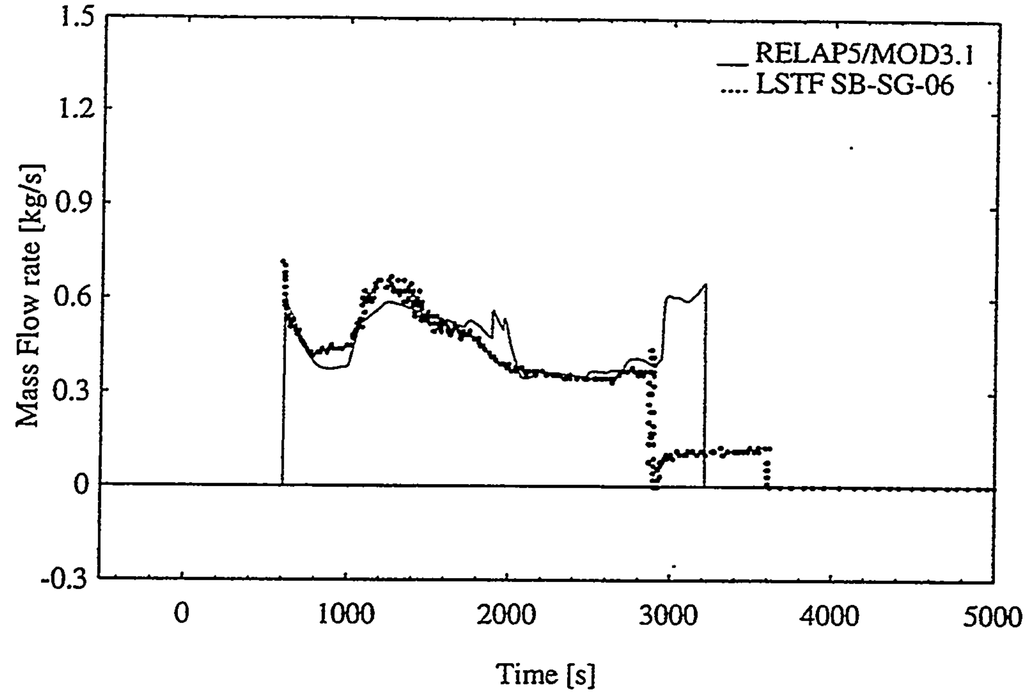


Figure 16 Comparison of HPSI-cold legs Mass Flow rate

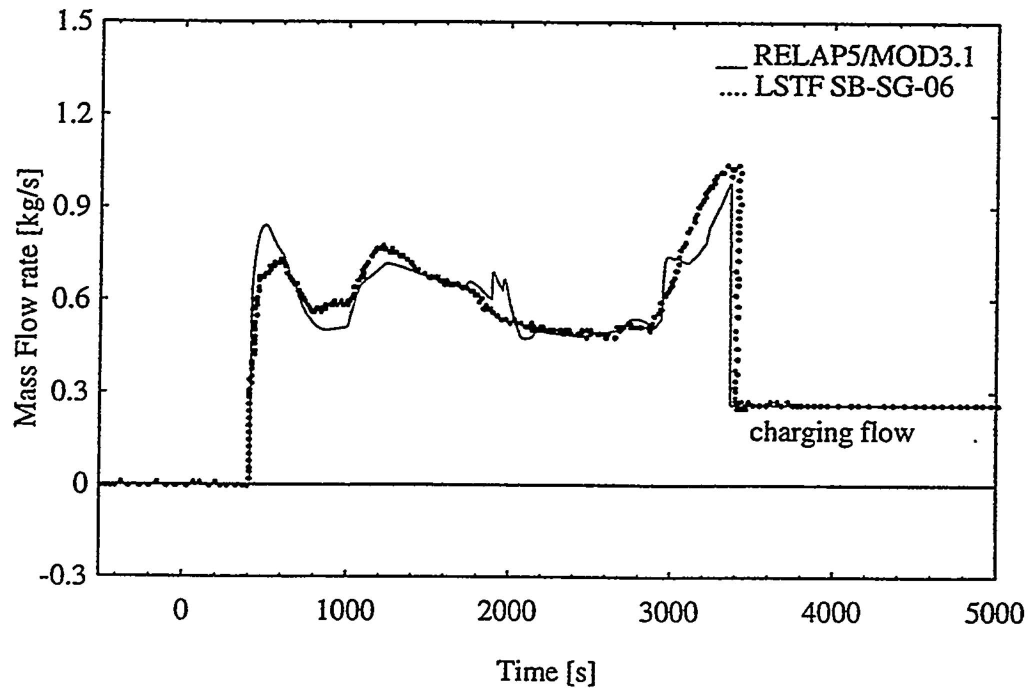


Figure 17 Comparison of Break Mass Flow rate between Experiment and Calculation

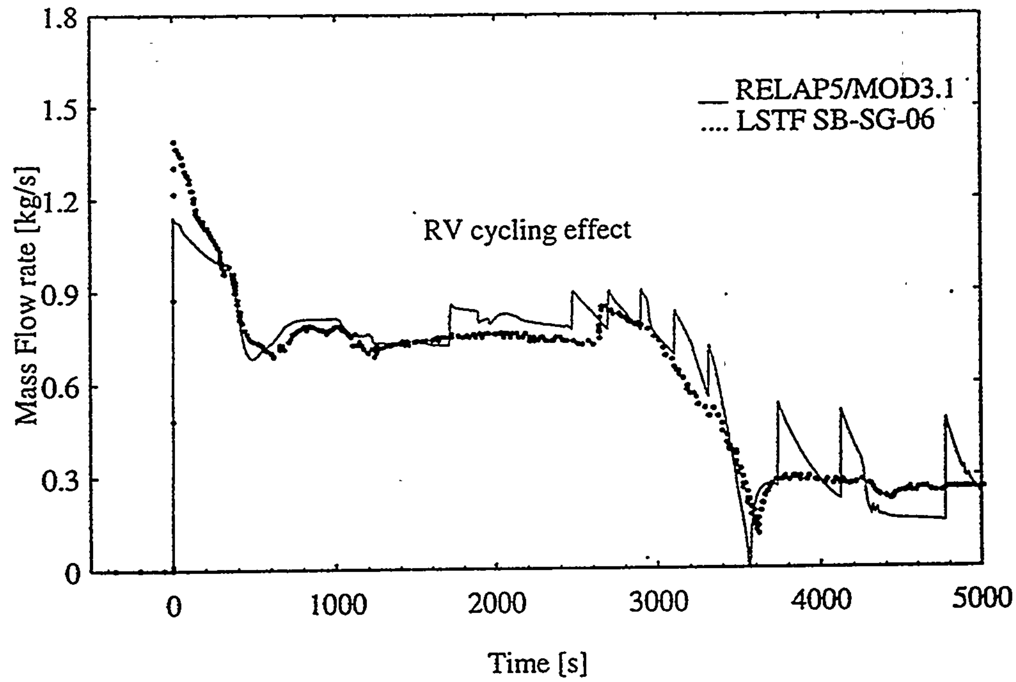


Figure 18 Integrated Break Mass Flow and HPSI Mass Flow

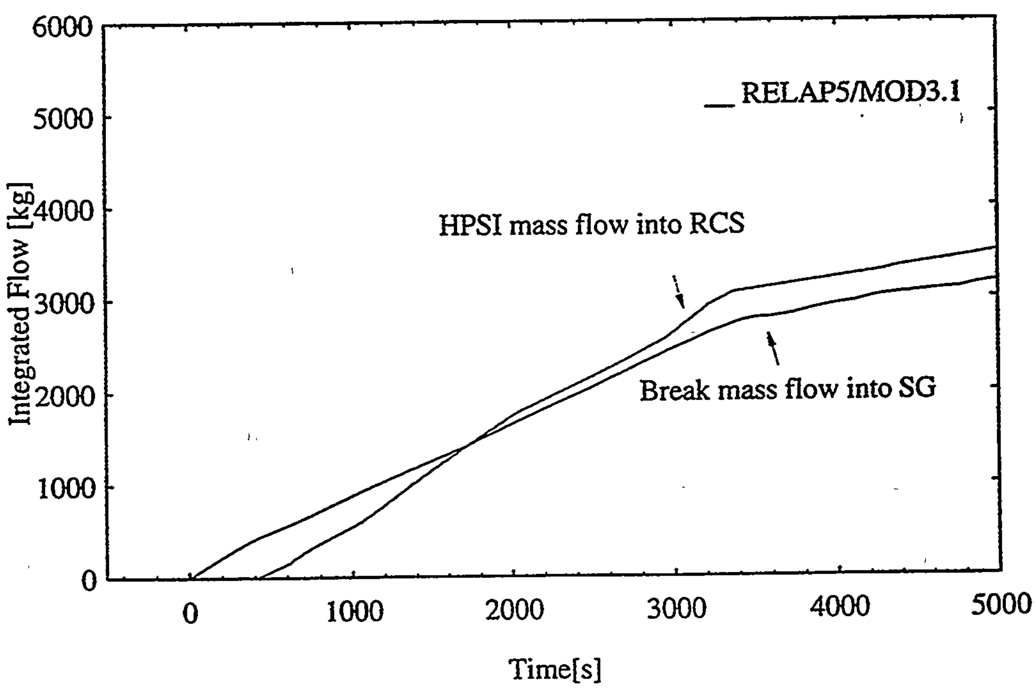


Figure 19 The Calculated Feedwater Flow rate in Intact Loop Secondary Side

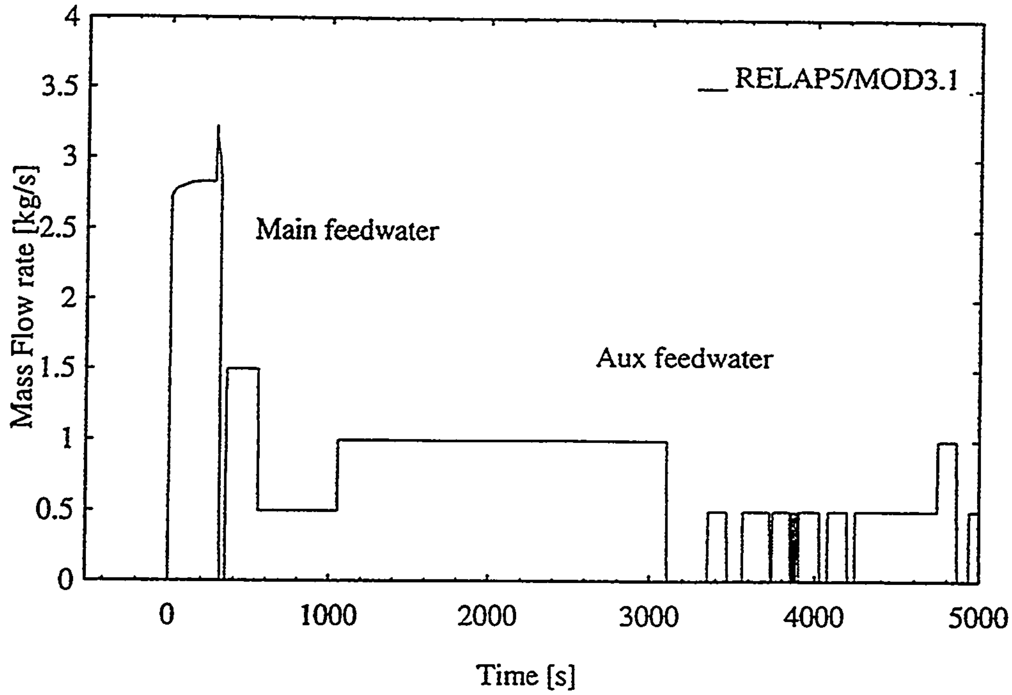


Figure 20 The Calculated Feedwater Flow rate in Broken Loop Secondary Side

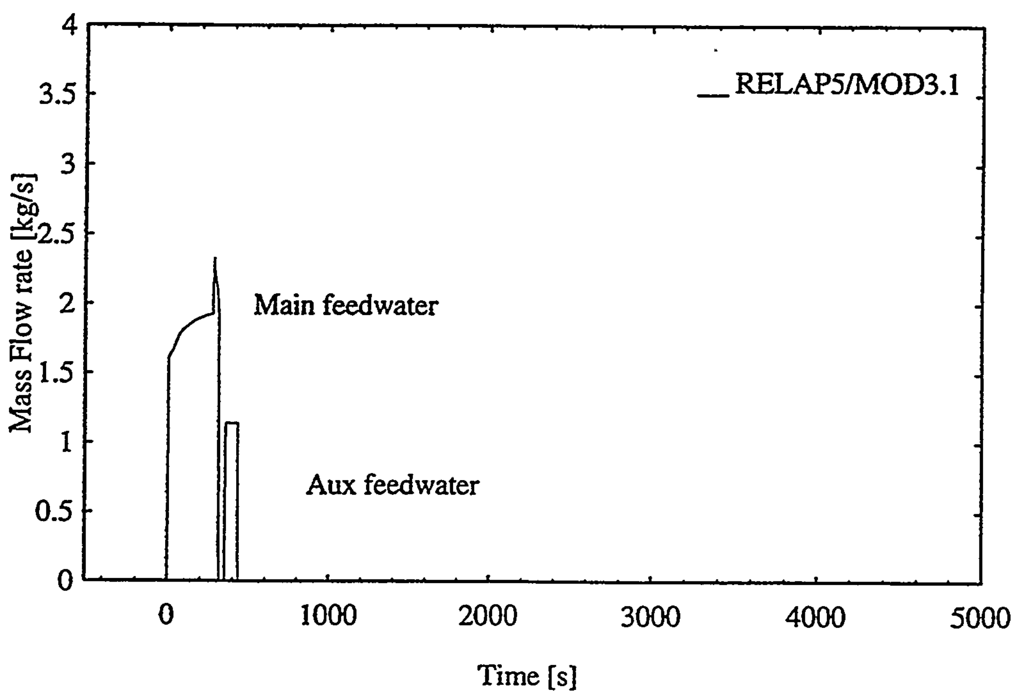


Figure 21 The Pressurizer Auxiliary Spray Mass Flow rate

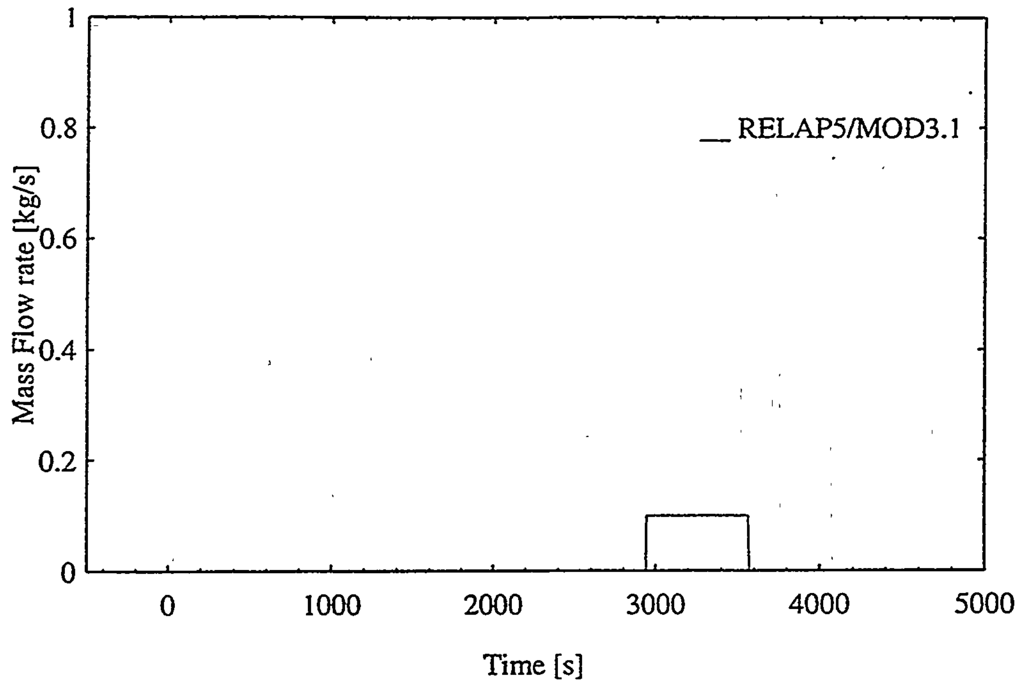


Figure 22 The Atmospheric Steam Dump Flow rate through Intact Loop Relief Valve

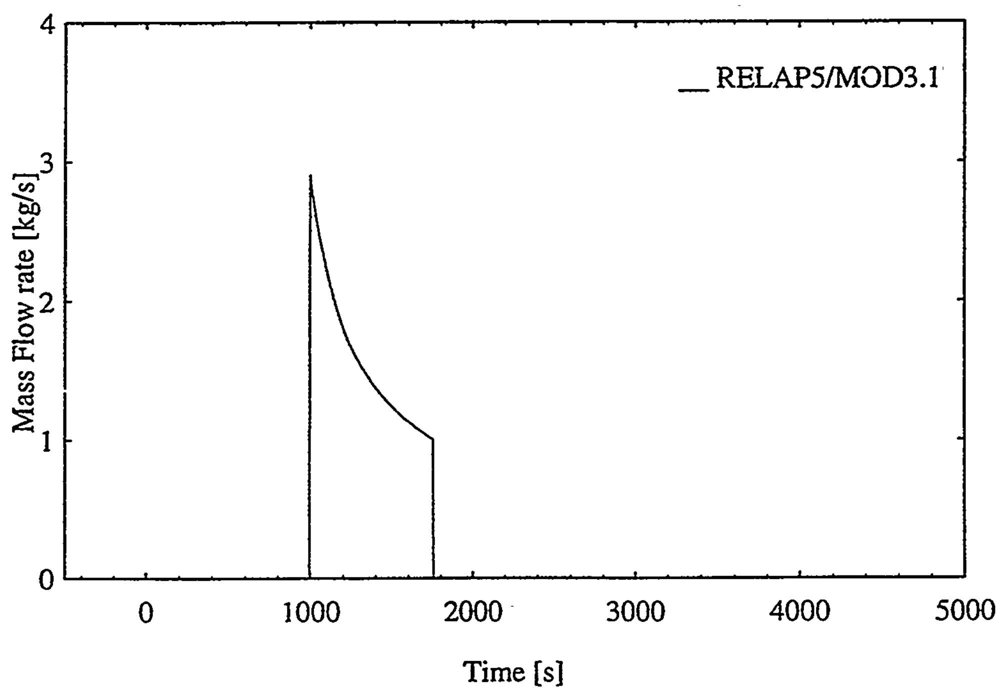


Figure 23 The Calculated Heat Flux on U-tube Wall in Broken Loop SG

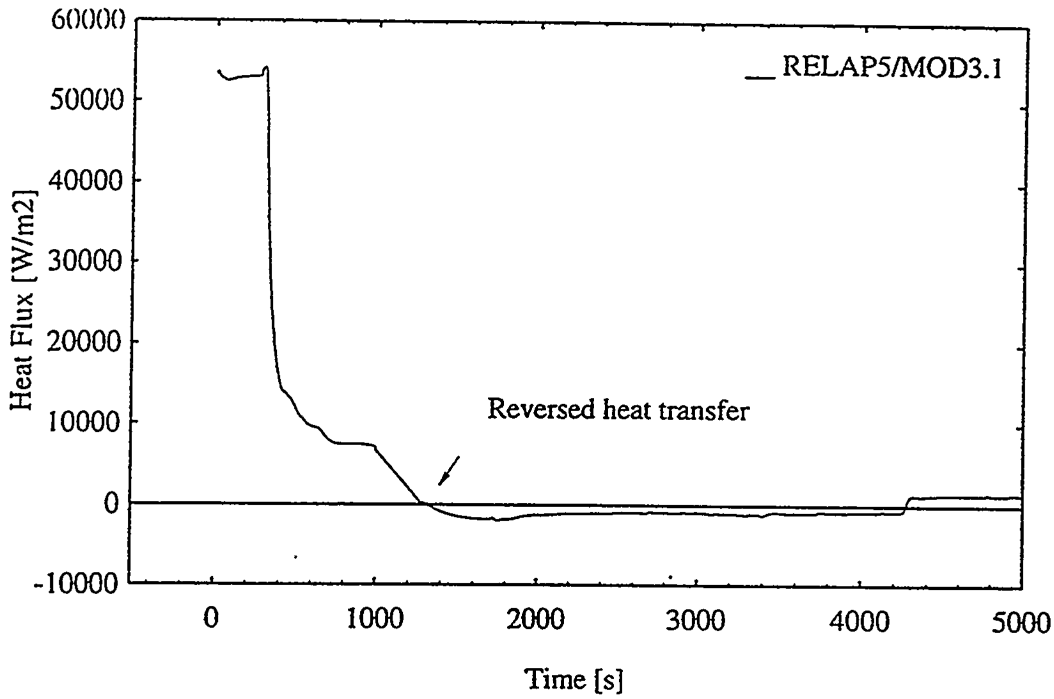


Figure 24 The Calculated Heat Flux on Steamdome Wall in Broken Loop SG

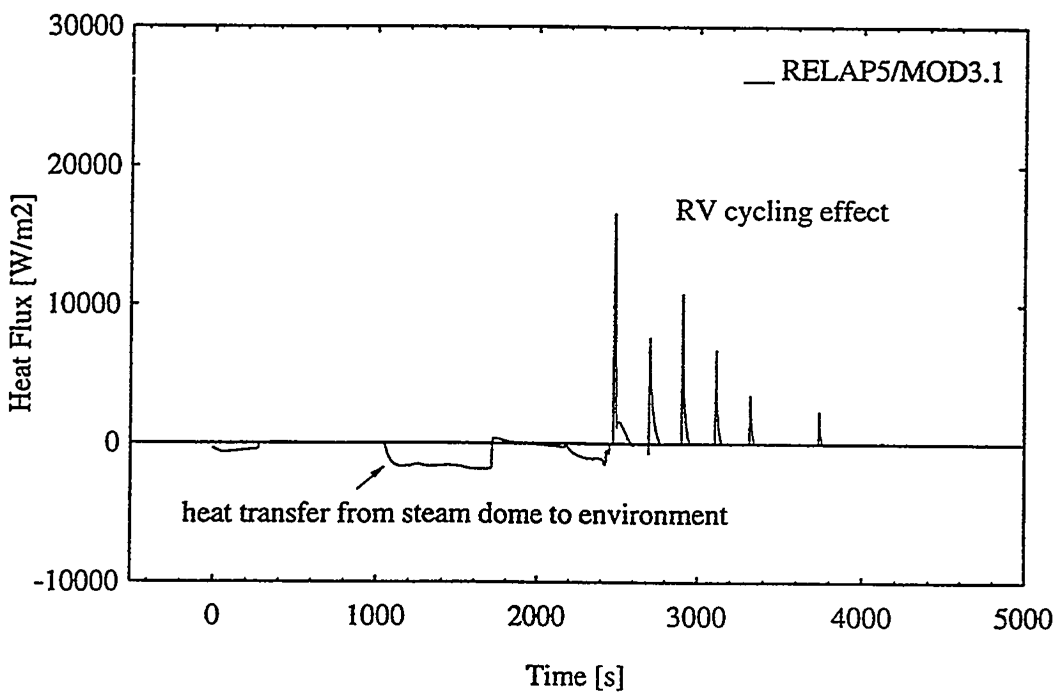


Figure 25 The Calculated Flow rate on Pressurizer Surge Line

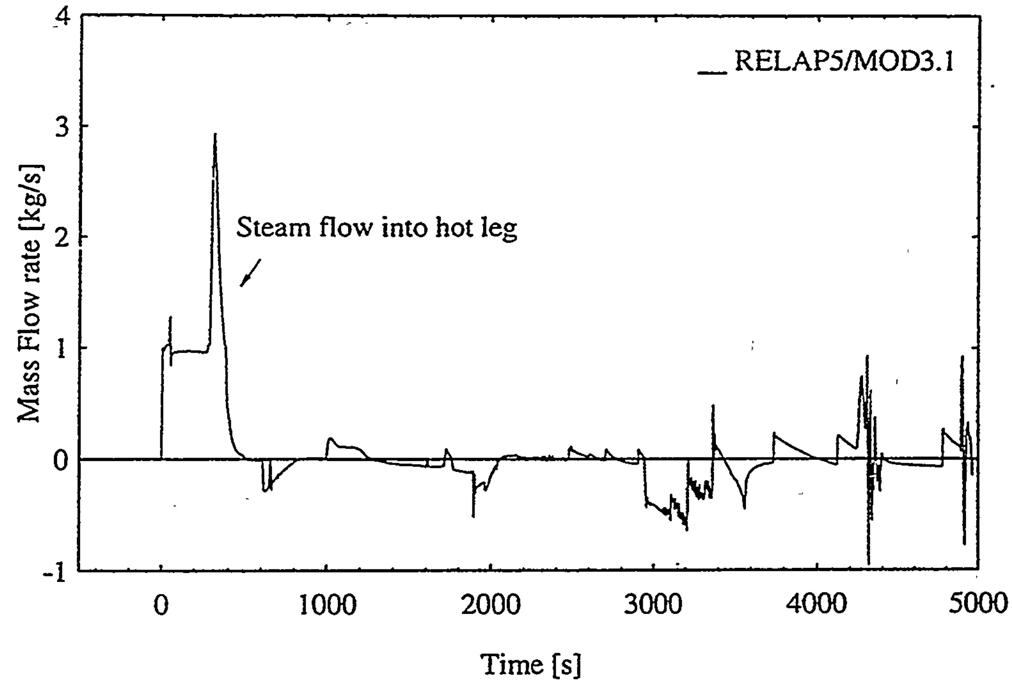


Figure 26 The Calculated Void Fraction in Pzr Surge Line and Hot Leg

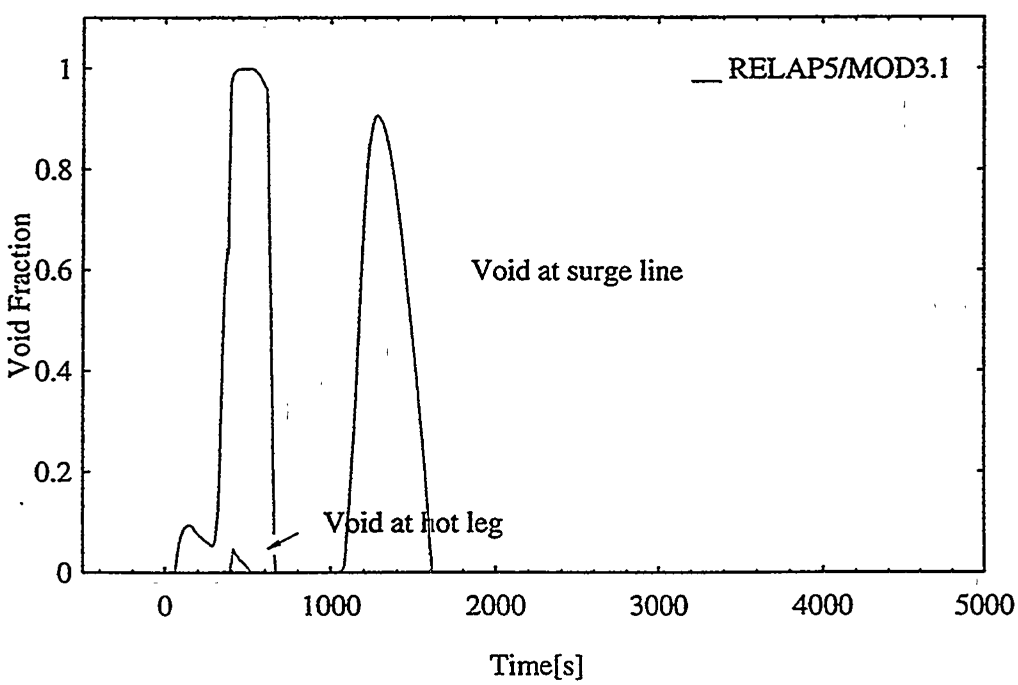


Figure 27 Comparison of Primary Pressure between MOD3.0 and MOD3.1

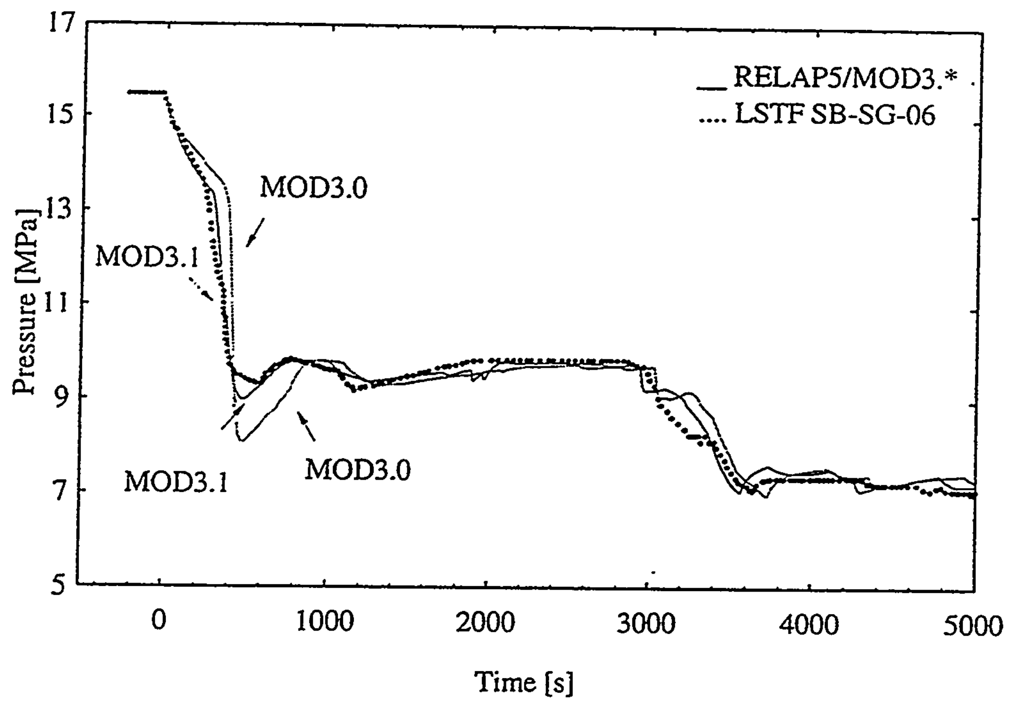


Figure 28 Comparison of Break Mass Flow rates on Break Simulation Model

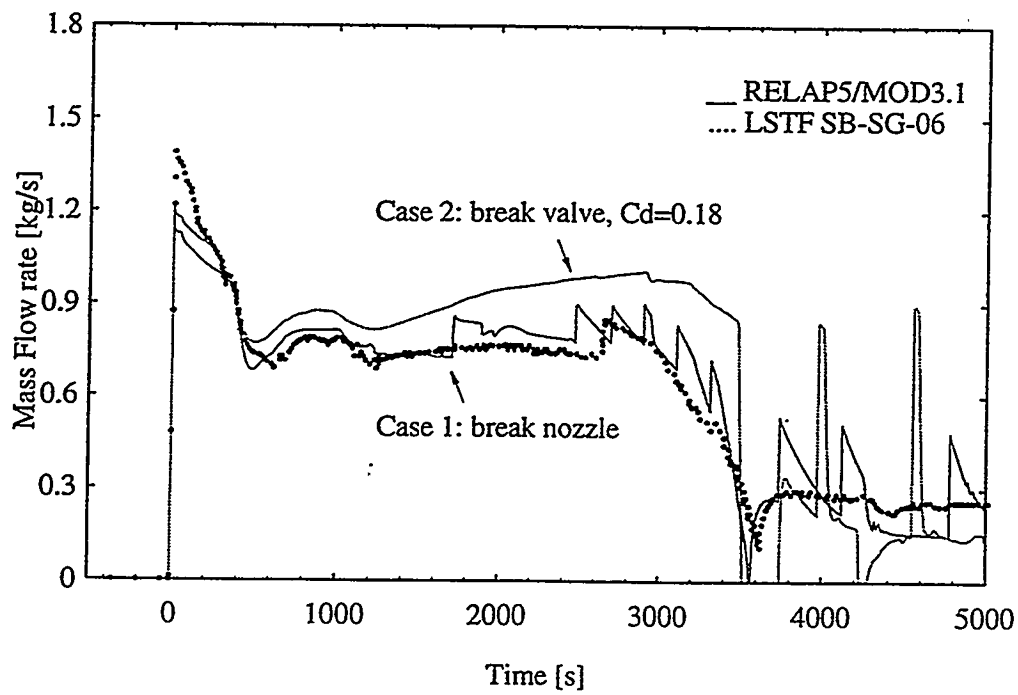


Figure 29 Comparison of Break Mass Flow rates on Break Discharge Coefficient

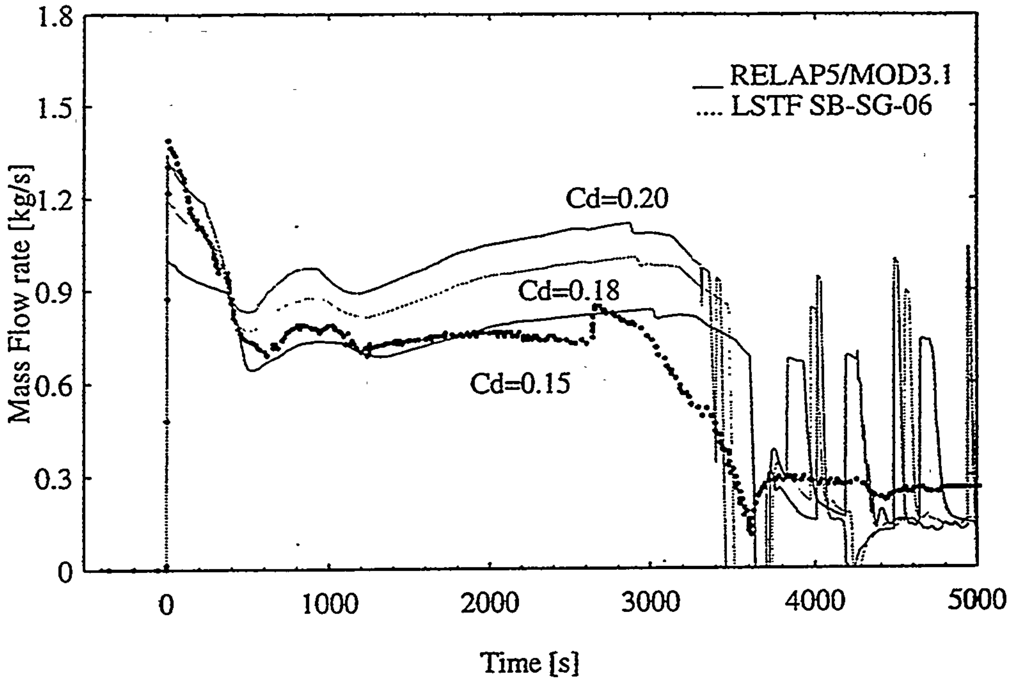


Figure 30 Comparison of CPU Times

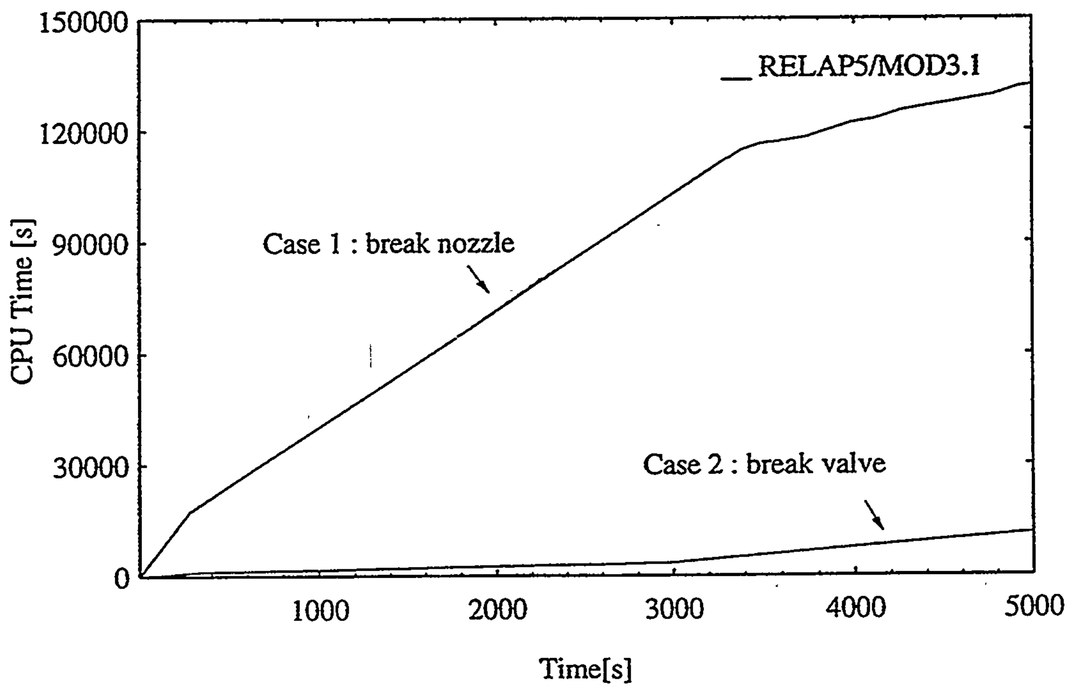
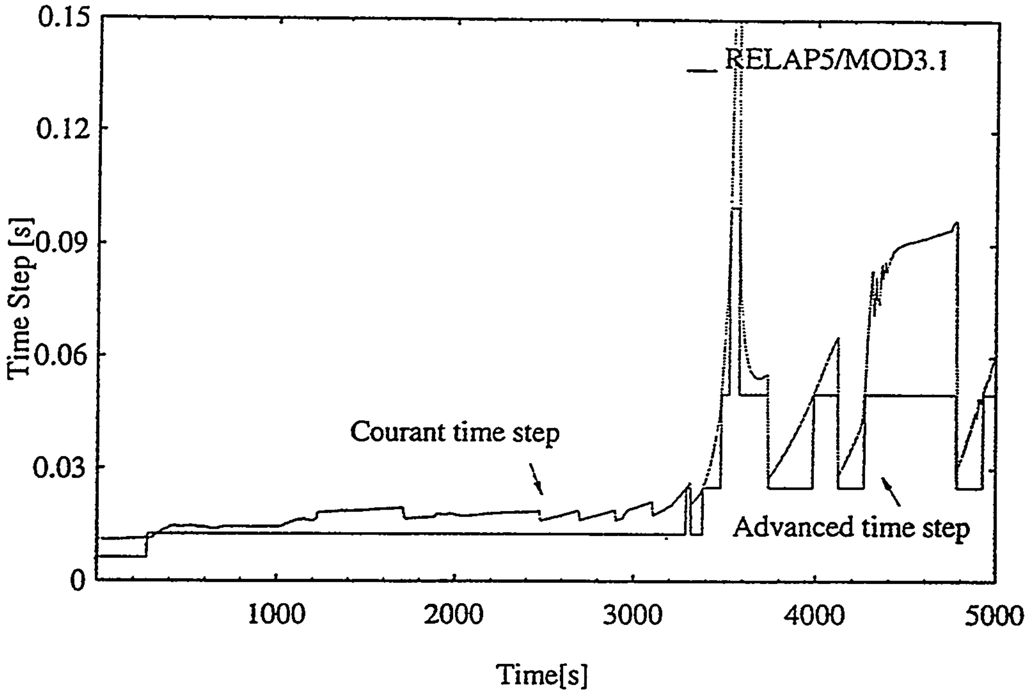


Figure 31 Courant Time Step and Advanced Time Step Size



Appendix A Input Deck for Steady State Calculation

```
*******************************************************
*
= lstf sgtr base input deck with relap5/mod3.1
*
*******************************************************
*
0000100   new   stdy-st
*
0000101   run
0000102   si  si
0000105   1.0  2.0
*
0000110   nitrogen
0000115   1.0
*
0000120   124010000   0.00   h2o   primary
*0000121   504010000   7.9639  h2o   secndry
C000121   900010000   0.00   h2o   contain
*
*  time step control
*
0000201   3000.0   1.0-6   0.5   3   10   200   200
*
*******************************************************
*   minor edits
*******************************************************
*
301  p         610010000   *pzr pressure
302  p         516010000   *sg-b steam pressure
303  p         316010000   *sg-i steam pressure
304  mflowj    208010000   *loop-i hot leg flow
305  mflowj    408010000   *loop-b hot leg flow
306  mflowj    248010000   *loop-i cold leg flow
307  mflowj    452010000   *loop-b cold leg flow
308  mflowj    108010000   *core bypass flow
309  mflowj    120010000   *core inlet flow
310  tempf     104010000   *vessel inlet temp
311  tempf     136010000   *vessel outlet temp
312  tempf     120010000   *core inlet temp
313  tempf     128010000   *core outlet temp
314  tempf     316010000   *sg-i steam temp
315  tempf     516010000   *sg-b steam temp
316  pmpvel    240
317  pmphead   240
318  pmpvel    440
319  pmphead   440
320  cntrlvar  512         *sg-b wr level
321  cntrlvar  508         *sg-b nr level
322  cntrlvar  504         *sg-b boiling water level
323  cntrlvar  312         *sg-i wr level
324  cntrlvar  308         *sg-i nr level
325  cntrlvar  304         *sg-i boiling water level
326  cntrlvar  610         *pzr level
327  cntrlvar  720         *primary mass
328  cntrlvar  309         *sg-i mass
329  cntrlvar  509         *sg-b mass
*
*******************************************************
* variable trips
*******************************************************
*
0000501  p         610010000  lt  null  0  1.342e+7  l *rx scram signal
0000502  time      0  ge  null  0  1.e6  l *power
0000505  p         610010000  lt  null  0  1.287e+7  l *rcp&si
0000506  time      0  ge  timeof  505  17.0  l *lpsi delay
0000507  time      0  ge  null  0  1.0e6  n *rcp delay
0000510  time      0  ge  timeof  505  10.0  l *il hpi
0000511  time      0  ge  timeof  505  300.0  l *il hppi to up
0000512  time      0  ge  timeof  505  10.0  n *bl hpi
0000514  cntrlvar  30  ge  cntrlvar  31  0.0  n *mean temp
0000516  cntrlvar  30  lt  cntrlvar  31  0.0  n
0000520  p         610010000  ge  null  0  1.646e+7  l *high pres
0000522  p         610010000  ge  null  0  1.726e+7  n *pzr sfty
0000524  p         610010000  ge  null  0  1.568e+7  n *pzr spry
0000526  p         610010000  gt  null  0  1.607e+7  n * porv
0000528  p         610010000  gt  null  0  1.620e+7  n
0000529  time      0  ge  null  0  0.0  l *pzr prp. htrs
0000530  p         610010000  lt  null  0  1.540e+7  n *pzr bkup htrs
0000531  p         610010000  lt  null  0  1.534e+7  n
0000532  cntrlvar  610  lt  null  0  0.25656  n *lo nrm pr lvl
0000535  time      0  ge  null  0  1000.0  l *tube break
0000536  time      0  ge  null  0  0.0  l *bl flow
0000537  time      0  lt  null  0  0.0  l *valve
0000538  time      0  lt  null  0  0.0  l *il flow
0000539  time      0  lt  null  0  0.0  l *valve
0000540  time      0  le  null  0  10000.0  n
0000550  p  610010000  ge  null  0  1.297e+7  l *main feed
0000552  time      0  ge  timeof  505  44.0  l *aux fed
*0000553  time     0  le  timeof  552  200.0  l *auxfeed
0000554  cntrlvar  308  lt  null  0  0.44  n *aux feed
0000555  cntrlvar  508  lt  null  0  0.44  n
*0000556  time     0  le  timeof  552  81.0  l *auxfeed
0000560  p  316010000  gt  null  0  7.82e+6  n *bl sg rel
0000561  p  316010000  gt  null  0  8.2e+6  n
0000564  p  316010000  gt  null  0  7.69e+6  n *bl sg saf
0000565  p  316010000  gt  null  0  8.68e+6  n
```

```
0000568 time 0 lt null 0 0.0 n *bl msiv
0000569 p 316010000 lt null 0 4.235e+6 l
0000570 p 516010000 gt null 0 7.82e+6 n *il sg rel
0000571 p 516010000 gt null 0 8.2e+6 n
0000574 p 516010000 gt null 0 7.69e+6 n *il sg saf
0000575 p 516010000 gt null 0 8.68e+6 n
0000578 time 0 lt null 0 0.0 n *il msiv
0000579 p 516010000 lt null 0 4.235e+6 l
0000580 cntrlvar 308 lt null 0 0.25 l *low sg lev
0000581 cntrlvar 508 lt null 0 0.25 l
0000583 time 0 ge null 0 0.0 n *stm hdr vlv
0000585 time 0 lt null 0 0.0 n *stm thrtl
0000586 time 0 ge null 0 11.0 n * valve
0000599 time 0 lt null 0 1000.0 n * ss pres
*************************************************************
* logical trips
*************************************************************
0000601 -603 and 571 n * il sec relief valve
0000602 603 and 570 n
0000603 601 or 602 n
0000604 -606 and 575 n * il sec safety valve
0000605 606 and 574 n
0000606 604 or 605 n
0000607 -609 and 561 n * bl sec relief valve
0000608 609 and 560 n
0000609 607 or 608 n
0000610 -612 and 565 n * bl sec safety valve
0000611 612 and 564 n
0000612 610 or 611 n
0000613 -615 and 528 n * porv
0000614 615 and 526 n
0000615 613 or 614 n
0000620 580 or 581 l * reactor trip
0000621 520 or 620 l
0000622 621 or 501 l
0000623 552 and 554 n * sg aux feed, bl
0000624 552 and 555 n * , il
0000625 -586 or -586 n * steam sink pressure
0000626 579 or 568 l * hpi
0000627 626 or 505 l
0000630 -632 and 531 n * pzr backup heater cntl
0000631 632 and 530 n
0000632 630 or 631 n
0000633 -505 and -532 n * pzr htrs off on sis or low pzr lvl
0000634 632 and 633 n * pzr htrs off on low pzr level
*************************************************************
* 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 003 15479968. 569.1
*
*************************************************************
1040000 inann branch
1040001 4 0
1040101 0.0 0.600 0.05425 0.0 -90.0 -0.600 4.57e-5
1040102 0.106 00
1040200 003 15487916. 560.4
1041101 104000000 100010000 0.0 0.0 0.0 0000
1042101 104010000 108000000 0.0 0.0 0.0 0000
1043101 252010000 104000000 0.03365 0.345 0.345 0101
1044101 452010000 104000000 0.03365 0.345 0.345 0101
1041201 5.42622-3 5.42622-3 0.0 * .24192712
1042201 1.0373539 1.0373539 0.0 * 48.158681
1043201 1.4005447 1.4005447 0.0 * 24.199945
1044201 1.4006109 1.4006109 0.0 * 24.200657
*
*************************************************************
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 00 9
1081101 0000 8
1081201 003 15482417. 560.5 0. 0. 0. 1
1081202 003 15498051. 560.5 0. 0. 0. 2
1081203 003 15493443. 560.5 0. 0. 0. 3
1081204 003 15497895. 560.5 0. 0. 0. 4
1081205 003 15502346. 560.5 0. 0. 0. 5
1081206 003 15506796. 560.5 0. 0. 0. 6
1081207 003 15511245. 560.5 0. 0. 0. 7
1081208 003 15515694. 560.5 0. 0. 0. 8
```

```
1081209   003        15522509.  560.5  0.  0.  0.  9
1081300   0
1081301   .96071571 .96071571 0.0     1          * 48.158687
1081302   .96098280 .96098280 0.0     2          * 48.158693
1081303   .96122606 .96122606 0.0     3          * 48.158697 .
1081304   .96145084 .96145084 0.0     4          * 48.158699
1081305   .96163484 .96163484 0.0     5          * 48.158700
1081306   .96176032 .96176032 0.0     6          * 48.158700
1081307   .96182512 .96182512 0.0     7          * 48.158698
1081308   .96184417 .96184417 0.0     8          * 48.158695
*
**************************************************************
1120000   lplovol     snglvol
1120101   0.0   0.626  0.1661  0.0   90.0   0.626   4.57e-5
1120102   0.0104   00
1120200   003        15532812.   560.5
*
**************************************************************
1160000   lowrplnm     branch
1160001   3        0
1160101   0.0   0.4762  0.0943   0.0  90.0  0.4762   4.57e-5
1160102   0.0104   00
1160200   003      15538774.     560.5
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   .96183851 .96183851 0.0                * 48.158680
1162201   .167004-9 .167679-9 0.0                * 17.0061-9
1163201   .90531130 .90531130 0.0                * 48.158664
1162110   0.0104     1.0      1.0      1.0
1163110   0.0104     1.0      1.0      1.0
*
**************************************************************
1200000   corein      branch
1200001   1         0
1200101   0.0   1.2588  0.1821   0.0   90.0   1.2588   4.57e-5
1200102   0.0104    00
1200200   003    15531639.   560.5
1201101   120010000    124000000   0.13657    0.85  0.85  0000
1201201   .701857   .701857    0.0                * 48.158607
1201110   0.009721     1.0      1.0      1.0
*
**************************************************************
1240000   core    pipe
1240001   6
1240101   0.0        6
1240201   0.119868    5
1240301   0.610       6
1240401   0.07312     6
1240601   90.0        6
1240701   0.610       6
1240801   4.57e-5    0.00832  6
1240901   0.68    0.68   5
1241001   00100       6
1241101   0000        5
1241201   003      15513996.    563.05  0.  0.  0.  1
1241202   003      15518831.    567.6   0.  0.  0.   2
1241203   003      15503749.    574.15  0.  0.  0.  3
1241204   003      15508764.    580.70  0.  0.  0.  4
1241205   003      15493863.    584.25  0.  0.  0.  5
1241206   003      15499012.    586.5   0.  0.  0.  6
1241300   0
1241301   1.4034412 1.4034412 0.0        1              * 48.158578
1241302   1.4215501 1.4215501 0.0        2              * 48.158541
1241303   1.4586451 1.4586451 0.0        3              * 48.158496
1241304   1.4601781 1.4601781 0.0        4              * 48.158441
1241305   1.4627423 1.4627423 0.0        5              * 48.158378
1241401   0.00832      1.0      1.0      1.0      5
*
**************************************************************
1280000   creoutlt    branch
1280001   3         0
1280101   0.0   0.867  0.1522    0.0   90.0    0.867    4.57e-5
1280102   0.0    00
1280200   003       15480901.    586.5
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   3.3840926 3.3840926 0.0                  * 48.158308
1282201   .67385815 .67385815 0.0                  * 48.399826
1283201   4.39830-3 4.39830-3 0.0                  * .24167236
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   upplnm       snglvol
1320101   0.0   0.6757  0.1060    0.0    90.0  0.6757   4.57e-5
1320102   0.321    00
1320200   003        15485850.     586.5
*
**************************************************************
1360000   upplnml      branch
1360001   5         0
1360101   0.0     0.600    0.09389  0.0  90.0    0.600     4.57e-5
1360102   0.321    00
```

```
1360200    003          15481715.   586.5
1361101    136000000  200000000  0.05520    0.265  0.265  0102
1362101    136000000  400000000  0.05520    0.265  0.265  0102
1363101    132010000  136000000  0.15669    0.0    0.0    0000
1364101    140000000  136010000  0.14305    0.0    0.0    0000
1365101    104000000  136000000  1.0e-4     40.    40.    0103
1361201    .95933557 .95933557 0.0                 * 24.200218
1362201    .95930429 .95930429 0.0                 * 24.199069
1363201    .67669046 .67669046 0.0                 * 48.399714
1364201    -5.8944-6 -5.8944-6 0.0                 * -326.21-6
1365201    0.802075   0.802175 0.0                 * 0.041000
1363110    0.321    1.0     1.0     1.0
1364110    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    003          15488458.    577.5
*
*************************************************************
1440000    tophat      snglvol
1440101    0.0   0.897   0.1655   0.0   90.0   0.897    4.57e-5
1440102    0.95    00
1440200    003           15461376.   577.0
*
*************************************************************
1480000    uhmidvol    branch
1480001    2        0
1480101    0.0   0.725  0.1970   0.0   90.0   0.725    4.57e-5
1480102    0.256   00
1480200    003          15455440.   576.0
1481101    100000000  148000000  9.5e-5  0.0   0.0   0100 *uh/dc leak
1482101    144010000  148000000  0.0    0.0    0.0    0000
1481201    5.44012-3 5.44012-3 0.0                 * .24180655
1482201    -519.36-9 -519.32-9 0.0                 * -49.179-6
*
*************************************************************
1520000    uhtopvol    branch
1520001    2        0
1520101    0.0   0.504  0.1475   0.0   90.0   0.504    4.57e-5
1520102    0.0     00
1520200    003          15450939.   576.0
1521101    148010000  152000000  0.0    0.0    0.0    0000
1522101    152000000  156000000  0.00199  1.472  1.472  0000
1521201    1.73108-3 1.73108-3 0.0                 * .24167128
1522201    .23663527 .23663526 0.0                 * .24176700
*
```

```
*************************************************************
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    00        2
1561101    0000      1
1561201    003          15469815.  578.  0.  0.  0. 1
1561202    003          15472498.  584.  0.  0.  0. 2
1561300    0
1561301    .04675404 .04675404 0.0        1      * .24169252
*************************************************************
* loop with pressurizer (broken loop)
*************************************************************
*
2000000    nphotleg   snglvol
2000101    0.0337  1.3246  0.0  0.0  0.0  0.0  4.57e-5 0.207  00
2000200    003          15471308.   586.5
*
*************************************************************
2020000    blhlbyps     branch
2020001    1         0
2020101    3.53e-4  2.65   0.0  0.0  0.0  0.0  4.57e-5  0.0    00
2020200    003          15481269.   560.5
2021101    104010000   202000000   3.53e-4   0.0    0.0   0100
2021201    0.0   0.0     0.0
*
*************************************************************
2030000    blhlbyp    valve
2030101    202010000   204000000  3.53e-4 27.6 27.6 0100
2030201    0     0.913 0.913 0.0
2030300    srvvlv
2030301    203
*
*************************************************************
2040000    blhlbyps     branch
2040001    1          0
2040101    3.53e-4  1.66    0.0  0.0 90.0  0.30  4.57e-5  0.0    00
2040200    003          15471269.   558.5
```

```
2041101   204010000   200000000   3.53e-4   0.0   0.0   0101
2041201   0.0   0.0   0.0
*
************************************************************
2060000   wphotleg   branch
2060001   3   0
2060101   0.0337  1.3195  0.0  0.0  0.0  0.0  4.57e-5  0.207  00
2060200   003   15471270.  586.5
2062101   200010000   206000000   0.0337   0.0   0.0   0000
2063101   206010000   208000000   0.0337   0.0   0.0   0000
2064101   600010000   206010000   0.00352   1.0   0.5   0001
2062201   1.5682911 1.5682911 0.0               * 24.199021
2063201   1.5683730 1.5683730 0.0               * 24.200785
2064201   1154.53-6 1154.53-6 0.0               * 1.80819-3
*
************************************************************
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   00   2
2081101   100000   1
2081201   003   15471238.  586.5  0.  0.  0. 1
2081202   003   15479897.  586.5  0.  0.  0. 2
2081300   0
2081301   1.5683412 1.5683412 0.0    1      * 24.200096
2081401   0.   0.   0.55   0.785   1
*
************************************************************
2090000   nphotleg   sngljun
2090101   208010000   212000000   0.0337   0.0   0.0   0100
2090201   0   1.5683441 1.5683441 0.0       * 24.200078
*
************************************************************
2120000   npsgin   snglvol
2120101   0.0   0.706   0.125   0.0   90.0   0.706   4.57e-5
2120102   0.377   00
2120200   003   15466381.   586.5
*
************************************************************
2130000   npsgfbj   sngljun
2130101   212010000   216000000   0.2093   0.0   0.0   0000
2130201   0   .25232836 .25232836 0.0       * 24.199962
*
************************************************************
2160000   npsgfb   snglvol
2160101   0.0   1.1035   0.2323   0.0   90.0   1.1035   4.57e-5
2160102   0.4474   00
2160200   003   15460476.   586.5
*
************************************************************
2170000   npsgin   sngljun
2170101   216010000   220000000   0.0425   0.0   0.0 100100
2170110   0.   0.   0.725   1.
2170201   0   1.2407596 1.2407596 0.0       * 24.199843
*
************************************************************
2200000   npsgtube   pipe
2200001   8
2200101   0.0425   8
2200301   2.8724   1
2200302   2.5654   3
2200303   2.1728   5
2200304   2.5654   7
2200305   2.8724   8
2200601   90.0   4
2200604   -90.0   8
2200701   2.8724   1
2200702   2.5654   3
2200703   2.0980   4
2200704   -2.0980   5
2200705   -2.5654   7
2200706   -2.8724   8
2200801   1.524-6   0.0196   8
2200901   0.0   0.0   3
2200902   0.006   0.0   4
2200903   0.006   0.006   5
2200904   0.0   0.006   6
2200905   0.0   0.0   7
2201001   00   8
2201101   0000   7
2201201   003   15446205.   578.83  0.  0.  0.  1
2201202   003   15426456.   572.17  0.  0.  0.  2
2201203   003   15407430.   568.50  0.  0.  0.  3
2201204   003   15389925.   566.83  0.  0.  0.  4
2201205   003   15389288.   564.17  0.  0.  0.  5
2201206   003   15405534.   562.50  0.  0.  0.  6
2201207   003   15423494.   561.83  0.  0.  0.  7
2201208   003   15442582.   560.17  0.  0.  0.  8
```

```
2201300    0
2201301    1.1888998 1.1568998 0.0     1          * 24.199823
2201302    1.1564485 1.1564485 0.0     2          * 24.199820
2201303    1.1372354 1.1372354 0.0     3          * 24.199823
2201304    1.1276379 1.1276379 0.0     4          * 24.199828
2201305    1.1209604 1.1209604 0.0     5          * 24.199833
2201306    1.1142686 1.1142686 0.0     6          * 24.199839
2201307    1.1111250 1.1111250 0.0     7          * 24.199844
*
****************************************************************
2210000    npsgout    sngljun
2210101    220010000  224000000  0.0425    0.0  0.0  0100
2210201    0          1.1089645 1.1089645 0.0    * 24.199848
*
****************************************************************
2240000    npsgfbo    snglvol
2240101    0.0  1.1035  0.2323  0.0  -90.0  -1.1035  4.57e-5
2240102    0.4474  00
2240200    003        15456792.  560.5
*
****************************************************************
2250000    npsgfbj    sngljun
2250101    224010000  228000000  0.2093    0.0  0.0  0000
2250201    0          .22448286 .22448286 0.0    * 24.199869
*
****************************************************************
2280000    npsgout    snglvol
2280101    0.0  0.706  0.125  0.0  -90.0  -0.706  4.57e-5
2280102    0.377  00
2280200    003        15463429.  560.5
*
****************************************************************
2290000    npcrsleg   sngljun
2290101    228010000  232000000  0.0222    0.0  0.0  0100
2290201    0          2.1244407 2.1244407 0.0    * 24.199885
*
****************************************************************
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    00       5
2321101    0000     4
2321201    003      15466371.  560.5  0.  0.  0.  1
2321202    003      15462314.  560.5  0.  0.  0.  2
2321203    003      15447133.  560.5  0.  0.  0.  3
2321204    003      15480360.  560.5  0.  0.  0.  4
2321205    003      15494826.  560.5  0.  0.  0.  5
2321300    0
2321301    2.1244352 2.1244352 0.0     1          * 24.199886
2321302    2.1244240 2.1244240 0.0     2          * 24.199890
2321303    2.1244071 2.1244071 0.0     3          * 24.199894
2321304    2.1243903 2.1243903 0.0     4          * 24.199899
*
****************************************************************
2330000    npfcv      valve
2330101    232010000  236000000  0.0222    0.0  0.0  0100
2330201    0          2.1243819 2.1243819 0.0    * 24.199903
2330300    mtrvlv
2330301    536        537        1.4200000 1.0000000 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    00       4
2361101    0000     3
2361201    003      15494735.  560.5  0.  0.  0.  1
2361202    003      15480528.  560.5  0.  0.  0.  2
2361203    003      15472206.  560.5  0.  0.  0.  3
2361204    003      15463883.  560.5  0.  0.  0.  4
2361300    0
2361301    2.1243819 2.1243819 0.0     1          * 24.199907
```

```
2361302      2.1243895 2.1243895 0.0       2              * 24.199912
2361303      2.1244048 2.1244048 0.0       3              * 24.199916
*
***************************************************************
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      003            15473807.  560.5
2400201      0             2.1244201 2.1244201 0.0        * 24.199921
2400202      0             1.3993350 1.3993350 0.0        * 24.199925
2400301      0    0    0    -1    0    0    0
2400302      188.50000 .680636  .05400000 10.000000 55.200000
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  -0.90  -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  -1.00  -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
*
*   pump coastdown data
```

```
*
2406100    501              * norm speed
2406101    0.0     128.3    * 160.22
2406102    80.0    128.3    * 160.22
2406103    83.0    122.0    * 153.75
2406104    86.0    118.9    * 149.87
2406105    89.0    114.9    * 144.86
2406106    101.0   96.7     * 121.90
2406107    110.0   82.6     * 104.12
2406108    119.0   74.4     * 93.77
2406109    131.0   63.4     * 79.86
2406110    140.0   56.7     * 71.46
2406111    149.0   51.8     * 65.31
2406112    161.0   46.3     * 58.36
2406113    170.0   41.7     * 52.54
2406114    179.0   38.2     * 48.18
2406115    191.0   34.8     * 43.81
2406116    200.0   32.3     * 40.74
2406117    209.0   30.0     * 37.38
2406118    221.0   27.3     * 34.43
2406119    230.0   25.3     * 31.85
2406120    239.0   23.2     * 29.26
2406121    251.0   21.4     * 27.00
2406122    260.0   20.3     * 25.54
2406123    269.0   19.0     * 23.92
2406124    281.0   16.3     * 20.53
2406125    290.0   14.6     * 18.43
2406126    299.0   12.4     * 15.60
2406127    320.0   9.9      * 12.48
2406128    341.0   7.4      * 9.36
2406129    359.0   5.0      * 6.24
2406130    380.0   2.5      * 3.12
2406131    400.0   0.0
2406132    1000.0  0.0
*
**************************************************************
2440000    wpcolleg   snglvol
2440101    0.0337   1.0562   0.0   0.0   0.0   0.0  4.57e-5  0.207 00
2440200    003        15487643.  560.5
*
**************************************************************
2480000    wpcolleg   branch
2480001    3          0
2480101    0.0337   1.1945   0.0  0.0  0.0  0.0    4.57e-5  0.207 00
2480200    003        15487614.  560.5
2481101    244010000   248000000   0.0337    0.0   0.0   0000
2482101    248010000   252000000   0.0337    0.0   0.0   0000
2483101    790010000   248010000   0.0060    1.0   0.5   0001
2481201    1.3993524 1.3993524 0.0                    * 24.200649
2482201    1.3993528 1.3993528 0.0                    * 24.200653
2483201    .574788-9 .574777-9 0.0                    * 2.38120-9
*
**************************************************************
2520000    wpcolleg    snglvol
2520101    0.0337   1.3125   0.0  0.0  0.0  0.0   4.57e-7 0.207  00
2520200    003             15487585.  560.5
*
**************************************************************
*
*  secondary loop 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    00         5
3001101    0000       3
3001102    0100       4
3001201    003        6850719.   546.  0.  0.  0.  1
3001202    003        6865934.   546.  0.  0.  0.  2
3001203    003        6883272.   546.  0.  0.  0.  3
3001204    003        6912349.   546.  0.  0.  0.  4
3001205    003        69371666.  546.  0.  0.  0.  5
3001300    0
3001301    .61390359 .61390359 0.0       1          * 13.834317
```

```
3001302   .61389325 .61389325 0.0     2            * 13.834278
3001303   .61387866 .61387866 0.0     3            * 13.834214
3001304   .61386007 .61386007 0.0     4            * 13.834133
*
**************************************************************
3010000   npstgdcm   sngljun
3010101   300010000  304000000  0.0   100.0  100.0   0000
3010201   0          .48038520 .69708130 0.0       * 13.833941
*
**************************************************************
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   00         5
3041101   0000       3
3041102   0000       4
3041201   0          6900485.9 1261112.3 2580244.6 .14219192 0.0  1
3041202   0          6887036.6 1264931.2 2580399.8 .28828728 0.0  2
3041203   0          6874704.9 1264683.5 2580530.3 .28643954 0.0  3
3041204   0          6863302.6 1264128.3 2580649.9 .27887377 0.0  4
3041205   0          6853423.5 1263801.8 2580702.3 .27518532 0.0  5
3041300   0
3041301   .09940788 .37087476 0.0     1            * 13.810074
3041302   .11458638 .49504010 0.0     2            * 13.804585
3041303   .10794204 .71300003 0.0     3            * 13.802420
3041304   .09899163 .87128853 0.0     4            * 13.799040
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    0
3080101   0.0   2.120   0.572   0.0   90.0   2.120   4.57e-5
3080102   0.2134   00
3080200   0        6844590.2 1263471.6 2580768.1 .50638217
3081101   308010000   316000000   0.0615   0.0   0.0   0100 0.2
3082101   308000000   300000000   0.03964 100.0 100.0   0000
3083101   304010000   308000000   0.1986   0.0   0.0   0000
3081201   -.3840036 .27406855 0.0                    * 2.7469745
3082201   .37743398 -1.777076 0.0                    * 11.041964
3083201   .11701332 1.0458935 0.0                    * 13.801835
*
**************************************************************
3120000   npsgspbp   branch
3120001   2      0
3120101   0.0   2.120   0.6288   0.0   90.0   2.120   4.57e-5
3120102   0.1242   00
3120200   0        6841893.0 1236857.5 2584233.4 .87891994
3121101   300000000   312000000   0.3164    0.0   0.0   0000
3122101   312010000   316000000   0.0392    1.5   1.5   0000
3121201   30.0480-6 1.1555824 0.0                   * 7.23798-3
3122201   -42.50990 -1.5229-3 0.0                   * -2.6126-3
*
**************************************************************
3160000   stmdome    snglvol
3160101   0.0   3.7778   2.0288   0.0   90.0   3.7778   4.57e-5
3160102   0.7696   00
3160200   0        6849946.7 1262926.9 2580859.5 .99999968
*
**************************************************************
*   blsg steam line
**************************************************************
3200000   blstmln1   branch
3200001   2      0
3200101   0.0286   5.286   0.0   0.0   0.0   0.0   4.57e-5
3200102   0.1909   00
3200200   0        6849057.2 1262882.9 2580880.3 .99999786
3201101   316010000   320000000   0.0286    0.0   0.0   0100
3202101   320010000   324000000   0.0286    0.0   0.0   0000
3201201   2.4791454 2.5876488 0.0                   * 2.7470311
3202201   2.4234202 2.5881767 0.0                   * 2.7472440
*
**************************************************************
3240000   blstmln2   branch
3240001   1      0
3240101   0.0286   9.9213   0.0   0.0   0.0   0.0   4.57e-5
```

```
3240102    0.1909    00
3240200    0         6848966.1 1262878.4 2580896.2 .99999675
3241101    324010000   328000000   0.00429   0.0   0.0   0000
3241201    14.028836 17.257852 0.0                     * 2.7477108
*
****************************************************************
3280000    blstmln3    snglvol
3280101    0.00429   8.3215   0.0   0.0   0.0   0.0   4.57e-5
3280102    0.0739    00
3280200    0         6828063.0 1262339.0 2580962.3 .99998690
*
****************************************************************
3290000    blmsiv    valve
3290101    328010000   332000000   0.00429   0.0  0.0  0100
3290201    0         12.637699 17.284590 0.0           * 2.7477202
3290300    mtrvlv
3290301    568       501       2.0000000 1.0000000 0
*
****************************************************************
3320000    vlvtovlv    snglvol
3320101    0.00429   6.446   0.0   0.0   0.0   0.0   4.57e-5
3320102    0.0739    00
3320200    0         6828346.0 1261857.2 2581064.5 .99997696
*
****************************************************************
3330000    blchkvl    valve
3330101    332010000   804000000   0.00429   0.0   0.0   0000
3330201    0         10.389571 17.310434 0.0           * 2.7477882
3330300    chkvlv
3330310    0   0     0.0   0.0
*
****************************************************************
3500000    auxfed      tmdpvol
3500101    8.0         5.0   0.0   0.0   0.0   0.0   0.0   0     00
3500200    3
3500201    0.0         5.95300e+6        313.0
*
****************************************************************
3510000    auxfed      tmdpjun
3510101    350000000   300000000   0.004
3510200    1   623
3510201    0.0   0.0   0.0   0.0
3510202    0.01   1.500 0.0   0.0
3510203 5000.0    1.500 0.0   0.0
****************************************************************
3600000    npstegfw    tmdpvol
3600101    0.139       5.0   0.0   0.0   0.0   0.0   0.0   0     00
3600200    3
3600201    0.0         5.83400e+6        495.35
*
****************************************************************
3610000    npstegfw    tmdpjun
3610101    360000000   300000000   4.00e-3
3610200    1   550   cntrlvar   361
3610201    0.0   0.0     0.0  0.0
3610202    5.0   5.0     0.0  0.0
3610203    7.0   7.0     0.0  0.0
3610204 1000.0   7.0     0.0  0.0
*
****************************************************************
* secondary relief and safety valves, broken loop
****************************************************************
*
3690000    blsgrv    valve
3690101    320010000   370000000   2.96e-4   0.0149   0.0   0100
3690201    0         0.0       0.0       0.0               * 0.0
3690300    trpvlv
3690301    609
*
****************************************************************
3700000    contain    tmdpvol
3700101    1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
3700200    3
3700201    0.0   1.01325e+5   293.15
*
****************************************************************
3790000    blsgsv    valve
3790101    324010000   380000000   0.00195   0.00055   0.0   0100
3790201    0         0.0       0.0       0.0               * 0.0
3790300    trpvlv
3790301    612
*
****************************************************************
3800000    contain    tmdpvol
3800101    1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
3800200    3
3800201    0.0   1.01325e+5   293.15
*
****************************************************************
*  loop without pressurizer (intact loop)
****************************************************************
*
4000000    wphotleg    snglvol
4000101    0.0337  1.3246  0.0  0.0  0.0  0.0  4.57e-5 0.207  00
4000200    003         15471308.  586.5
*
```

```
***************************************************************
4020000   ilhlbyps   branch
4020001   1   0
4020101   3.53e-4  2.65   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4020200   003        15481269.  560.5
4021101   104010000   402000000   3.53e-4   0.0   0.0   0100
4021201   0.0   0.0   0.0
*
***************************************************************
4030000   blhlbyp   valve
4030101   402010000   404000000  3.53e-4 27.6 27.6 0100
4030201   0   0.913 0.913 0.0
4030300   srvvlv
4030301   403
*
***************************************************************
4040000   blhlbyps   branch
4040001   1   0
4040101   3.53e-4  1.66   0.0  0.0 90.0  0.30  4.57e-5  0.0   00
4040200   003        15471269.  558.5
4041101   404010000   400000000   3.53e-4   0.0   0.0   0101
4041201   0.0   0.0   0.0
*
***************************************************************
4060000   nphotleg   branch
4060001   2   0
4060101   0.0337  1.3843  0.0  0.0  0.0  0.0  4.57e-5  0.207  00
4060200   003        15471269.   586.5
4061101   400010000   406000000   0.0337   0.0   0.0   0000
4062101   406010000   408000000   0.0337   0.0   0.0   0000
4061201   1.5683423 1.5683423 0.0                * 24.200171
4062201   1.5683417 1.5683417 0.0                * 24.200126
*
***************************************************************
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   00   2
4081101   100000   1
4081201   003        15471238.  586.5  0.  0.  0.  1
4081202   003        15479897.  586.5  0.  0.  0.  2
4081300   0
4081301   1.5683725 1.5683725 0.0      1         * 24.200756
4081401   0.   0.   0.55   0.785   1
*
***************************************************************
4090000   wphotleg   sngljun
4090101   408010000   412000000   0.0337   0.0   0.0   0100
4090201   0        1.5683754 1.5683754 0.0        * 24.200738
*
***************************************************************
4120000   wpsgin   snglvol
4120101   0.0   0.706   0.125   0.0   90.0   0.706   4.57e-5
4120102   0.377   00
4120200   003        15466381.  586.5
*
***************************************************************
*
4160000   wpsgfb   branch
4160001   3   0
4160101   0   1.1035   0.2323   0.0   90.0   1.1035   4.57e-5
4160102   0.4474   00
4160200   003     15460476.   586.5
4162101   412010000   416000000   0.2093   0.0   0.0   0000
4163101   416010000   420000000   0.04254   0.0   0.0   0000
4164101   416010000   417000000   5.0e-4   0.0   0.0   0100
4162201   1.247   1.247   0.0
4163201   1.247   1.247   0.0
4164201   0.1   0.1   0.0
*
***************************************************************
*
4170000   bktln1   snglvol
4170101   5.0e-4  1.18   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4170200   003        15453426.  560.5
*
4180000   bktln4   branch
4180001   2   0
4180101   5.0e-4   2.06   0.0  0.0  -90.0  -2.06  4.57e-5  0.0  00
4180200   003        15441269.   586.5
4181101   417010000   418000000   5.0e-4   0.0   0.0   0000
4182101   418010000   419000000   5.0e-4   0.0   0.0   0000
4181201   0.1   0.1   0.0
4182201   0.1   0.1   0.0
*
4190000   bktln5   snglvol
4190101   5.0e-4  1.9   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4190200   003        15433426.  560.5
```

```
*
4930000    break     valve
4930101    419010000   494000000  5.0e-4   0.0   0.0   0000
4930201    1   0.0   0.0   0.0
4930300    trpvlv
4930301    535
*
*****************************************************************
*
4940000    bkln5     snglvol
4940101    5.0e-4  0.24   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4940200    003         7310426.  540.5
*
4950000    bkln4     branch
4950001    2         0
4950101    5.0e-4   0.35   0.0  0.0  90.0  0.35  4.57e-6  0.0  00
4950200    003          7311269.   546.5
4951101    495010000   496000000   3.02e-5  0.0   0.0   0100
4952101    494010000   495000000   5.0e-4   0.0   0.0   0000
4951201    0.1    0.1    0.0
4952201    0.1    0.1    0.0
*
4960000    brknozl    pipe
4960001    3
4960101    3.02e-5     3
4960301    0.6         3
4960401    0.0         3
4960601    90.0        3
4960701    0.6         3
4960801    1.2e-7      0.0062  3
4960901    0.0         0.0     2
4961001    00          3
4961101    01000       2
4961201    003         7315536. 546.50  0.  0.  0.  1
4961202    003         7325536. 546.50  0.  0.  0.  2
4961203    003         7330536. 546.50  0.  0.  0.  3
4961300    0
4961301    0.1   0.1   0.0     1
4961302    0.1   0.1   0.0     2
*
4970000    bkln2     branch
4970001    2         0
4970101    5.0e-4   0.75   0.0  0.0  90.0  0.75  4.57e-6  0.0  00
4970200    003         7331269.   546.5
4971101    496010000   497000000   3.02e-5   0.0   0.0   0100
4972101    497010000   498000000   5.0e-4    0.0   0.0   0000
4971201    0.1    0.1    0.0
4972201    0.1    0.1    0.0
```

```
*
4980000    bkln2    pipe
4980001    2
4980101    5.0e-4   2
4980301    1.25     2
4980601    0.0      2
4980701    0.0      2
4980801    4.57e-5  0.0      2
4980901    0.0      0.0      1
4981001    00       2
4981101    0000     1
4981201    003         7344729.  540.5  0.  0.  0.  1
4981202    003         7350523.  540.5  0.  0.  0.  2
4981300    0
4981301    0.1    0.1    0.0       1
*
4990000    bkln1     sngljun
4990101    498010000    504010003   5.0e-4    0.0    0.0    0100
4990201    0         0.1    0.1    0.0
*
*****************************************************************
4200000    wpsgtube     pipe
4200001          5
4200101    0.04254      5
4200301    2.8724       1
4200302    2.5654       3
4200303    2.1728       5
4200601    90.0         4
4200602    -90.0        5
4200701    2.8724       1
4200702    2.5654       3
4200703    2.0980       4
4200704    -2.0980      5
4200801    1.524-6      0.0196       5
4200901    0.0          0.0          3
4200902    0.006        0.0          4
4201001    00           5
4201101    0000         4
4201201    003          15446206.  578.83  0.  0.  0.  1
4201202    003          15426457.  572.17  0.  0.  0.  2
4201203    003          15407432.  568.5   0.  0.  0.  3
4201204    003          15389928.  566.83  0.  0.  0.  4
4201205    003          15389291.  564.17  0.  0.  0.  5
4201300    0
4201301    1.1884545 1.1884545 0.0        1              * 24.200508
4201302    1.1561451 1.1561451 0.0        2              * 24.200513
4201303    1.1379927 1.1379927 0.0        3              * 24.200523
4201304    1.1274428 1.1274428 0.0        4              * 24.200534
```

```
*
****************************************************************
4220000   wpsgtub2   pipe
4220001   3
4220101   0.04254   3
4220301   2.5654    2
4220302   2.8724    3
4220601   -90.0     3
4220701   -2.5654   2
4220702   -2.8724   3
4220801   1.524-6   0.0196   3
4220901   0.0       0.006    1
4220902   0.0       0.0      2
4221001   00        3
4221101   0000      2
4221201   003       15405536. 562.50  0.  0.  0.  1
4221202   003       15423494. 561.83  0.  0.  0.  2
4221203   003       15442580. 560.17  0.  0.  0.  3
4221300   0
4221301   1.1140999 1.1140999 0.0   1   * 24.200557
4221302   1.1119639 1.1119639 0.0   2   * 24.200568
*
****************************************************************
4230000   bsgtjun   sngljun
4230101   420010000   422000000   0.04254   0.4   0.4   00100
4230201   0   1.1200999   1.1200999   0.0
*
****************************************************************
4240000   wpsgfbo   branch
4240001   2   0
4240101   0   1.1035   0.2323   0.0   -90.0   -1.1035   4.57e-5
4240102   0.4474   00
4240200   003   15456790.   560.5
4242101   422010000   424000000   0.04254   0.0   0.0   0000
4243101   424010000   430000000   0.2093    0.0   0.0   0000
4242201   1.247   1.247   0.0
4243201   1.247   1.247   0.0
*
****************************************************************
4300000   wpsgout   snglvol
4300101   0.0   0.706   0.125   0.0   -90.0   -0.706   4.57e-5
4300102   0.377   00
4300200   003   15463426.   560.5
*
****************************************************************
4290000   wpcrsleg   sngljun
4290101   430010000   432000000   0.0222   0.0   0.0   0100
4290201   0   2.1246026 2.1246026 0.0   * 24.200614
```

```
*
****************************************************************
4320000   wpcrsieg   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   00        5
4321101   0000      4
4321201   003   15466368.   560.5  0.  0.  0.  1
4321202   003   15462310.   560.5  0.  0.  0.  2
4321203   003   15471332.   560.5  0.  0.  0.  3
4321204   003   15480354.   560.5  0.  0.  0.  4
4321205   003   15494820.   560.5  0.  0.  0.  5
4321300   0
4321301   2.1245970 2.1245970 0.0   1   * 24.200615
4321302   2.1245858 2.1245858 0.0   2   * 24.200619
4321303   2.1245689 2.1245689 0.0   3   * 24.200622
4321304   2.1245520 2.1245520 0.0   4   * 24.200625
*
****************************************************************
4330000   wpfcv   valve
4330101   432010000   436000000   0.0222   0.0   0.0   0100
4330201   0   2.1245435 2.1245435 0.0   * 24.200629
4330300   mtrvlv
4330301   538   539   1.4200000 1.0000000 0
*
****************************************************************
4360000   wpcrslgu   pipe
4360001   4
4360101   0.0222   4
4360301   1.1919   1
4360302   1.1222   2
4360303   1.1763   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   00      4
4361101   0000    3
4361201   003         15494729.  560.5  0.  0.  0.  1
4361202   003         15480523.  560.5  0.  0.  0.  2
4361203   003         15472201.  560.5  0.  0.  0.  3
4361204   003         15463879.  560.5  0.  0.  0.  4
4361300   0
4361301   2.1245435 2.1245435 0.0       1          * 24.200632
4361302   2.1245512 2.1245512 0.0       2          * 24.200635
4361303   2.1245664 2.1245664 0.0       3          * 24.200639
*
*************************************************************
4400000   wprcpump    pump
4400101   0.0  0.802  0.0235  0.0  90.0  0.351  00
4400108   436010000  0.0222     0.0  0.0  0000
4400109   444000000  0.0337     0.0525 0.0525 0000
4400200   003        15473801.  560.5
4400201   0          2.1245817 2.1245817 0.0     * 24.200642
4400202   0          1.3993995 1.3993995 0.0     * 24.200645
4400301   240   240   240    -1    0    0    0
4400302   188.50000 .65942  .05400000 10.000000 55.200000
4400303   0.54       750.0      0.0   0.0   0.0   0.0   0.0
*
*  pump coastdown data
*
4406100   501          * norm speed
4406101   0.0     124.3  * 160.22
4406102   80.0    124.3  * 160.22
4406103   83.0    118.2  * 153.75
4406104   86.0    115.2  * 149.87
4406105   89.0    111.4  * 144.86
4406106   101.0   93.7   * 121.90
4406107   110.0   80.1   * 104.12
4406108   119.0   72.1   * 93.77
4406109   131.0   61.4   * 79.86
4406110   140.0   54.9   * 71.46
4406111   149.0   50.2   * 65.31
4406112   161.0   44.9   * 58.36
4406113   170.0   40.4   * 52.54
4406114   179.0   37.0   * 48.18
4406115   191.0   33.7   * 43.81
4406116   200.0   31.3   * 40.74
4406117   209.0   29.1   * 37.38
4406118   221.0   26.5   * 34.43
4406119   230.0   24.5   * 31.85
4406120   239.0   22.5   * 29.26
4406121   251.0   20.8   * 27.00
4406122   260.0   19.6   * 25.54
4406123   269.0   18.4   * 23.92
4406124   281.0   15.8   * 20.53
4406125   290.0   14.2   * 18.43
4406126   299.0   12.0   * 15.60
4406127   320.0   9.6    * 12.48
4406128   341.0   7.2    * 9.36
4406129   359.0   4.8    * 6.24
4406130   380.0   2.4    * 3.12
4406131   400.0   0.0
4406132   1000.0  0.0
*
*************************************************************
4440000   npcolleg   branch
4440001   2          0
4440101   0.0337   0.7348   0.0  0.0  0.0  0.0   4.57e-5  0.207 00
4440200   003          15487656.  560.5
4441101   444010000   448000000   0.0337      0.0   0.0   0000
4442101   740010000   444010000   0.0060      1.0   0.5   0001
4441201   1.3992878 1.3992878 0.0                      * 24.199929
4442201   .204252-9 .204251-9 0.0                      * .845944-9
*
*************************************************************
4480000   npcolleg   branch
4480001   1          0
4480101   0.0337     0.9429  0.0  0.0  0.0  0.0  4.57e-5  0.207  00
4480200   003          15487636.  560.5
4482101   448010000   452000000   0.0337      0.0   0.0   0000
4482201   1.3992879 1.3992879 0.0                      * 24.199934
*
*************************************************************
4520000   npcolleg      pipe
4520001   2
4520101   0.0337        2
4520301   0.9752        2
4520601   0.0           2
4520701   0.0           2
4520801   4.57e-5  0.207  2
4521001   00            2
4521101   0000          1
4521201   003          15487611.  560.5  0.  0.  0.  1
4521202   003          15487584.  560.5  0.  0.  0.  2
4521300   0
4521301   1.3992883 1.3992883 0.0       1          * 24.199940
```

```
*
**************************************************************
*
*  secondary loop for the primary loop with pressurizer
*
**************************************************************
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   00        5
5001101   0000      3
5001102   0100      4
5001201   0     6854312.9 1200751.2 2580753.5 0.0     0.0  1
5001202   0     6879527.0 1200829.9 2580590.8 0.0     0.0  2
5001203   0     6886864.0 1200899.7 2580405.7 0.0     0.0  3
5001204   0     6905938.6 1200941.7 2580202.5 0.0     0.0  4
5001205   0     6915253.0 1202649.1 2580103.4 0.0     0.0  5
5001300   0
5001301   .61387739 .61387739 0.0     1        * 13.832253
5001302   .61388537 .61388537 0.0     2        * 13.832171
5001303   .61388694 .61388694 0.0     3        * 13.832038
5001304   .61387788 .61387788 0.0     4        * 13.831877
*
**************************************************************
5010000   wpstgdcm   sngljun
5010101   500010000   504000000   0.0   100.0   100.0   0000
5010201   0    .48039121 .69720931 0.0          * 13.831555
*
**************************************************************
5040000   wpsteamg   pipe
5040001   5
5040101   0.2293    3
5040102   0.0       5
5040201   0.2293    2
5040202   0.2293    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   1.5   1.5   4
5041001   00        5
5041101   0100      3
5041102   0000      4
5041201   0     6904072.6 1261303.5 2580206.5 .14246717 0.0   1
5041202   0     6890625.7 1265108.6 2580362.4 .28828137 0.0   2
5041203   0     6878293.4 1264860.6 2580492.4 .28643270 0.0   3
5041204   0     6866890.7 1264305.8 2580611.9 .27887426 0.0   4
5041205   0     6857011.3 1263978.6 2580664.8 .27519078 0.0   5
5041300   0
5041301   .09947453 .37096577 0.0     1        * 13.814456
5041302   .11462864 .49520300 0.0     2        * 13.809526
5041303   .10797253 .71294955 0.0     3        * 13.805859
5041304   .09902432 .87101253 0.0     4        * 13.802399
5041401   0.036    1.0   1.0   1.0   3
5041402   0.1258   1.0   1.0   1.0   4
*
**************************************************************
5080000   wpsepar   separatr
5080001   3   0
5080101   0.0   2.120   0.572   0.0   90.0   2.120   4.57e-5
5080102   0.2134   00
5080200   0     6848284.2 1263648.5 2580734.6 .52097025
5081101   508010000   516000000   0.0715   0.0   0.0   0100 0.2
```

```
5082101    508000000   500000000   0.03964 100.0 100.0   0000
5083101    504010000   508000000   0.1986   0.0   0.0   0000
5081201    -.4037061 .27393586 0.0                   * 2.7472266
5082201    .37739895 -1.743057 0.0                   * 11.039985
5083201    .11699245 1.0455258 0.0                   * 13.799421
*
*************************************************************
5120000    wpsgspbp    branch
5120001    2           0
5120101    0.0   2.120   0.6288   0.0   90.0   2.120   4.57e-5
5120102    0.1242   00
5120200    0          6845583.4 1236787.3 2582575.1 .89235283
5121101    500000000   512000000   0.3164    0.0   0.0   0000
5122101    512010000   516000000   0.0392    1.5   1.5   0000
5121201    30.5398-6 1.3297404 0.0                   * 7.35566-3
5122201    -46.00500 -1.6715-3 0.0                   * -2.8209-3
*
*************************************************************
5160000    stmdome     snglvol
5160101    0.0   3.7778   2.0288   0.0   90.0   3.7778   4.57e-5
5160102    0.7696    00
5160200    0          6843731.5 1263114.0 2580824.8 .99999971
*
*************************************************************
*  ilsg steam line
*************************************************************
5200000    ilstmln1    branch
5200001    2           0
5200101    0.0286   5.282  0.0   0.0   0.0   0.0   4.57e-5
5200102    0.1909   00
5200200    0          6842807.7 1263069.3 2580824.5 .99991553
5201101    516010000   520000000   0.0286    0.0   0.0   0100
5202101    520010000   524000000   0.0286    0.0   0.0   0000
5201201    1.8244014 2.5842639 0.0                   * 2.7450542
5202201    .27793749 2.5848676 0.0                   * 2.7455870
*
*************************************************************
5240000    ilstmln2    branch
5240001    1           0
5240101    0.0286   8.5867  0.0   0.0   0.0   0.0   4.57e-5
5240102    0.1909   00
5240200    0          6842699.9 1263063.4 2580835.0 .99967266
5241101    524010000   528000000   0.00429   0.0   0.0   0000
5241201    1.5658958 17.236995 0.0                   * 2.7466368
*
*************************************************************
5280000    ilstmln3    snglvol
5280101    0.00429   10.9965   0.0   0.0   0.0   0.0   4.57e-5
5280102    0.0739    00
5280200    0          6820393.8 1262454.1 2580955.8 .99988240
*
*************************************************************
5290000    ilmsiv      valve
5290101    528010000   532000000 · 0.00429   0.0  0.0  0100
5290201    0          5.7878014 17.263954 0.0          * 2.7467386
5290300    mtrvlv
5290301    578         501        2.0000000 1.0000000 0
*
*************************************************************
5320000    vlvtovlv    snglvol
5320101    0.00429   5.5275   0.0   0.0   0.0   0.0   4.57e-5
5320102    0.0739    00
5320200    0          6828376.3 1261858.7 2581063.9 .99978697
*
*************************************************************
5330000    ilchkvl     valve
5330101    532010000   800000000   0.00429   0.0   0.0  0000
5330201    0          3.7947922 17.296149 0.0          * 2.7468079
5330300    chkvlv
5330310    0   0      0.0   0.0
*
*************************************************************
5500000    auxfed      tmdpvol
5500101    8.0         5.0   0.0   0.0   0.0   0.0   0.0   0    00
5500200    3
5500201    0.0         5.95300e+6        313.0
*
*************************************************************
5510000    auxfed      tmdpjun
5510101    550000000   500000000   0.004
5510200    1   624
5510201    0.0   0.0   0.0   0.0
5510202    0.01   1.140 0.0   0.0
5510203  5000.0   1.140 0.0   0.0
*************************************************************
5600000    wpstegfw    tmdpvol
5600101    0.139       5.0   0.0   0.0   0.0   0.0   0.0   0    00
5600200    3
5600201    0.0         5.83400e+6        495.35
*
*************************************************************
5610000    wpstegfw    tmdpjun
5610101    560000000   500000000   4.00e-3
5610200    1   550     cntrlvar   561
5610201    0.0   0.0     0.0  0.0
5610202    5.0   5.0     0.0  0.0
```

```
5610203     7.0    7.0      0.0  0.0
5610204  1000.0    7.0      0.0  0.0
*
****************************************************************
* secondary relief and safety valves, broken loop
****************************************************************
*
5690000     blsgrv    valve
5690101     520010000   570000000   2.96e-4   0.0164   0.0   0100
5690201     0        0.0       0.0       0.0              * 0.0
5690300     trpvlv
5690301     603
*
****************************************************************
5700000     contain    tmdpvol
5700101     1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
5700200     3
5700201     0.0   1.01325e+5   293.15
*
****************************************************************
5790000     blsgsv    valve
5790101     524010000   580000000   0.00195   0.00050   0.0   0100
5790201     0        0.0       0.0       0.0              * 0.0
5790300     trpvlv
5790301     606
*
****************************************************************
5800000     contain    tmdpvol
5800101     1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
5800200     3
5800201     0.0   1.01325e+5   293.15
*
****************************************************************
* 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     0           15410474. 1556744.0 2445245.8 0.0      0.0   1
6001202     0           15449376. 1533202.1 2444562:7 0.0      0.0   2
6001203     0           15463068. 1499159.9 2444003.5 0.0      0.0   3
6001300     0
6001301     794.073-6 794.073-6 0.0      1                 * 1.73199-3
6001302     793.544-6 793.544-6 0.0      2                 * 1.76418-3
*
****************************************************************
6030000     prssurgl    sngljun
6030101     610010000   600000000   3.515e-3   0.0   0.0   0100
6030201     0           794.821-6 -7.2196-3 0.0            * 1.70555-3
*
****************************************************************
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     0           15390000. 1607801.4 2445974.9 .99999877 0.0  1
6101202     0           15390442. 1607813.9 2445975.3 .99999675 0.0  2
6101203     0           15390921. 1607831.5 2446061.4 .99999994 0.0  3
6101204     0           15391858. 1596982.5 2446633.1 .5999999  0.0  4
6101205     0           15394581. 1584708.6 2445858.7 .00000001 0.0  5
6101206     0           15398636. 1581616.9 2445762.7 712.940-9 0.0  6
6101207     0           15402261. 1581131.6 2445676.8 16.3771-6 0.0  7
6101208     0           15405460. 1575430.8 2445601.1 11.8471-6 0.0  8
```

```
6101300    0
6101301    .05232152 34.2199-6 0.0      1          * 574.912-6
6101302    .02728026 19.2080-6 0.0      2          * 573.057-6
6101303    2.5326376 18.8555-6 0.0      3          * 572.780-6
6101304    22.5335-6 -3.544149 0.0      4          * 1.03481-3
6101305    6.04839-6 -6.1795-3 0.0      5          * 1.03511-3
6101306    6.39100-6 -.0391352 0.0      6          * 1.04155-3
6101307    8.43805-6 -.0518302 0.0      7          * 1.38226-3
*
*****************************************************************
6190000    spryin    sngljun
6190101    244010000   620000000   0.0   0.0   0.0   00102
6190201    0     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    0          15458294. 1258472.7 2445534.0 0.0     0.0   1
6201202    0          15399928. 1258581.6 2446917.6 0.0     0.0   2
6201300    0
6201301    0.0  0.0   0.0      1
*
*****************************************************************
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    3
6500201    0.0         1.01325e+5        293.15
*
*****************************************************************
6510000    porv        valve
6510101    610000000   650000000   3.66e-5   0.0251   0.0   0100
6510201    0       0.0        0.0        0.0             * 0.0
6510300    trpvlv
```

```
6510301    615
*
*****************************************************************
6600000    prsfvout    tmdpvol
6600101    1.0e+8     10.0  0.0   0.0   0.0   0.0   0.0   0     00
6600200    3
6600201    0.0         1.01325e+5        293.15
*
*****************************************************************
6610000    prsfvalv    valve
6610101    610000000   660000000   1.54e-4   0.2052   0.0   0100
6610201    0       0.0        0.0        0.0             * 0.0
6610300    trpvlv
6610301    522
*
*****************************************************************
* eccs
*****************************************************************
*
7200000    ilsi       tmdpvol
7200101    4.375      10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7200200    3
7200201    0.0          1.013e+5    310.00
*
*****************************************************************
* high pressure safety injection to cold leg
*****************************************************************
*
7210000    ilsi    tmdpjun
7210101    720000000   740000000   2.552e-3
7210200    1   510    p    448010000
7210201    -1.0      0.0    0.0    0.0
7210202    0.0       0.0    0.0    0.0
7210203    0.0       0.694    0.0   0.0
7210204    6.0e6     0.694    0.0   0.0
7210205    6.2e6     0.671    0.0   0.0
7210206    6.4e6     0.6525   0.0   0.0
7210207    6.6e6     0.634    0.0   0.0
7210208    6.8e6     0.619    0.0   0.0
7210209    7.0e6     0.600    0.0   0.0
7210210    7.2e6     0.577    0.0   0.0
7210211    7.4e6     0.562    0.0   0.0
7210212    7.6e6     0.540    0.0   0.0
7210213    7.8e6     0.521    0.0   0.0
7210214    8.0e6     0.499    0.0   0.0
7210215    8.2e6     0.476    0.0   0.0
7210216    8.4e6     0.450    0.0   0.0
7210217    8.6e6     0.427    0.0   0.0
```

```
7210218     8.8e6    0.405    0.0    0.0
7210219     9.0e6    0.379    0.0    0.0
7210220     9.2e6    0.352    0.0    0.0
7210221     9.4e6    0.319    0.0    0.0
7210222     9.6e6    0.289    0.0    0.0
7210223     9.8e6    0.255    0.0    0.0
7210224     10.0e6   0.202    0.0    0.0
7210225     10.2e6   0.124    0.0    0.0
7210226     10.35e6  0.0      0.0    0.0
*
*7500000    ilsi        tmdpvol
*7500101    4.375       10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
*7500200    3
*7500201    0.0         1.013e+5     310.00
*
*7220000    ilsi     tmdpjun
*7220101    750000000    152000000    2.552e-3
*7210200    1    511    p    152010000
*7220201    -1.0       0.0    0.0    0.0
*7220202    0.0        0.0    0.0    0.0
*7220203     0.0       1.388    0.0    0.0
*7220204     6.0e6     1.388    0.0    0.0
*7220205     6.2e6     1.343    0.0    0.0
*7220206     6.4e6     1.305    0.0    0.0
*7220207     6.6e6     1.268    0.0    0.0
*7220208     6.8e6     1.238    0.0    0.0
*7220209     7.0e6     1.200    0.0    0.0
*7220210     7.2e6     1.155    0.0    0.0
*7220211     7.4e6     1.125    0.0    0.0
*7220212     7.6e6     1.080    0.0    0.0
*7220213     7.8e6     1.043    0.0    0.0
*7220214     8.0e6     0.998    0.0    0.0
*7220215     8.2e6     0.953    0.0    0.0
*7220216     8.4e6     0.900    0.0    0.0
*7220217     8.6e6     0.855    0.0    0.0
*7220218     8.8e6     0.810    0.0    0.0
*7220219     9.0e6     0.758    0.0    0.0
*7220220     9.2e6     0.705    0.0    0.0
*7220221     9.4e6     0.638    0.0    0.0
*7220222     9.6e6     0.578    0.0    0.0
*7220223     9.8e6     0.510    0.0    0.0
*7220224     10.0e6    0.405    0.0    0.0
*7220225     10.2e6    0.248    0.0    0.0
*7220226     10.35e6   0.0      0.0    0.0
*
*****************************************************************
7300000    ilchrg      tmdpvol
7300101    4.375       10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7300200    3
7300201    0.0         1.013e+5          300.00
*
*****************************************************************
7310000    ilchrg   tmdpjun
7310101    730000000    740000000    2.552e-3
7310200    1    505    p    448010000
7310201    -1.0      0.0      0.0    0.0
7310202    0.0       0.0      0.0    0.0
7310203    0.0       0.13     0.0    0.0
7310204    15.0e6    0.13     0.0    0.0
*
*****************************************************************
7400000    ileccsln     snglvol
7400101    2.552e-3    16.0   0.0   0.0   0.0   0.0   3.333e-5
7400102    0.0   00
7400200    0           15598371. 83230.665 2445532.2 0.0
*
*****************************************************************
7700000    blsi        tmdpvol
7700101    4.375       10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7700200    3
7700201    0.0         1.013e+5     293.15
*
*****************************************************************
* eccs flows from zion deck, assume even flow split betwen loops
*****************************************************************
*
7710000    blsi     tmdpjun
7710101    770000000    790000000    2.552e-3
7710200    1    512    p    248010000
7710201    -1.0      0.0    0.0    0.0
7710202    0.0       0.0    0.0    0.0
7710203     0.0      0.694     0.0    0.0
7710204     6.0e6    0.694     0.0    0.0
7710205     6.2e6    0.671     0.0    0.0
7710206     6.4e6    0.6525    0.0    0.0
7710207     6.6e6    0.634     0.0    0.0
7710208     6.8e6    0.619     0.0    0.0
7710209     7.0e6    0.600     0.0    0.0
7710210     7.2e6    0.577     0.0    0.0
7710211     7.4e6    0.562     0.0    0.0
7710212     7.6e6    0.540     0.0    0.0
7710213     7.8e6    0.521     0.0    0.0
7710214     8.0e6    0.499     0.0    0.0
7710215     8.2e6    0.476     0.0    0.0
7710216     8.4e6    0.450     0.0    0.0
7710217     8.6e6    0.427     0.0    0.0
```

```
7710218    8.8e6    0.405   0.0   0.0
7710219    9.0e6    0.379   0.0   0.0
7710220    9.2e6    0.352   0.0   0.0
7710221    9.4e6    0.319   0.0   0.0
7710222    9.6e6    0.289   0.0   0.0
7710223    9.8e6    0.255   0.0   0.0
7710224    10.0e6   0.202   0.0   0.0
7710225    10.2e6   0.124   0.0   0.0
7710226    10.35e6  0.0     0.0   0.0
*
***************************************************************
7800000    blchrg   tmdpvol
7800101    4.375    10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7800200    3
7800201    0.0      1.013e+5      293.15
*
***************************************************************
7810000    blchrg  tmdpjun
7810101    780000000   790000000   2.552e-3
7810200    1   505   p   248010000
7810201    -1.0     0.0     0.0   0.0
7810202     0.0     0.0     0.0   0.0
7810203     0.0     0.13    0.0   0.0
7810204     15.0e6  0.13    0.0   0.0
*
***************************************************************
7900000    bleccsln    snglvol
7900101    9.079e-4   16.0   0.0   0.0   0.0   0.0   3.333e-5
7900102    0.0  00
7900200    0    15488401.  83231.356  2445531.5  0.0
*
***************************************************************
* common steam header to jet condensor
***************************************************************
*
8000000    header1     snglvol
8000101    0.00741   3.2   0.0   0.0   0.0   0.0   4.57e-5
8000102    0.0  00
8000200    0         6728063.0 1261843.5 2581117.8 .99983487
*
***************************************************************
8010000    headvlv     valve
8010101    800010000   804000000   0.00741  0.0   0.0   0000
8010201    0         2.8818423 10.014497 0.0          * 2.7468959
8010300    trpvlv
8010301    583
*
***************************************************************
8030000    trbbpvlv    valve
8030101    800000000   808000000   5.56e-4  0.0   0.0  0100
8030201    0         0.0       0.0       0.0          * 0.0
8030300    srvvlv
8030301    40
*
***************************************************************
8040000    header2     snglvol
8040101    0.00741   3.2   0.0   0.0   0.0   0.0   4.57e-5
8040102    0.0   00
8040200    0         6710989.5 1261492.4 2581112.5 .99991458
*
***************************************************************
8050000    thrvlv  valve
8050101    804010000   812000000   0.00741  0.0   0.0  0100
8050201    0         8.6399460 20.055846 0.0          * 5.4949115
8050300    srvvlv
8050301    805
*
***************************************************************
8080000    trbbpln     snglvol
8080101    0.00741   13.3305   0.0   0.0   0.0   0.0   4.57e-5
8080102    0.0971    00
8080200    0         6658740.0 1262372.2 2580999.5 .99988891
*
***************************************************************
8090000    bplnjc     sngljun
8090101    808010000   816000000   0.00741   0.0    0.0    0100
8090201    0         2.13640-3 -237.33-9 0.0          * 1.23347-6
*
***************************************************************
8120000    trbthrln    snglvol
8120101    0.00741   8.730   0.0   0.0   0.0   0.0   4.57e-5
8120102    0.0971    00
8120200    0         6506022.4 1248286.1 2583199.0 .99913646
*
***************************************************************
8130000    thrlnjc     sngljun
8130101    812010000   820000000   0.00741   0.0    0.0    0100
8130201    0         8.3986178 20.802777 0.0          * 5.4948355
*
***************************************************************
8160000    jctdvl      tmdpvol
8160101    1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
8160200    2
8160201    0.0   6.54e+6   1.0
*
***************************************************************
```

```
8200000    jctdv2    tmdpvol
8200101    1.0e-8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
8200200    2
8200201    0.0   6.54e+6   1.0
*
****************************************************************
* containment volume for environmental heat losses
****************************************************************
9000000    envsink    snglvol
9000101    2000.    100.    0.0   0.0   0.0   0.0   4.57e-5
9000102    0.0   00
9000200    0    1.034e5    322.0  1.0
*
9100000    envsijn    sngljun
9100101    900010000   920000000  0.00741   0.0   0.0   0100
9100201    1    1.0e-5    1.0e-5    0.0
*
9200000    envsink    tmdpvol
9200101    2000.    100.    0.0   0.0   0.0   0.0   0.0   0    10
9200200    4
9200201    0.0    1.034e5    322.0    1.0
*
****************************************************************
*  boundary system for steady state
****************************************************************
*
9900000    bdryvol   tmdpvol
9900101    0.255   0.69  0.0  0.0  0.0  0.0  0.0  0.0  0000
9900200    2
9900201    0.0   1.538e+7   1.0
*
9890000    bdryvlv   valve
9890101    990000000   610000000   1.0  0.0  0.0  0000
9890201    0   1.62936-3  5.59379-6  0.0
9890300    trpvlv
9890301    599
*
****************************************************************
*  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   562.2      7
11001501    100010000      0   1     1    0.823    1
11001601    900010000      0   1     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   562.2      7
11041501    104010000      0   1     1    0.600    1
11041502    108010000      0   1     1    0.677    2
11041503    108020000      0   1     1    0.867    3
11041504    108030000  10000   1     1    0.610    9
11041510    108090000      0   1     1    1.2588  10
11041511    112010000      0   1     1    0.445   11
11041512    116010000      0   1     1    0.4762  12
11041601    900010000      0   1     1    0.600    1
11041602    900010000      0   1     1    0.677    2
11041603    900010000      0   1     1    0.867    3
11041604    900010000      0   1     1    0.610    9
11041610    900010000      0   1     1    1.2588  10
11041611    900010000      0   1     1    0.445   11
11041612    900010000      0   1     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    562.2      7
11121501    112010000     0   1   0    0.686    1
11121601    900010000     0   1   1    0.686    1
11121701    0    0    0    0    1
11121801    0. 10.0  10.0    0.0 0. 0. 0. 1.       1
11121901    0. 10.0  10.0    0.0 0. 0. 0. 1.       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    562.2      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   1    1   731.2   1
11122602    116010000        0   1    1   556.2   2
11122603    120010000        0   1    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
*****************************************************************
*
11201000    12   5    2    1    0.257
11201100    0    1
11201101    4    0.267
```

```
11201201    5    4
11201301    0.0  4
11201400    0
11201401    562.2      5
11201501    120010000       0   1    1    1.2588    1
11201502    124010000   10000   1    1    0.610     7
11201503    128010000       0   1    1    0.867     8
11201504    132010000       0   1    1    0.677     9
11201505    136010000       0   1    1    0.600    10
11201506    140010000       0   1    1    0.3674   11
11201507    144010000       0   1    1    0.897    12
11201601    108090000       0   1    1    1.2588    1
11201602    108080000  -10000   1    1    0.6100    7
11201603    108020000       0   1    1    0.867     8
11201604    108010000       0   1    1    0.677     9
11201605    104010000       0   1    1    0.600    10
11201606    100010000       0   1    1    0.3674   11
11201607    100010000       0   1    1    0.897    12
11201701    0    0    0    0    12
11201801    0. 10.0    10.0    0.0  0. 0. 0. 1.    12
11201901    0. 10. 10.    0.0     0.  0.  0.0   1.  12
*
*****************************************************************
* 124-1: heated section of heater rods
*****************************************************************
*
11241000    6    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    600.6      9
11241501            0      0   0    1    649.00    6
11241601    124010000  10000   1    1    649.00    6
11241701    888   0.08568    0.0   0.0   1
11241702    888   0.17532    0.0   0.0   2
11241703    888   0.23900    0.0   0.0   3
11241704    888   0.23900    0.0   0.0   4
11241705    888   0.17532    0.0   0.0   5
```

```
11241706    888   0.08568     0.0   0.0   6
11241901    0.   0.305    3.355  0.  0.   0.  0. 1.0  1
11241902    0.   0.915    2.745  0.  0.   0.  0. 1.0  2
11241903    0.   1.525    2.135  0.  0.   0.  0. 1.0  3
11241904    0.   2.135    1.525  0.  0.   0.  0. 1.0  4
11241905    0.   2.745    0.915  0.  0.   0.  0. 1.0  5
11241906    0.   3.355    0.305  0.  0.   0.  0. 1.0  6
*
****************************************************************
* 124-2: unheated instrument rods
****************************************************************
*
11242000    6    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    600.6     6
11242501              0    0   0    1    63.44    6
11242601    124010000 10000 1   1    63.44    6
11242701    0    0       0     0    6
11242901    0.   10.0      10.0 0. 0.   0.0 0. 1.   6
*
****************************************************************
* 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    584.2     5
11281501    128010000     0   1    0    0.773    1
11281601    128010000     0   1    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    600.6     4
11321501    156020000    0  1    1    5.406    1
11321502    156020000    0  1    1    4.800    2
11321503    156010000    0  1    1    2.939    3
11321504    156010000    0  1    1    7.176    4
11321505    156010000    0  1    1    5.800    5
11321601    132010000    0  1    1    5.406    1
11321602    136010000    0  1    1    4.800    2
11321603    140010000    0  1    1    2.939    3
11321604    144010000    0  1    1    7.176    4
11321605    148010000    0  1    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    562.2     9
11441501    144010000     0   1    0    0.156    1
11441601    140010000     0   1    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   562.2      7
11481501    148010000     0   1    1    0.404    1
11481601    900010000     0   1    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   562.2      7
11521501    152010000     0   1    1    0.5     1
11521601    900010000     0   1    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
*
***************************************************************
*
*          loop heat structures
*
*======================================================*
*               ht str no. 212-1   blsg inlet/outlet plnm hemisph
*------------------------------------------------------*
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                           -1
12121401     583.000    583.000    583.000    583.000    583.000
+            583.000
12121402     557.000    557.000    557.000    557.000    557.000
+            557.000
12121501   212010000   0      1       1      0.1872      1
12121502   228010000   0      1       1      0.1872      2
12121601   900010000   0      1       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                           -1
12122401     583.000    583.000    583.000    583.000    583.000
+            583.000
12122402     557.000    557.000    557.000    557.000    557.000
+            557.000
12122403     583.000    583.000    583.000    583.000    583.000
+            583.000
12122404     557.000    557.000    557.000    557.000    557.000
+            557.000
12122501   212010000   0      1       1      0.4237      1
12122502   228010000   0      1       1      0.4237      2
12122503   216010000   0      1       1      1.1035      3
12122504   224010000   0      1       1      1.1035      4
12122601   900010000   0      1       1      0.4237      2
12122602   900010000   0      1       1      1.1035      4
12122701     0           0            0        0         4
12122801     0.       10.0   10.0     0.  0.   0.  0. 1.   2
12122802     0.       10.0   10.0     0.  0.   0.  0. 1.   4
12122901     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                    -1
12202401   583.000   583.000   583.000   583.000
12202402   557.000   557.000   557.000   557.000
12202501  220010000  0   1   1   45.40   1
12202502  220080000  0   1   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
*************************************************************
*     steam generator in the loop without pressurizer
*************************************************************
*
12201000   8   8   2   1   0.00980
12201100   0   1
12201101   7   0.0127
12201201   5   7
12201301   0.0   7
12201400   0
12201401   562.4    8
12201501   220010000   0   1   1   359.04   1
12201502   220020000  10000  1   1   361.72   3
12201503   220040000  10000  1   1   306.36   5
12201504   220060000  10000  1   1   361.72   7
12201505   220080000   0   1   1   359.04.   8
12201601   304010000   0   1   1   359.04   1
12201602   304020000  10000  1   1   361.72   3
12201603   304040000   0   1   1   306.36   5
12201604   304030000  -10000  1   1   361.72   7
12201605   304010000   0   1   1   359.04   8
12201701   0   0   0   0   8
12201801   0.   10.0   10.0  0.0  0.   0.0   0.   1.   8
12201901   0.   10.0   10.0  0.0  0.   0.0   0.   1.   8
*
*-----------------------------------------------------------*
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    564.0           5
13001501   300010000   0   1   1   9.0016   1
13001502   300020000   0   1   1   8.3920   2
13001503   300030000  10000  1   1   10.2616   4
13001504   300050000   0   1   1   10.2380   5
13001601   900010000   0   1   1   9.0016   1
13001602   900010000   0   1   1   8.3920   2
13001603   900010000   0   1   1   10.2616   4
13001604   900010000   0   1   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     560.           2
13002501   304050000   0   1   1   0.6461   1
13002502   308010000   0   1   1   2.120    2
13002601   300010000   0   1   1   0.6461   1
13002602   308010000   0   1   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     530.           6
13003501   300010000   0   1   1   0.6461   1
13003502   304050000   0   1   1   1.0104   2
13003503   312010000   0   1   1   2.120    3
13003504   316010000   0   1   1   3.4278   4
13003601   900010000   0   1   1   0.6461   1
13003602   900010000   0   1   1   1.0104   2
13003603   900010000   0   1   1   2.120    3
```

```
13003604   900010000  0      1      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       560.                 2
13004501   304010000  0     1      1       1.0637          1
13004601   300050000  0     1      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       530.                 6
13005501   300050000  0     1      1       1.2637          1
13005601   900010000  0     1      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       550.                 6
13041501   304010000  0       1      1       1.2827          1
13041502   304020000  10000   1      1       2.5654          3
13041503   304040000  0       1      1       2.098           4
13041504   304050000  0       1      1       0.3658          5
13041601   900010000  0       1      1       1.2827          1
13041602   900010000  0       1      1       2.5654          3
13041603   900010000  0       1      1       2.098           4
13041604   900010000  0       1      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       550.                 2
13121501   308010000  0     1      1       1.7886          1
13121601   312010000  0     1      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     550.            6
13161501   316010000   0   1   1   0.391   1
13161601   900010000   0   1   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             *
*------------------------------------------------------*
*      ht str no. 400-1    il + bl hl heat struct
*------------------------------------------------------*
14001000   8   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   583.0           5
14001501   400010000   0   1   1   1.3246   1
14001502   404010000   0   1   1   1.2668   2
14001503   408010000   0   1   1   0.5968   3
14001504   408020000   0   1   1   0.5278   4
14001505   200010000   0   1   1   1.3246   5
14001506   204010000   0   1   1   1.2668   6
14001507   208010000   0   1   1   0.5968   7
14001508   208020000   0   1   1   0.5278   8
14001601   900010000   0   1   1   1.3246   1
14001602   900010000   0   1   1   1.2668   2
14001603   900010000   0   1   1   0.5968   3
14001604   900010000   0   1   1   0.5278   4
14001605   900010000   0   1   1   1.3246   5
14001606   900010000   0   1   1   1.2668   6
14001607   900010000   0   1   1   0.5968   7
14001608   900010000   0   1   1   0.5278   8
14001701   0    0    0    0    8
14001801   0.   10.0   10.0   0.   0.   0.   0.   1.   8
14001901   0.   10.0   10.0   0.   0.   0.   0.   1.   8
*
*======================================================*
*      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   557.            5
14002501   432010000   0       1   1   0.516    1
14002502   432020000   10000   1   1   1.2422   4
14002503   432050000   0       1   1   1.1919   5
14002504   436010000   0       1   1   1.1919   6
14002505   436020000   10000   1   1   1.1222   9
14002506   232010000   0       1   1   0.516    10
14002507   232020000   10000   1   1   1.2422   13
14002508   232050000   0       1   1   1.1919   14
14002509   236010000   0       1   1   1.1919   15
14002510   236020000   10000   1   1   1.1222   18
14002601   900010000   0   1   1   0.516    1
14002602   900010000   0   1   1   1.2422   4
14002603   900010000   0   1   1   1.1919   6
14002604   900010000   0   1   1   1.1222   9
14002605   900010000   0   1   1   0.516    10
14002606   900010000   0   1   1   1.2422   13
14002607   900010000   0   1   1   1.1919   15
14002608   900010000   0   1   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   557.0           5
14003501   244010000   0   1   1   1.0562   1
14003502   248010000   0   1   1   1.1067   2
14003503   252010000   0   1   1   1.3125   3
14003504   444010000   0   1   1   0.647    4
14003505   448010000   0   1   1   0.878    5
```

```
14003506   452010000   10000   1   1   0.9752   7
14003601   900010000   0   1   1   1.0562   1
14003602   900010000   0   1   1   1.1067   2
14003603   900010000   0   1   1   1.3125   3
14003604   900010000   0   1   1   0.647   4
14003605   900010000   0   1   1   0.878   5
14003606   900010000   0   1   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   -1
14121401   583.000   583.000   583.000   583.000   583.000
+   583.000
14121402   557.000   557.000   557.000   557.000   557.000
+   557.000
14121501   412010000   0   1   1   0.1872   1
14121502   430010000   0   1   1   0.1872   2
14121601   900010000   0   1   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   -1
```

```
14122401   583.000   583.000   583.000   583.000   583.000
+   583.000
14122402   557.000   557.000   557.000   557.000   557.000
+   557.000
14122403   583.000   583.000   583.000   583.000   583.000
+   583.000
14122404   557.000   557.000   557.000   557.000   557.000
+   557.000
14122501   412010000   0   1   1   0.4237   1
14122502   430010000   0   1   1   0.4237   2
14122503   416010000   0   1   1   1.1035   3
14122504   424010000   0   1   1   1.1035   4
14122601   900010000   0   1   1   0.4237   2
14122602   900010000   0   1   1   1.1035   4
14122701   0   0   0   0   4
14122801   0.   10.0   10.0   0.   0.   0.   0.   1.   2
14122802   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   8   8   2   1   0.00980
14201100   0   1
14201101   7   0.0127
14201201   5   7
14201301   0.0   7
14201400   0
14201401   562.4   8
14201501   420010000   0   1   1   359.04   1
14201502   420020000   10000   1   1   361.72   3
14201503   420040000   10000   1   1   306.36   5
14201504   422010000   10000   1   1   361.72   7
14201505   422030000   0   1   1   359.04   8
14201601   504010000   0   1   1   359.04   1
14201602   504020000   10000   1   1   361.72   3
14201603   504040000   0   1   1   306.36   5
14201604   504030000   -10000   1   1   361.72   7
14201605   504010000   0   1   1   359.04   8
14201701   0   0   0   0   8
14201801   0.   10.0   10.0   0.0   0.   0.0   0.   1.   8
14201901   0.   10.0   10.0   0.0   0.   0.0   0.   1.   8
*
*======================================================
*        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                   -1
14202401   583.000   583.000   583.000   583.000
14202402   557.000   557.000   557.000   557.000
14202501   420010000   0   1   1   45.40   1
14202502   422030000   0   1   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. 421-1 intact loop sg tubes
*************************************************************
*
*14211000   8   8   2   1   0.00980
*14211100   0   1
*14211101   7   0.0127
*14211201   5   7
*14211301   0.0   7
*14211400   0
*14211401   562.4   8
*14211501   428010000   0       1   1   2.8724   1
*14211502   428020000   10000   1   1   2.5654   3
*14211503   428040000   10000   1   1   2.1728   5
*14211504   419010000   10000   1   1   2.5654   7
*14211505   419030000   0       1   1   2.8724   8
*14211601   504010000   0       1   1   2.8724   1
*14211602   504020000   10000   1   1   2.5654   3
*14211603   504040000   0       1   1   2.1728   5
*14211604   504030000   -10000  1   1   2.5654   7
*14211605   504010000   0       1   1   2.8724   8
*14211701   0   0   0   0   8
*14211801   0.  10.0  10.0  0.0  0.  0.0  0.  1.   8
*14211901   0.  10.0  10.0  0.0  0.  0.0  0.  1.   8
*
*=====================================================
*          ht str no. 421-2   ilsg inlet/outlet tube sheet
*---------------------------------------------------*
*14212000   2   4   2   1   0.0098   0
*14212100       0           1
*14212101       3           0.0163
*14212201       5           3
*14212301     0.0           3
*14212400                   -1
*14212401   583.000   583.000   583.000   583.000
*14212402   557.000   557.000   557.000   557.000
*14212501   428010000   0   1   1   2.8724   1
*14212502   419030000   0   1   1   2.8724   2
*14212601   0           0   0   1   2.8724   2
*14212701     0       0       0       0       2
*14212801     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   564.0           5
15001501   500010000   0       1   1   9.0016    1
15001502   500020000   0       1   1   8.3920    2
15001503   500030000   10000   1   1   10.2616   4
15001504   500050000   0       1   1   10.2380   5
15001601   900010000   0       1   1   9.0016    1
15001602   900010000   0       1   1   8.3920    2
15001603   900010000   0       1   1   10.2616   4
15001604   900010000   0       1   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   560.            2
15002501   504050000   0   1   1   0.6461   1
15002502   508010000   0   1   1   2.120    2
15002601   500010000   0   1   1   0.6461   1
15002602   508010000   0   1   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   530.             6
15003501  500010000  0   1   1   0.6461   1
15003502  504050000  0   1   1   1.0104   2
15003503  512010000  0   1   1   2.120    3
15003504  516010000  0   1   1   3.4278   4
15003601  900010000  0   1   1   0.6461   1
15003602  900010000  0   1   1   1.0104   2
15003603  900010000  0   1   1   2.120    3
15003604  900010000  0   1   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   560.             2
15004501  504010000  0   1   1   1.0637   1
15004601  500050000  0   1   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   530.             6
15005501  500050000  0   1   1   1.2637   1
15005601  900010000  0   1   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   550.             6
15041501  504010000  0      1   1   1.2827   1
15041502  504020000  10000  1   1   2.5654   3
15041503  504040000  0      1   1   2.098    4
15041504  504050000  0      1   1   0.3658   5
15041601  900010000  0      1   1   1.2827   1
15041602  900010000  0      1   1   2.5654   3
15041603  900010000  0      1   1   2.098    4
15041604  900010000  0      1   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     550.           2
15121501   508010000   0    1      1     1.7886      1
15121601   512010000   0    1      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     550.           6
15161501   516010000   0    1      1     0.391       1
15161601   900010000   0    1      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     636.           6
16101501   610020000  10000  1     1     0.475       2
16101502   610040000   0     1     1     0.600       3
16101503   610050000  10000  1     1     0.682       5
16101504   610070000  10000  1     1     0.5375      7
16101601   900010000   0     1     1     0.475       2
16101602   900010000   0     1     1     0.600       3
16101603   900010000   0     1     1     0.682       5
16101604   900010000   0     1     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     636.           5
16102402     636.           6
16102501   610010000   0    1      1     0.311       1
16102601   900010000   0    1      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     636.           6
16103501   610080000   0    1      1     0.2731      1
16103601   900010000   0    1      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
*
*=======================================================*
*        ht str no. 610-4   prizer htrs (prop+bkup) ht struct
*-------------------------------------------------------*
16104000   2      3    2     1     0.0     0
*
*htstr        mesh locn        mesh fmt
16104100          0                1
*
*htstr        intervals        rt. coord
16104101          2              0.0115
*
*htstr        compxn no.       interval
16104201          2                1
16104202          5                2
*
*htstr        source           interval
16104301        1.0                1
16104302        0.0                2
*
*htstr                         temp flg
16104400                           0
*
*htstr        temp             mesh pt.
16104401      650.                 3
*
*htstr    left vol     incr  b.cond  sa code  area/factor   ht str no.
16104501  0            0     0       0        0             2
*
*htstr    right vol    incr  b.cond  sa code  area/factor   ht str no.
16104601  610070000    10000  1      1        0.5375        2
*
*htstr    s. type   s. mult    left heat  right heat   ht str no.
16104701  10606     0.5        0.0        0.0          2
*
16104901    0.     10.0   10.0   0.   0.   0.  0.  1.  2
*
****************************************************************
* 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    373.15  379.  473.15  374.  573.15  369.
20100302    673.15  363.  873.15  353.
*
* inconel 600
20100401    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    373.15  25.122 473.15  20.935 573.15 16.748 773.15 12.561
20100702   1073.15  8.374 1473.15  8.374
*
* rockwool insulation
*
20100901    311.15  0.1192  422.15  0.1681  533.15  0.2166
20100902    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    373.15  3.23e+6   573.15  3.62e+6    773.15  4.10e+6
```

```
20100252   1073.15  4.61e+6  1173.15  4.73e+6   1273.15  4.95e+6
20100253   1473.15  5.29e+6  10000.0  5.29e+6
*
*  copper
20100351    3.43e6
*
*  inconel 600
20100451    373.15  3.94e+6   573.15  4.18e+6   873.15   4.71e+6
20100452   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    373.15 3.015e+6   473.15 3.482e+6   573.15  3.796e+6
20100752    673.15 3.946e+6   773.15 4.093e+6   873.15  4.239e+6
20100753    973.15 4.384e+6  1073.16 4.373e+6  1173.16  4.529e+6
20100754   1373.16 4.529e+6  1473.16 4.685e+6
*
*  rockwool
20100951    1.36e+5
*
*============================================================*
**************************************************************
*  core power
**************************************************************
*
20288800    power    501
20288801        -1.0     10.00e+6
20288802         0.0     10.00e+6
20288803        10.0     10.00e+6
20288804        13.94    10.00e+6
20288805        15.0     8.5093e+6
20288806        20.0     5.5464e+6
20288807        30.0     3.6521e+6
20288808        40.0     3.0656e+6
20288809        50.0     2.6580e+6
20288810        60.0     2.5579e+6
20288811        80.0     2.3982e+6
20288812       100.0     2.3092e+6
20288813       150.0     2.0900e+6
20288814       200.0     2.0261e+6
20288815       300.0     1.8832e+6
20288816       400.0     1.7569e+6
20288817       500.0     1.6865e+6
20288818       600.0     1.6257e+6
20288819       800.0     1.5419e+6
20288820      1000.0     1.5357e+6
20288821      1500.0     1.3603e+6
20288822      2000.0     1.2058e+6
20288823      3000.0     1.0656e+6
20288824      4000.0     0.97510e+6
20288825      5000.0     0.91049e+6
20288826      6000.0     0.86154e+6
20288827      8000.0     0.79102e+6
20288828     10000.0     0.74152e+6
20288829     20000.0     0.61196e+6
20288830     50000.0     0.47759e+6
20288831    100000.0     0.39343e+6
*
**************************************************************
*  pressurizer heater power
**************************************************************
*
20260000   reac-t              * backup heaters
20260001      15.34e6   1.125e5
20260002      15.40e6   1.125e5
20260003      15.40e6   0.0
*
20260100   reac-t              * proportional heaters
20260101      15.41e6   7.5e3
20260102      15.62e6   0.0
*
**************************************************************
*    control systems
**************************************************************
*
**************************************************************
*  calculate time step
**************************************************************
*
20500100  "time stp"      sum       1.0000000 .20000000 1
20500101   0.0     1.0    time    0
20500102          -1.0    cntrlvar  2
*
20500200  "old time"      mult      1.0000000    0.0      1
20500201   time    0
*
**********************************************
*  control system turbine bypass valve control     *
*  during loca calcualtions                        *
*  based on mean primary temperature control       *
**********************************************
```

```
*
*************************************************************
*  calculate il + bl mean temperature and select the larger
*************************************************************
*
20503000  "ilmtemp"     sum      1.0000000 580.37388 1
20503001  0.0     0.5   tempf  452010000
20503002          0.5   tempf  400010000
*
20503100  "blmtemp"     sum      1.0000000 580.35764 1
20503101  0.0     0.5   tempf  252010000
20503102          0.5   tempf  200010000
*
20503200  "ilmtempl"    tripunit  1.0000000 1.0000000 1
20503201  514
*
20503300  "blmtempl"    tripunit  1.0000000 0.0      1
20503301  516
*
20503400  "cilmtmp "    mult     1.0000000 580.37388 1
20503401  cntrlvar  32   cntrlvar  30
*
20503500  "blmtempl"    mult     1.0000000 0.0      1
20503501  cntrlvar  33   cntrlvar  31
*
20503600  "pmtemp  "    sum      1.0000000 580.37388 1
20503601  0.0    1.0  cntrlvar  34
20503602         1.0  cntrlvar  35
*
*************************************************************
*  input to tb valve control after core trip-pmt setpt = 564.9 k
*************************************************************
*
20503700  "pmterra "    sum      -.0902500 1.1456230 1
20503701  566.3   -1.0  cntrlvar  36
*
****************************
*  check for reactor scram
****************************
*
20503800  "arcttrp "    tripunit  1.0000000 0.0      1
20503801  501
*
20503900  "arcttrpc"    mult     1.0000000 0.0      1
20503901  cntrlvar  38   cntrlvar  37
*
*********************
*  tb valve control
*********************
*
20504000  "tbp area"    sum      1.0000000 0.0      1
+                       3        0.0      1.0000000
20504001  0.0      1.0     cntrlvar  39
*
*************************************************************
* calculate core collapsed liquid level
*************************************************************
*
20512400  "core lvl"    sum      1.0000000 3.6600000 1
20512401       0.0      0.610      voidf    124010000
20512402                0.610      voidf    124020000
20512403                0.610      voidf    124030000
20512404                0.610      voidf    124040000
20512405                0.610      voidf    124050000
20512406                0.610      voidf    124060000
*************************************************************
* calculate core collapsed liquid level ---vessel---
*************************************************************
*
20512500  "core lvl"    sum      1.0000000 5.8027000 1
20512501       0.0      0.610      voidf    124010000
20512502                0.610      voidf    124020000
20512503                0.610      voidf    124030000
20512504                0.610      voidf    124040000
20512505                0.610      voidf    124050000
20512506                0.610      voidf    124060000
20512507                0.867      voidf    128010000
20512508                0.6757     voidf    132010000
20512509                0.6        voidf    136010000
*
*************************************************************
* calculate core heat input
*************************************************************
*
20512600  "coreheat"    sum      1.00000-6 9.8651798 1
20512601       0.0      1.0        q        124010000
20512602                1.0        q        124020000
20512603                1.0        q        124030000
20512604                1.0        q        124040000
20512605                1.0        q        124050000
20512606                1.0        q        124060000
*
*************************************************************
* calculate vessel dc collapsed level
*************************************************************
*
```

```
20510900  "vsldclvl"      sum      1.0000000 3.6600000 1
20510901  0.0   0.610     voidf    108030000
20510902        0.610     voidf    108040000
20510903        0.610     voidf    108050000
20510904        0.610     voidf    108060000
20510905        0.610     voidf    108070000
20510906        0.610     voidf    108080000
*
*****************************************
* energy transferred to generators
*****************************************
*
20530000  "blsgheat"      sum      1.00000-6 4.9783641 1
20530001  0.0   1.0    q     304010000
20530002        1.0    q     304020000
20530003        1.0    q     304030000
20530004        1.0    q     304040000
*
20550000  "ilsgheat"      sum      1.00000-6 4.9752834 1
20550001  0.0   1.0    q     504010000
20550002        1.0    q     504020000
20550003        1.0    q     504030000
20550004        1.0    q     504040000
*
**************************************************************
*    calculate sg recirculation ratios
**************************************************************
*
20530100  "recircbl"      div      1.0000000 5.0243769 1
20530101     mflowj   308010000    mflowj   301000000
*
20550100  "recircil"      div      1.0000000 5.0230369 1
20550101     mflowj   508010000    mflowj   501000000
*
*****************************************
* calculate narrow range sg liquid levels
*****************************************
*
20530800  "ilsgll  "      sum      .15390000 .13184474 1
20530801  0.0   0.600   voidf   300010000
20530802        2.12    voidf   312010000
20530803        3.7778  voidf   316010000
*
20550800  "blsgll  "      sum      .15390000 .12746200 1
20550801  0.0   0.600   voidf   500010000
20550802        2.12    voidf   512010000
20550803        3.7778  voidf   516010000
*
**************************************************************
* set il main feedwater on 9.5 m wide range sg level
**************************************************************
*
20535900  "il lv er"      sum      1.000000  0.      1
20535901      2450.          -1.0   cntrlvar  309
*
20536100  "il feed "      sum      1.0000000 2.8000000 1
20536101   0.0     1.0   mflowj 329000000
20536102           2.0   cntrlvar  359
*
**************************************************************
* set bl main feedwater on 9.6 m wide range sg level
**************************************************************
*
20555900  "bl lv er"      sum      1.000000  0.      1
20555901      2450.          -1.0   cntrlvar  509
*
20556100  "bl feed "      sum      1.0000000 2.8000000 1
20556101   0.0     1.0   mflowj 529000000
20556102           2.0   cntrlvar  559
*20556103          1.0   mflowj   493000000
*
**************************************************************
* pressurizer heater power
**************************************************************
*
20560000  "pbkuphtr"      function  1.0000000 0.0       1
20560001   p    610010000     600
*
20560100  "pprohtr "      function  1.0000000 836.59446 1
20560101   p    610010000     601
*
20560200  "bkphtrtp"      tripunit  1.0000000 0.0       1
20560201   634
*
20560300  "bkphtrpw"      mult      1.0000000 0.0       1
20560301   cntrlvar   600    cntrlvar   602
*
20560400  "pzrhtrpw"      sum       1.0000000 836.59446 1
20560401   0.0          1.0    cntrlvar   601
20560402                1.0    cntrlvar   603
*
20560500  "pzhtrtp"       tripunit  1.0000000 0.0       1
20560501   633
*
20560600  "pzhtrpw"       mult      1.0000000 0.0       1
20560601   cntrlvar   604    cntrlvar   605
```

```
*
***************************************************************
* calculate collapsed prssurizer liquid level
***************************************************************
*
20561000 "pzr lev "    sum     1.00000000    2.594213
1
20561001    0.0    0.201    voidf    610010000
20561002           0.470    voidf    610020000
20561003           0.470    voidf    610030000
20561004           0.600    voidf    610040000
20561005           0.682    voidf    610050000
20561006           0.682    voidf    610060000
20561007           0.5375   voidf    610070000
20561008           0.5375   voidf    610080000
*
***************************************************************
* calculate broken loop steam generator mass
***************************************************************
*
20530900 "sgb mass"    sum     1.0000000 2860.9843 1
20530901    0.0    0.3228    rho    300010000
20530902           0.0621    rho    300020000
20530903           0.0759    rho    300030000
20530904           0.0759    rho    300040000
20530905           0.1302    rho    300050000
20530906           0.5839    rho    304010000
20530907           0.5882    rho    304020000
20530908           0.5882    rho    304030000
20530909           0.4951    rho    304040000
20530910           0.7979    rho    304050000
20530911           0.5720    rho    308010000
20530912           0.6288    rho    312010000
20530913           2.0288    rho    316010000
*
***************************************************************
* calculate intact loop steam generator mass
***************************************************************
*
20550900 "sga mass"    sum     1.0000000 2848.8553 1
20550901    0.0    0.3228    rho    500010000
20550902           0.0621    rho    500020000
20550903           0.0759    rho    500030000
20550904           0.0759    rho    500040000
20550905           0.1302    rho    500050000
20550906           0.5839    rho    504010000
20550907           0.5882    rho    504020000
20550908           0.5882    rho    504030000
20550909           0.4951    rho    504040000
20550910           0.7979    rho    504050000
20550911           0.5720    rho    508010000
20550912           0.6288    rho    512010000
20550913           2.0288    rho    516010000
*
***************************************************************
* calculate intact primary loop mass
***************************************************************
*
20570000 "ihl mass"    sum    1.0000000 2848.8553 1
20570001    0.0    0.04463902    rho    400010000
20570002           0.00093545    rho    402010000
20570003           0.00058598    rho    404010000
20570004           0.04665091    rho    406010000
20570005           0.02373491    rho    408010000
20570006           0.01778686    rho    408020000
20570007           0.1250        rho    412010000
20570008           0.2323        rho    416010000
*
20570100 "isg mass"    sum    1.000000  2500.0   1
20570101    0.0    0.1212112    rho    420010000
20570102           0.1082557    rho    420020000
20570103           0.1082557    rho    420030000
20570104           0.091689     rho    420040000
20570105           0.091689     rho    420050000
20570106           0.1082557    rho    422010000
20570107           0.1082557    rho    422020000
20570108           0.1212112    rho    422030000
*20570109          0.0008658    rho    428010000
*20570110          0.0007733    rho    428020000
*20570111          0.0007733    rho    428030000
*20570112          0.000655     rho    428040000
*20570113          0.000655     rho    428050000
*20570114          0.0007733    rho    419010000
*20570115          0.0007733    rho    419020000
*20570116          0.0008658    rho    419030000
*
20570200 "ils mass"    sum    1.000000  2500.0   1
20570201    0.0    0.2323        rho    424010000
20570202           0.125         rho    430010000
20570203           0.0114552     rho    432010000
20570204           0.02757684    rho    432020000
20570205           0.02757684    rho    432030000
20570206           0.02757684    rho    432040000
20570207           0.02646018    rho    432050000
20570208           0.02646018    rho    436010000
20570209           0.02491284    rho    436020000
```

```
20570210                 0.02611386    rho     436030000
20570211                 0.02491284    rho     436040000
*
20570300  "icl mass"     sum    1.000000  2500.0   1
20570301      0.0        0.0235        rho     440010000
20570302                 0.02476276    rho     444010000
20570303                 0.03177573    rho     448010000
20570304                 0.03286424    rho     452010000
20570305                 0.03286424    rho     452020000
20570306                 0.040832      rho     740010000
*
20570400  "pr mass"      sum    1.000000 2500.0    1
20570401      0.0        0.0325        rho     610010000
20570402                 0.132869      rho     610020000
20570403                 0.132869      rho     610030000
20570404                 0.169620      rho     610040000
20570405                 0.192801      rho     610050000
20570406                 0.192801      rho     610060000
20570407                 0.146791      rho     610070000
20570408                 0.146791      rho     610080000
20570409                 0.02382748    rho     600010000
20570410                 0.03249617    rho     600020000
20570411                 0.01905868    rho     600030000
20570412                 0.00791779    rho     620010000
20570413                 0.00791779    rho     620020000
*
20570500  "il mass"      sum    1.000000  2500.0   1
20570501      0.0        1.0           cntrlvar   700
20570502                 1.0           cntrlvar   701
20570503                 1.0           cntrlvar   702
20570504                 1.0           cntrlvar   703
20570505                 1.0           cntrlvar   704
*
***************************************************************
*  calculate broken primary loop mass
***************************************************************
*
20570600  "bhl mass"     sum    1.0000000 2848.8553 1
20570601      0.0        0.04463902    rho     200010000
20570602                 0.00093545    rho     202010000
20570603                 0.00058598    rho     204010000
20570604                 0.04446715    rho     206010000
20570605                 0.02373491    rho     208010000
20570606                 0.01778686    rho     208020000
20570607                 0.1250        rho     212010000
20570608                 0.2323        rho     216010000
*
20570700  "bsg mass"     sum    1.000000  2500.0   1
20570701      0.0        0.122077      rho     220010000
20570702                 0.109029      rho     220020000
20570703                 0.109029      rho     220030000
20570704                 0.092344      rho     220040000
20570705                 0.092344      rho     220050000
20570706                 0.109029      rho     220060000
20570707                 0.109029      rho     220070000
20570708                 0.122077      rho     220080000
*
20570800  "bls mass"     sum    1.000000  2500.0   1
20570801      0.0        0.2323        rho     224010000
20570802                 0.125         rho     228010000
20570803                 0.0114552     rho     232010000
20570804                 0.02757684    rho     232020000
20570805                 0.02757684    rho     232030000
20570806                 0.02757684    rho     232040000
20570807                 0.02646018    rho     232050000
20570808                 0.02930844    rho     236010000
20570809                 0.02491284    rho     236020000
20570810                 0.02534574    rho     236030000
20570811                 0.02491284    rho     236040000
*
20570900  "bcl mass"     sum    1.000000  2500.0   1
20570901      0.0        0.0235        rho     240010000
20570902                 0.03559394    rho     244010000
20570903                 0.04025465    rho     248010000
20570904                 0.04423125    rho     252010000
20570905                 0.0145264     rho     790010000
*
20571000  "bl mass"      sum    1.000000  2500.0   1
20571001      0.0        1.0           cntrlvar   706
20571002                 1.0           cntrlvar   707
20571003                 1.0           cntrlvar   708
20571004                 1.0           cntrlvar   709
*
***************************************************************
*        pressure vessel mass
***************************************************************
*
20571100  "pvd mass"     sum    1.000000  2500.0   1
20571101      0.0        0.136090      rho     100010000
20571102                 0.054250      rho     104010000
20571103                 0.06604292    rho     108010000
20571104                 0.08474058    rho     108020000
20571105                 0.0596214     rho     108030000
20571106                 0.0596214     rho     108040000
20571107                 0.0596214     rho     108050000
20571108                 0.0596214     rho     108060000
```

```
20571109              0.0596214     rho       108070000
20571110              0.0596214     rho       108080000
20571111              0.123035      rho       108090000
*
20571200  "pvlpmass"   sum     1.000000  2500.0   1
20571201     0.0       0.1661       rho       112010000
20571202               0.0943       rho       116010000
*
20571300  "pvc mass"   sum     1.000000  2500.0   1
20571301     0.0       0.1821       rho       120010000
20571302               0.07312      rho       124010000
20571303               0.07312      rho       124020000
20571304               0.07312      rho       124030000
20571305               0.07312      rho       124040000
20571306               0.07312      rho       124050000
20571307               0.07312      rho       124060000
20571308               0.15220      rho       128010000
20571309               0.10600      rho       132010000
20571310               0.09389      rho       136010000
20571311               0.04450      rho       140010000
20571312               0.06209      rho       156010000
20571313               0.06288      rho       156020000
*
20571400  "pvupmass"   sum     1.000000  2500.0   1
20571401     0.0       0.1655       rho       144010000
20571402               0.1970       rho       148010000
20571403               0.1475       rho       152010000
*
20571500  "pv mass"    sum     1.000000  2500.0   1
20571501     0.0       1.0          cntrlvar  711
20571502               1.0          cntrlvar  712
20571503               1.0          cntrlvar  713
20571504               1.0          cntrlvar  714
*
*************************************************************
*   primary mass
*************************************************************
*
20572000  "pv mass"    sum     1.000000  2500.0   1
20572001     0.0       1.0          cntrlvar  705
20572002               1.0          cntrlvar  710
20572003               1.0          cntrlvar  715
*
*************************************************************
* differential pressure calculations
*************************************************************
*
20575000 "dp050d"      sum     1.00000   80000.   1
20575001     0.0       1.0          p  416010000
20575002              -1.0          p  420040000
*
20575100 "dp060d"      sum     1.00000   80000.   1
20575101     0.0       1.0          p  424010000
20575102              -1.0          p  420050000
*
20575200 "dpe070"      sum     1.00000   45000.   1
20575201     0.0       1.0          p  424010000
20575202              -1.0          p  436010000
*
20575300 "dpe080"      sum     1.00000   266000.  1
20575301     0.0       1.0          p  436010000
20575302              -1.0          p  440010000
*
20575400 "dp190d"      sum     1.00000   80000.   1
20575401     0.0       1.0          p  216010000
20575402              -1.0          p  220040000
*
20575500 "dp200d"      sum     1.00000   80000.   1
20575501     0.0       1.0          p  224010000
20575502              -1.0          p  220050000
*
20575600 "dpe210"      sum     1.00000   45000.   1
20575601     0.0       1.0          p  224010000
20575602              -1.0          p  236010000
*
20575700 "dpe220"      sum     1.00000   266000.  1
20575701     0.0       1.0          p  236010000
20575702              -1.0          p  240010000
*
20576100 "dpe300"      sum     1.00000   32000.   1
20576101     0.0       1.0          p  124010000
20576102              -1.0          p  128010000
*
*************************************************************
* control steam valve to give sg pressure of 7.10 mpa.
*************************************************************
*
20580300  "pres err"   sum     100.000-9 -5.3342-6 1
+                      3       -.05      .05
20580301  -6.90e6      1.0 p   316010000
*
20580400  "del area"   mult    1.0000000 -1.0668-6 1
20580401  cntrlvar  1  cntrlvar  803
*
20580500  "vlv area"   sum     1.0000000 .2300    1
-                      3       0.0       1.0000000
```

```
20580501   0.0      1.0   cntrlvar  805
*
*****************************************
* calculate wide range sg liquid levels
*****************************************
*
20531200  "blsglwde"     sum       1.0000000 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       1.0000000 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
*
*****************************************************
* set rcp speed to control to loop flow of 24.2 kg/s
*****************************************************
*
20523800  "spd err "       sum       2.0000000 158.365-6 1
+                           3          -5.000000 5.0000000
20523801    34.65     -1.0      mflowj     240010000
*
20523900  "delspeed"     mult      1.0000000 31.6731-6 1
20523901    cntrlvar    1    cntrlvar   238
*
20524000  "rcpspeed"     sum       1.0000000 89.403724 1
20524001   0.0      1.0   cntrlvar   239
20524002            1.0   cntrlvar   240
*
*****************************************************
* set hot leg bypass valve areas to 0.0
*****************************************************
*
20520300  "blhtlbyp"   constant  0.0985
*
20540300  "ilhtlbyp"   constant  0.0985
*
*****************************************

* calculate net flow to secondary
*****************************************
*
20585000  "netsecfl"       sum       1.0000000       0.  1
20585001   0.0     1.      mflowj   361000000
20585002           1.      mflowj   351000000
20585003           1.      mflowj   561000000
20585004           1.      mflowj   551000000
20585005          -1.      mflowj   805000000
20585006          -1.      mflowj   803000000
20585007          -1.      mflowj   369000000
20585008          -1.      mflowj   379000000
20585009          -1.      mflowj   569000000
20585010          -1.      mflowj   579000000
*
**************************************************************
*  calculate the overall pressure vessel liquid level
**************************************************************
*
20512800   "uh level"        sum      1.000000     10.657100     1
20512801      0.0           0.626       voidf    112010000
20512802                    0.4762      voidf    116010000
20512803                    1.2588      voidf    120010000
20512804                    0.610       voidf    124010000
20512805                    0.610       voidf    124020000
20512806                    0.610       voidf    124030000
20512807                    0.610       voidf    124040000
20512808                    0.610       voidf    124050000
20512809                    0.610       voidf    124060000
20512810                    0.867       voidf    128010000
20512811                    0.6757      voidf    132010000
20512812                    0.600       voidf    136010000
20512813                    0.3674      voidf    140010000
20512814                    0.897       voidf    144010000
20512815                    0.725       voidf    148010000
20512816                    0.504       voidf    152010000
*
**************************************************************
* calculate the steam generator liquid level
**************************************************************
*
20551600   "sga lvl"         sum      1.000000     17.695300     1
20551601      0.0           2.5464      voidf    504010000
20551602                    2.5654      voidf    504020000
20551603                    2.5654      voidf    504030000
20551604                    2.0980      voidf    504040000
20551605                    2.0223      voidf    504050000
20551606                    2.120       voidf    508010000
```

```
20551607                3.7778    voidf     516010000
*
20531600   "sgb lvl"    sum       1.000000    17.695300    1
20531601     0.0        2.5464    voidf     304010000
20531602                2.5654    voidf     304020000
20531603                2.5654    voidf     304030000
20531604                2.0980    voidf     304040000
20531605                2.0223    voidf     304050000
20531606                2.120     voidf     308010000
20531607                3.7778    voidf     316010000
*
**************************************************************
* calculate the steam generator level in the boiler section
**************************************************************
*
20550400   "sga blvl"   sum       1.000000    11.797500    1
20550401     0.0        2.5464    voidf     504010000
20550402                2.5654    voidf     504020000
20550403                2.5654    voidf     504030000
20550404                2.0980    voidf     504040000
20550405                2.0223    voidf     504050000
*
20530400   "sgb blvl"   sum       1.000000    11.797500    1
20530401     0.0        2.5464    voidf     304010000
20530402                2.5654    voidf     304020000
20530403                2.5654    voidf     304030000
20530404                2.0980    voidf     304040000
20530405               -2.0223    voidf     304050000
*
**************************************************************
* core power
**************************************************************
*
20588800   "core pow"   function  1.000000    10.020e+6    1
20588801   time    0       888
*
**************************************************************
* total break flowrate
**************************************************************
*
20591600    break    sum    1.0   0.0   1
20591601    0.0    1.0    mflowj   493000000
*
**************************************************************
* calculate time-integrated break mass flow
**************************************************************
*
20591500   "int bflo"    integral    1.000000    0.000000    1
20591501    cntrlvar    916
*
**************************************************************
* intact total feedwater flow
**************************************************************
*
20591700    intfeed   sum   1.0   0.0   1
20591701    0.0   1.0   mflowj   361000000
20591702          1.0   mflowj   351000000
*
**************************************************************
* broken total feedwater flow
**************************************************************
*
20591800    intfeed   sum   1.0   0.0   1
20591801    0.0   1.0   mflowj   561000000
20591802          1.0   mflowj   551000000
*
**************************************************************
* calculate the mass error
**************************************************************
*
20574000   "mass err"      sum       1.000000    0.000000    1
20574001   -14560.577      1.0       cntrlvar    720
20574002                   1.0       cntrlvar    915
*
**************************************************************
* differential pressure calculations
**************************************************************
*
20576500   "dpe140"    sum     1.000000    5000.        1
20576501     0.0       1.0     p           104010000
20576502              -1.0     p           136010000
*
20576800   "dpe055"    sum     1.000000    2000.        1
20576801     0.0       1.0     p           416010000
20576802              -1.0     p           424010000
*
20576900   "dpe195"    sum     1.000000    2000.        1
20576901     0.0       1.0     p           216010000
20576902              -1.0     p           224010000
*
*
*
. zzz
```

Appendix B Input Deck for SGTR Transient Calculation

```
**********************************************************
*
= lstf sgtr transient input deck with relap5/mod3.1
*
*******************************************************
*
0000100    restart   transnt
*
0000101    run
0000102    si  si
0000103    4265
*
*  time step control
*
0000201   3000.0   1.0-6   0.5   3    10    1000    1000
0000202   5000.0   1.0-6   0.1   3    50    5000    5000
*
20800001   dt        0.0
20800002   dtcrnt    0.0
*
**********************************************************
*    minor edits
*********************************************************
*
301  p          610010000   *pzr pressure
302  p          516010000   *sg-b steam pressure
303  p          316010000   *sg-i steam pressure
304  mflowj     208010000   *loop-i hot leg flow
305  mflowj     408010000   *loop-b hot leg flow
306  mflowj     248010000   *loop-i cold leg flow
307  mflowj     452010000   *loop-b cold leg flow
308  mflowj     108010000   *core bypass flow
309  mflowj     120010000   *core inlet flow
310  tempf      104010000   *vessel inlet temp
311  tempf      136010000   *vessel outlet temp
312  tempf      120010000   *core inlet temp
313  tempf      128010000   *core outlet temp
314  tempf      316010000   *sg-i steam temp
315  tempf      516010000   *sg-b steam temp
316  tempf      200010000   *loop-i hot leg temp
317  tempf      400010000   *loop-b hot leg temp
318  tempf      124010000   *core fluid temp-1
319  tempf      124020000   *core fluid temp-2
320  tempf      124030000   *core fluid temp-3
321  tempf      124040000   *core fluid temp-4
322  tempf      124050000   *core fluid temp-5
323  tempf      124060000   *core fluid temp-6
324  sattemp    248010000   *hot leg sat. temp
325  sattemp    208010000   *cold leg sat. temp
326  voidg      152010000   *upper head voidf
327  pmpvel     240
328  pmphead    240
329  pmpvel     440
330  pmphead    440
331  cntrlvar   512         *sg-b wr level
332  cntrlvar   508         *sg-b nr level
333  cntrlvar   504         *sg-b boiling water level
334  cntrlvar   312         *sg-i wr level
335  cntrlvar   308         *sg-i nr level
336  cntrlvar   304         *sg-i boiling water level
337  cntrlvar   610         *pzr level
338  cntrlvar   720         *primary mass
339  cntrlvar   309         *sg-i mass
340  cntrlvar   509         *sg-b mass
341  cntrlvar   888         *rx power
342  cputime    0           *cpu time
343  cntrlvar   916         *break flowrate
344  cntrlvar   915         *integrated break flow
345  cntrlvar   917         *total feedwater to sg-a
346  cntrlvar   918         *total feedwater to sg-b
*347 mflowj     391000000   *sg-a steam dump
348  mflowj     612000000   *pzr aux spray
349  mflowj     351000000   *aux feed a  (hot)
350  mflowj     353000000   *aux feed a  (cold)
351  mflowj     551000000   *aux feed b  (hot)
352  cntrlvar   919         *aux feed a (total)
353  mflowj     771000000   *hpsi to cl-i
354  mflowj     721000000   *hpsi to cl-b
355  mflowj     722000000   *hpsi to up
356  tempf      152010000   *up head temp
357  tempf      108040000   *mid downcomer temp
358  cntrlvar   921         *total water inject
359  cntrlvar   922         *HPSI-CL total flow
*
************************************************************
* variable trips
************************************************************
*
0000501  p         610010000  lt   null    0    1.342e+7  l *rx trip signal
0000502  time      0          ge   null    0    1.e6      l *power
0000505  p         610010000  lt   null    0    1.287e+7  l *rcp&si
0000506  time      0          ge   timeof  505  17.0      l *lpsi delay
0000507  cntrlvar  610        le   null    0    1.0       n *hpsi termi.
0000508  time      0          le   timeof  505  2900.0    n *hpsi termi.
0000510  time      0          ge   timeof  505  98.0      n *il hpi
0000511  time      0          ge   timeof  505  300.0     n *il hppi to up
```

```
0000512 time          0   ge   timeof 505  98.0    n *bl hpi
0000514 cntrlvar  30      ge   cntrlvar  31   0.0  n *mean temp
0000516 cntrlvar  30      lt   cntrlvar  31   0.0  n
0000520 p       610010000 ge   null 0  1.646e+7    l *high pres
0000522 p       610010000 ge   null 0  1.726e+7    n *pzr sfty
0000524 p       610010000 ge   null 0  1.568e+7    n *pzr spry
0000525 time          0   ge timeof 501 2666.0 l *pzr aux spray
0000526 p       610010000 gt   null 0  1.607e+7    n * porv
0000527 p       516010000 gt p 610010000  0.0 l *aux spray term.
0000528 p       610010000 gt   null 0  1.620e+7    n
0000529 time          0   ge   null 0  0.0         l *pzr prp. htrs
0000530 p       610010000 lt   null 0  1.540e+7 n *pzr bkup htrs
0000531 p       610010000 lt   null 0  1.534e+7    n
0000532 cntrlvar    610   lt   null 0  0.25656   n *lo nrm pr lvl
0000535 time          0   ge   null 0  0.0         l *tube break
0000536 time          0   ge   null 0  0.0         l *bl flow
0000537 time          0   lt   null 0  0.0         l *valve
0000538 time          0   lt   null 0  0.0         l *il flow
0000539 time          0   lt   null 0  0.0         l *valve
*0000540 time         0   le   null 0  10000.0     n
0000550 p       610010000 ge   null 0  1.297e+7    n *main feed
0000552 time          0   ge   timeof 505  37.0    n *aux feed
0000553 time          0   le   timeof 552  200.0   n *aux feed
0000554 cntrlvar  312     lt   null  0     12.85   n *aux feed
0000555 time       0  gt  timeof 505 237.0  n *aux feed a cold
0000556 time          0   le   timeof 552  81.0    n *aux feed
0000557 tempf 206010000  ge  null  0 531.4  n * termi. of stdump
0000560 p  316010000   gt   null  0    6.4e+6   n *il sg rel
0000561 p  316010000   gt   null  0    7.3e+6   n
0000564 p  316010000   gt   null  0    7.69e+6  n *il sg saf
0000565 p  316010000   gt   null  0    8.68e+6  n
0000568 p  316010000   le   null  0    0.0      l *il msiv
0000569 p  316010000   lt   null  0    4.235e+6 l
0000570 p  516010000   gt   null  0    6.4e+6   n *bl sg rel
0000571 p  516010000   gt   null  0    7.3e+6   n
0000574 p  516010000   gt   null  0    7.69e+6  n *bl sg saf
0000575 p  516010000   gt   null  0    8.68e+6  n
0000578 time      0    ge   timeof 501  722.0   l *bl msiv
0000579 p     516010000  lt   null  0  4.235e+6  l
0000580 cntrlvar  308   lt   null  0  0.25      l *low sg lev
0000581 cntrlvar  508   lt   null  0  0.25      l
0000583 time      0     ge   null  0   0.0     n *stm hdr vlv
0000585 time      0     lt   null  0   0.0     n *stm thrtl
0000586 time      0     ge   null  0   11.0    n * valve
0000599 time      0     lt   null  0  1000.0   n * ss pres
**************************************************************
*  logical trips
**************************************************************
```

```
0000601   -603   and   571   n * bl sec relief valve
0000602    603   and   570   n
0000603    601   or    602   n
0000604   -606   and   575   n * bl sec safety valve
0000605    606   and   574   n
0000606    604   or    605   n
0000607   -609   and   561   n * il sec relief valve
0000608    609   and   560   n
0000609    607   or    608   n
0000610   -612   and   565   n * il sec safety valve
0000611    612   and   564   n
0000612    610   or    611   n
0000613   -615   and   528   n * porv
0000614    615   and   526   n
0000615    613   or    614   n
0000616    510   and   507   n * hpsi to il cl
0000617    511   and   508   n * hpsi to core up
0000618    512   and   507   n * hpsi to il
0000619    525   and   -527  n * aux spray
0000620    580   or    581   l * reactor trip
0000621    520   or    620   l
0000622    621   or    501   l
0000623    552   and   553   n * sg aux feed, il
0000624    552   and   556   n *           , bl
0000625   -586   or    -586  n * steam sink pressure
0000626    579   or    568   l * hpi
0000627    626   or    505   l
0000630   -632   and   531   n * pzr backup heater cntl
0000631    632   and   530   n
0000632    630   or    631   n
0000633   -505   and   -532  n * pzr htrs off on sis or low pzr lvl
0000634    632   and   633   n * pzr htrs off on low pzr level
0000635   -568   and   -568  n  0
0000636   -578   and   -578  n  0
0000637    555   and   554   n
0000638    578   and   557   n  * intact loop RV manual open
0000700   -535   and   -535  n  0  *break close
*
**************************************************************
*  hydrodynamic components
**************************************************************
*
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   003            15471507.  560.76
2400201   0          2.0813     2.2480     0.0
```

```
2400202    0         1.3711    1.3711    0.0
2400301    0    0    0    -1    0    505    0
2400302    188.50000 .680636 .05400000 10.000000 55.200000
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  -0.90  -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  -1.00  -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
*
*   pump coastdown data
*
2406100    501               * norm speed
2406101    0.0     128.3   * 160.22
2406102    80.0    128.3   * 160.22
2406103    83.0    122.0   * 153.75
2406104    86.0    118.9   * 149.87
2406105    89.0    114.9   * 144.86
2406106    101.0   96.7    * 121.90
2406107    110.0   82.6    * 104.12
2406108    119.0   74.4    * 93.77
```

```
2406109     131.0    63.4   * 79.86
2406110     140.0    56.7   * 71.46
2406111     149.0    51.8   * 65.31
2406112     161.0    46.3   * 58.36
2406113     170.0    41.7   * 52.54
2406114     179.0    38.2   * 48.18
2406115     191.0    34.8   * 43.81
2406116     200.0    32.3   * 40.74
2405117     209.0    30.0   * 37.38
2406118     221.0    27.3   * 34.43
2406119     230.0    25.3   * 31.85
2406120     239.0    23.2   * 29.26
2406121     251.0    21.4   * 27.00
2406122     260.0    20.3   * 25.54
2406123     269.0    19.0   * 23.92
2406124     281.0    16.3   * 20.53
2406125     290.0    14.6   * 18.43
2406126     299.0    12.4   * 15.60
2406127     320.0    9.9    * 12.48
2406128     341.0    7.4    * 9.36
2406129     359.0    5.0    * 6.24
2406130     380.0    2.5    * 3.12
2406131     400.0    0.0
2406132     1000.0   0.0
2406133     3960.0   0.0    *il rcp restart
2406134     3970.0   50.0
2406135     3980.0   90.0
2406136     3990.0   128.3
2406137     5000.0   128.3
*
****************************************************************
3290000     ilmsiv      valve
3290101     328010000   332000000   0.00429   0.0  0.0  0100
3290201     0           12.637699 17.284590 0.0        * 2.7477202
3290300     mtrvlv
3290301     635         568         2.0000000 1.0000000 0
*
****************************************************************
3500000     auxfed      tmdpvol
3500101     8.0         5.0   0.0   0.0   0.0   0.0   0.0   0   00
3500200     3
3500201     0.0         5.95300e+6       495.2
*
****************************************************************
3510000     auxfed      tmdpjun
3510101     350000000   300000000   0.004
3510200     1   623
3510201     0.0   0.0   0.0   0.0
3510202     0.01  1.500 0.0   0.0
3510203  5000.0   1.500 0.0   0.0
*
****************************************************************
3520000     auxfedc     tmdpvol
3520101     8.0         5.0   0.0   0.0   0.0   0.0   0.0   0   00
3520200     3
3520201     0.0         5.95300e+6       300.2
*
****************************************************************
3530000     auxfedc     tmdpjun
3530101     352000000   300000000   0.004
3530200     1   637
3530201     0.0   0.0   0.0   0.0
3530202     0.01  0.500 0.0   0.0
3530203     500.0 0.500 0.0   0.0
3530204     500.1 1.0   0.0   0.0
3530205  5000.0   1.0   0.0   0.0
*
****************************************************************
3600000     npstegfw    tmdpvol
3600101     0.139       5.0   0.0   0.0   0.0   0.0   0.0   0   00
3600200     3
3600201     0.0         5.83400e+6       495.35
*
****************************************************************
3610000     npstegfw    tmdpjun
3610101     360000000   300000000   4.00e-3
3610200     1   550   cntrlvar   361
3610201     -1.0e75   0.0   0.0   0.0
3610202     0.0   0.0   0.0   0.0
3610203     5.0   5.0   0.0   0.0
3610204     7.0   7.0   0.0   0.0
3610205  1000.0   7.0   0.0   0.0
*
****************************************************************
* 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            * 0.0
3690300     trpvlv
3690301     638
*
****************************************************************
3700000     contain     tmdpvol
3700101     1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
```

```
3700200     3
3700201     0.0   1.01325e+5   293.15
*
****************************************************************
3790000     blsgsv    valve
3790101     324010000   380000000   0.00195   0.00055   0.0   0100
3790201     0      0.0      0.0      0.0           * 0.0
3790300     trpvlv
3790301     612
*
****************************************************************
3800000     contain    tmdpvol
3800101     1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0   0.0   00
3800200     3
3800201     0.0   1.01325e+5   293.15
*
****************************************************************
*
4160000     wpsgfb      branch
4160001     3     0
4160101     0   1.1035   0.2323   0.0   90.0   1.1035   4.57e-5
4160102     0.4474   00
4160200     003      15460476.   586.5
4162101     412010000   416000000   0.2093   0.0   0.0   0000
4163101     416010000   420000000   0.04254   0.0   0.0   0000
4164101     416010000   417000000   5.0e-4   0.0   0.0   0100
4162201     1.247     1.247     0.0
4163201     1.247     1.247     0.0
4164201     0.1       0.1       0.0
*
****************************************************************
*
4170000     bktln1     snglvol
4170101     5.0e-4  1.18   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4170200     003        15453426.   560.5
*
4180000     bktln4     branch
4180001     2         0
4180101     5.0e-4   2.06   0.0  0.0  -90.0  -2.06  4.57e-5  0.0  00
4180200     003        15441269.   586.5
4181101     417010000   418000000   5.0e-4     0.0   0.0   0000
4182101     418010000   419000000   5.0e-4     0.0   0.0   0000
4181201     0.1    0.1    0.0
4182201     0.1    0.1    0.0
*
4190000     bktln5     snglvol
4190101     5.0e-4  1.9   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4190200     003        15433426.   560.5
*
4930000     break     valve
4930101     419010000   494000000   5.0e-4   0.0   0.0   0000
4930201     1   0.0   0.0   0.0
4930300     trpvlv
4930301     535
*
****************************************************************
*
4940000     bkln5     snglvol
4940101     5.0e-4  0.24   0.0  0.0  0.0  0.0  4.57e-5  0.0   00
4940200     003        7310426.   540.5
*
4950000     bkln4     branch
4950001     2         0
4950101     5.0e-4   0.35   0.0  0.0  90.0  0.35  4.57e-6  0.0  00
4950200     003        7311269.    546.5
4951101     495010000   496000000   3.02e-5   0.0   0.0   0100
4952101     494010000   495000000   5.0e-4   0.0   0.0   0000
4951201     0.1    0.1    0.0
4952201     0.1    0.1    0.0
*
4960000     brknozl    pipe
4960001     3
4960101     3.02e-5      3
4960301     0.6          3
4960401     0.0          3
4960601     90.0         3
4960701     0.6          3
4960801     1.2e-6       0.0062   3
4960901     0.0          0.0     2
4961001     00           3
4961101     01000        2
4961201     003          15315536. 586.50  0.  0.  0.  1
4961202     003          11325536. 569.50  0.  0.  0.  2
4961203     003           7330536. 552.50  0.  0.  0.  3
4961300     0
4961301     0.1    0.1    0.0      1
4961302     0.1    0.1    0.0      2
*
*4960000    brknozl    pipe
*4960001    12
*4960101    3.02e-5      12
*4960301    0.15         12
*4960401    0.0          12
*4960601    90.0         12
*4960701    0.15         12
*4960801    1.2e-6       0.0062   12
```

```
*4960901   0.0        0.0    11
*4961001   00         12
*4961101   01000      11
*4961201   003        15315536. 586.50  0.  0.  0.  1
*4961202   003        14625536. 583.50  0.  0.  0.  2
*4961203   003        13930536. 580.50  0.  0.  0.  3
*4961204   003        13295536. 577.50  0.  0.  0.  4
*4961205   003        12625536. 574.50  0.  0.  0.  5
*4961206   003        11930536. 571.50  0.  0.  0.  6
*4961207   003        11215536. 568.50  0.  0.  0.  7
*4961208   003        10625536. 565.50  0.  0.  0.  8
*4961209   003         9949276. 562.50  0.  0.  0.  9
*4961210   003         9278626. 559.50  0.  0.  0. 10
*4961211   003         7935536. 556.50  0.  0.  0. 11
*4961212   003         7330536. 552.50  0.  0.  0. 12
*4961300   0
*4961301   0.1   0.1   0.0     1
*4961302   0.1   0.1   0.0     2
*4961303   0.1   0.1   0.0     3
*4961304   0.1   0.1   0.0     4
*4961305   0.1   0.1   0.0     5
*4961306   0.1   0.1   0.0     6
*4961307   0.1   0.1   0.0     7
*4961308   0.1   0.1   0.0     8
*4961309   0.1   0.1   0.0     9
*4961310   0.1   0.1   0.0    10
*4961311   0.1   0.1   0.0    11
*
4970000    bkln2      branch
4970001    2          0
4970101    5.0e-4   0.75   0.0  0.0  90.0  0.75  4.57e-6  0.0  00
4970200    003        7331269.   546.5
4971101    496010000   497000000   3.02e-5   0.0   0.0   0100
4972101    497010000   498000000   5.0e-4    0.0   0.0   0000
4971201    0.1    0.1    0.0
4972201    0.1    0.1    0.0
*
4980000    bkln2    pipe
4980001    2
4980101    5.0e-4    2
4980301    1.25      2
4980601    0.0       2
4980701    0.0       2
4980801    4.57e-5  0.0      2
4980901    0.0      0.0      1
4981001    00        2
4981101    0000      1
4981201    003          7344729.  540.5  0.  0.  0.  1
4981202    003          7350523.  540.5  0.  0.  0.  2
4981300    0
4981301    0.1   0.1    0.0        1
*
4990000    bkln1    sngljun
4990101    498010000   504010003   5.0e-4    0.0   0.0   0100
4990201    0         0.1    0.1    0.0
*
****************************************************************
*
4400000    wprcpump    pump
4400101    0.0   0.802   0.0235   0.0   90.0   0.351   00
4400108    436010000   0.0222      0.0   0.0   0000
4400109    444000000   0.0337      0.0525 0.0525 0000
4400200    003          15471901.  560.6
4400201    0         2.0050    2.1683     0.0
4400202    0         1.3208    1.3208     0.0
4400301    240   240   240     -1     0   505   0
4400302    188.50000 .65942  .05400000 10.000000 55.200000
4400303    0.54        750.0       0.0   0.0   0.0   0.0   0.0
*
*   pump coastdown data
*
4406100    501              * norm speed
4406101    0.0       124.3  * 160.22
4406102    80.0      124.3  * 160.22
4406103    83.0      118.2  * 153.75
4406104    86.0      115.2  * 149.87
4406105    89.0      111.4  * 144.86
4406106    101.0     93.7   * 121.90
4406107    110.0     80.1   * 104.12
4406108    119.0     72.1   * 93.77
4406109    131.0     61.4   * 79.86
4406110    140.0     54.9   * 71.46
4406111    149.0     50.2   * 65.31
4406112    161.0     44.9   * 58.36
4406113    170.0     40.4   * 52.54
4406114    179.0     37.0   * 48.18
4406115    191.0     33.7   * 43.81
4406116    200.0     31.3   * 40.74
4406117    209.0     29.1   * 37.38
4406118    221.0     26.5   * 34.43
4406119    230.0     24.5   * 31.85
4406120    239.0     22.5   * 29.26
4406121    251.0     20.8   * 27.00
4406122    260.0     19.6   * 25.54
4406123    269.0     18.4   * 23.92
4406124    281.0     15.8   * 20.53
```

```
4406125    290.0    14.2  * 18.43
4406126    299.0    12.0  * 15.60
4406127    320.0    9.6   * 12.48
4406128    341.0    7.2   * 9.36
4406129    359.0    4.8   * 6.24
4406130    380.0    2.4   * 3.12
4406131    400.0    0.0
4406132    1000.0   0.0
*
**************************************************************
5290000    ilmsiv     valve
5290101    528010000  532000000  0.00429  0.0  0.0  0100
5290201    0          5.7878014 17.263954 0.0          * 2.7467386
5290300    mtrvlv
5290301    636        578        2.0000000 1.0000000 0
*
**************************************************************
5500000    auxfed     tmdpvol
5500101    8.0        5.0  0.0  0.0  0.0  0.0  0.0  0    00
5500200    3
5500201    0.0        5.95300e+6       495.2
*
**************************************************************
5510000    auxfed     tmdpjun
5510101    550000000  500000000  0.004
5510200    1   624
5510201    0.0   0.0   0.0   0.0
5510202    0.01  1.140 0.0 · 0.0
5510203  5000.0  1.140 0.0   0.0
*
**************************************************************
5610000    wpstegfw   tmdpjun
5610101    560000000  500000000  4.00e-3
5610200    1  550  cntrlvar  561
5610201    -1.0e75  0.0  0.0  0.0
5610202    0.0  0.0    0.0  0.0
5610203    5.0  5.0    0.0  0.0
5610204    7.0  7.0    0.0  0.0
5610205  1000.0  7.0    0.0  0.0
*
**************************************************************
* pzr aux spray
**************************************************************
*
6110000    auxtank    tmdpvol
6110101    1.0e+5     10.0  0.  0.  0.  0.  0.  0  00
6110200    3
6110201    0.0   16.0e+6   310.0
```

```
*
6120000    auxjun     tmdpjun
6120101    611000000  610010001  2.552e-3
6120200    1      619
6120201    -1.0    0.0    0.0    0.0
6120202    0.0     0.1    0.0    0.0
6120203    10.0    0.1    0.0    0.0
6120204    700.0   0.1    0.0    0.0
6120205    1000.0  0.1    0.0    0.0
*
**************************************************************
* eccs
**************************************************************
*
7200000    ilsi       tmdpvol
7200101    4.375      10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7200200    3
7200201    0.0        1.013e+5     310.00
*
**************************************************************
* high pressure safety injection to cold leg
**************************************************************
*
7210000    ilsi    tmdpjun
7210101    720000000  740000000  2.552e-3
7210200    1   616   p   448010000
7210201    -1.0      0.0   0.0   0.0
7210202    0.0       0.0   0.0   0.0
7210203    0.0       0.629    0.0   0.0
7210204    5.88e6    0.629    0.0   0.0
7210205    6.08e6    0.6065   0.0   0.0
7210206    6.28e6    0.5875   0.0   .0.0
7210207    6.47e6    0.569    0.0   0.0
7210208    6.67e6    0.554    0.0   0.0
7210209    6.86e6    0.535    0.0   0.0
7210210    7.06e6    0.5125   0.0   0.0
7210211    7.26e6    0.4975   0.0   0.0
7210212    7.45e6    0.475    0.0   0.0
7210213    7.65e6    0.4565   0.0   0.0
7210214    7.85e6    0.434    0.0   0.0
7210215    8.04e6    0.4115   0.0   0.0
7210216    8.24e6    0.385    0.0   0.0
7210217    8.43e6    0.3625   0.0   0.0
7210218    8.63e6    0.340    0.0   0.0
7210219    8.83e6    0.314    0.0   0.0
7210220    9.02e6    0.2875   0.0   0.0
7210221    9.22e6    0.254    0.0   0.0
7210222    9.41e6    0.224    0.0   0.0
```

```
7210223     9.61e6    0.190    0.0    0.0
7210224     9.81e6    0.1375   0.0    0.0
7210225     10.0e6    0.059    0.0    0.0
7210226     10.15e6   0.0      0.0    0.0
*
7500000     ilsi      tmdpvol
7500101     4.375     10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7500200     3
7500201     0.0       1.013e+5    310.00
*
7220000     ilsi    tmdpjun
7220101     750000000   140000000   2.552e-3
7220200     1   617   p   140010000
7220201     -1.0      0.0    0.0    0.0
7220202     0.0       0.0    0.0    0.0
7220203     0.0       1.388    0.0    0.0
7220204     5.88e6    1.388    0.0    0.0
7220205     6.08e6    1.343    0.0    0.0
7220206     6.28e6    1.305    0.0    0.0
7220207     6.47e6    1.268    0.0    0.0
7220208     6.67e6    1.238    0.0    0.0
7220209     6.86e6    1.200    0.0    0.0
7220210     7.06e6    1.155    0.0    0.0
7220211     7.26e6    1.125    0.0    0.0
7220212     7.45e6    1.080    0.0    0.0
7220213     7.65e6    1.043    0.0    0.0
7220214     7.85e6    0.998    0.0    0.0
7220215     8.04e6    0.953    0.0    0.0
7220216     8.24e6    0.900    0.0    0.0
7220217     8.43e6    0.855    0.0    0.0
7220218     8.63e6    0.810    0.0    0.0
7220219     8.83e6    0.758    0.0    0.0
7220220     9.02e6    0.705    0.0    0.0
7220221     9.22e6    0.638    0.0    0.0
7220222     9.41e6    0.578    0.0    0.0
7220223     9.61e6    0.510    0.0    0.0
7220224     9.81e6    0.405    0.0    0.0
7220225     10.0e6    0.248    0.0    0.0
7220226     10.15e6   0.0      0.0    0.0
*
*****************************************************************
7300000     ilchrg    tmdpvol
7300101     4.375     10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7300200     3
7300201     0.0       1.013e+5          310.00
*
*****************************************************************
7310000     ilchrg  tmdpjun
7310101     730000000   740000000   2.552e-3
7310200     1   510   p   444010000
7310201     -1.0      0.0     0.0    0.0
7310202     0.0       0.0     0.0    0.0
7310203     0.0       0.13    0.0    0.0
7310204     15.0e6    0.13    0.0    0.0
*
*****************************************************************
7400000     ileccsln    snglvol
7400101     2.552e-3    16.0   0.0   0.0   0.0   0.0   3.333e-5
7400102     0.0    00
7400200     0           15598371. 83230.665 2445532.2 0.0
*
*****************************************************************
7700000     blsi      tmdpvol
7700101     4.375     10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7700200     3
7700201     0.0       1.013e+5     310.0
*
*****************************************************************
*
7710000     blsi    tmdpjun
7710101     770000000   790000000   2.552e-3
7710200     1   618   p   248010000
7710201     -1.0      0.0    0.0    0.0
7710202     0.0       0.0    0.0    0.0
7710203     0.0       0.629     0.0    0.0
7710204     5.88e6    0.629     0.0    0.0
7710205     6.08e6    0.6065    0.0    0.0
7710206     6.28e6    0.5875    0.0    0.0
7710207     6.47e6    0.569     0.0    0.0
7710208     6.67e6    0.554     0.0    0.0
7710209     6.86e6    0.535     0.0    0.0
7710210     7.06e6    0.5125    0.0    0.0
7710211     7.26e6    0.4975    0.0    0.0
7710212     7.45e6    0.475     0.0    0.0
7710213     7.65e6    0.4565    0.0    0.0
7710214     7.85e6    0.434     0.0    0.0
7710215     8.04e6    0.4115    0.0    0.0
7710216     8.24e6    0.385     0.0    0.0
7710217     8.43e6    0.3625    0.0    0.0
7710218     8.63e6    0.340     0.0    0.0
7710219     8.83e6    0.314     0.0    0.0
7710220     9.02e6    0.2875    0.0    0.0
7710221     9.22e6    0.254     0.0    0.0
7710222     9.41e6    0.224     0.0    0.0
7710223     9.61e6    0.190     0.0    0.0
7710224     9.81e6    0.1375    0.0    0.0
```

```
7710225     10.0e6    0.059    0.0    0.0
7710226     10.15e6   0.0      0.0    0.0
*
****************************************************************
7800000     blchrg     tmdpvol
7800101     4.375      10.0  0.0   0.0   0.0   0.0   0.0   0.0   00
7800200     3
7800201     0.0        1.013e+5        310.0
*
****************************************************************
7810000     blchrg  tmdpjun
7810101     780000000   790000000   2.552e-3
7810200     1   510    p    248010000
7810201     -1.0     0.0     0.0    0.0
7810202      0.0     0.0     0.0    0.0
7810203      0.0     0.13    0.0    0.0
7810204     15.0e6   0.13    0.0    0.0
*
****************************************************************
7900000     bleccsln      snglvol
7900101     9.079e-4   16.0   0.0   0.0   0.0   0.0   3.333e-5
7900102     0.0  00
7900200     0      15488401.  83231.356  2445531.5  0.0
*
****************************************************************
* intact loop secondary pressure control
****************************************************************
*8160000    jctdv1       tmdpvol
*8160101    1.0e+8      10.0   0.0   0.0   0.0   0.0   0.0   0.0  00
*8160200    2
*8160201    0.0       6.54e+6     1.0
*8160202    2900.0    6.54e+6     1.0
*8160203    3000.0    2.70e+6     1.0
*8160204    5000.0    2.70e+6     1.0
*
8200000     jctdv2        tmdpvol
8200101     1.0e+8      10.0   0.0   0.0   0.0   0.0   0.0   0.0  00
8200200     2
8200201     0.0       6.54e+6     1.0
8200202     2500.0    6.54e+6     1.0
8200203     2600.0    2.70e+6     1.0
8200204     5000.0    2.70e+6     1.0
*
****************************************************************
* boundary system for steady state
****************************************************************
*
9900000     bdryvol    delete
*
9890000     bdryvlv    delete
*
****************************************************************
*
20574000   "mass err"      sum       1.000000     0.000000     1
20574001   -14488.61        1.0       cntrlvar     720
20574002                    1.0       cntrlvar     915
*
20591900    auxfeed   sum   1.0   0.0   1
20591901    0.0   1.0   mflowj   351000000
20591902          1.0   mflowj   353000000
*
20591700    intfeed   sum   1.0   0.0   1
20591701    0.0   1.0   mflowj   361000000
20591702          1.0   mflowj   351000000
20591703          1.0   mflowj   353000000
*
20591800    brkfeed   sum   1.0   0.0   1
20591801    0.0   1.0   mflowj   561000000
20591802          1.0   mflowj   551000000
*
20592000    totwatr   sum   1.0   0.0   1
20592001    0.0   1.0   mflowj   771000000
20592002          1.0   mflowj   721000000
20592003          1.0   mflowj   722000000
20592004          1.0   mflowj   731000000
20592005          1.0   mflowj   781000000
*
20592100    totalinj   integral   1.0   0.0   1
20592101    cntrlvar   920
*
20592200    tothpicl   sum   1.0   0.0   1
20592201    0.0   1.0   mflowj   771000000
20592202          1.0   mflowj   721000000
20592204          1.0   mflowj   731000000
20592205          1.0   mflowj   781000000
*
****************************************************************
* integrated flow in broken loop
****************************************************************
*
20592300   "si-cltot"   integral    1.0     0.0     1
20592301   cntrlvar     922
*
20592500   "feedtot"    integral    1.0     0.0     1
20592501   cntrlvar     917
*
```

```
20592600   "auxtot"   integral   1.0   0.0   1
20592601   cntrlvar   918
*
20592800   "arvtot"   integral   1.0   0.0   1
20592801   mflowj      569000000
*
20592900   "msltot"   integral   1.0   0.0   1
20592901   mflowj      529000000
*
. zzz
```

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, If any.)

NUREG/IA-0130
CAMP002

2. TITLE AND SUBTITLE

Assessment of RELAP5/MOD3.1 With the LSTF SB-SG-06 Experiment Simulating a Steam Generator Tube Rupture Transient

3. DATE REPORT PUBLISHED

MONTH	YEAR
September	1996

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

K.W. Seul, Y.S. Bang, S. Lee, H.J. Kim

6. TYPE OF REPORT

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Korea Institute of Nuclear Safety
P.O. Box 16, Daeduck Danji
Taejon, 305-600 Korea

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

The objective of the present work is to identify the predictability of RELAP5/MOD3.1 regarding thermal-hydraulic behavior during a steam generator tube rupture (SGTR). To evaluate the computed results, LSTF SB-SG-06 test data simulating the SGTR that occurred at the Mihama Unit 2 in 1991 are used. Also, some sensitivity studies of the code change in RELAP5, the break simulation model, and the break valve discharge coefficient are performed. The calculation results indicate that the RELAP5/MOD3.1 code predicted well the sequence of events and the major phenomena during the transient, such as the asymmetric loop behavior, reactor coolant system (RCS) cooldown and heat transfer by natural circulation, the primary and secondary system depressurization by the pressurizer auxiliary spray and the steam dump using the intact loop steam generator (SG) relief valve, and so on. However, there are some differences from the experimental data in the number of the relief valve cycling in the affected SG, and the flow regime of the hot leg with the pressurizer, and the break flow rates. Finally, the calculation also indicates that the coolant in the core could remain in a subcooled state as a result of the heat transfer caused by the natural circulation flow even if the reactor coolant pumps (RCPs) turned off and that the affected SG could be properly isolated to minimize the radiological release after the SGTR.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

RELAP5/MOD3, CAMP, SGTR

13. AVAILABILITY STATEMENT

unlimited

14. SECURITY CLASSIFICATION

(This Page) unclassified

(This Report) unclassified

15. NUMBER OF PAGES

16. PRICE