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.

DISCLAIMER NOTICE

This report was prepared under an international cooperative agreement for the exchange of technical information. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product, or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

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

NUREG/IA-0130 has been reproduced
from the best available copy.

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

Abstract iii
Contents v
List of Tables vi
List of Figures vi
Acknowledgements viii
Executive Summary ix

I. Introduction 1
II. Experimental Facility, Conditions and Procedures 4
  II.1 Facility Description 4
  II.2 Experimental Conditions and Procedures 5
III. Code and Modeling 6
  III.1 Code Description 6
  III.2 Modeling Description 6
IV. Analysis Results and Discussion 8
  IV.1 Analysis Conditions 8
  IV.2 Analysis Results 9
  IV.3 Code Predictability 13
  IV.4 Sensitivity Study 15
  IV.5 Run Statistics 17
V. Conclusions 18

References 20
Appendix A. Input Deck for Steady State Calculation
Appendix B. Input Deck for SGTR Transient Calculation

List of Tables

Table 1 Comparison of Initial Conditions
Table 2 Setpoints and Conditions used in RELAP5/MOD3.1 Calculation
Table 3 Event Sequence of SGTR Transient
Table 4 Lists of Measured Data and Corresponding Calculated Parameters
Table 5 Comparison of Integrated Total Mass Flows during Transient

List of Figures

Figure 1 ROSA-IV LSTF Flow Diagram
Figure 2 RELAP5 Nodalization of ROSA-IV LSTF for SGTR Transient Assessment
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 Steam dome 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

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 hehavior 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 $L_{IL\text{-}SG}$>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 ($T_{IL\text{-}hotleg}$< 531.4 K)
-Affected SG RV Cycling	-6.4 MPa < $P_{BL\text{-}SGdome}$< 7.3 MPa
-SG Safety Valves Cycling	-7.69 MPa < $P_{BL\text{-}SGdome}$< 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} = $P_{IL\text{-}SGdome}$

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) C_d=0.15	C_d=0.18	C_d=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

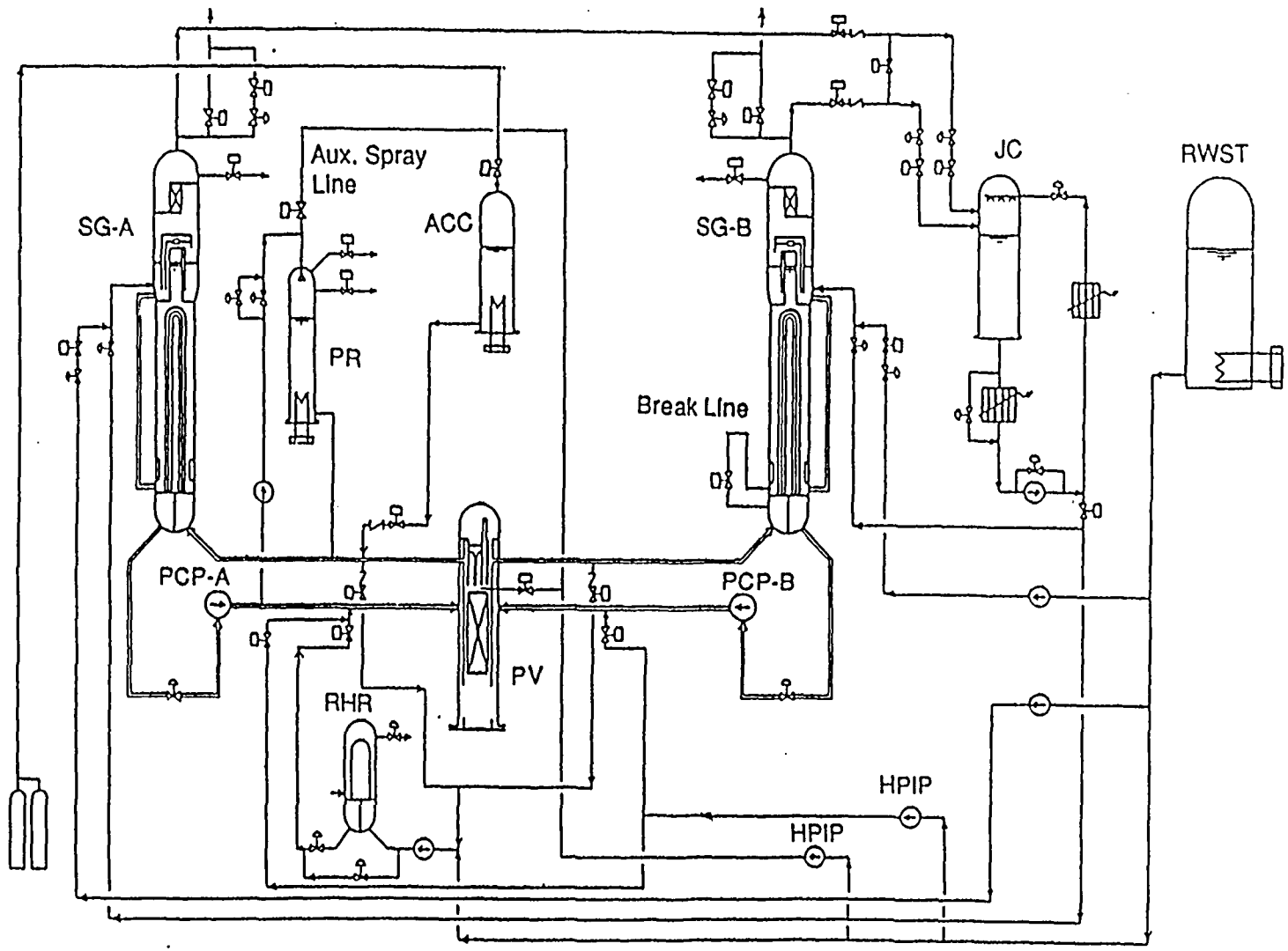


Figure 1 ROSA-IV LSTF Flow Diagram

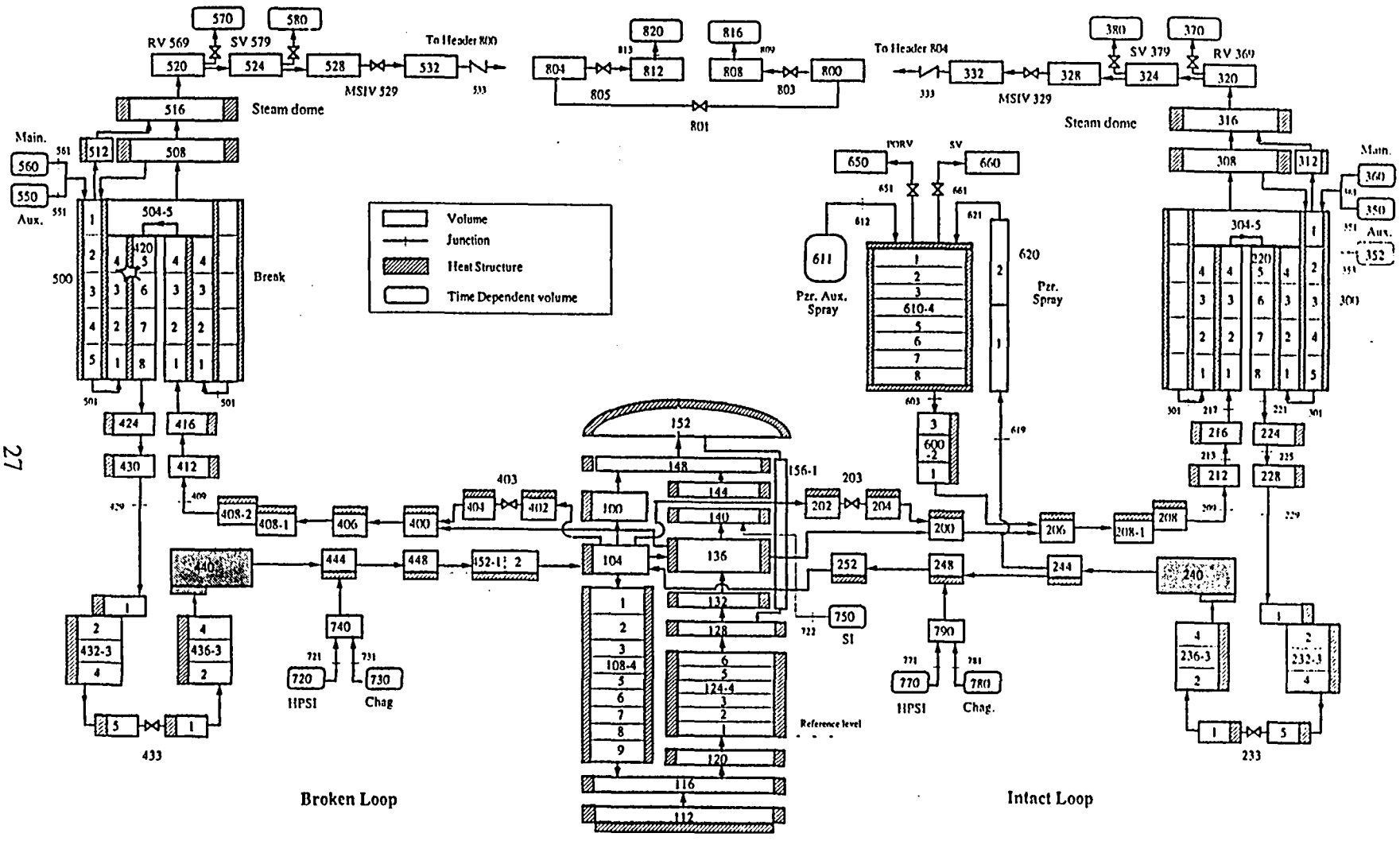
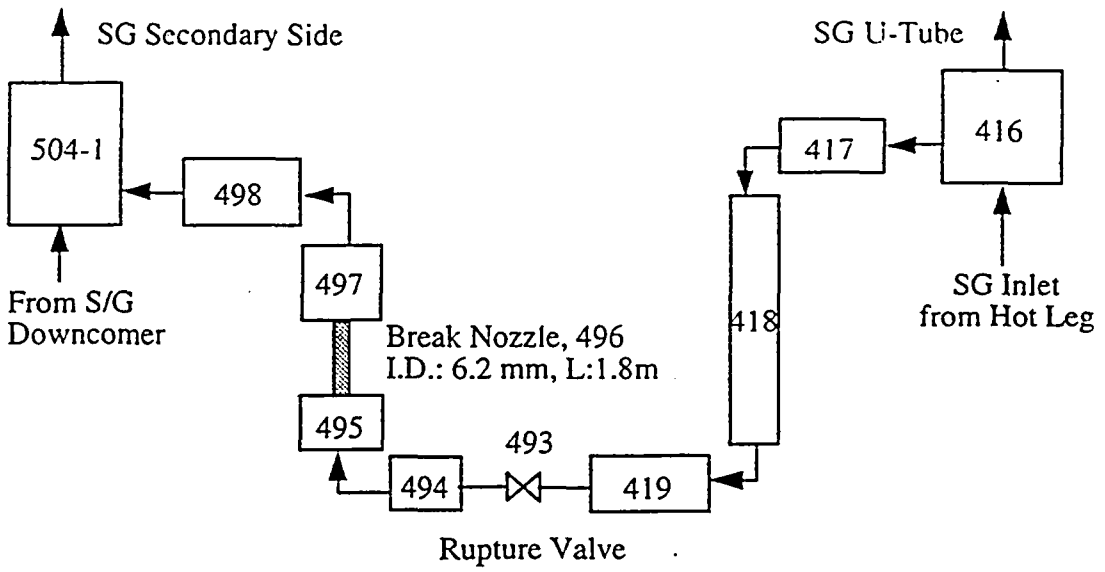


Figure 2 RELAP5 Nodalization of ROSA-IV LSTF for SGTR Transient Assessment

(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

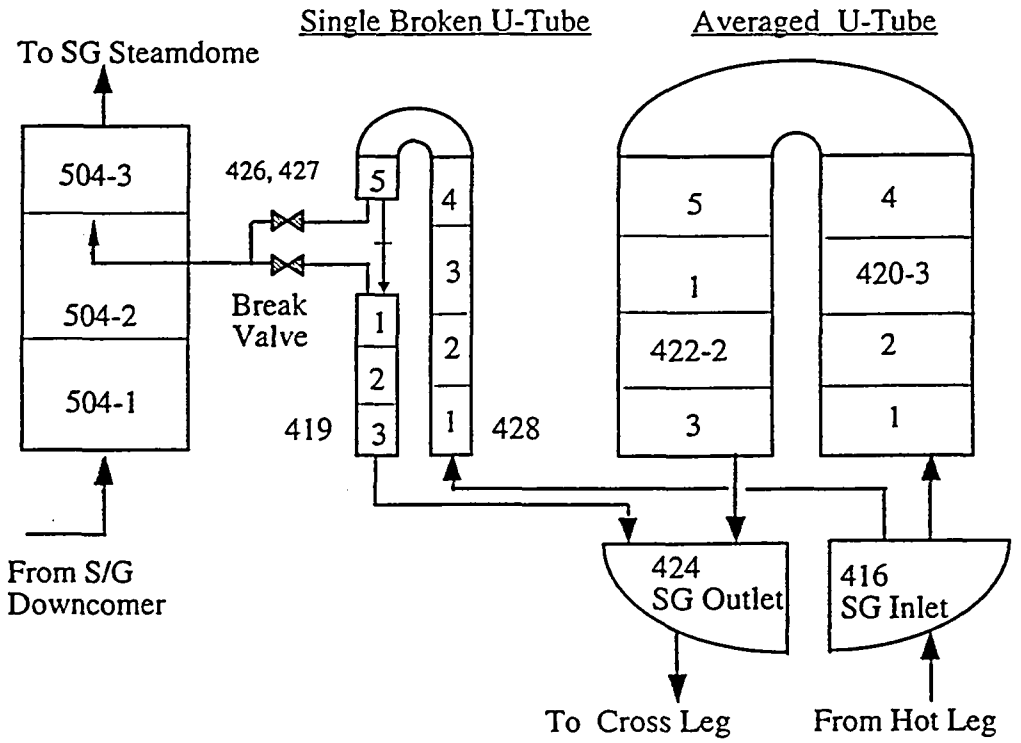


Figure 3 Break Simulation and Nodalization

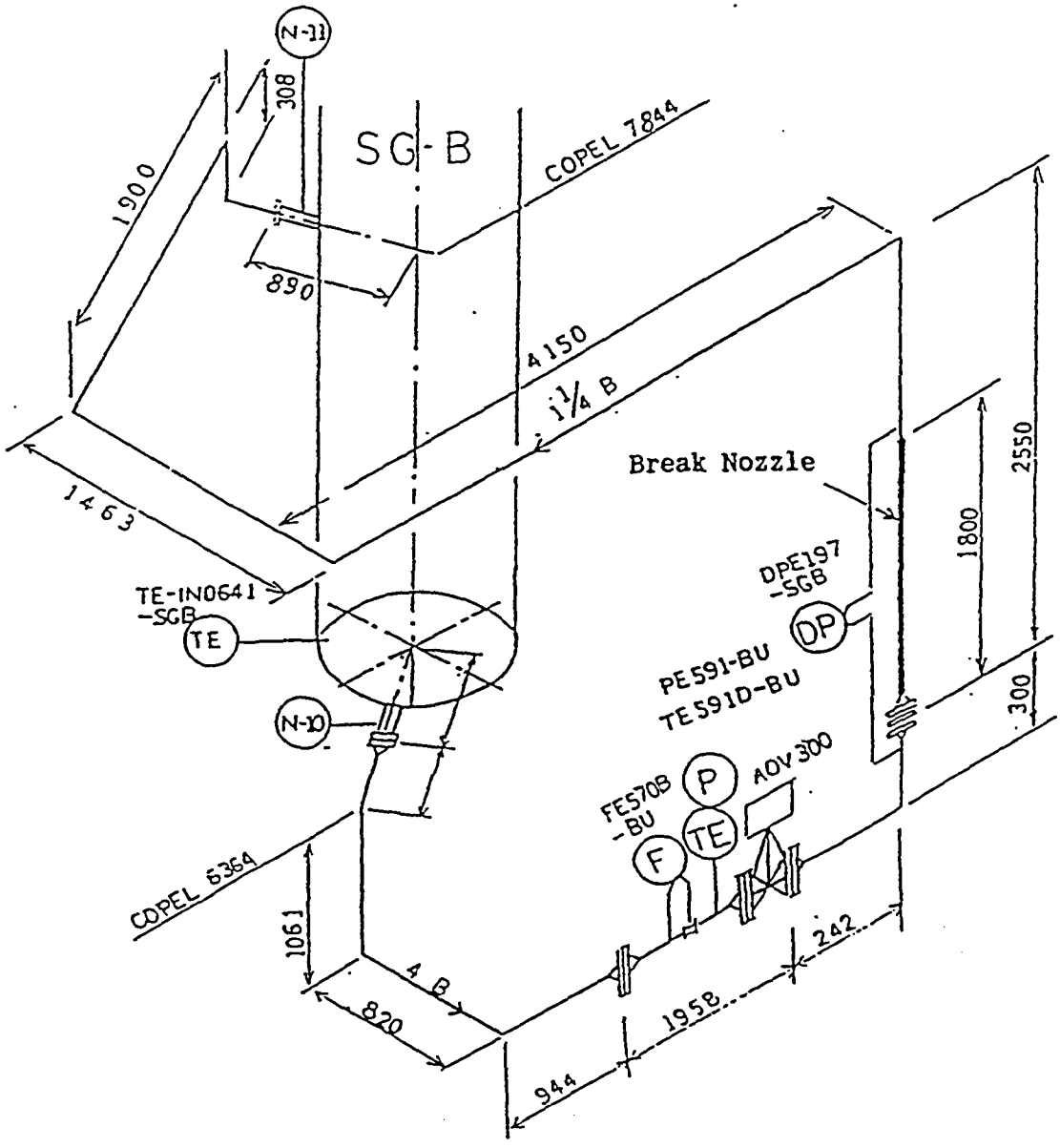


Figure 4 Break Line Configuration in LSTF SB-SG-06 Test

Figure 5 Comparison of Primary Pressure between Experiment and Calculation

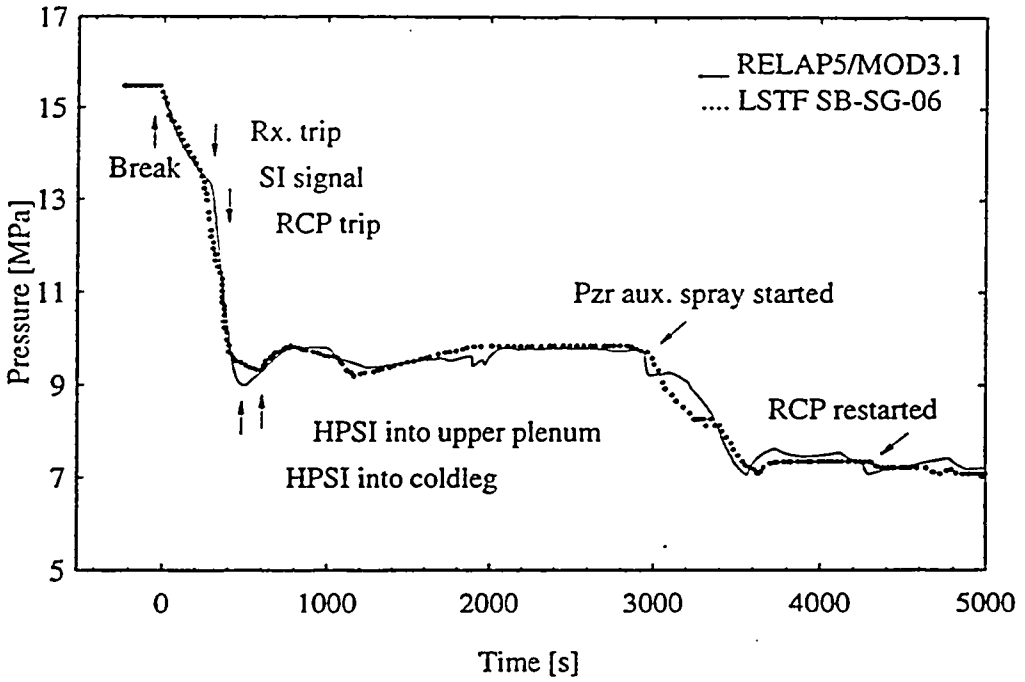


Figure 6 Comparison of Secondary Pressures between Experiment and Calculation

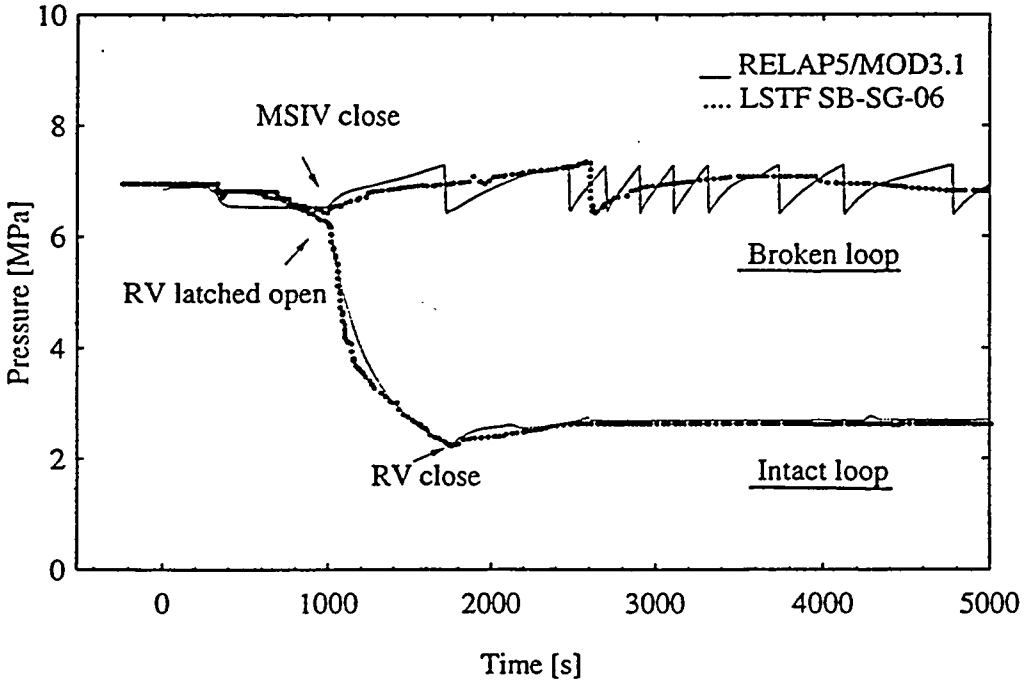


Figure 7 Comparison of Core Fluid Temperatures

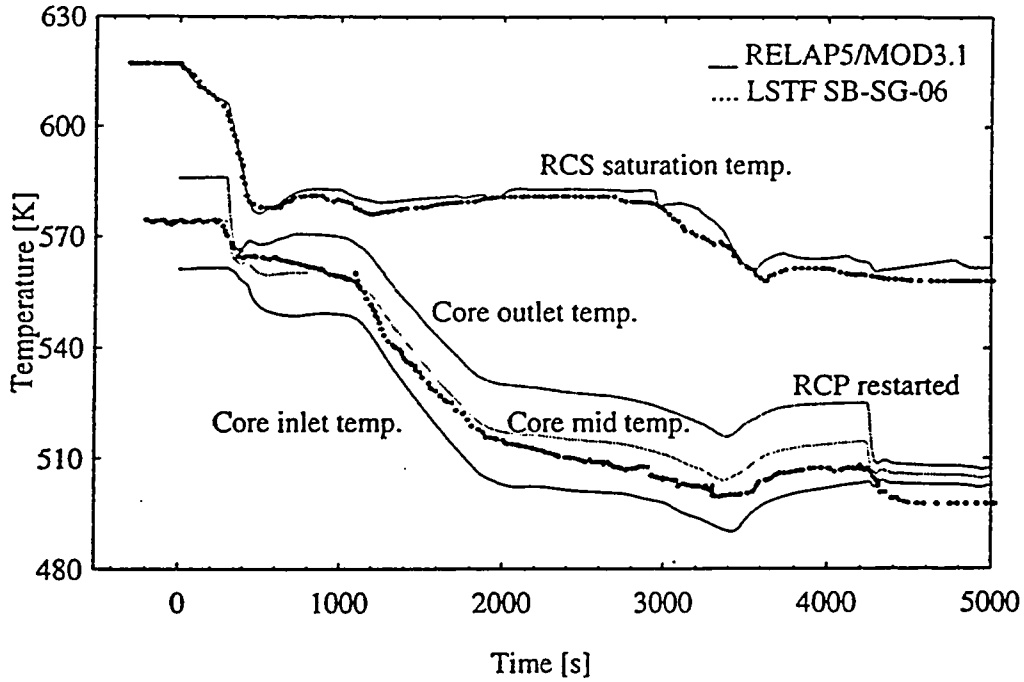


Figure 8 Comparison of Broken Loop Secondary Side Fluid Temperatures

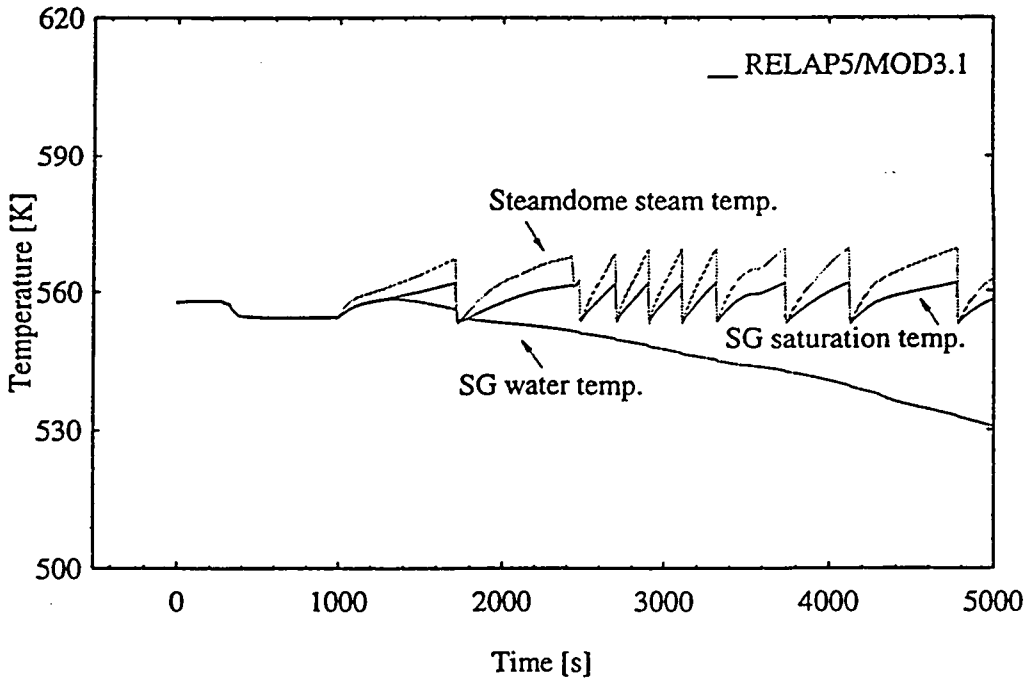


Figure 9 Comparison of Intact Loop Hot leg Temperature

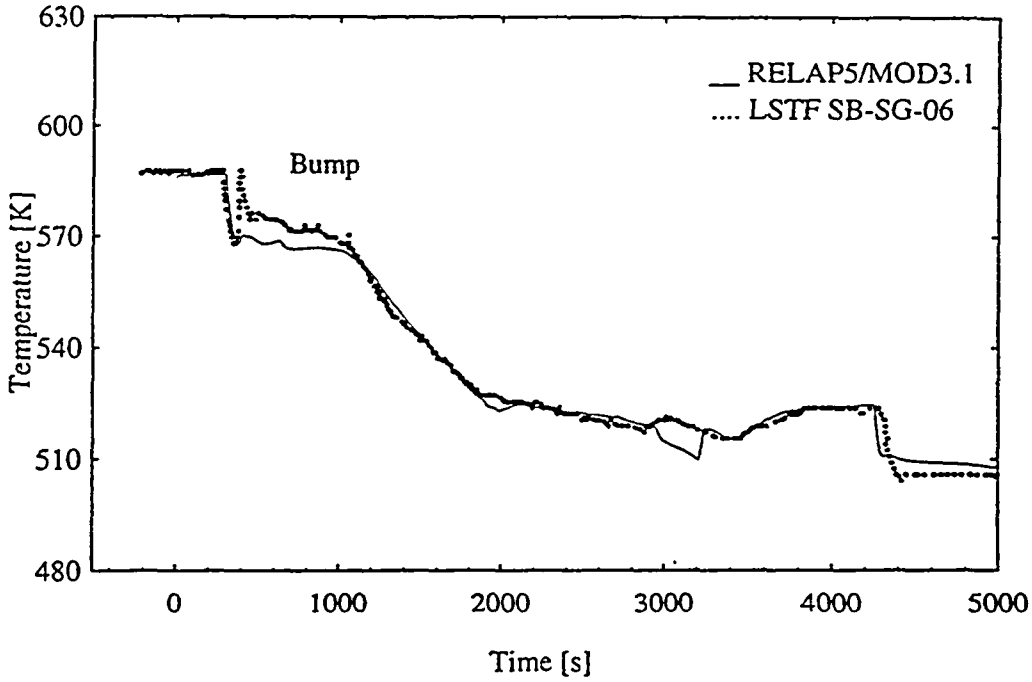


Figure 10 Comparison of Broken Loop Hot leg Temperature

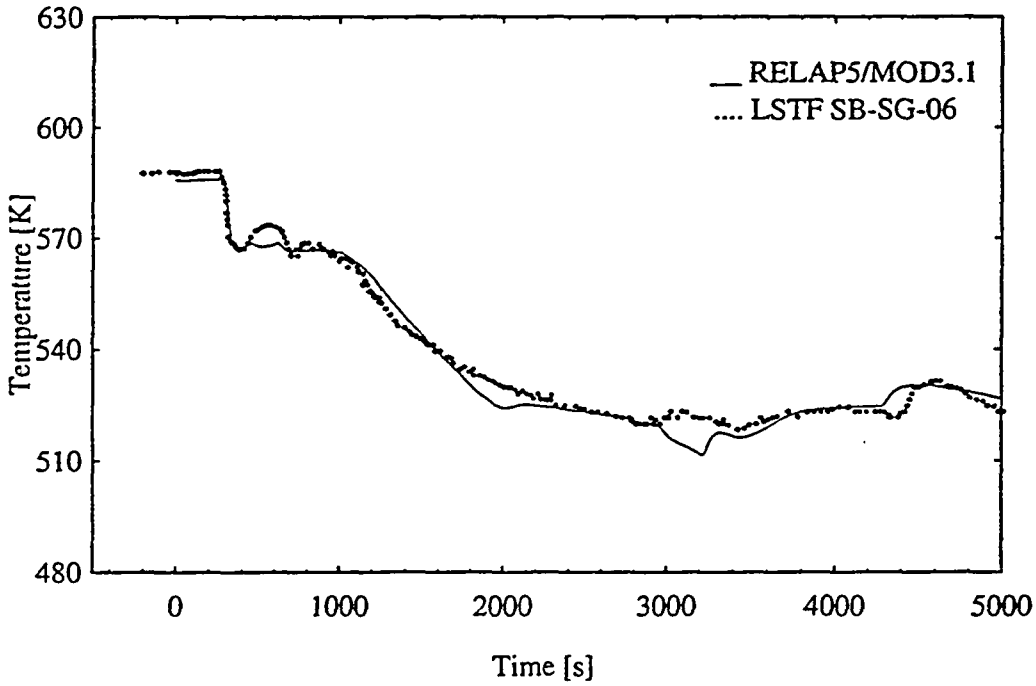


Figure 11 Comparison of Pressurizer Water Level

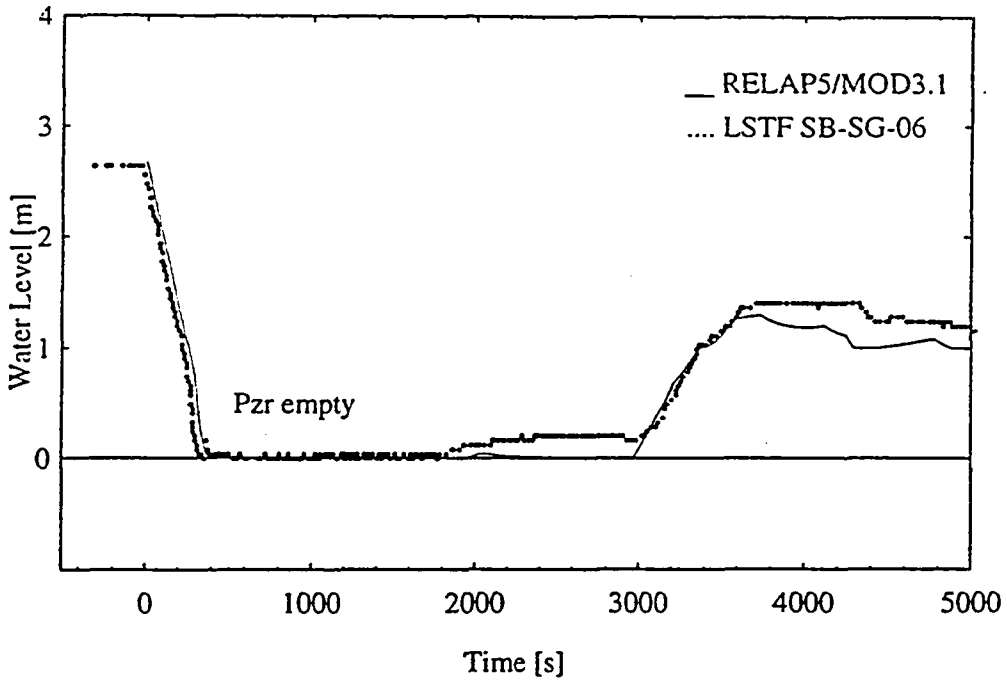


Figure 12 Comparison of SG Water Levels

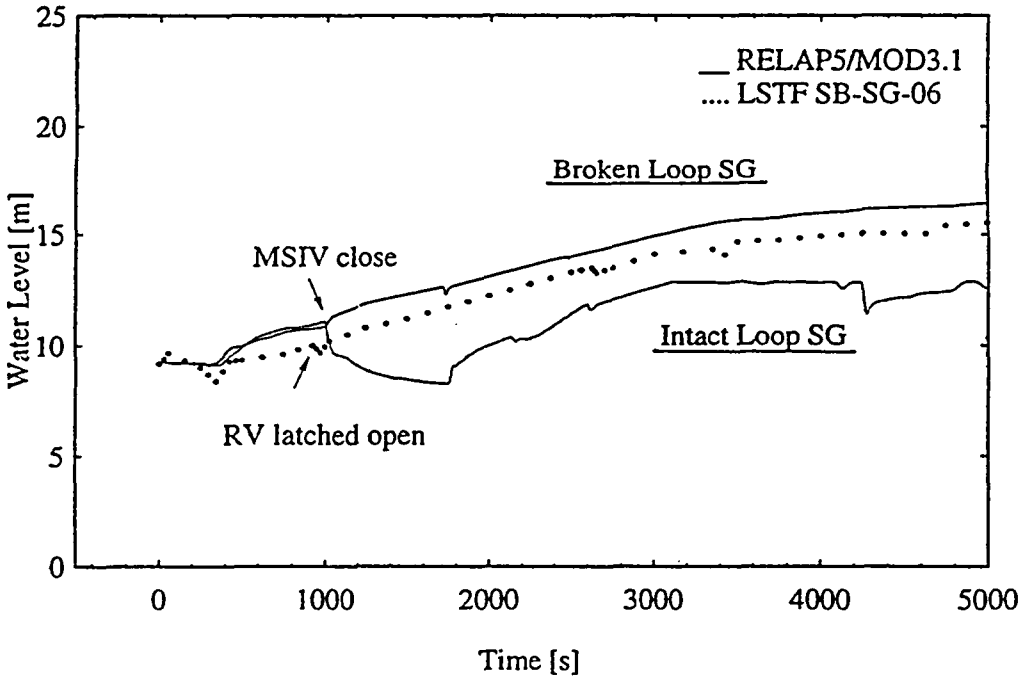


Figure 13 Comparison of Intact Loop Mass Flow rate

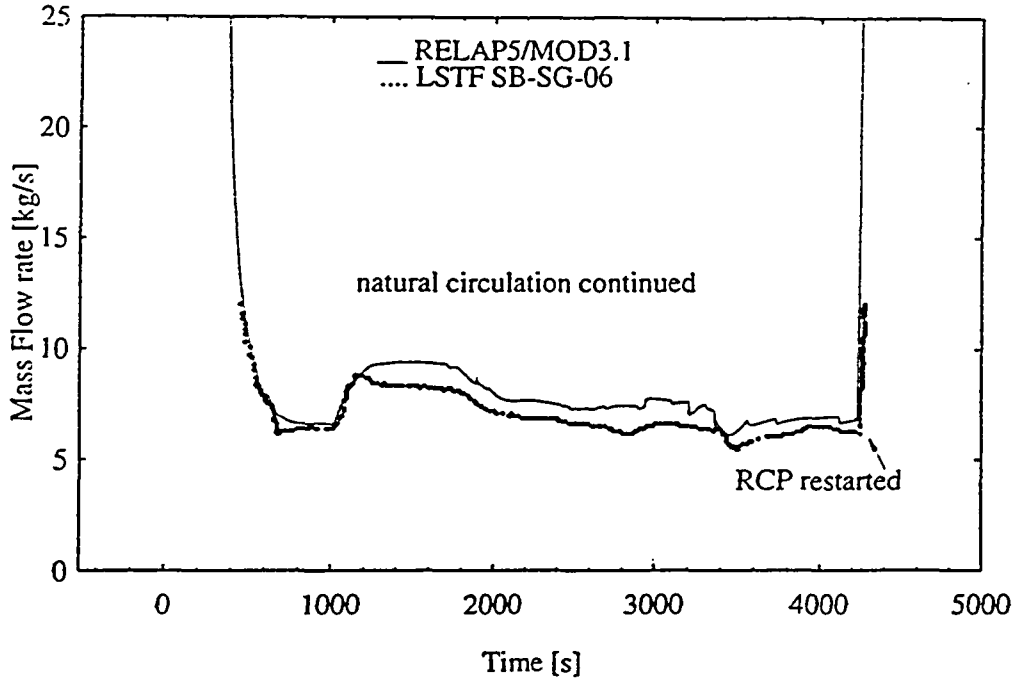


Figure 14 Comparison of Broken Loop Mass Flow rate

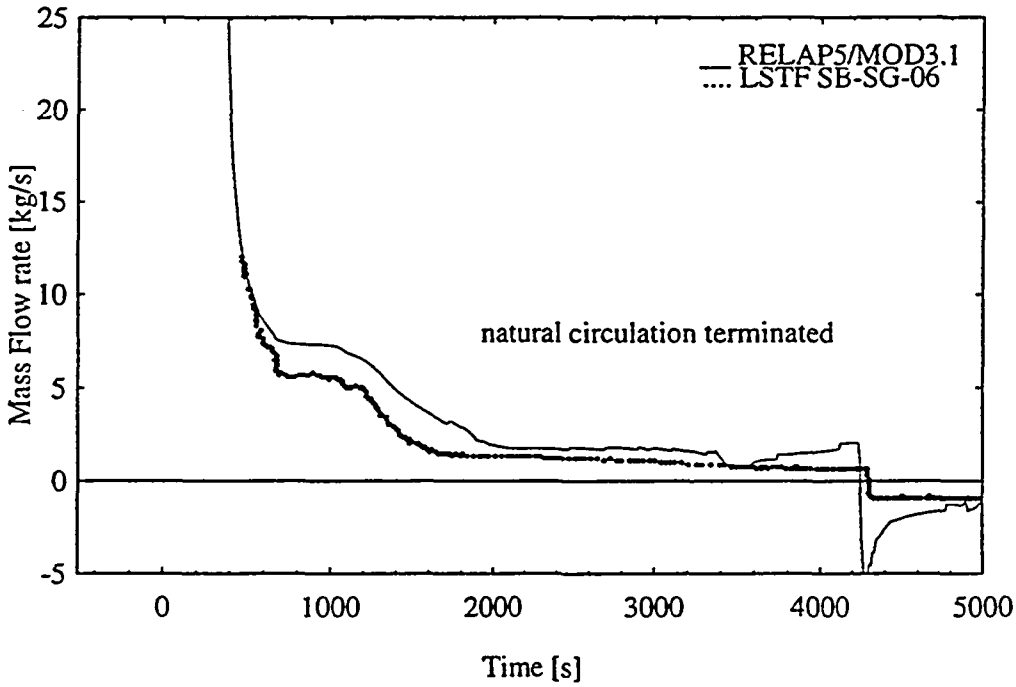


Figure 15 Comparison of HPSI-core upper plenum Mass Flow rate

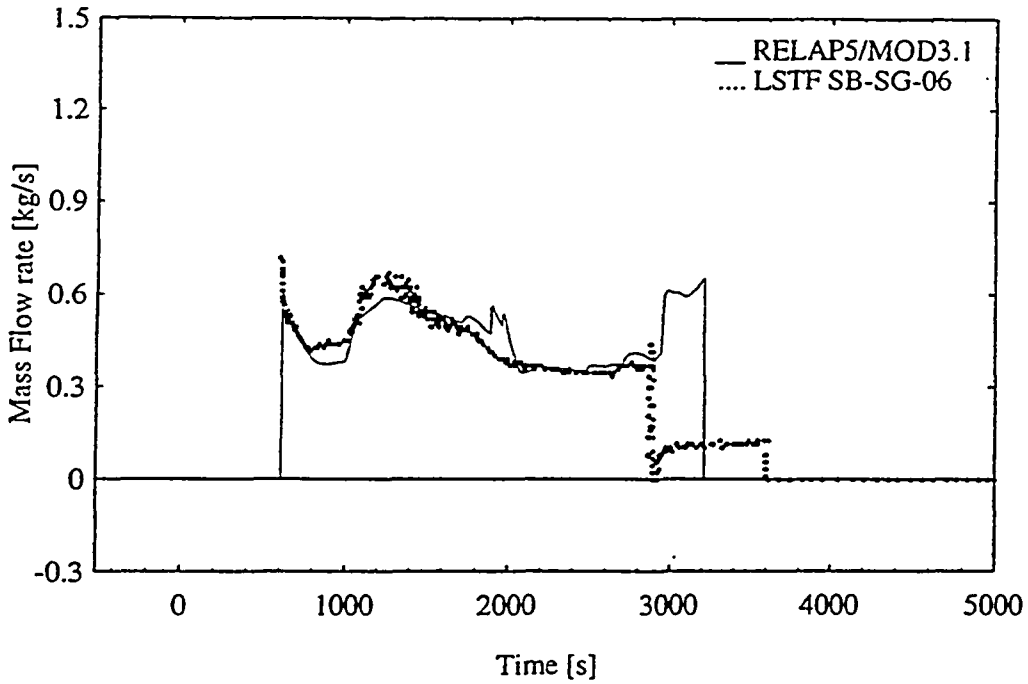


Figure 16 Comparison of HPSI-cold legs Mass Flow rate

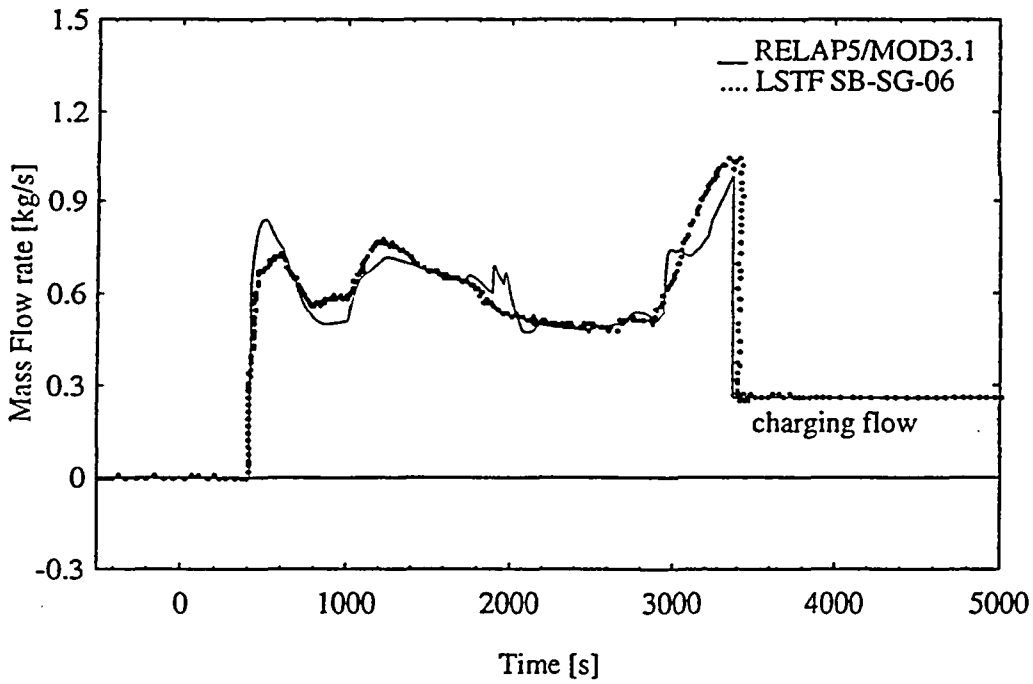


Figure 17 Comparison of Break Mass Flow rate between Experiment and Calculation

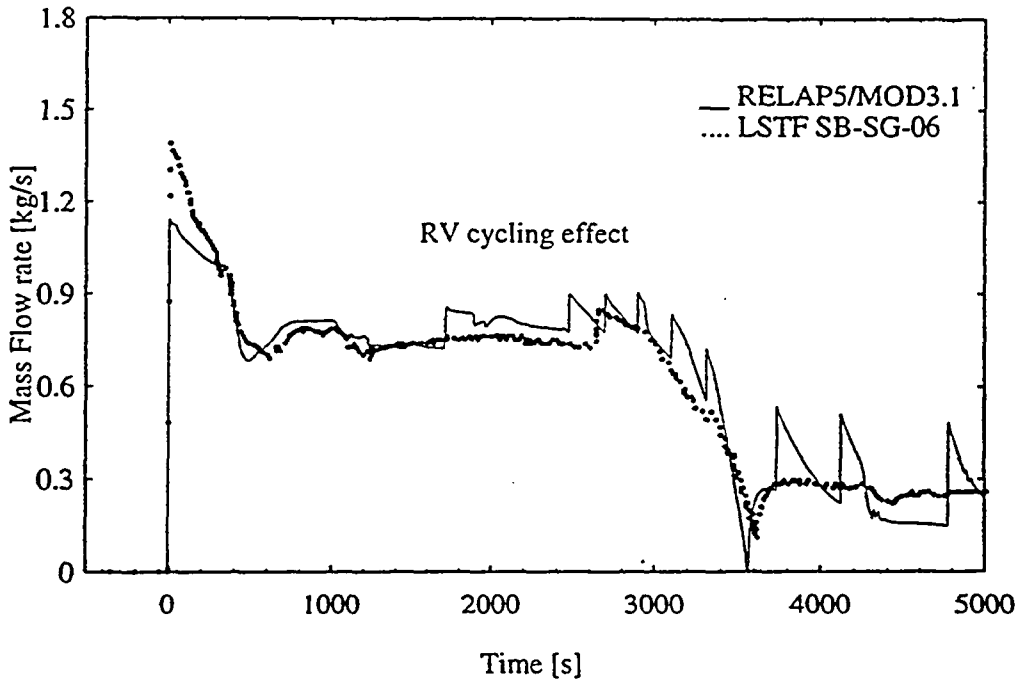


Figure 18 Integrated Break Mass Flow and HPSI Mass Flow

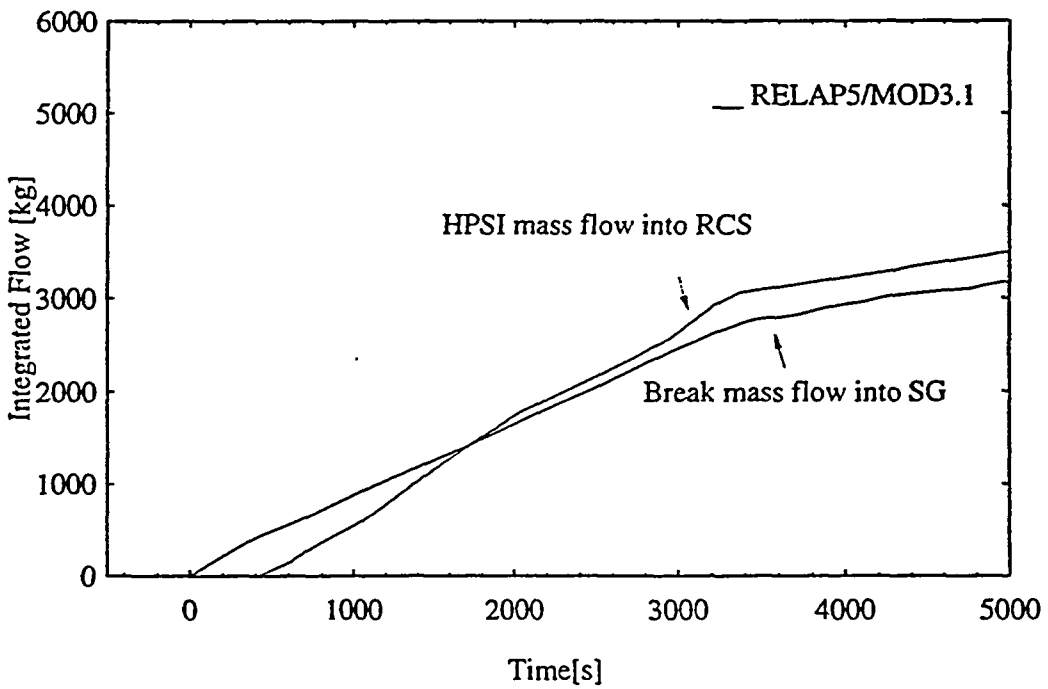


Figure 19 The Calculated Feedwater Flow rate in Intact Loop Secondary Side

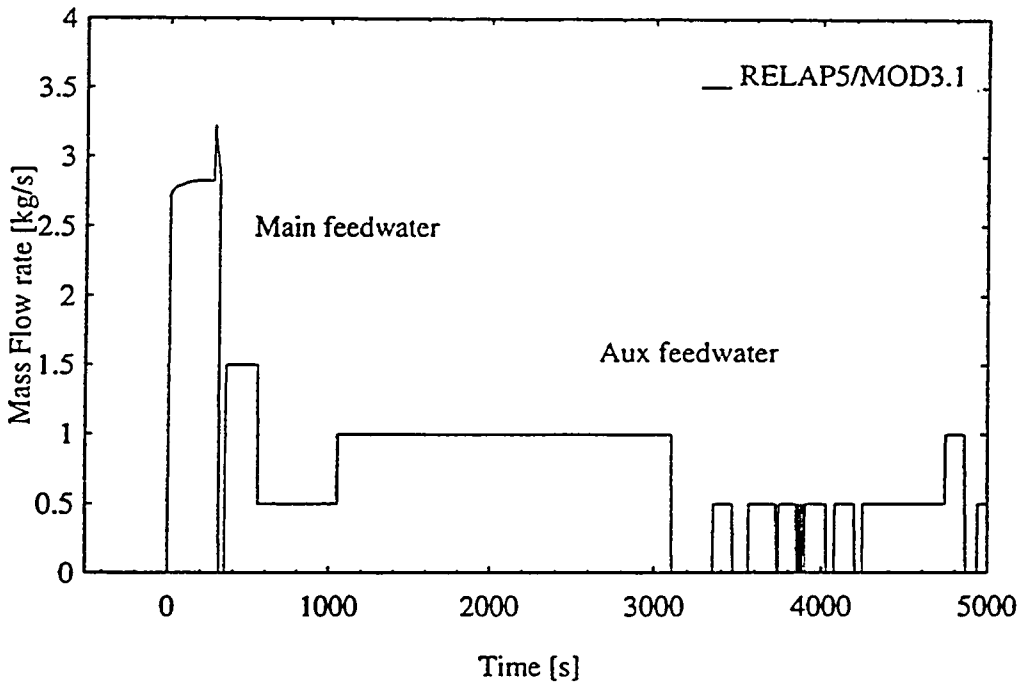


Figure 20 The Calculated Feedwater Flow rate in Broken Loop Secondary Side

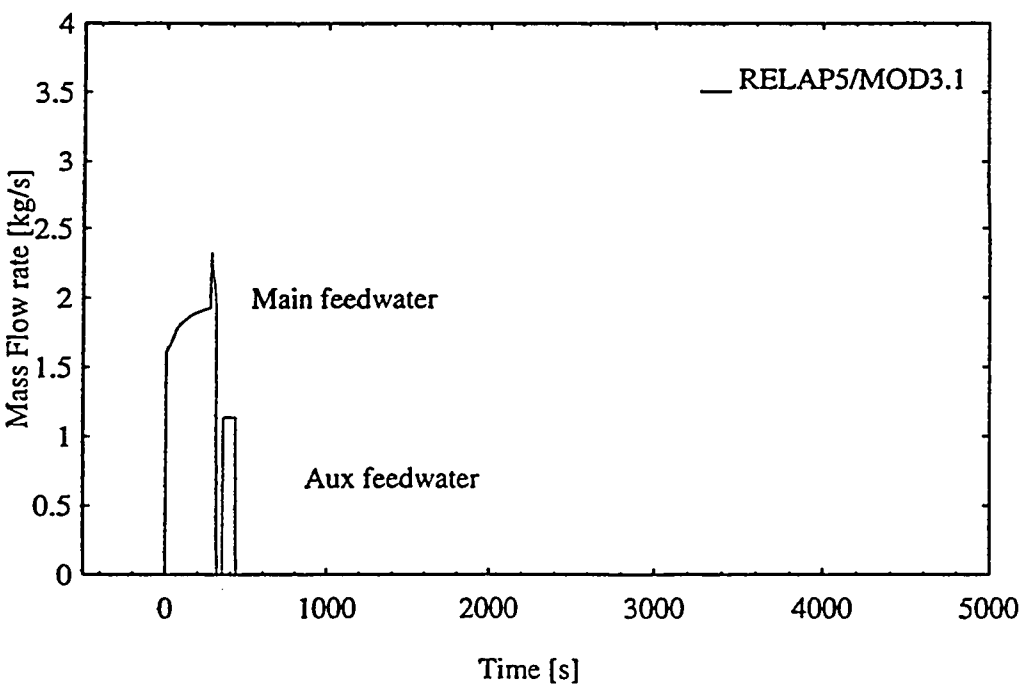


Figure 21 The Pressurizer Auxiliary Spray Mass Flow rate

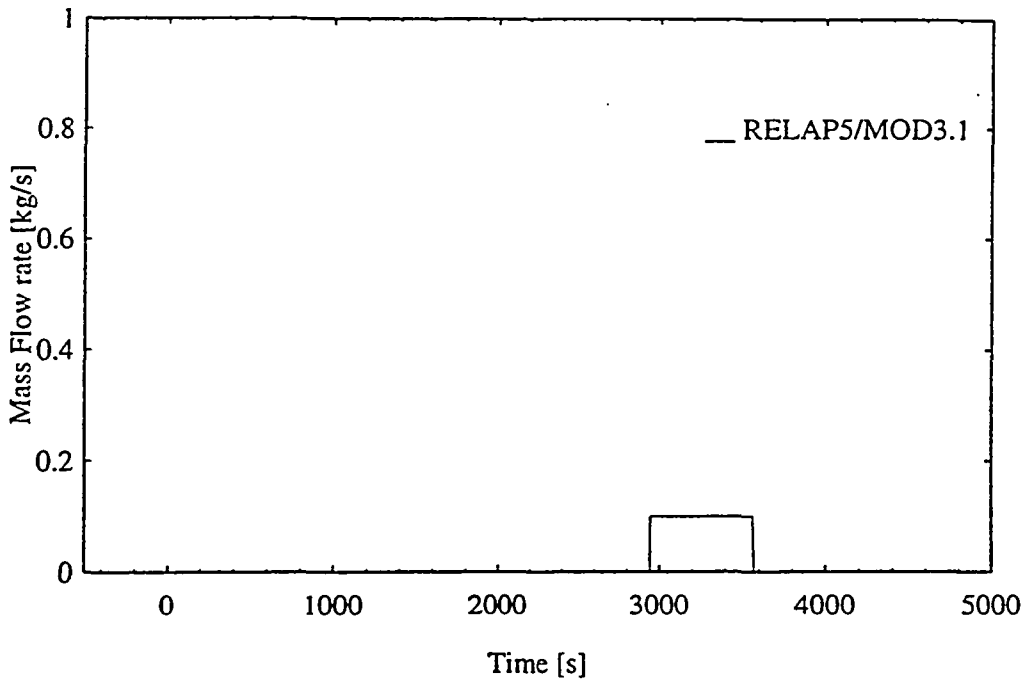


Figure 22 The Atmospheric Steam Dump Flow rate through Intact Loop Relief Valve

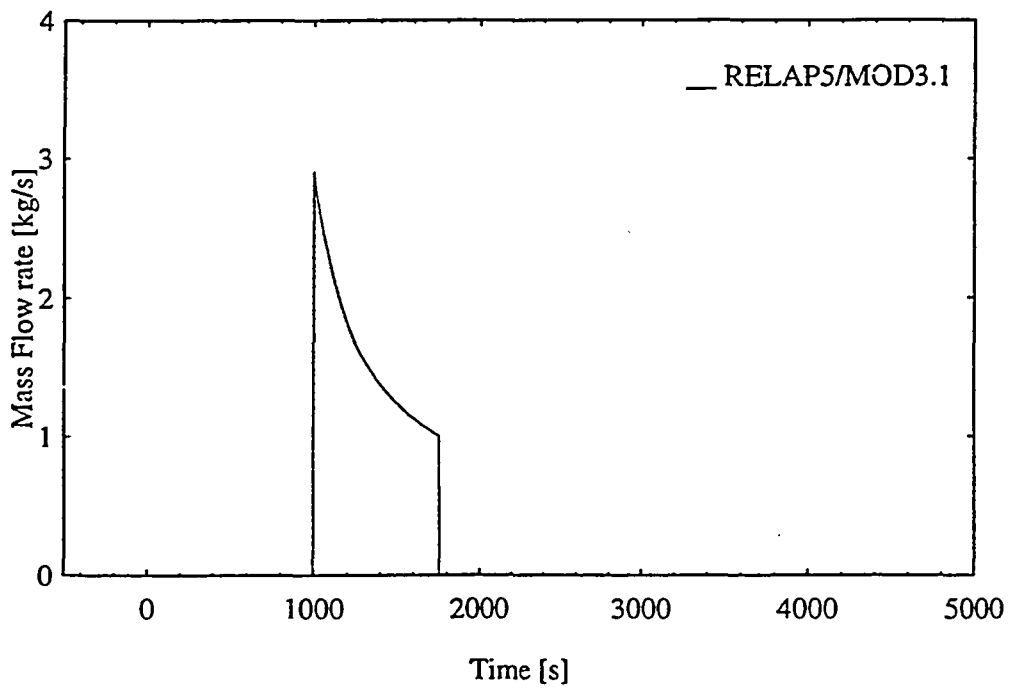


Figure 23 The Calculated Heat Flux on U-tube Wall in Broken Loop SG

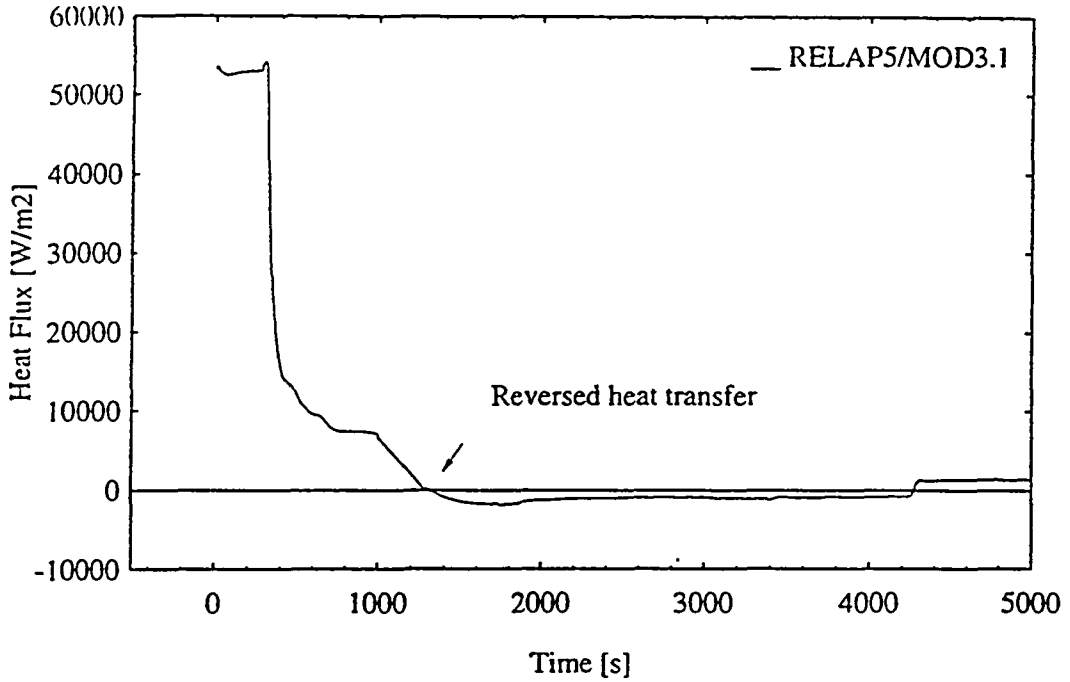


Figure 24 The Calculated Heat Flux on Steamdome Wall in Broken Loop SG

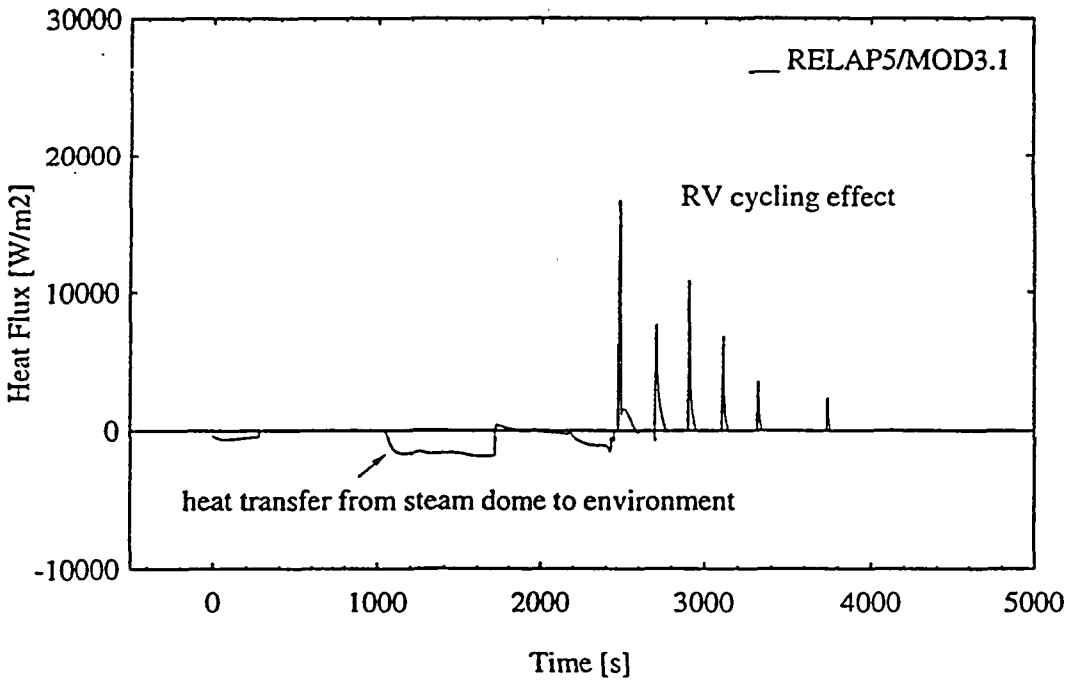


Figure 25 The Calculated Flow rate on Pressurizer Surge Line

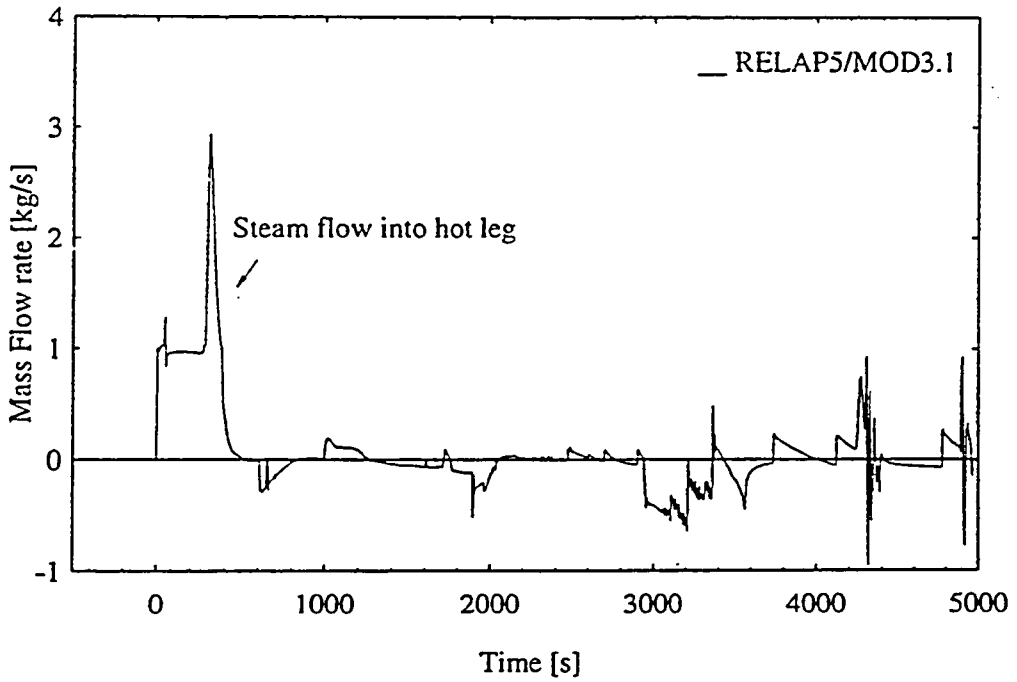


Figure 26 The Calculated Void Fraction in Pzr Surge Line and Hot Leg

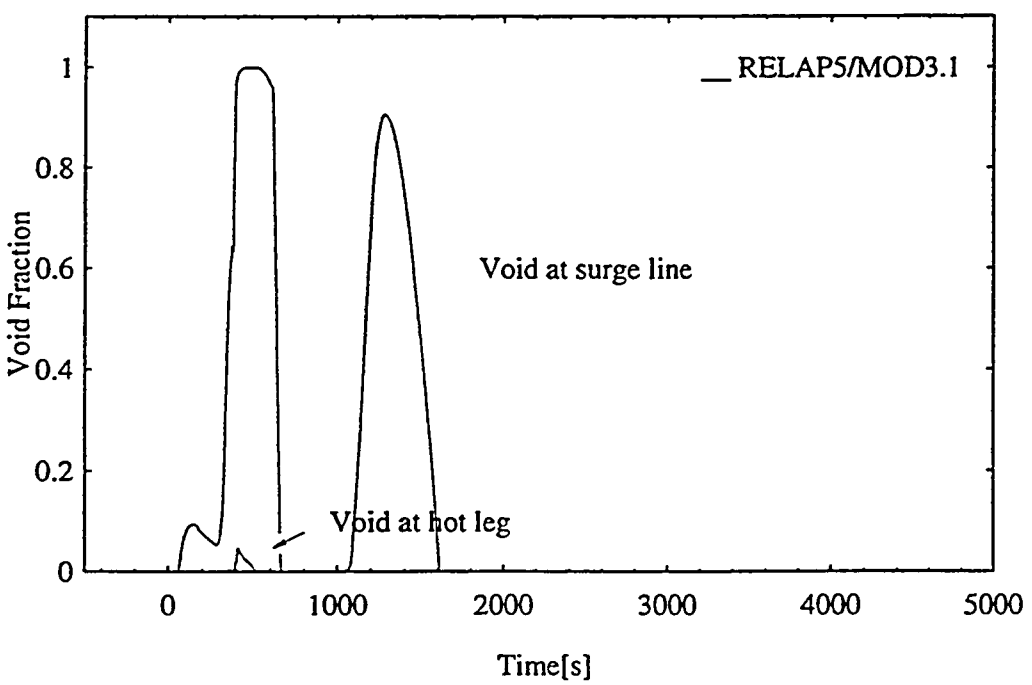


Figure 27 Comparison of Primary Pressure between MOD3.0 and MOD3.1

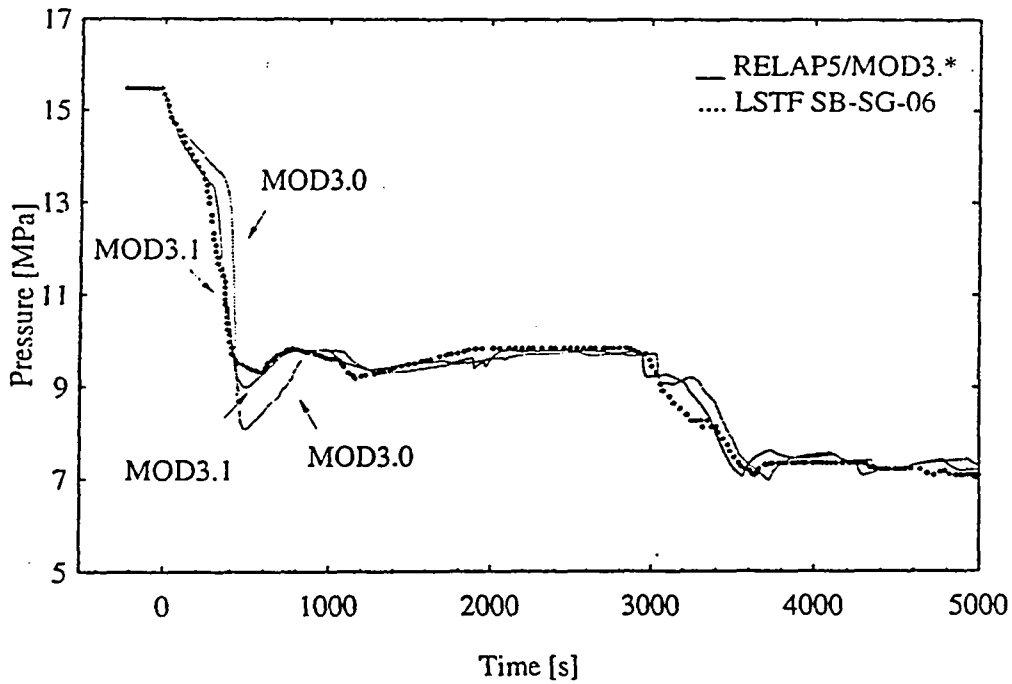


Figure 28 Comparison of Break Mass Flow rates on Break Simulation Model

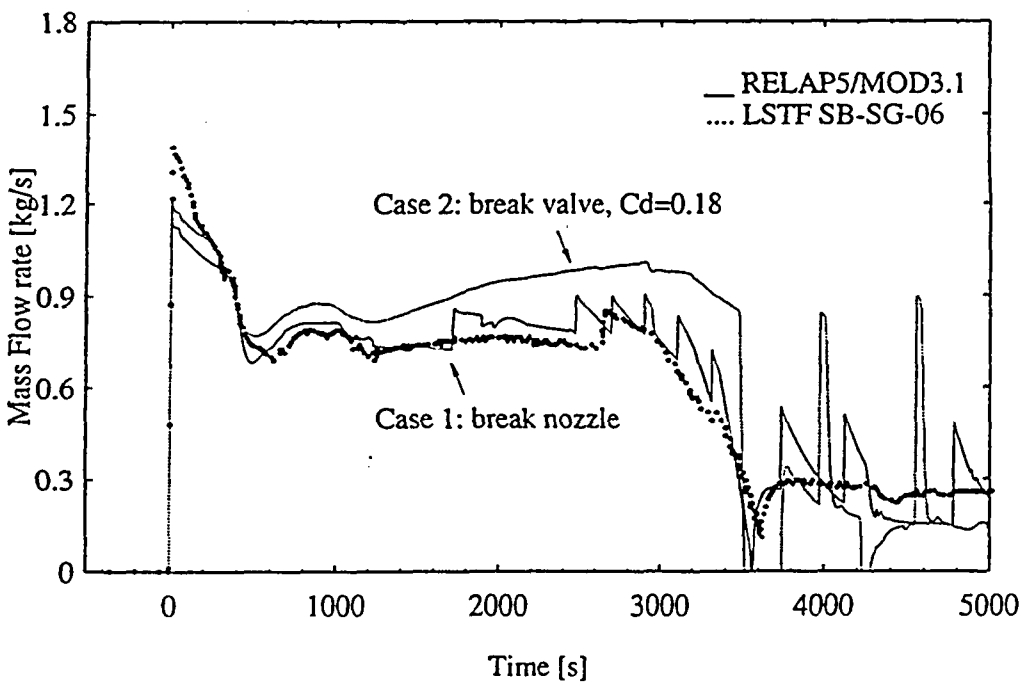


Figure 29 Comparison of Break Mass Flow rates on Break Discharge Coefficient

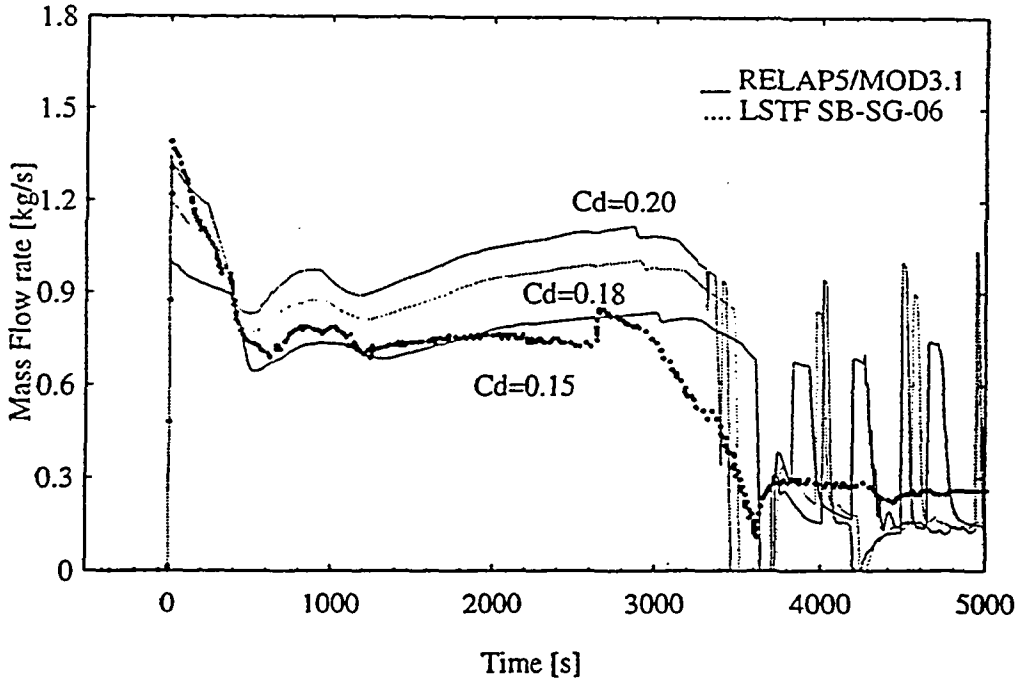


Figure 30 Comparison of CPU Times

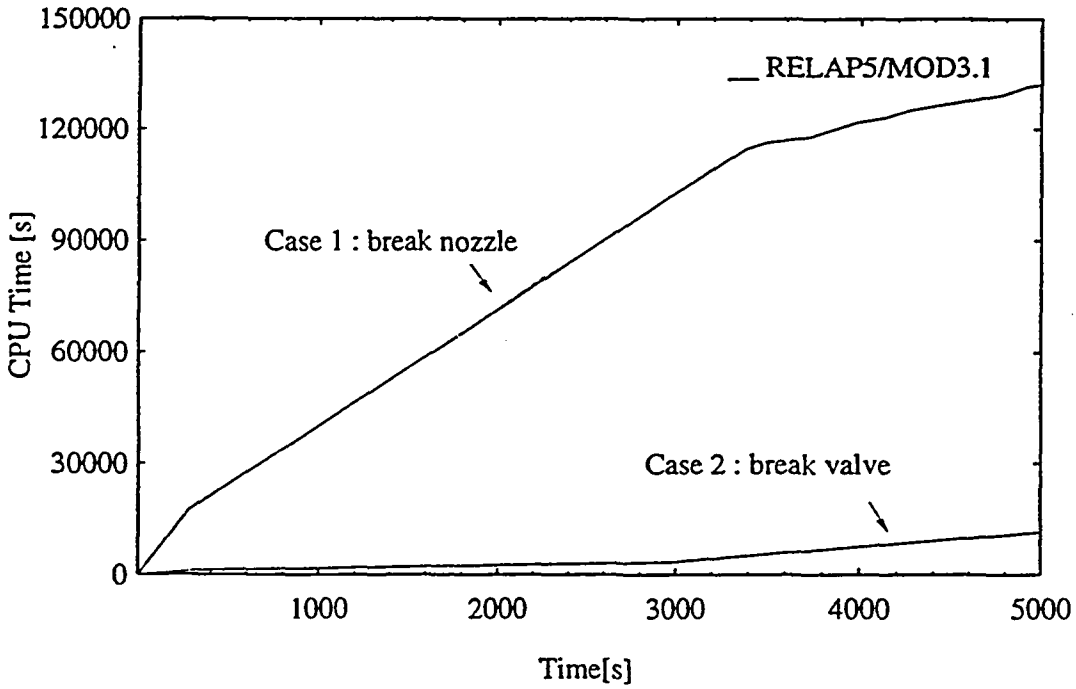
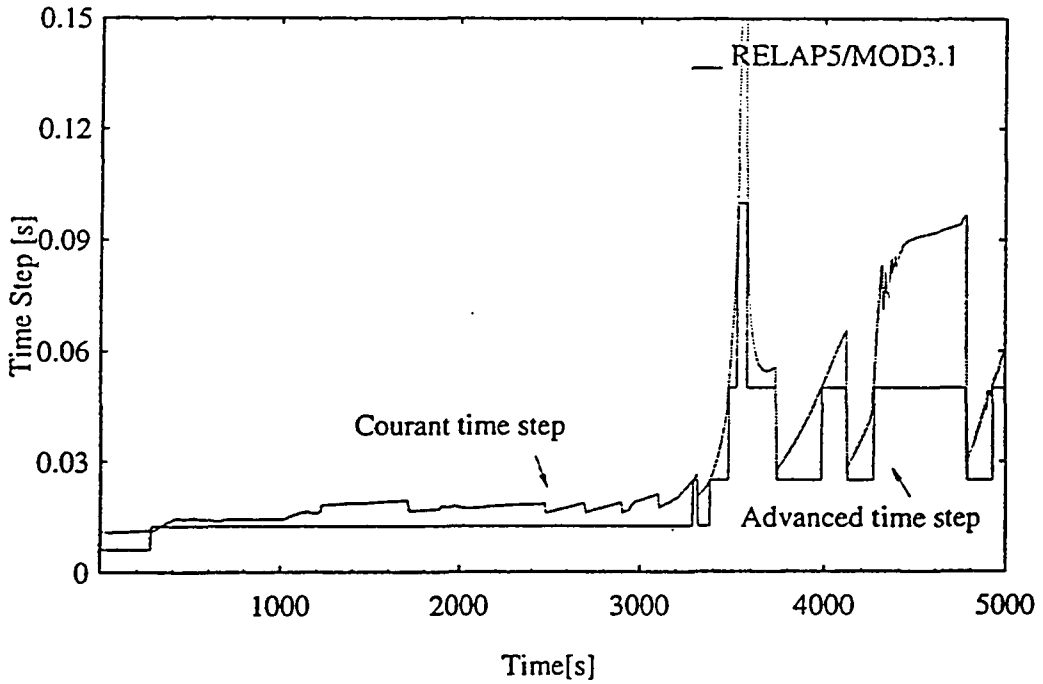


Figure 31 Courant Time Step and Advanced Time Step Size



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  7.82c+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   inann1     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    snglju n
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   wpcrsleg   pipe
4320001   5
4320101   0.0222   5
4320301   0.516    1
4320302   1.2422   4
4320303   1.1919   5
4320601   -50.0    1
4320602   -90.0    4
4320603   0.0      5
4320701   -0.3953  1
4320702   -1.2422  4
4320703   0.0      5
4320801   4.57e-5  0.1682   5
4320901   0.036    0.036    1
4320902   0.0      0.0      3
4320903   0.065    0.065    4
4321001   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   44S010000
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    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
*
*************************************************************
```

```
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           0.4406
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
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
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        7330523.  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          15593371. 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

This form was electronically produced by Elite Federal Forms, Inc.

Printed on recycled paper

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

SPECIAL STANDARD MAIL
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G-67