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International Agreement Report

Assessment of RELAP5/MOD2 Computer Code Against the Natural Circulation Test Data from Yong-Gwang Unit 2

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

June 1993

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
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Abstract

The results of the RELAP5/MOD2 computer code simulation for the Natural Circulation Test in Yong-Gwang Unit 2 are analyzed here and compared with the plant operation data. The result of comparison reveals that the code calculation does present well the overall macroscopic behaviors of thermalhydraulic parameters in primary and secondary system compared with the plant operating data. The sensitivity study is performed to find out the effect of steam dump flow rate on the primary temperatures and it is found that the primary temperatures are very sensitive to the steam dump flow rate during the Natural Circulation. Because of the inherent uncertainties in the plant data, the assessment work is forcussed on phenomena whereby the comparison between plant data and calculated data is based more on trends than on absolute values.

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1.0 Introduction

Natural Circulation,hereinafter named NCT, is one of the most important heat transfer mechanisms to remove decay heat from a pressurizer water reactor when the reactor coolant pumps are not available. This situation could be occured during a small break loss of coolant accident, during a station black-out transient, during a steam generator tube rupture transient or when the RCP are ceased due to other reasons.

NCT was conducted at Yong-Gwang Unit 2 on October 20, 1986. This initial start up program test was structured to demonstrate the capability of the Nuclear Steam Supply System ,hereinafter named NSSS, for removing fission product decay heat by natural circulation.

The objective of this work is to perform the best estimate transient analysis using the RELAP5/MOD2/36.04 computer code to demonstrate that Reactor Coolant System Natural Cooldown Test which was performed at Yong-Gwang unit 2 as a part of the initial power ascension program, can be simulated by this best estimate computer code. The code assessment work presented in this report is based on all the available data(from plant computer and plant recordings) from this incident. Although the initial plant conditions are well known, it must be emphasized that the the quantity and the quality of the available data from real plant are inferior to the well

instrumented test facility data. Hence the objective of this study is to assess a code performance based on the comparison of trends rather than the comparison of absolute values.

The plant description and transient are described in chapter 2 and chapter 3. In chapter 4, the plant nodalization and initialization methodology are presented. The calculation results are analyzed in chapter 5. The result of sensitivity study is introduced in chapter 6. Finally, the run statistics and conclusions are added in chapter 7 and chapter 8.

2.0 Plant description

The Yong-Gwang Nuclear Power Plant Unit 2, located on the southwestern coast of the Republic of Korea, is comprised of PWR NSSS and the Turbine Generator ,hereinafter named TG, designed by Westinghouse.

2.1 Primary system

As shown in Figure 2.1, the reactor coolant system ,hereinafter named RCS, is composed of the reactor vessel, reactor coolant pump, hereinafter named RCP, pressurizer and steam generator. The reactor vessel is cylindrical, with a welded, hemispherical bottom head and a removable, flanged and gasketed, hemispherical upper head. The vessel contains the core, core support structure,control rods, neutron pads, and other parts directly associated with the core. The control rods are operated by sealed drive mechanisms mounted on the upper head. The vessel has inlet and outlet nozzles located in a horizontal plane just below the upper head flange but above the top of the core. Coolant enters the vessel through the inlet nozzles and flow down the core barrel vessel wall annulus, turns at the bottom and flows up through the core to the outlet nozzles. The vessel is carbon steel with weld deposited austenitic stainless steel or inconel cladding on all surfaces exposed to the reactor coolant. The core generates 2785 Mwt and contains three independent primary coolant loops, each of which has one RCP and one steam generator.

Three RCPs are identical single speed centrifugal units driven by air-cooled, three phase induction motors. The shaft is vertical with the motor mounted above the pump. A flywheel on the shaft above the motor provides additional inertia to extend pump coastdown.

The steam generators are vertical shell and U-tube evaporators with integral moisture separating equipment, a 48000 ft2 heat transfer area and a 964 psia steam pressure at full power. The reactor coolant flows through the inverted U-tubes, entering and leaving through the nozzles located in the hemispherical bottom head of the steam generator. The head is divided into inlet and outlet chambers by a vertical partition plate extending from the head to the tube sheet. Steam is generated on the shell sides and flows upward through the moisture separators to the outlet nozzle at the top of the vessel. The heat transfer tubes are inconel, the primary side of the tube sheet is clad with inconel, and the interior surface of the reactor coolant channel head and nozzles are clad with austenitic stainless steel.

A pressurizer, with a 1400 ft3 volume and 1400 Mw heater capacity ,as shown in Figure 2.2, provides a point in the RCS where liquid and vapor can be maintained in equilibrium under saturated conditions for pressure control purpose. The pressurizer is designed to accommodate positive and negative surges caused by load transients. The surge line, which is attached to the bottom of the pressurizer, connects the pressurizer to the hot leg of a reactor coolant loop.

Auxiliary system components are provided to charge the RCS and add makeup water, purify reactor coolant water, provide chemicals for corrosion inhibition and reactivity control, cooling system components, remove the decay heat when the reactor is shutdown, and inject the cooling water to the reactor core under the emergency condition.

2.2 Secondary system

The secondary system conveys steam from the steam generators to the turbine generator system. The system consists of main steam pipings, power operated relief valves, safety valves, main steam isolation valves and the atmosphere and condenser dump valves.

The steam dump control system whose schematic representation is shown in Figure 2.3 , is comprised of 16 valves which can bypass steam to the condenser and to the atmosphere. These valves have a total capacity of approximately 70 % of the full load turbine steam flow at full load steam pressure. These steam dump valves are working by the signal from the deviation between the actual pressure and the reference pressure in the steam generator. The functional block diagram of the steam dump control system can be found in Figure 2.4. The steam dump valves are actuated to maintain the steam pressure within control range until a new equilibrium condition is reached and strokes full open or modulated, depending upon the magnitude of the pressure error signal resulting from the transient.

2.3 Plant data acquisition

For the parameter values of plant operating data, a global recorder uncertainty of 1.5 % should be added to the instrument uncertainty [5].

The instrument uncertainty is estimated 1.5 % [5]. Hence some engineering judgement is required to synchronize the recorder data with the calculated data because they can be done on the basis of some important events and on the basis of the timing in the plant computer listing.

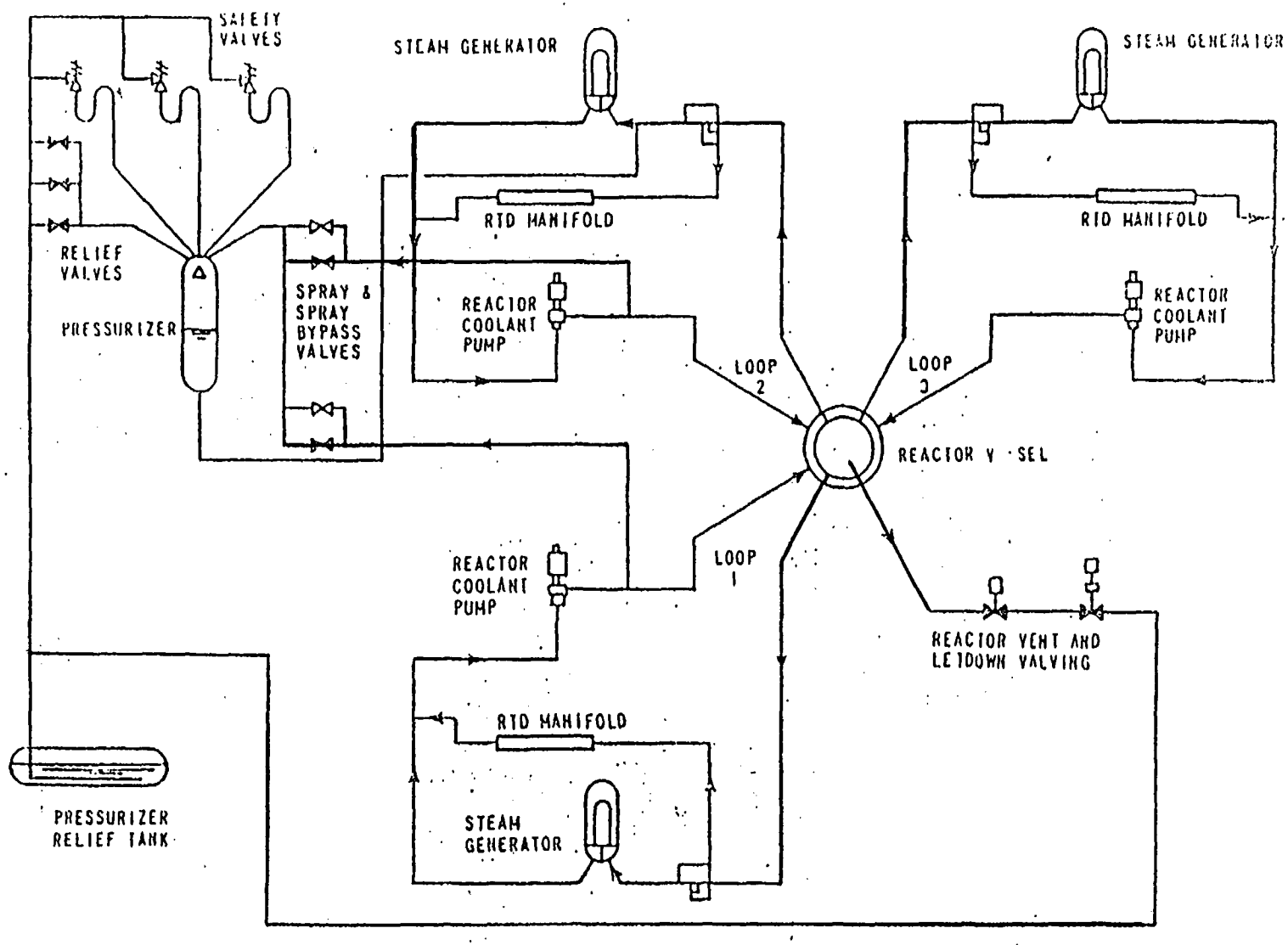

Figure 2.1 Reactor Coolant System

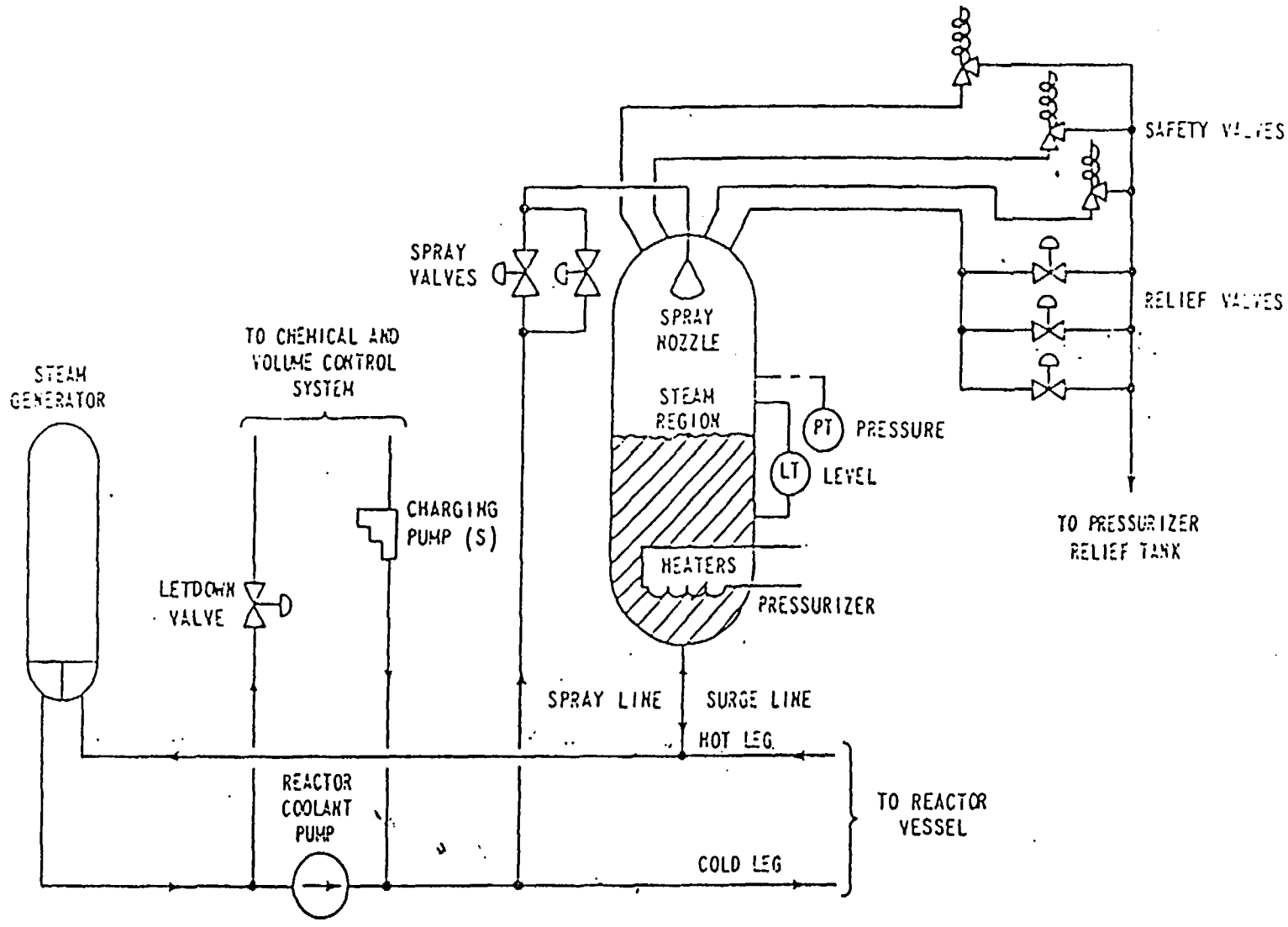

Figure 2-2. Pressurizer Pressure and Level Associated Equipment Arrangement

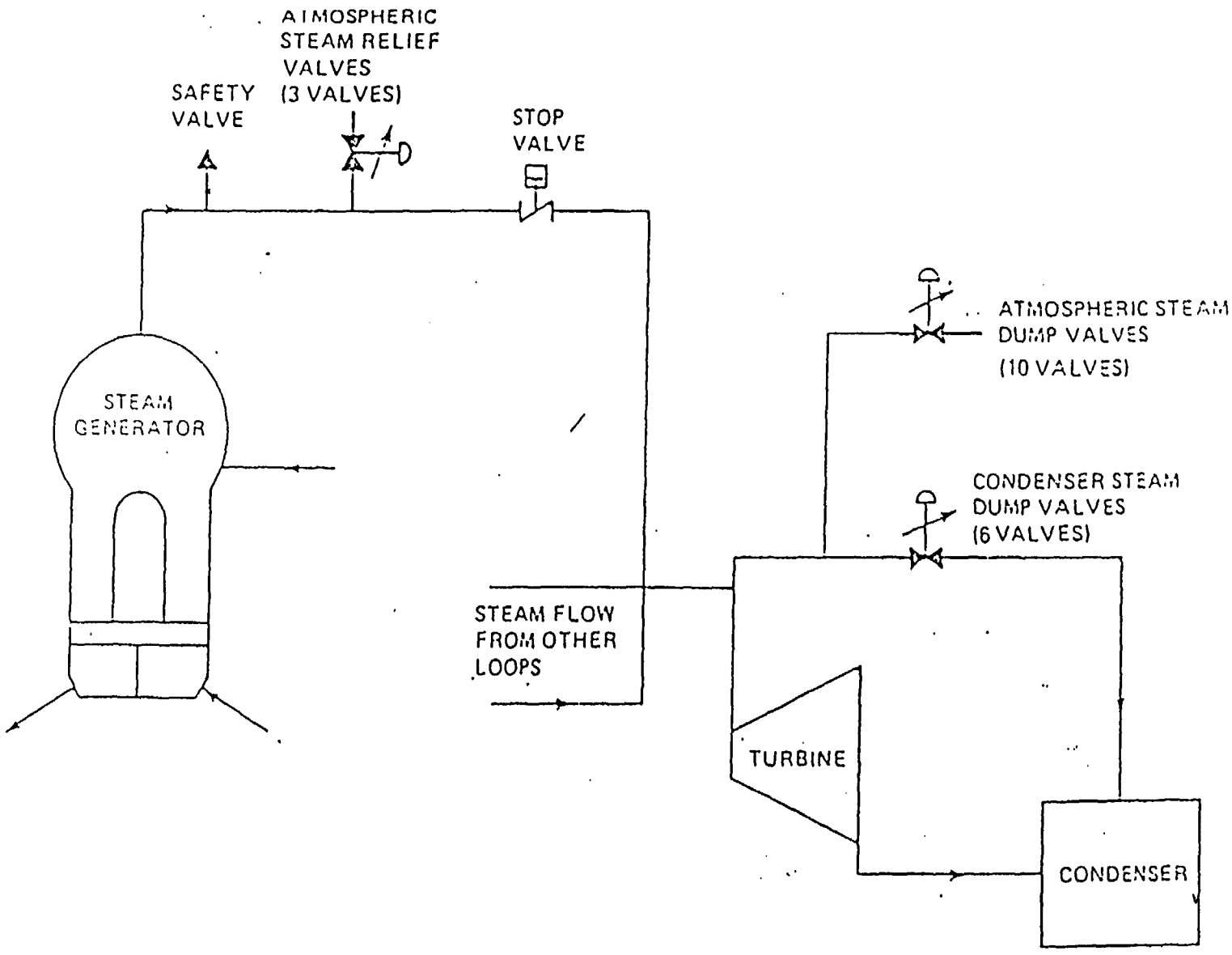

Figure 23 Schematic Representation of the Steam Dump Control System

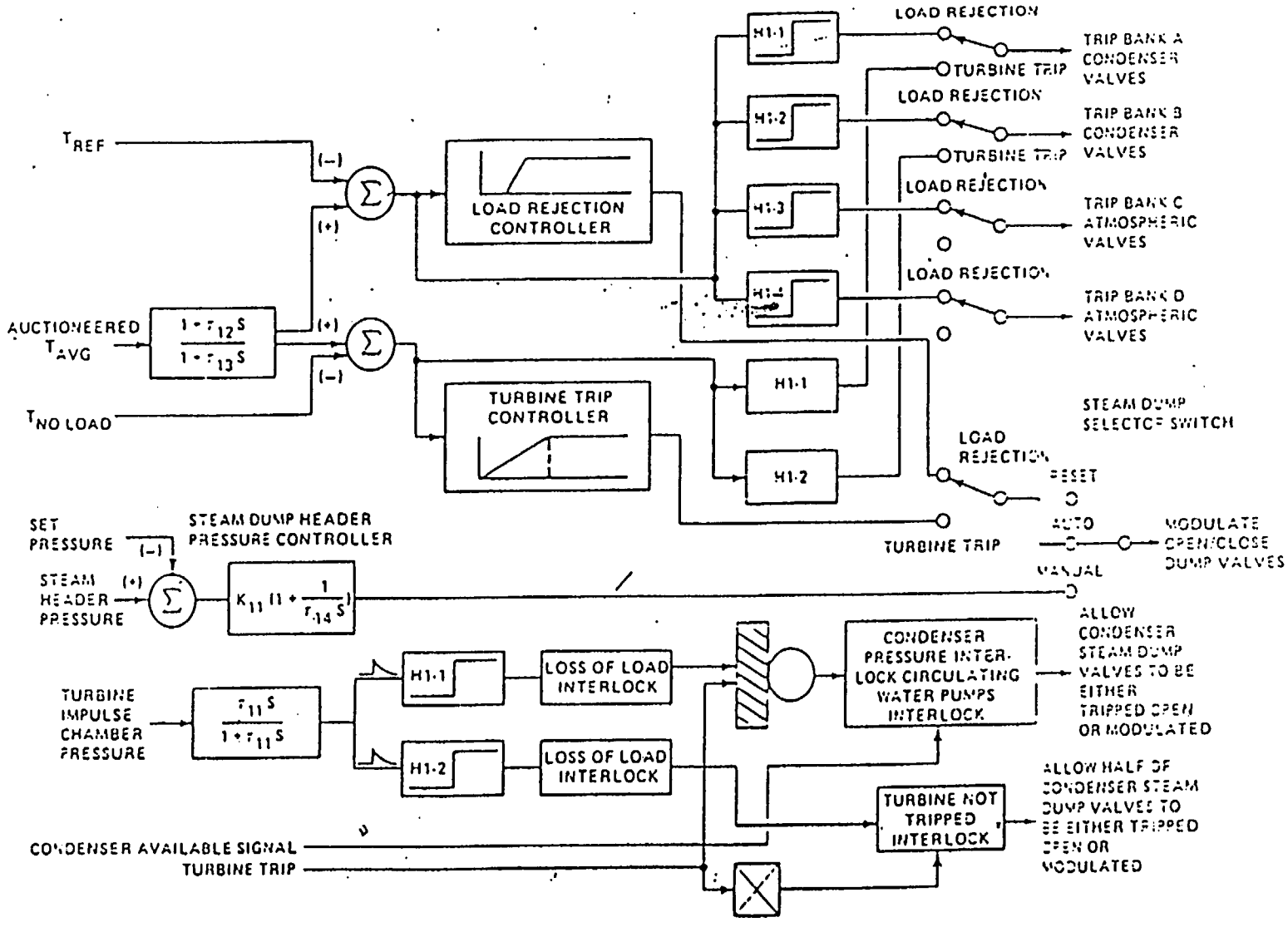

Figure 24 Functional Block Diagram of the Steam Dump Control System

Table 1 Steam dump control system setpoints

	set point
Header pressure controller set pressure	76.8 kgf/cm2
proportional gain K	14% /(kgf/cm2)
Reset time constant	180 sec

3.0 Plant transient description

The natural circulation in a closed loop is an effective means for the core cooling of a reactor after the main coolant pump has tripped. In particular, for pressurized water reactors, single phase natural circulation is essential for eliminating the decay heat generated in core without the help of pump.

Single phase natural circulation is driven by an overall fluid density gradient between the hot and cold sides of the loop. It occurs when only fluids in the liquid phase is present in the primary system. The circulation carries the heat from the core through the hot leg to the steam generator. In steam generator, it is cooled by the secondary system and returns to the core through the cold leg.

NCT is initiated by manually tripping all three RCPs simultaneously without reactor trip, then maintain the RCS in hot standby for approximately 30 minutes. In case of loss of main pumps flow following the RCP trip, differential gravity heads between cold and hot fluids, respectively in the steam generators and in the core regions, create a driving force which is counter balanced by the pressure losses all around the loop. This constitutes an inherently safe mechanism suitable in removing nuclear decay heat for several minutes even in the absense of emergency cooling.

Right after tripping all three RCPs, the RCS flow decreases following the loss of enforced coolant flow. The RCS flow then

decreases exponentially as the RCPs coasted down prior to the RCS developing natural circulation. As shown in Figure 3.1, on tripping all RCPs , the RCS flow rate does not drop to the equilibrium flow. The RCS flow rate decreases to 50% RCS flow rate during 10 seconds and approximately after 300 seconds it reaches to the equilibrium flow. The hot leg temperatures increases as the RCS flow decreases and results in pressurizer water level increase, maintaining a constant RCS mass by matching charging and letdown flow. Pressurizer spray from the loops will be lost and pressurizer pressure increases during transition to natural circulation. The RCS temperature is determined by the steam dump flow rate in the constant steam pressure mode. The hot leg temperature increases sharply due to the sudden reduction of RCS flow resulting from the RCP trip. The increase of the hot leg temperature causes to increase the steam pressure. The increase of steam pressure results in the increase of steam dump flow rate, because the steam dump control system is operated by a steam pressure mode. The increase of steam dump flow rate removes more heat from the coolant and this causes the decrease of the cold leg temperature.

Recognition of the existance of natural circulation is crucial to the safe performance of this test. During natural circulation, stable core thermocouple readings, stable distinct T cold and T hot based on the wide range temperature recorders, existence of steam dump to condenser or atmosphere are indicative of natural circulation cooling.

This recognition of the existence of natural circulation should continue at least for 30 minutes. After 30 minutes, the reactor power increases and is synchronized to the grid again and returns to 100 % power level. This test was performed at the plant with satisfying the acceptance criteria specified in Table 2.

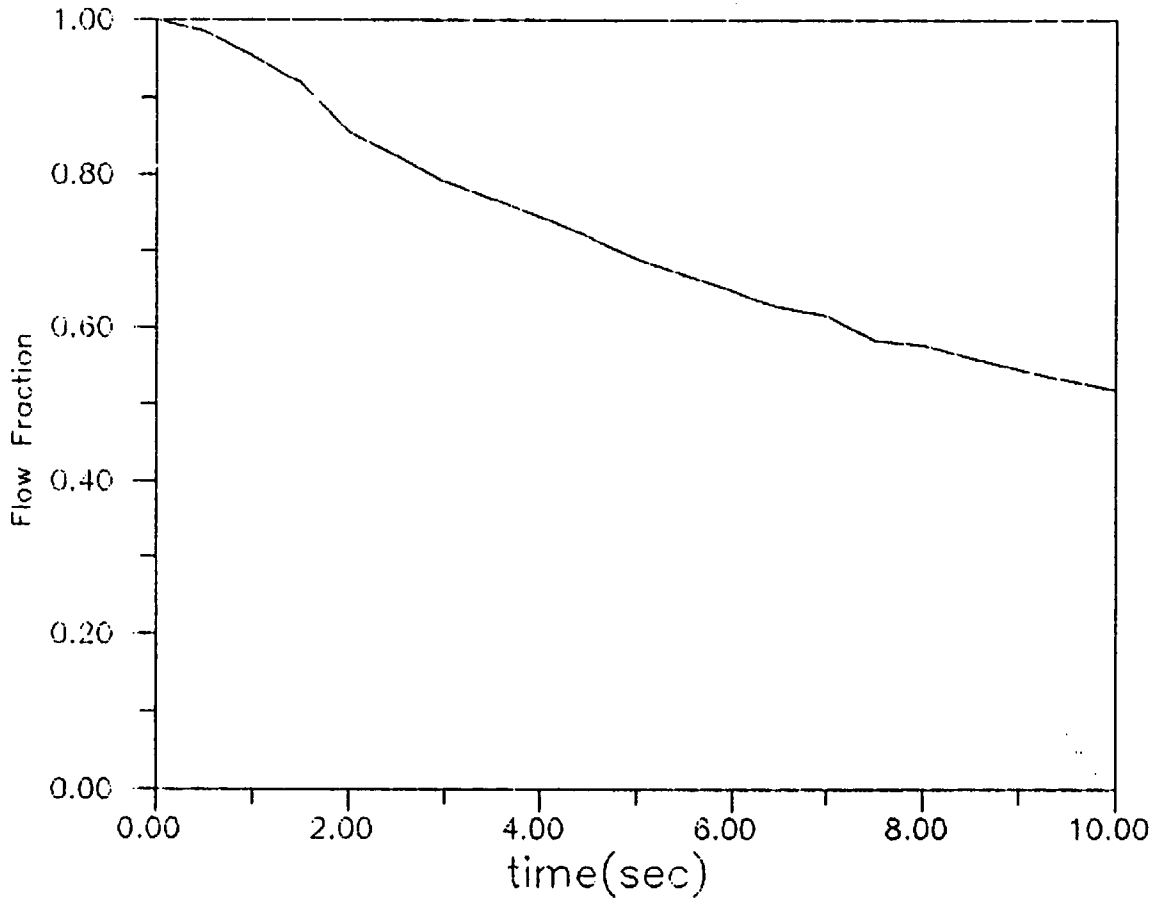

Figure 3.1 RCS Flow Fraction

Table 2 Acceptance Criteria

1. RCS loop T avg and Del T must be less than 309.2 c and 34.99 c
2. RCS T hot must be less than or equal to 320.0 c
3. Recognition of the existence of natural circulation
   - Stable thermocouple readings
   - Stable distinct T cold and T hot
   - Existence of steam dump to condenser or atmosphere

4.0 RELAP5/MOD2 plant nodalization and initialization

The used code version was RELAP5/MOD2/CY 36.04 and was processed on a CDC machine cyber 170-875. The input deck was prepared by KEPCO. The nodalization philosophy is based on the guideline of RELAP5 code manual and the detailed data for specific volumes and junctions are based on the design and drawing values for Yong-Gwang Unit 2.

The nodalization can be found in Figure 4.1, which was previously developed for the LOCA analysis and was qualified through the analysis of Net Load Trip Test in the Yong-Gwang Unit2. The whole system is devided into 118 volumes, 122 junctions and 79 heat slabs. The reactor core is described with 6 volumes and 6 core heat slabs. The reactor power is computed by using the RELAP5/MOD2 point kinetics model, which assumes that power can be separated into the product of space and time functions. The reactor vessel consists of 4 volumes, ie, the downcomer, the lower plenum and core inlet, the upper plenum, the upper head and control rod guide tube. Steam generator is divided into the primary and the secondary system with the boundary of U-tube and the primary system is described with 10 volumes and the secondary with 9 volumes. Two steam generators are lumped in order to match with the RCP loop. Separator is depicted by using the RELAP5 SEPARATOR model. The RCP and the accumulator are also modeled in this simulation. RELAP5 ANS79 model is applied for computing the decay heat and the

negative reactivity of temperature and doppler coefficient is considered. The plant consists of 3 loop coolant system but for the convenience of the analysis, the reactor coolant system is modeled with two loops, one is the loop which lumps the two loops in which the pressurizer is not connected and the other is the single loop in which pressurizer is added. Each loop is depicted with the RELAP5 pipe component and consider the fluid-metal interaction by using the heat structure. The safety and relief valve nodes of steam generator and pressurizer are not included because it was confirmed by the simple calculation that they did not open during this transient.

The outlet of both S/Gs are connected to a single volume, steam header, which is connected to the turbine and the condenser volume. The condenser volume in this nodalization contains the atmosphere volume. According to the test result performed in the power plant, the steam dump system was operated manually and the history of steam dump control valve opening is not known. The test procedure recommends that the steam dump control system be operated automatically in the constant steam pressure mode. Therefore in the RELAP5/MOD2 initialization, the steam dump valve opening is modeled to be determined by the difference between the steam header pressure and the set point pressure(76.8 kgf/cm2). In this case, the steam header pressure is used in a proportional plus integral controller to supply a modulated signal to the condenser dump valves. The condenser dump

valves are described using the time dependent junction and the dump flow rate is modelled as a boundary condition which is determined by the pressure difference between the steam header and the set point. Turbine is modelled with the time dependent volume.

For the steady state initialization, the RELAP5/MOD2 code requires the initial conditions which results in zero time deviation for each of balance equation. The first part of activity consisted in achieving the boundary and initial conditions in the loop (ie, secondary feedwater flow, steam dump flow rate, RCS flow rate and the temperature distribution of the hot leg at cold leg in the primary system without pump running). The steady state initialization should be obtained with the condition of closing the governor valves. Only the steam dump flow makes a role of the secondary heat sink during the natural circulation. The summaries of the steady state initialization values for the important thermal hydraulic parameters are shown in Table 3.

The core power used in the RELAP5/MOD2 simulation was 3% full power, which is equal to fission product decay heat power. The main purpose of this test is to prove the capability of NSSS to remove the fission product decay heat by natural circulation, thus the core power should be maintained with 3 % full power without reactor trip.

As shown in Table 4, the plant operating data of the initial hot leg and cold leg temperatures for each loop reveal some differences. Therefore, the initial hot leg and cold leg temperatures are calculated by averaging the three operating values in order to minimize the data collection error. The comparison between the plant operating data and the simulation data for the initial hot leg and cold leg temperature shows a little difference, but this difference can be neglected if the instrument and recording uncertainty is considered.

The initial RCS flow rate is determined with the RCS flow rate for the 100% full power. The RCS flow rate should be determined to be coupled with the temperature of hot leg and cold leg in the reactor coolant system in order to obtain the steady state condition at 3% full power. The RCS flow rate used in this simulation is the flow rate which is determined by steady state initialization at 100 % full power. The plant operating data for the RCS flow at 100 % full power is not available.

Pressurizer pressure is used as a boundary condition because the pressurizer pressure and water level control at the start up test is in manual and pressurizer water level is at the hot no-load programed value of 22 % level of span.

The pump model has the capability of coastdown effect of RCP after it is tripped, which is one of the most important thermal-hydraulic characteristics for the heat transfer mechanism during the single phase natural circulation.

The feedwater flow rate is determined as a boundary condition by applying the time dependent junction at the feedwater valve and this boundary conditions is determined with a value of the auxiliary feedwater flow rate(47 kg/sec).

Steam generator water levels are at the nominal hot no-load value of 50% level of span and being maintained by a auxiliary feedwater flow rate.

All reactor trip function models are eliminated in the RELAP5/MOD2 simulation for preventing reactor trip.

The transients are initiated after 200 seconds steady state run in the RELAP5/MOD2 simulation. Thus the figures for comparison between the plant data and the calculation results indicate the transients after the elapsed time of 200 seconds. As mentioned above, only the steam dump flow is the secondary heat sink during the natural circulation. Therefore, the steady state is reached with the help of steam dump system. At the steady state condition, the steam dump flow rate is 63.1 kg/sec.

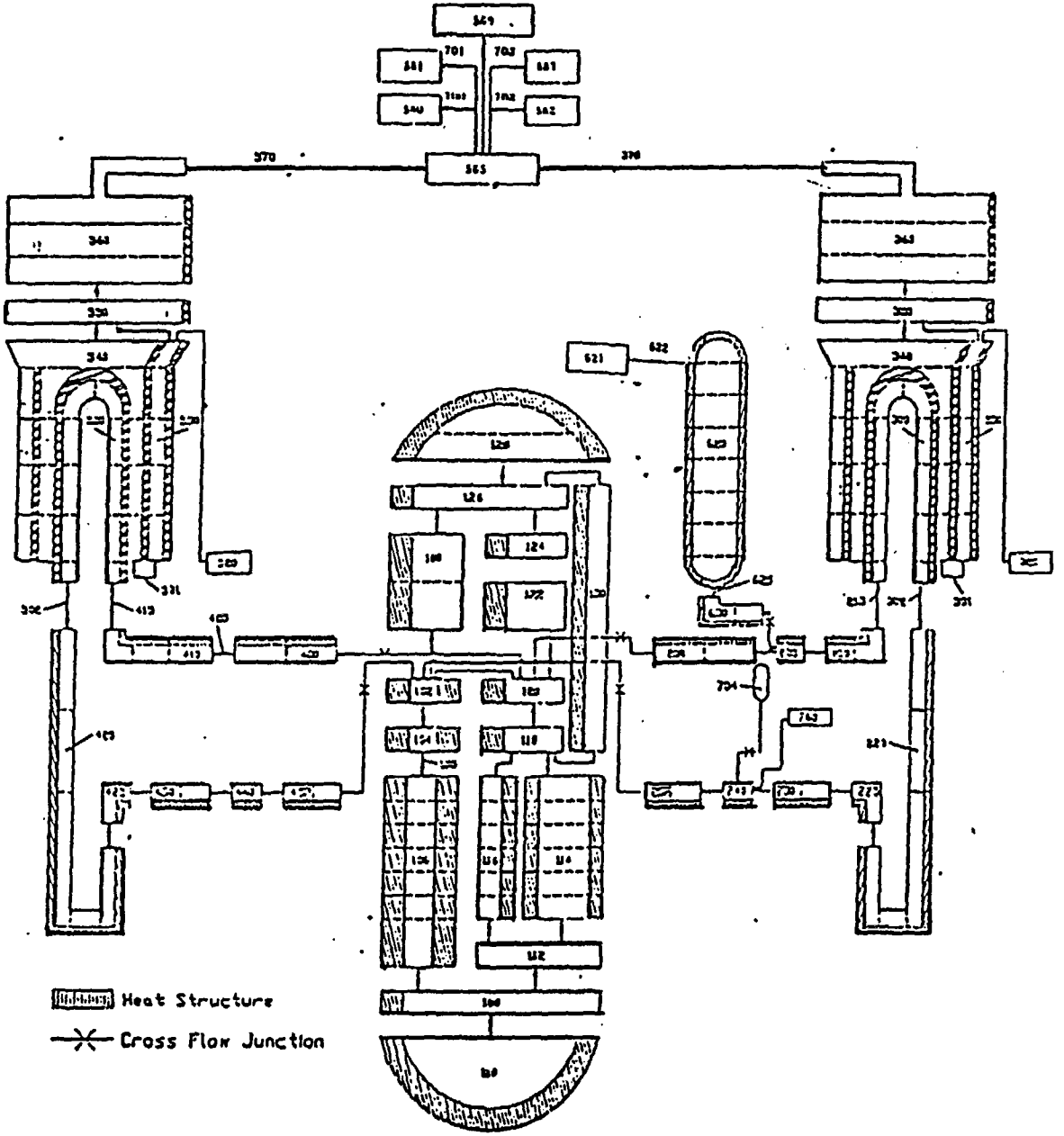

Fig 4.1 Nodalization

Table 3 Initialization Data

	Plant Data	RELAP5/MOD2 Data
1.0 Core		
T cold	291.8 (c)	292.0 (c)
T hot	293.1 (c)	293.5 (c)
Core Power	83.3 Mwt	83.3 Mwt
2.0 Pressurizer		
Level	0.22	0.22
Pressure	157 (kgf/cm2)	157.4 (kgf/cm2)
3.0 S/G		
Level	0.5	0.5
Pressure	66.4 (kgf/cm2)	67.2 (kgf/cm2)

Table 4 Plant Data for Initial Temperature

	initial temperature (c)			
	loop 1	loop 2	loop 3	average
T hot	293.5	293.7	292.1	293.1
T cold	292.5	293.0	290.0	291.8

5.0 Calculation results and Analysis

The single phase natural circulation in a RCS loop is the only effective means for the core cooling of a reactor after the main reactor coolant pump has tripped. During a single phase natural circulation, heat generated in the core is transported to the heat exchanger where it is dissipated. The driving mechanism for this energy transport is an overall loop fluid density difference caused by changes in the temperature of the fluid as it flows through the loop. The coolant in the core, hot leg and upflow side of the heat exchanger is less dense than coolant in the down flow side of the heat exchanger and cold leg, thus causing an imbalance gravity head which drives the single phase flow.

The plant operating data is compared with the calculated data by RELAP5/MOD2 simulation for the important thermal-hydraulic parameters. Uncertainties in boundary and initial conditions do not allow the complete agreement between the plant operating data and the calculated data. Therefore an emphasis is given to the ascertainment of the capability of the code in predicting the measured transients instead of the complete agreement by confirming the acceptance criteria specified in the test procedure.

During the normal operation of RCP, the RCS flow rate is about 4800 kg/sec and the core power is 3 % full power. After all RCPs are

tripped, they experience the coast down prior to the RCS's developing the Natural Circulation. Shown in Figure 5.1 is the RCS flow rate trend which explains well the effect of the coast down. It reaches to the steady flow rate whose value is 250 kg/sec equal to 5.2 % full RCS flow rate after 400 seconds.

The test procedure requires at least 5% of full RCS flow rate during the natural circulation and the calculated RCS flow satisfies this criteria. The effect of core power on single phase natural circulation flow is strong. Increasing the core power causes the increase of overall density gradient between the hot and cold sides of the system, resulting in higher loop mass flow rate. It is found that there is some influence of secondary flow rate to the primary flow. Higher secondary feedwater flow rate causes lower temperature difference between hot leg and cold leg because of higher cooling effect. This makes lower primary flow rate. In this RELAP5/MOD2 simulation, the constant feed water flow rate is used, which is equal to the auxiliary feedwater flow rate. The plant operating data for RCS flow rate is not available, thus the comparison between the plant operating data and the simulation data for the RCS flow rate is not made.

Right after tripping all three RCPs, the decrease in the RCS flow rate limits the amount of energy which can be removed from the core. The RCS flow rate decrease is not matched by an equivalent drop in the

core power. This unbalance of power drop results in increasing the hot leg temperature. Figure 5.2 shows the comparison between the calculated and the measured temperature of the hot leg in the RCS. Both trends show the sharp increase in the hot leg temperature. The calculated temperature increases up to 313 c during 400 seconds following the RCP trip and then reaches to the equilibrium state. The measured temperature reveals a little different trend. It goes up to 311 c with the same slope as the calculated one during 500 seconds and then reach to the equilibrium state with some oscillation. This instability due to the oscillation reflect to the thermal hydraulic parameters as shown in the other figures. The period of measured temperature oscillation ranges around 450 seconds, while the calculated one does not show any oscillation. The difference between the measured and calculated hot leg temperature appears to be induced by the steam dump flow rate difference. The steam dump control system was in manual mode at the startup test and the maneuvering history of the steam dump valve is not available. In the RELAP5/MOD2 simulation, it is modelled in auto mode. According to the result of comparison, it is assumed that the steam dump flow rate used in the RELAP5/MOD2 simulation is higher than that used in the power plant. Even though the calculated temperature shows a little difference from the plant operating data, its result satisfies the permitted error band (2.5 %) and the peak temperature criterion (322 C) which is specified in the test procedure .

The result of comparison between the plant operating data and the calculated cold leg temperature during the transient is found in Figure 5.3. With the onset of natural circulation, the cold leg temperature decreases due to the increase of steam dump flow rate under the constant steam pressure mode. More heat is transported from the primary system to the secondary system due to the increase of steam dump flow rate. Therefore, the cold leg temperature decreases. Both trends indicate this effect. The calculated cold leg temperature drops to 291.6 c for 50 seconds and then builds up to the initial temperature(292.6 c). After some oscillation, it reaches to the steady temperature. The plant operating data shows a different response. It drops to 291.0 c for 100 seconds and then increases more slowly than the calculated one. It decreases slowly with some oscillation. The test procedure requires that the RCS cold leg temperature be kept under the saturation temperature for the steam generator pressure and this criteria is satisfied.

The calculated Tavg and Del-T are compared with the plant operating data, which are shown in Figure 5.4 and Figure 5.5. These temperatures are obtained mathematically from the hot leg temperature and the cold leg temperature. Figure 5.4 shows that the calculated Del-T increases and reaches to the peak temperature (20.4 c). It has the similar trend with the plant operating data and both results are

satisfying the permitted peak Del-T 34.94 c, specified in the test procedure. As shown in Figure 5.5, the plant operating data for the Tavg shows lower values than the calculated Tavg at the beginning stage of the transient and reaches to the peak temperature (302 c) with some oscillation. The trends for the calculated and measured peak Tavg reveal far lower value than the permitted peak temperature (309 c), specified in the test procedure.

Shown in Figure 5.6 is the steam generator pressure by the RELAP5/MOD2 simulation which indicates the peak pressure with a value of 77.5 kgf/cm2 about 100 second. The first increase of steam pressure results from the decrease of steam dump flow in order to match to the setpoint pressure. After then, it begins to decrease for 100 seconds. It reaches to the saturated pressure around 550 second through some fluctuation. Since the plant operating data is not available, the comparison with the operating data is not made. The test procedure requirement for the steam generator pressure is that it should be stable or decreasing during the transient. The result of simulation shows that the steam generator pressure is stable.

The steam dump flow rate with the steam pressure mode is determined by the pressure difference between the steam header pressure and the set point pressure (76.8 kgf/cm2) with 120 second reset time. The steam header pressure is used in a proportional plus integral controller to supply a modulated signal to the condenser dump valves. Figure 5.7 shows that the initial steam dump flow rate (63.1 kg/sec)

for the first 100 seconds in order to increase the steam pressure. After 100 second, the steam dump flow begin to increase sharply up to the 50 kg/sec and then reaches to the saturated flow rate with a value of 51 kg/sec through some fluctuations. The dump flow rate after saturated condition without RCPs shows a little lower value (11kg/sec) than the flow rate with RCPs. This caused by the fact that three RCPs supply about 10 Mwt energy to the RCS. Some small fluctuations are found for around 400 seconds after 200 second. These oscillations are mainly due to the steam generator pressure oscillation.

In consideration of instrument and recording uncertainty of the plant operating data, the errors shown from the comparisons between the calculated values and the plant operating data of the primary system can be neglected. The operating data permit around 3.0 % instrument and recording uncertainty [5].

Judging from the results of the above comparisons, it can be concluded that the results of calculation show the similar trend to the plant operating data and satisfy the criteria specified in the test procedure.

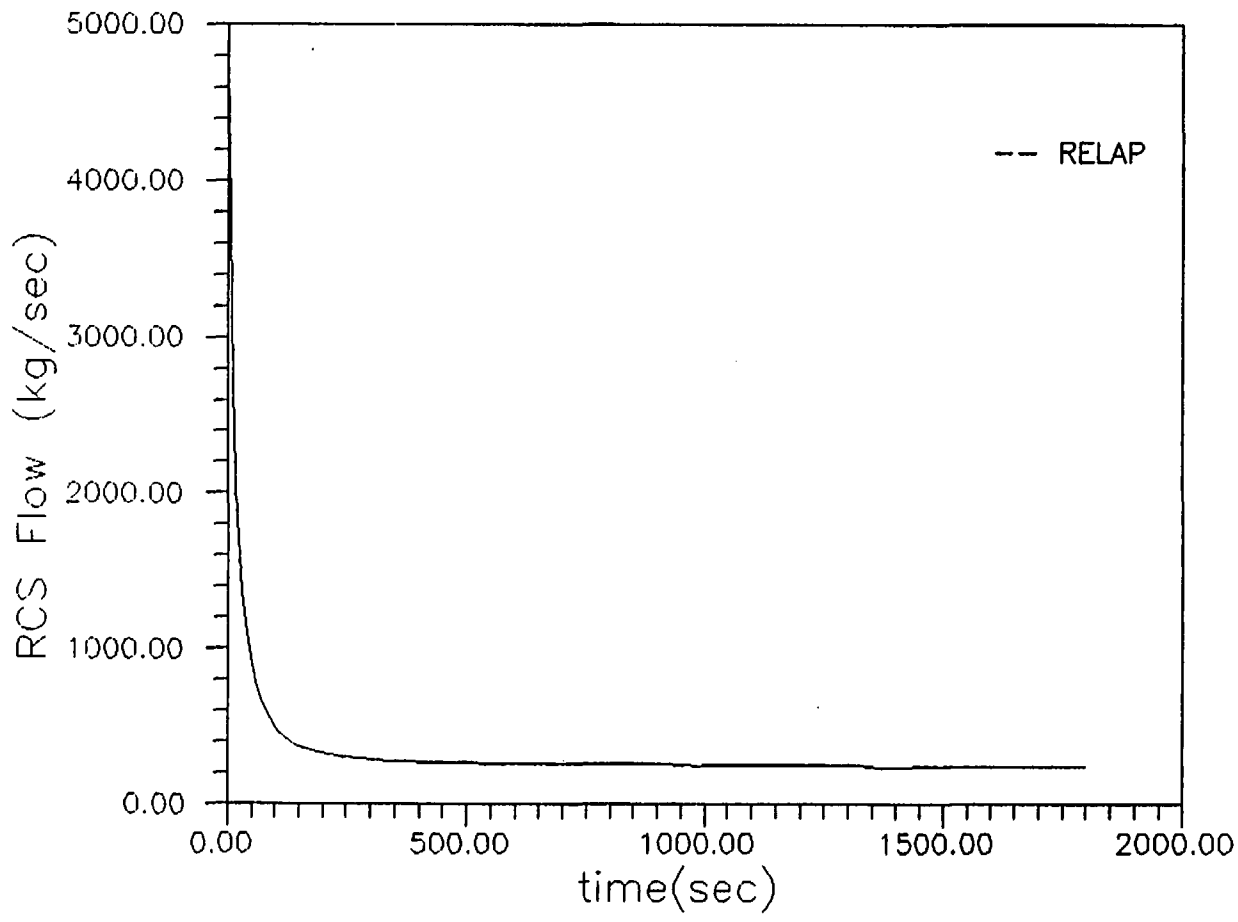

Figure 5.1 RCS Flow Rate

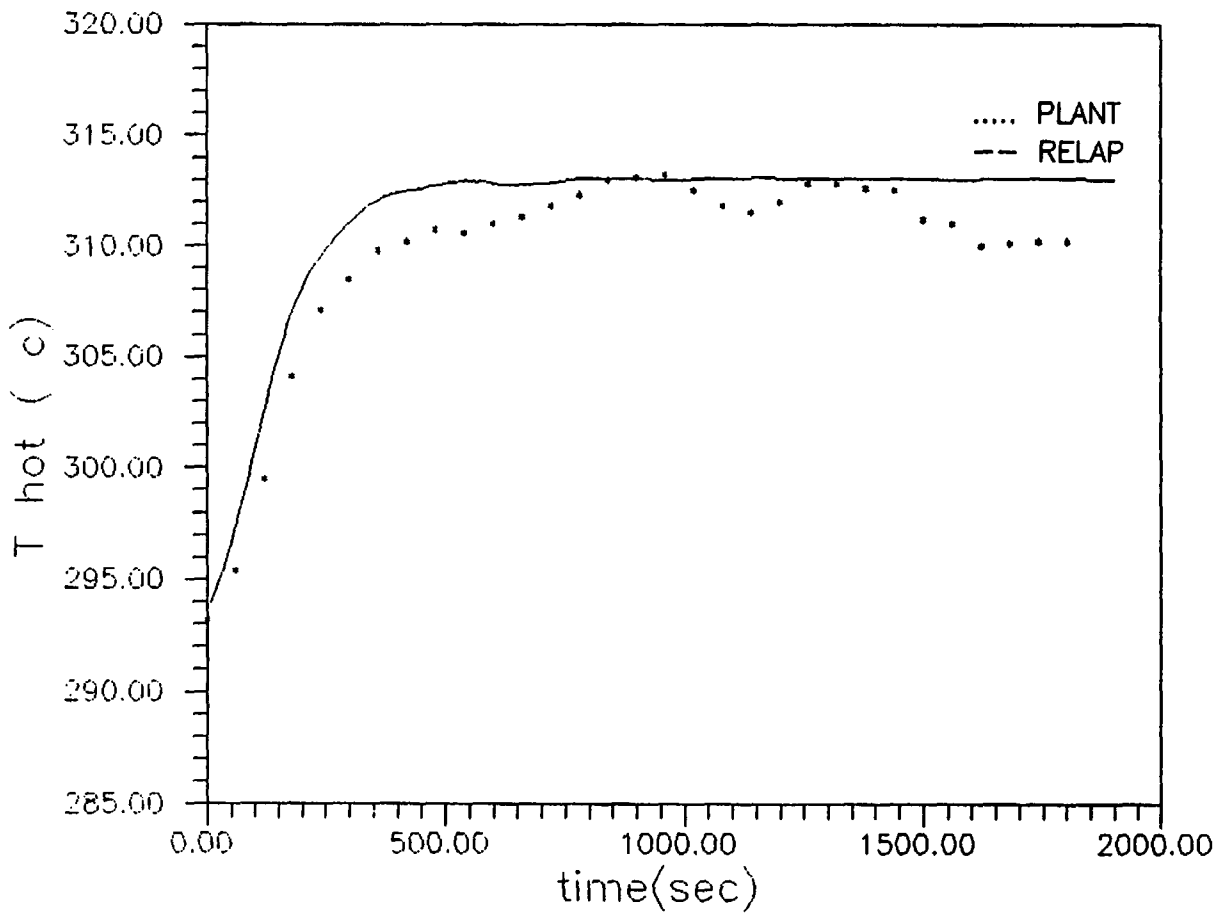

Figure 5.2 Hot Leg Temp.

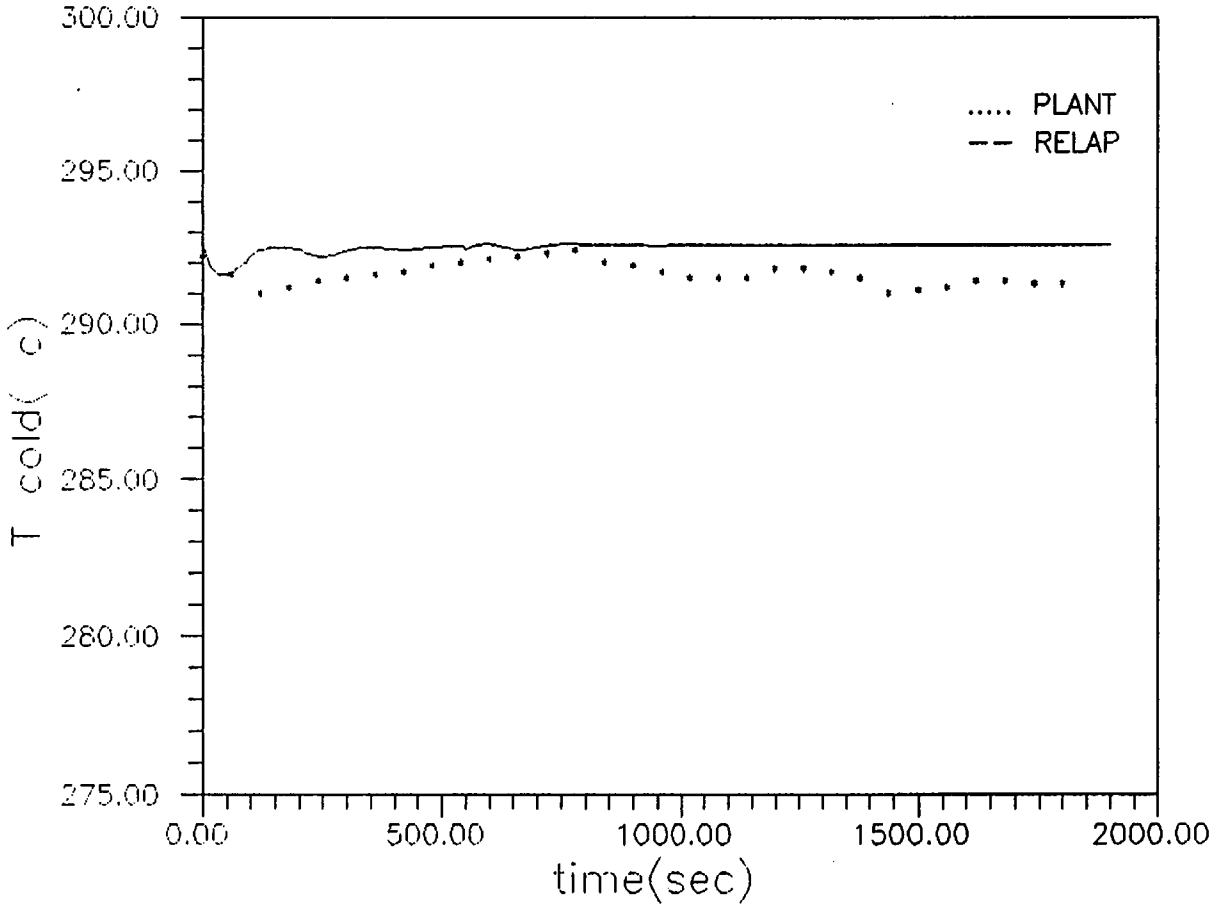

Figure 5.3 Cold Leg Temp.

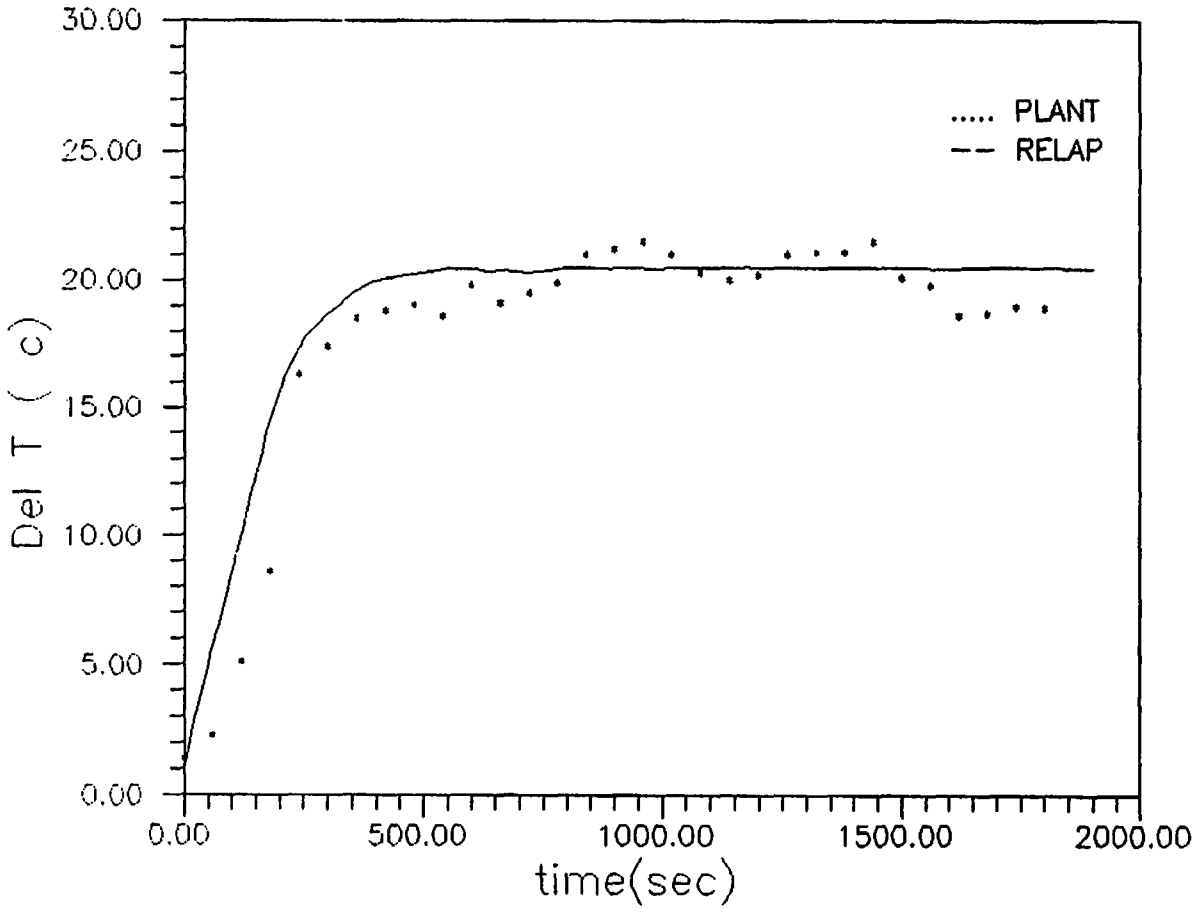

Figure 5.4 T hot– T cold

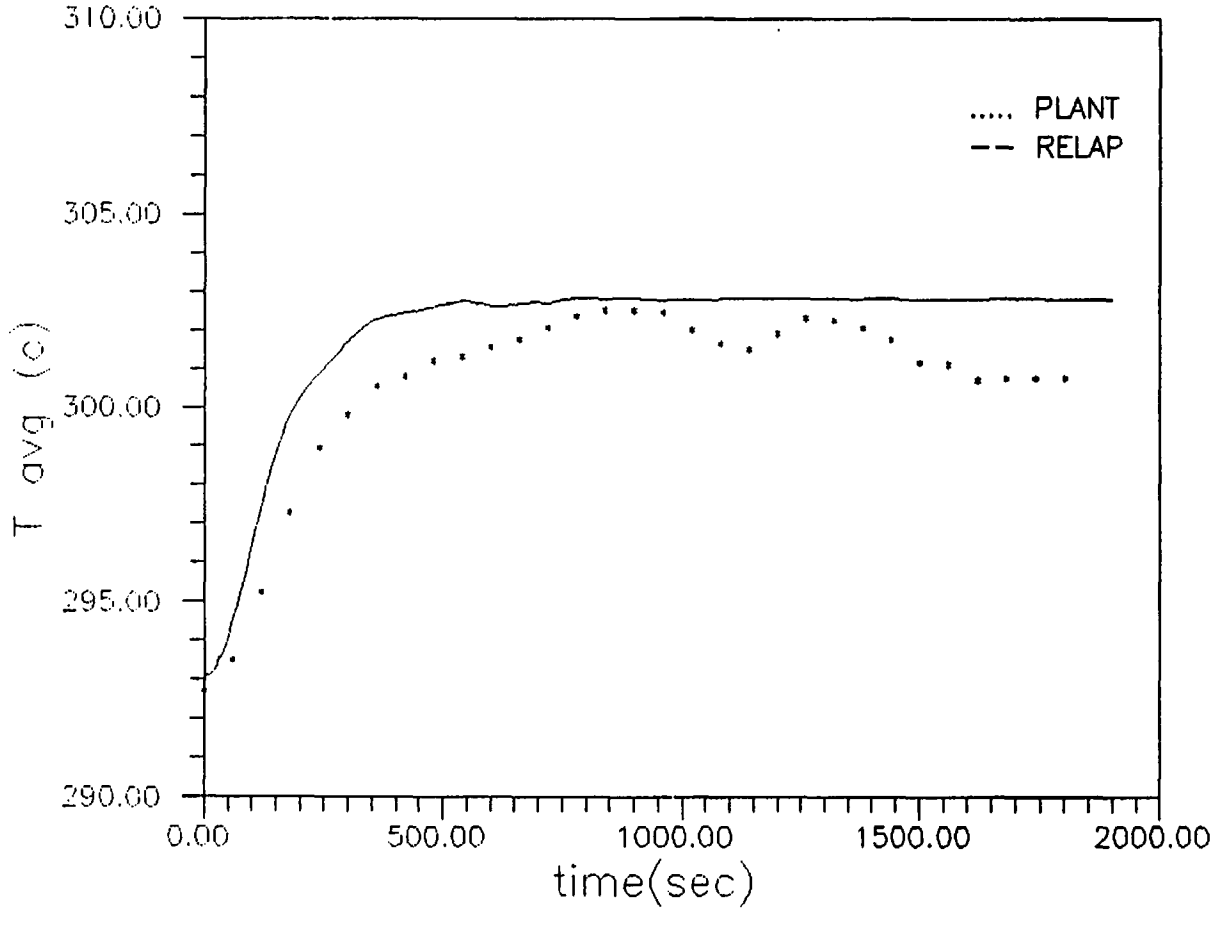

Figure 5.5 Average Temp.

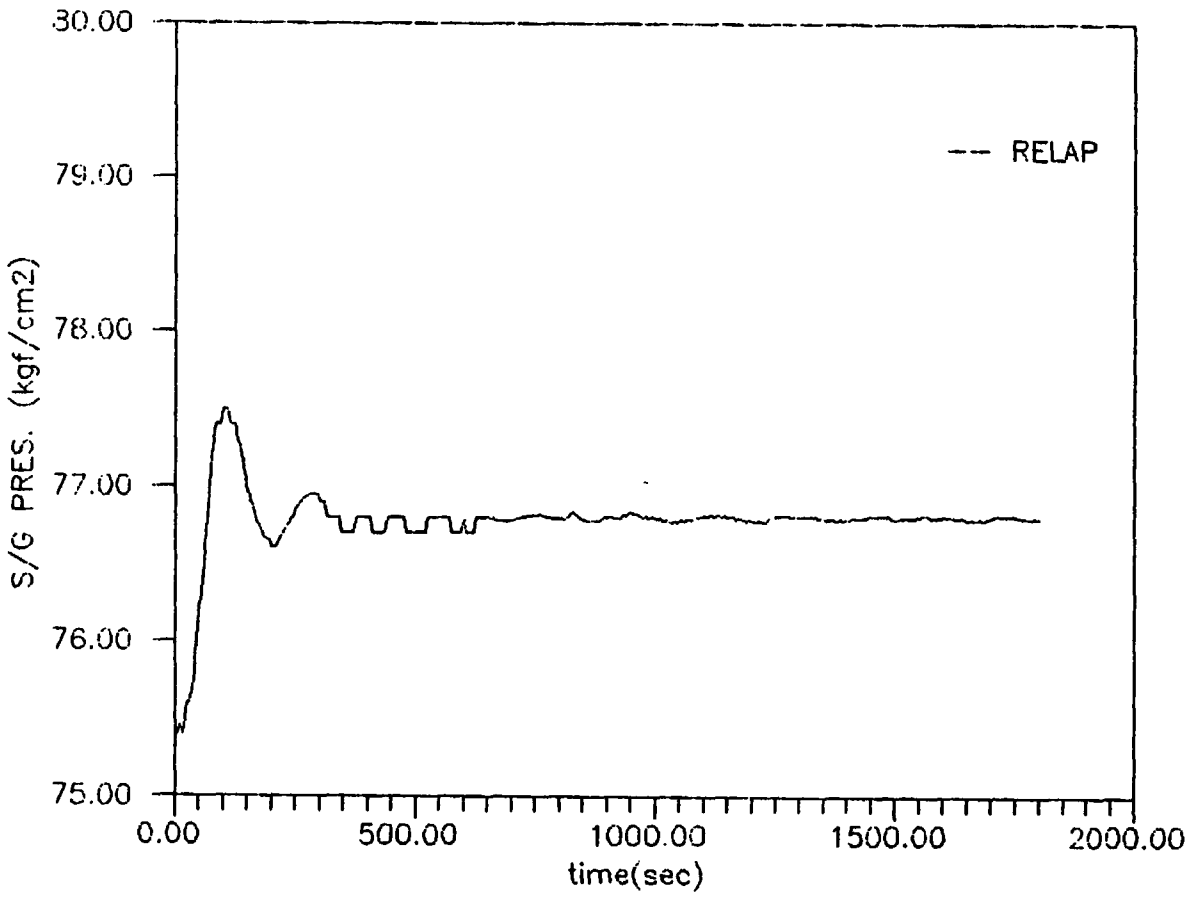

Figure 5.6 S/G PRES.

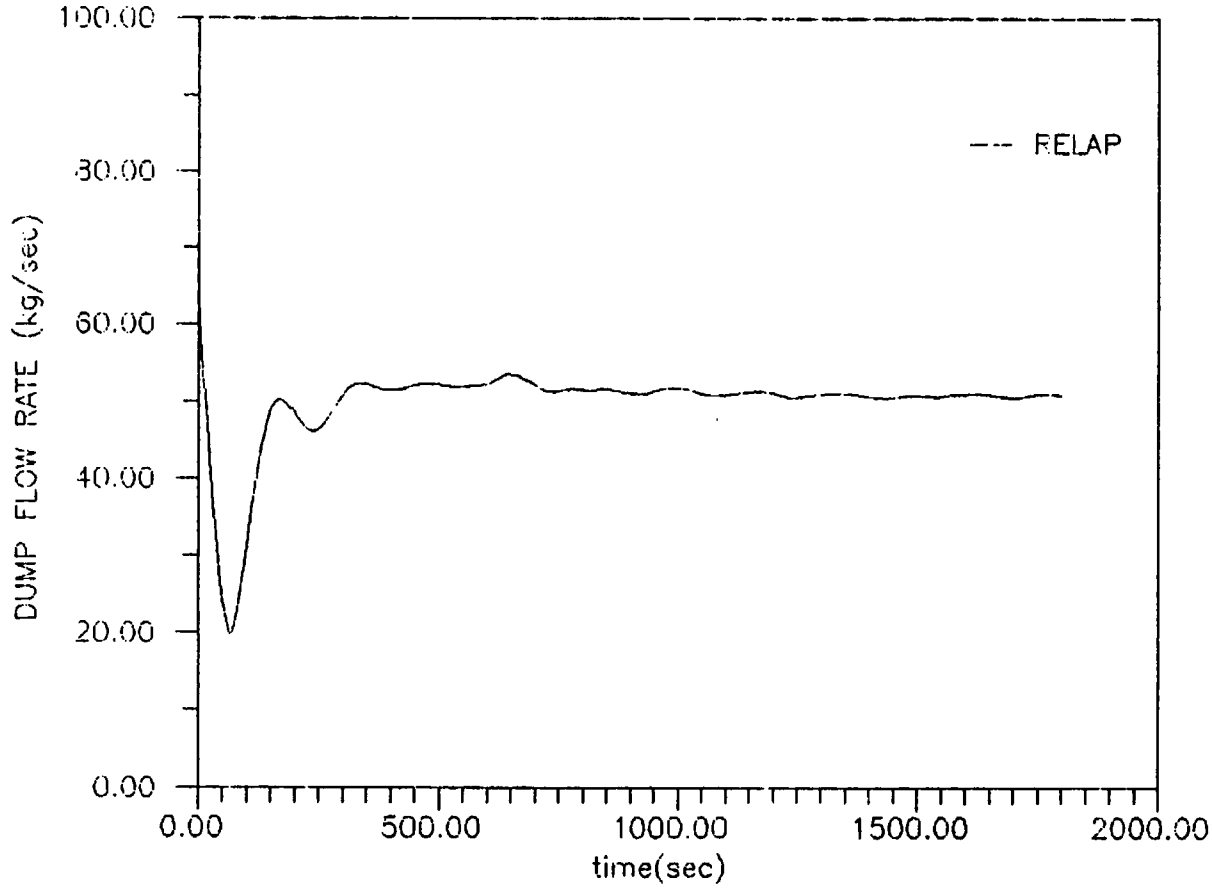

Figure 5.7 Dump Flow Rate

6.0 Sensitivity study

During the Natural Circulation, the heat removal in the steam generator depends strongly on the steam dump flow rate. It is of great interest to find out the effect of steam dump flow rate on the primary RCS temperature. To illustrate this effect, the RCS hot leg and cold leg temperatures are compared for the different steam dump flow rates. Data 1, the base calculation data, is obtained from RELAP5/MOD2 simulation by the automatic steam dump control with the constant steam pressure mode . Data 2 curve, as shown in Figure 6.1, shows 20 percent more steam than Data1 and applies to the RELAP5/MOD2 simulation as a boundary condition. The difference in the hot leg temperatures is observed in Figure 6.2. Data 2 reveals the same increase rate as Data 1 for the first 300 seconds. After 300 seconds, it reaches to the peak temperature, lower than Data 1 peak value, and continues to decrease. Figure 6.3 illustrates the comparison fot the cold leg temperature. Data 2 shows the similar trend to Data 1 for the first 300 seconds and after that time, it continues to decrease.

The result of this sensitivity study illustrates that the steam dump flow rate can have a significant impact on the primary RCS flow rate.

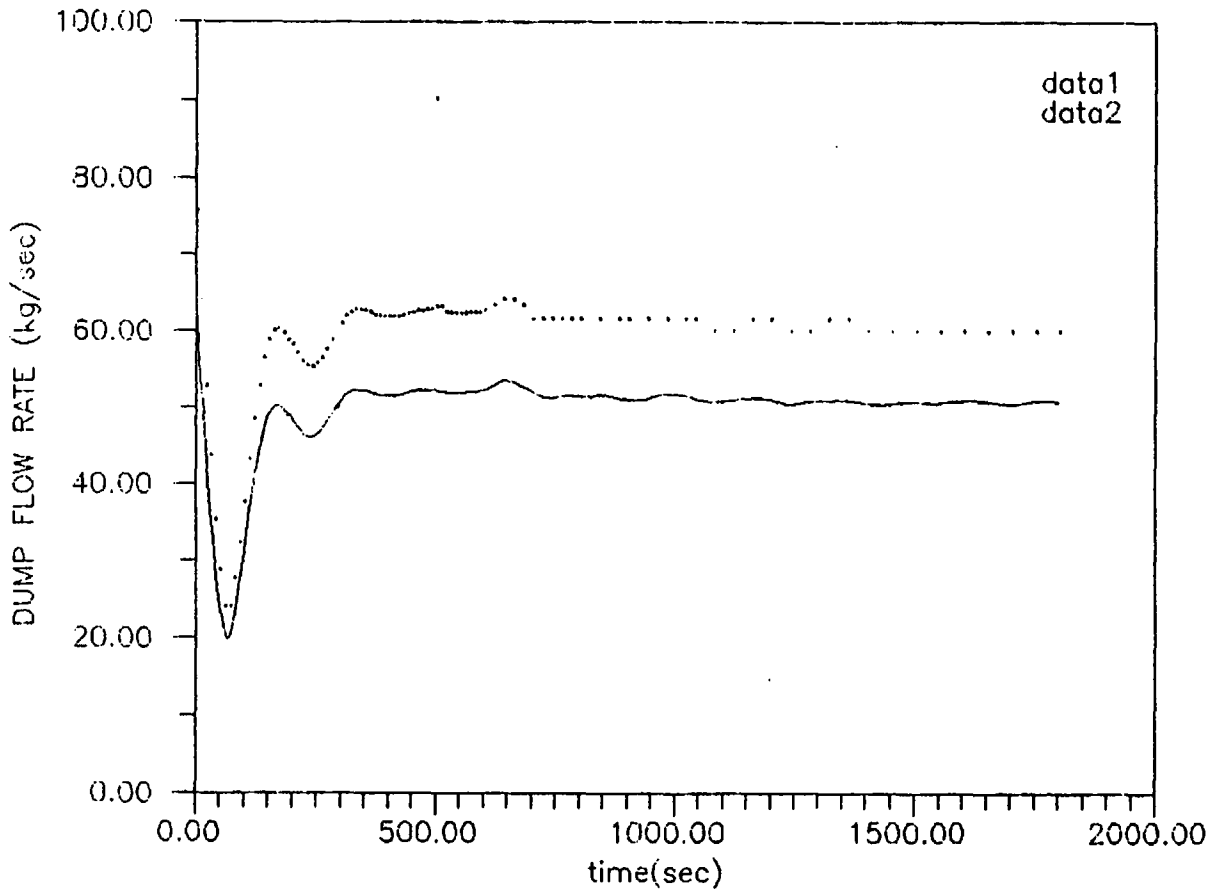

Figure 6.1 Sensitivity Study (Dump Flow Rate)

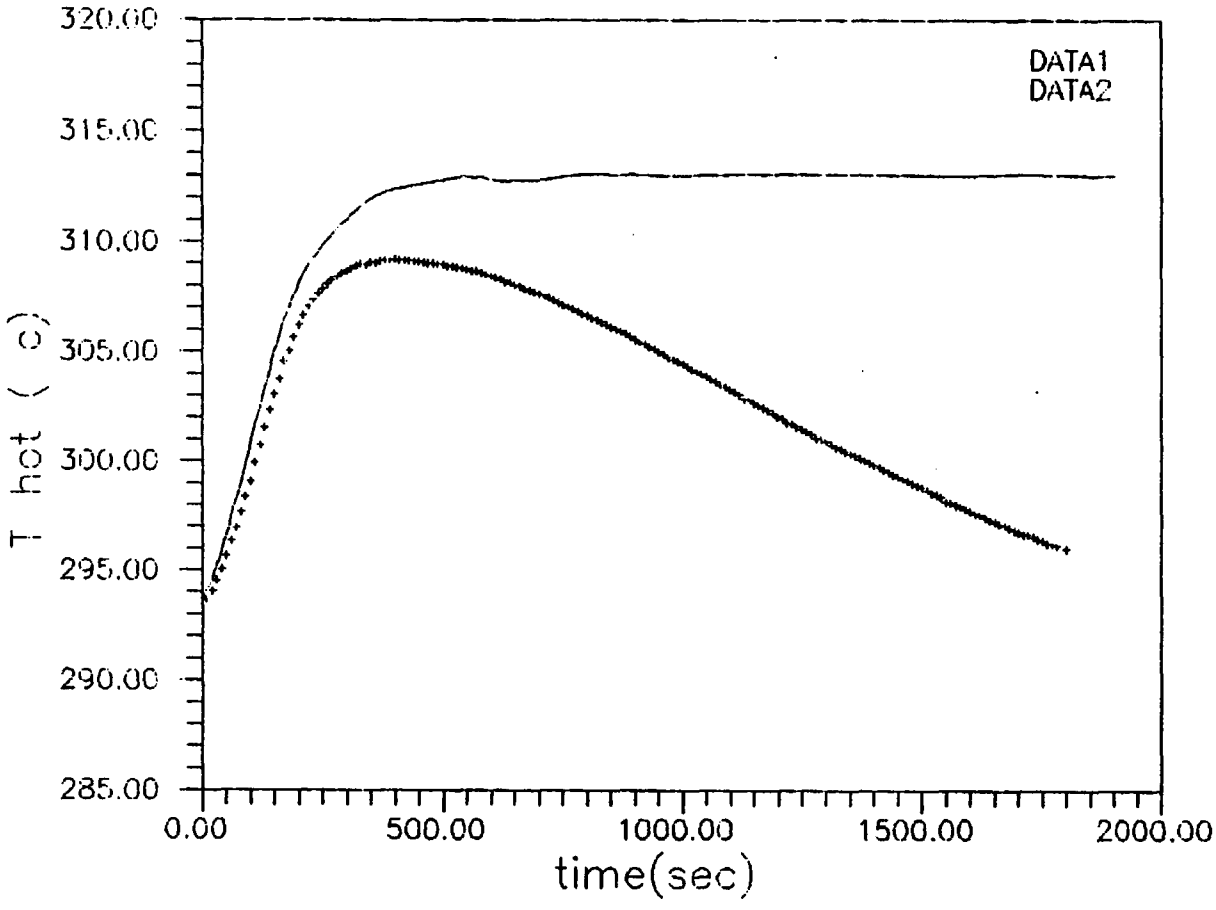

Figure 6.2 Sensitivity study (T hot)

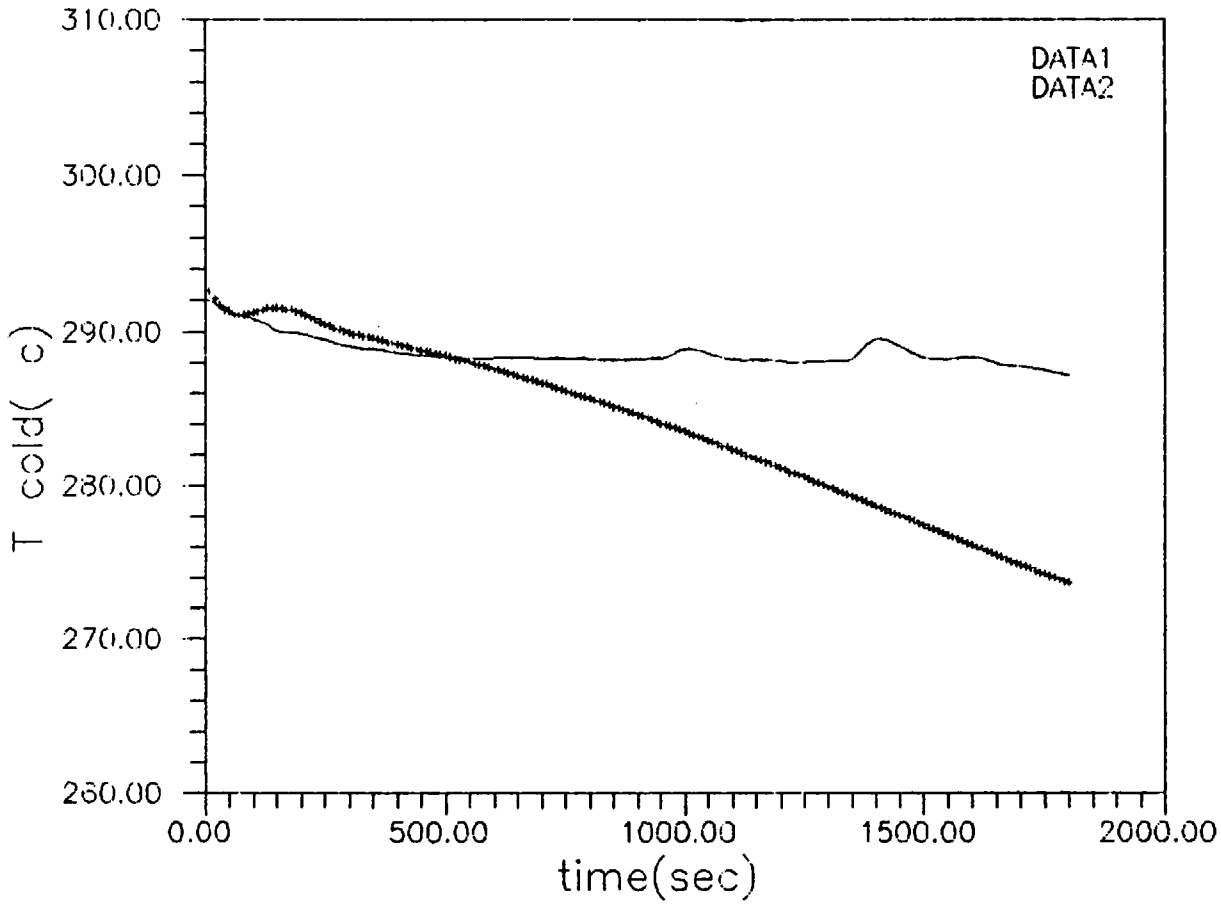

Figure 6.3 Sensitivity study (T cold)

7.0 Run Statistics

The CDC CYBER 170-875 which has one unified extended memery unit is used for this analysis and the operating system is the NOS 2.6.1 level 700. A plot of CPU vs RT and a plot of DT vs RT are shown in Figure 7.1 and Figure 7.2 respectively. Since the transient is initiated after 100 seconds steady state run, the consumed CPU time and time step size are computed after 100 seconds. The total CPU time consumed for this simulation of the whole transient 1800 seconds is 650.47 seconds.

Figure 7.1 indicates that the slope of CPU time in the first 100 seconds is sharper than that in the last 1800 seconds. The time step size trend, shown in Figure 7.2, reveals the same phenomena as the CPU trend. The advancement of calculation could not be successful with the given maximum time step size 1.0 second during the first 230 seconds, so the advancement was made with reduced time step size. For the first 50 seconds , the used time step size was 0.125 second. After 230 seconds, the time step was 1.0 second, which was given in the input. From the both figures, it can be known that at the begining of the transient, the transient is very severe enough not to be calculated with the given maximum time step size. The calculated grind time is 2.68. The summaries for the run statistics is given in Table 5.

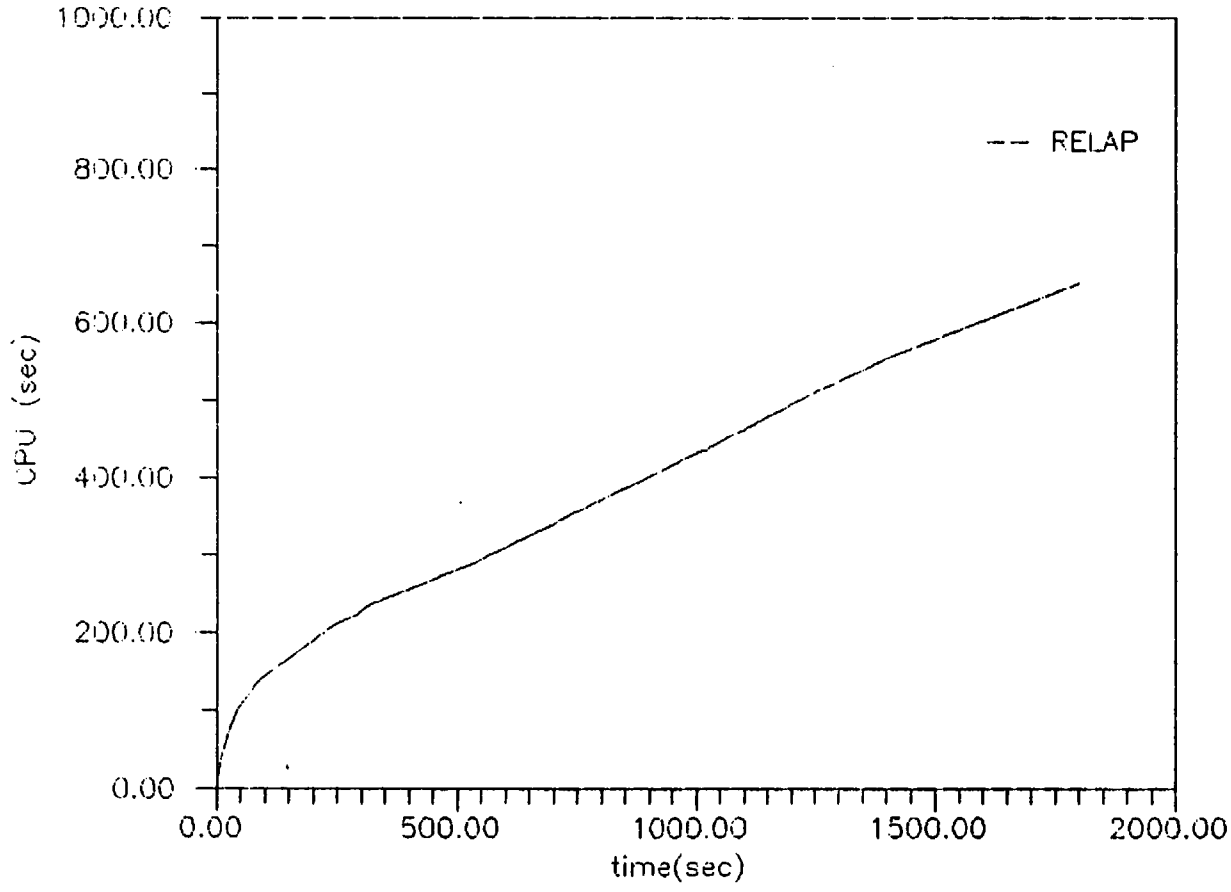

Figure 7.1 CPU

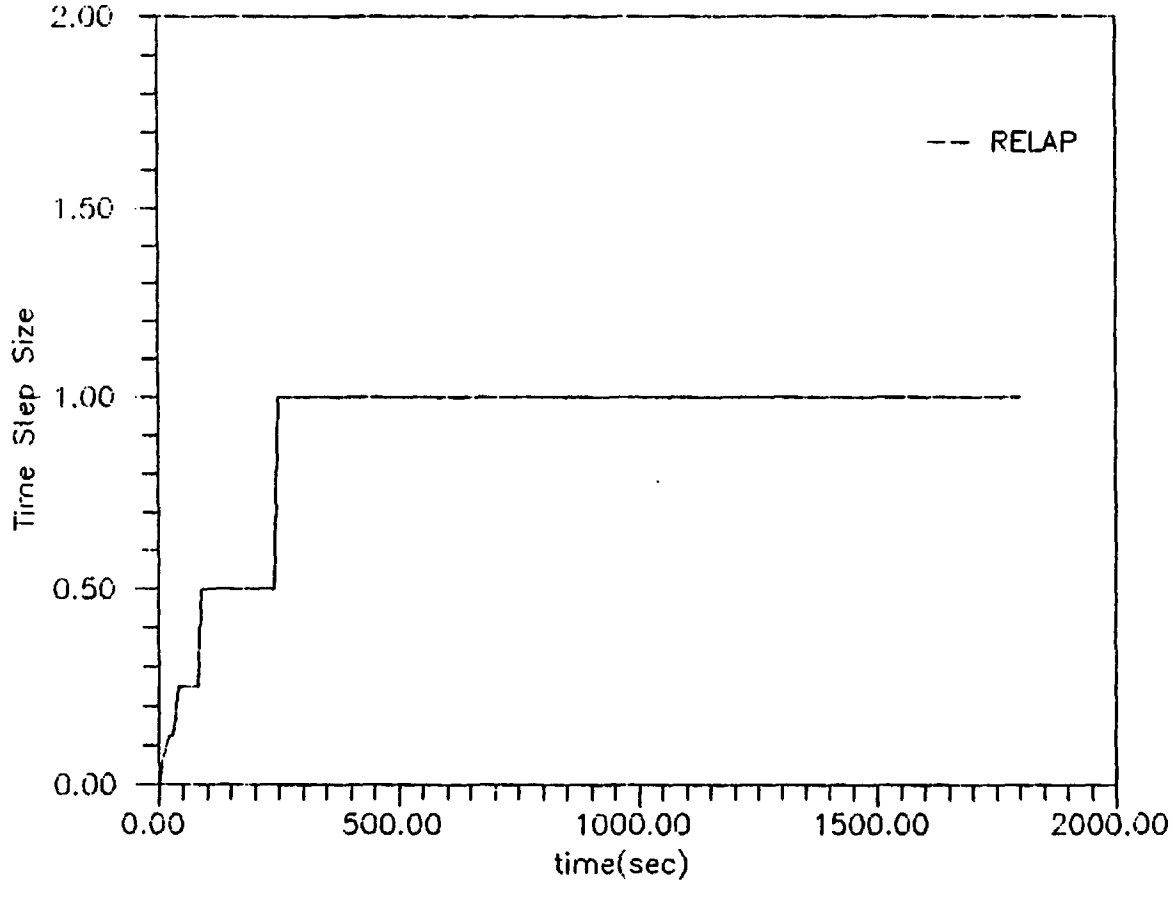

Figure 7.2 Time Step Size

Table 5 Summary of the Run Statistics

Run Statistics	
Computer	CDC CYBER 170-875
Operating System	NOS Vers.2.6.1
C P U	650.47
# of Time Steps	1927
# of Volumes	126
Transient Real Time (sec)	1800
Grind Time	2.68

8.0 Conclusion and recommendations

The results of RELAP5/MOD2 simulation using the natural circulation test data of Yong-Gwang Unit 2 were compared with the plant operating data. As far as the code application on the nuclear power plant operation is concerned, the simulation results show a good behavior of the code even in the prediction of the period and amplitude of the important thermal-hydraulic parameters. Uncertainties in boundary and initial conditions did not allow a complete identification of the reasons of discrepancies between measured and calculated trends.

The sensitivity study shows that the steam dump flow rate has a great impact on the determination of primary temperatures during Natural Circulation.

Finally, it can be concluded the thermal-hydraulic characteristics of the natural circulation flow after RCP pump tripping can be estimated very well by this RELAP5/MOD2 simulation and any possibility to clearly identify code limitation was not found.

Reference

1. Precation,Limitation and Setpoints for NSSS, January,1986 prepared by Westinghouse

2. Setpoint Study for KNU 7 $ 8.October 1984,by Westinghouse

3. Young Gwang Unit 2 F.S.A.R by KEPCO in 1983

4. RELAP5/MOD2 Code Manual Volume 2 by EG $ G

5. Yong Gwang Unit 2 System Manual by KEPCO in 1980

6. Developement of Thermal-Hydraulic Safety Analysis Code for Nuclear Power Plant by KAERI in 1989

7. Test Procedure for Natural circulation in Yong-Gwang Unit 2 prepared by Westinghouse

```
= RUN OF RELAP CODE FOR UNIT YK-2
*
*
100 NEW TRANSNT
101   RUN
*
*
102  BRITISH   SI
105  90.  100.
110  NITROGEN
*****************************************************
*                                                   *
*              TIME STEP CARDS                      *
*                                                   *
*****************************************************
*
201 1900. 1.E-7 0.5    3 10  2000 00800
*
*-----------------------------------------------*
*              MINOR EDIT VARIABLE              *
*-----------------------------------------------*
*
301   CNTRLVAR     250
302   CNTRLVAR     251
303   CNTRLVAR     254
304   CNTRLVAR   255
305   MFLOWJ     430010000
306   MFLOWJ     521000000
307   MFLOWJ     566000000
308   MFLOWJ     579000000
309   CNTRLVAR     49
310   CPUTIME    0
311   CNTRLVAR     43
*                                                                   *
*********************************************************************
*
506  TIME   0          GE   NULL    0      2000.0     L
507  TIME   0          GE   NULL    0      0.0       L
508  TIME   0          GE   NULL    0      1000.0    L
509  TIME   0          GE   NULL    0       100.0     L
*-----------------------------------------------*
*              REACTOR VESSEL                   *
*-----------------------------------------------*
*
*
**************************************************
*   COMPONENT 100 :  VESSEL INLET ANNULUS ABOVE  *
*                    COLD LEG  CENTERLINE        *
**************************************************
*
```

```
1000000  INL-ANN    ANNULUS
1000001  2
1000101  0.0        2
1000301  1.8064     1
1000302  3.311      2
1000401  51.284     1
1000402  54.119     2
1000601  90.0       2
1000801  0.00015    1.4792     1
1000802  0.00015    1.0662     2
1001001  00         2
1001101  10000      1
1001201  003        2332.7     557.00    0 0 0 1
1001202  003        2331.9     557.00    0 0 0 2
1001300  1
1001301  438.20    0.0        0.0        1
*
**************************************************
*   COMPONENT 102 : VESSEL INLET ANNULUS BELOW   *
*                   COLD LEG  CENTERLINE         *
*                   (UPPER VOLUME)               *
**************************************************
*
1020000  INL-ANN    BRANCH
1020001  5          1
1020101  0.0        3.6128     79.9315    0.0      -90.0
1020102  -3.6128    0.00015    1.3685     00
1020200  003        2333.6     557.00
1021101  102000000  100000000  28.3899    0.0      0.0      00000
1022101  102000000  120000000  0.08932    1.0170   1.0170   0000316:50:32
1023101  252010000  102000000  13.531     0.1122   0.1122   00001
1024101  452010000  102000000  6.766      0.1122   0.1122   00001
1025101  102010000  104000000  28.390     0.0      0.0      00000
1021201  438.20    0.0        0.0
1022201  342.80     0.0        0.0
1023201  20208.     0.0        0.0
1024201 10104.00   0.0        0.0
1025201  29531.000  0.0        0.0
*
**************************************************
*   COMPONEMT 104 : VESSEL INLET ANNULUS BELOW   *
*                   COLD LEG  CENTERLINE         *
*                   (LOWER VOLUME)               *
**************************************************
*
1040000  INL-ANN    ANNULUS
1040001  1
1040101  0.0        1
1040301  2.2481     1
1040401  67.1589    1
```

```
1040601  -90.0       1
1040801  0.00015     1.5515    1
1041001  00          1
1041201  003         2332.2    557.00    0 0 0 1
*
**************************************************
*   COMPONENT 105 : JUNCTION BETWEEN INLET       *
*                   ANNULUS AND DOWNCOMER        *
**************************************************
*
1050000  INL-DNCO    SNGLJUN
1050101  104010000   106000000  371.358   0.0    0.0    00000
1050201  1           29531.000  0.0       0.0
*
**************************************************
*   COMPONENT 106 : DOWNCOMER                    *
**************************************************
*
1060000  DOWNCOMR    ANNULUS
1060001  7
1060101  0.0         7
1060301  2.1060      6
1060302  4.1084      7
1060401  56.7903     1
1060402  52.5935     6
1060403  124.619     7
1060601  -90.0       7
1060801  0.00015     1.3855     1
1060802  0.00015     1.2776     6
1060803  0.00015     1.5702     7
1061001  00          7
1061101  20000       6
1061201  003         2332.30    557.00    0 0 0 1
1061202  003         2333.000   557.00    0 0 0 2
1061203  003         2333.6     557.00    0 0 0 3
1061204  003         2334.2     557.00    0 0 0 4
1061205  003         2334.8     557.00    0 0 0 5
1061206  003         2335.4     557.00    0 0 0 6
1061207  003         2326.6     557.00    0 0 0 7
1061300  1
1061301  29531.000   0.0        0.0       6
*
**************************************************
*   COMPONENT 108 : LOWER PLENUM (UPPER VOLUME)  *
**************************************************
*
1080000  LOW-PLEM    BRANCH
1080001  3           1
1080101  0.0   2.0486  243.693  0.0  -90.0  -2.0486  0.00015  5.40124  00
1080200  003         2337.00     557.00
```

```
1081101  106010000  108000000   30.6454    1.3180   1.3180   00000
1082101  110010000  108010000   85.8360    0.0      0.0      00000
1083101  108000000  112000000   31.7180    3.2184   3.2184   00000
1081201  29531.000  0.0         0.0
1082201  0.0        0.0         0.0
1083201  29531.000  0.0         0.0
*
**************************************************
*   COMPONENT 110 : LOWER PLENUM (LOWER VOLUME)   *
**************************************************
*
1100000  LOW-PLEM   SNGLVOL
1100101  0.0   3.777   228.2687  0.0  90.0   3.777   0.00015  2.6400   00
1100200  003        2337.00     557.00
*
**************************************************
*   COMPONENT 112 : CORE INLET                   *
**************************************************
*
1120000  CORE-INL   BRANCH
1120001  2          1
1120101  0.0   4.1084  293.7050  0.0  90.0   4.1084  0.00015  0.1281   00
1120200  003        2328.90     557.00
1121101  112010000  114000000   44.0363    0.1979   0.1979   00000
1122101  112010000  116000000   4.7853     59.4200  59.4200  00000
1121201  28513.000  0.0         0.0
1122201  1018.700    0.0         0.0
*
**************************************************
*  COMPONENT 114 : CORE FLOW CHANNEL             *
**************************************************
*
1140000  CORE       PIPE
1140001  6
1140101  0.0        6
1140301  2.1060     6
1140401  92.7394    6
1140601  90.0       6
1140701  2.1060     6
1140801  0.00015    0.040092   6
1140901  2.8000     2.8000     5
1141001  00         6
1141101  00000      5
1141201  003        2326.3     567.630   0 0 0 1
1141202  003        2321.4     579.320  0 0 0 2
1141203  003        2316.4     591.010  0 0 0 3
1141204  003        2311.3     603.620  0 0 0 4
1141205  003        2306.1     617.210  0 0 0 5
1141206  003        2300.8     624.750  0 0 0 6
1141300  1
```

```
1141301  28513.000  0.0        0.0       5
*
**************************************************
*   COMPONENT 116 : CORE BYPASS CHANNEL          *
**************************************************
*
1160000  BYPASS     PIPE
1160001  6
1160101   0.0      6
1160301  2.1060     6
1160401  38.9608    6
1160601  90.0       6
1160701  2.1060     6
1160801  0.00015    0.0     6
1160901  59.4200    59.4200 5
1161001  00         6
1161101  00000      5
1161201  003        2322.0     557.000  0 0 0 1
1161202  003        2320.9     557.000  0 0 0 2
1161203  003        2319.8     557.000  0 0 0 3
1161204  003        2318.7     557.000  0 0 0 4
1161205  003        2317.6     557.000  0 0 0 5
1161206  003        2316.5     557.000  0 0 0 6
1161300  1
1161301  1018.700    0.0        0.0          5
*
**************************************************
*   COMPONENT 118 : UPPER PLENUM BELOW HOT LEG   *
*                   CENTERLINE (LOWER VOLUME)    *
**************************************************
*
1180000  UP-PLEM    BRANCH
1180001  4          1
1180101  0.0  2.2481  158.2969  0.0  90.0  2.2481  0.00015  0.2936  00
1180200  003        2298.4      621.270
1181101  116010000  118000000   2.9090     59.4200  59.4200  00000
*1181101  116010000  118000000   0.0001     59.4200  59.4200  00000
1182101  114010000  118000000   44.0363    1.4483   1.4483   00000
1183101  130010000  118000000   12.7033    0.0      0.0      00000
1184101  118010000  120000000   75.8606    0.0      0.0      00000
1181201  1018.700    0.0         0.0
*1181201  0.000000    0.0         0.0
1182201  28513.000  0.0         0.0
1183201  438.20    0.0         0.0
1184201  29970.000  0.0         0.0
*
**************************************************
*   COMPONENT 120 : UPPER PLENUM BELOW HOT LEG   *
*                   CENTERLINE (UPPER VOLUME)    *
**************************************************
```

```
*
1200000  UP-PLEM    BRANCH
1200001  3          1
1200101  0.0  3.6128  303.8130  0.0  90.0  3.6128  0.00015  1.7577  00
1200200  003        2297.8      621.270
1201101  120010000  400000000   4.5775     0.04     1.00     00002
1202101  120010000  200000000   9.1549     0.04     1.00     00002
1203101  122010000  120010000   76.7457    0.0      0.0      00000
1201201  10104.00   0.0         0.0
1202201  20208.000  0.0         0.0
1203201  0.0        0.0         0.0
*
**************************************************
*   COMPONENT 122 : UPPER PLENUM ABOVE HOT LEG    *
*                   CENTERLINE                    *
**************************************************
*
1220000  UP-PLEM    SNGLVOL
1220101  0.0  1.8064   154.6250  0.0  -90.0  -1.8064  0.00015 1.7577  00
1220200  003  2297.2   621.27
*
**************************************************
*   COMPONENT 124 : UPPER HEAD (LOWER VOLUME)     *
**************************************************
*
1240000  UP-HEAD    SNGLVOL
1240101  0.0  2.311  154.854  0.0  90.0  2.311  0.00015  1.7327  00
1240200  003        2299.10   557.00
*
**************************************************
*   COMPONENT 126 : UPPER HEAD (MIDDLE VOLUME)    *
**************************************************
*
1260000  UP-HEAD    BRANCH
1260001  4          1
1260101  0.0  3.0117  277.7566  0.0  90.0  3.0117  0.00015  2.3769  00
1260200  003        2298.20     557.00
1261101  100010000  126000000   0.1442     1.52000  1.52000  00000
1262101  124010000  126000000   67.0074    0.0      0.0      00000
1263101  128010000  126010000   72.7028    0.0      0.0      00000
1264101  126010000  130000000   0.5973     1.52     1.52     00100
1261201  438.20    0.0         0.0
1262201  0.0        0.0         0.0
1263201  0.0        0.0         0.0
1264201  438.20    0.0         0.0
*
**************************************************
*   COMPONENT 128 : UPPER HEAD (UPPER VOLUME)     *
**************************************************
*
```

```
1280000  UP-HEAD    PIPE
1280001  2
1280101  0.0        2
1280301  1.4833     2
1280401  40.4626    1
1280402  109.4264   2
1280601  -90.0      2
1280801  0.00015    2.4415     1
1280802  0.00015    4.0476     2
1280901  0.0        0.0        1
1281001  00         2
1281101  00000      1
1281201  003        2297.00    557.00   0 0 0 2
1281300  1
1281301  0.0        0.0        0.0        1
*
**************************************************
*   COMPONENT 130 : GUIDE TUBES                  *
**************************************************
*
1300000  GUIDE      SNGLVOL
1300101  0.0  13.9900. 217.8076  0.0  -90.0  -13.9900  0.00015  0.7455  00
1300200  003        2296.90     557.00
*
*
*-------------------------------------------------*
*             INTACT LOOP PIPINGS                 *
*-------------------------------------------------*
*
*
**************************************************
*   COMPONENT 200 : INTACT LOOP HOT LEG          *
**************************************************
*
2000000  I-HOTLEG   PIPE
2000001  2
2000101  0.0        2
2000301  6.4413     2
2000401  59.0536    2
2000601  0.0        2
2000801  0.00015    2.4167    2
2001001  00         2
2001101  00000      1
2001201  003        2284.4    621.270   0 0 0 2
2001300  1
2001301  20208.000  0.0       0.0       1
*
**************************************************
*   COMPONENT 205 : INTACT LOOP BRANCH           *
*                   BETWEEN HOT LEG SEGMENTS     *
```

```
*                    AND PZR SURGELINE            *
**************************************************
*
2050000  I-HOTLEG   BRANCH
2050001  3          1
2050101  0.0   3.5499  32.5662  0.0  0.0  0.0  0.00015  2.4167  00
2050200  003   2283.7  621.270
2051101  200010000  205000000   0.0  0.0  0.0  00000
2052101  205010000  210000000   0.0  0.0  0.0  00000
2053101  630010000  205000000   0.0  0.0  0.0  00101
2051201 20208.000  0.0         0.0
2052201 20208.000  0.0         0.0
2053201  0.0        0.0         0.0
*2050000  I-HOTJUN   SNGLJUN
*2050101  200010000  210000000   0.0   0.0   0.0   00000
*2050201  1          21734.840   0.0   0.0
*
*
**************************************************
*   COMPONENT 210 : INTACT LOOP HOT LEG          *
**************************************************
*
2100000  I-HOTLEG   PIPE
2100001  2
2100101  0.0        2
2100301  3.5499     1
2100302  3.7973     2
2100401  32.5662    1
2100402  39.8066    2
2100601  0.0        1
2100602  50.0       2
2100701  0.0        1
2100702  2.9087     2
2100801  0.00015    2.4167    1
2100802  0.00015    2.5833    2
*2100901  0.0        0.0       1
2100901  0.07007    0.071929  1
2101001  00         2
2101101  00000      1
*2101102  00000      2
2101201  003        2283.5    621.270     0 0 0 1
2101202  003        2285.0    621.270     0 0 0 2
2101300  1
2101301  20208.000  0.0       0.0       1
*
**************************************************
*   COMPONENT 215 : JUNCTION BETWEEN HOT LEG AND *
*                   STEAM GENERATOR INLET PLENUM *
**************************************************
*
```

```
2150000  I-HOT-SG   SNGLJUN
2150101  210010000  300000000  10.4828  0.7324  0.459   00000
2150201  1          20208.000  0.0      0.0
*
**************************************************
*   COMPONENT 502 : JUNCTION BETWEEN S/G OUTLET   *
*                   PLENUM AND PUMP SUCTION       *
**************************************************
*
3020000  I-SG-SUC   SNGLJUN
3020101  300010000  220000000  10.4828  0.459   0.7324  00000
3020201  1          20208.000  0.0      0.0
*
**************************************************
*   COMPONENT 220 : INTACT LOOP PUMP SUCTION      *
*                   PIPING                        *
**************************************************
*
2200000  I-PMPSUC   PIPE
2200001  5
2200101  0.0        5
2200301  4.8392     1
2200302  4.5283     2
2200303  7.0686     3
2200304  2.5573     4
2200305  7.0686     5
2200401  50.7290    1
2200402  47.4700    2
2200403  74.0992    3
2200404  26.8078    4
2200405  74.0992    5
2200601  -60.0475   1
2200602  -90.0      2
2200603  -39.5402   3
2200604  0.0        4
2200605  39.5402    5
2200801  0.00015    2.5833     5
2200901  0.05645    0.05645    1
2200902  0.0        0.0        2
2200903  0.143      0.143      3
2200904  0.143      0.143      4
2201001  00         5
2201101  00000      2
2201102  00000      4
2201201  003        2243.8     556.6    0 0 0 5
2201300  1
2201301  20208.000  0.0        0.0      4
*
**************************************************
*   COMPONENT 225 : INTACT LOOP RC PUMP           *
```

```
**************************************************
*
2250000  I-PUMP     PUMP
2250101  0.0        9.8458     160.0  0.0   36.182   5.8125   00
2250108  220010000  10.4828    0.0    0.0   00000
2250109  230000000  8.2494     0.0    0.0   00000
2250200  003        2289.6     557.0
2250201  1          20208.000  0.0    0.0
2250202  1          20208.000  0.0    0.0
2250301     -2     -1     -2    -1     -1     509     0
2250302  1188.0   1.0  205600.0  294.0  56000.0  190000.0  46.43  0.0
2250303  1162.16  0.0  1736.06   -399.66
*250310   100.0   1188.0   0.0
*256001   0.0   0.95   716.56   1.15   955.4   1.6
*256002   1079.6   2.08   1162.7   2.53   1188.0   1.0
*256003   1200.0   0.0   1239.6   -2.62   1442.6   -1.87
*256004   1681.5   -1.32   2159.2   -1.0   2398.1   -0.95
*256005   3000.0   -0.94
  *
*
**************************************************
*   COMPONENT 230 : INTACT LOOP COLD LEG FROM     *
*                   PUMP DISCHARGE TO             *
*                   ACCUMULATOR LINE / BREAK      *
**************************************************
*
2300000  I-COLDLG   PIPE
2300001  2
2300101  8.2494     2
2300301  4.4073     2
2300401  0.0        2
2300601  0.0        2
2300801  0.00015    2.2917    2
2301001  00         2
2301101  00000      1
2301201  003        2321.60   557.00     0 0 0 2
2301300  1
2301301  20208.000  0.0       0.0        1
*
**************************************************
*   COMPONENT 240 : INTACT LOOP COLD LEG FROM     *
*                   ACCUMULATOR LINE / BREAK      *
*                   TO SI LINE                    *
**************************************************
*
2400000  I-COLDLG   BRANCH
2400001  2          1
2400101  8.2494     3.6833  0.0   0.0   0.0   0.0   0.00015   2.2917  00
2400200  003        2321.60       557.00
2401101  230010000  240000000     8.2494    0.0   0.0   00000
```

```
2402101  240010000  252000000     8.2494    0.0   0.0   00000
2401201  20208.000  0.0           0.0
2402201  20208.000  0.0           0.0
*
*****************************************************
*   COMPONENT 252 : INTACT LOOP COLD LEG FROM      *
*                   SI LINE TO VESSEL              *
*****************************************************
*
2520000  I-COLDLG   PIPE
2520001  2
2520101  0.0        2
2520301  6.5969     2
2520401  54.4204    1
2520402  64.4660    2
2520601  0.0        2
2520801  0.00015    2.2917     1
2520802  0.00015    2.4942     2
2521001  00         2
2521101  00000      1
2521201  003        2320.7     557.00    0 0 0 2
2521300  1
2521301  20208.000  0.0        0.0       1
*
*****************************************************************
*  COMPONENT 300; INTACT STEAM GENERATOR TUBES                  *
*****************************************************************
3000000   BSGTBS   PIPE
3000001   10
3000101   0.0   01
3000102  21.550 09
3000103   0.0   10
3000301   4.0095  1
3000302   7.20    9
3000303   4.0095  10
3000401   284.52   1
3000402   0.000    9
3000403   284.52   10
3000601   90.   4
3000602   61.733  5
3000603  -61.733  6
3000604  -90.   10
3000801   0.00015 6.72127 1
3000802   0.00000 0.0505  9
3000803   0.00015 6.72127 10
3001001   00   10
3001101   00100   1
3001102   00000   8
3001103   00100   9
3001201   3   2286.3    620.64   0.0   0   0   1
```

```
3001202   3   2279.7  607.44   0.0   0 0 2
3001203   3   2273.8  593.99   0.0   0 0 3
3001204   3   2267.8  584.00   0.0   0 0 4
3001205   3   2262.0  575.96   0.0   0 0 5
3001206   3   2258.3  569.56   0.0   0 0 6
3001207   3   2256.8  564.30   0.0   0 0 7
3001208   3   2255.4  559.78   0.0   0 0 8
3001209   3   2254.1  556.71   0.0   0 0 9
3001210   3   2255.0  556.71   0.0   0 0 10
3001300   1
3001301   20208.000  0.0   0.0   9
*************************************************************
*  COMPONENT 340; INTACT STEAM GENERATOR RISER              *
*************************************************************
3400000   "ISG-RSR"  PIPE
3400001   5
3400101   0.0    5
3400201   43.94     3
3400202    0.0      4
3400301   5.43    1
3400302   7.20    3
3400303   6.34    4
3400304   12.22   5
3400401   615.12   1
3400402   787.56   3
3400403   740.96   4
3400404   1548.8   5
3400601   90.     5
3400801   1.5E-4   0.0908    4
3400802   1.5E-4   10.25     5
3400901   0.5   0.5   4
3401001   00   5
3401101   10100   4
3401201   2    975.7  2.736E-2   0.0    0   0   1
3401202   2    974.4  8.294E-2   0.0    0   0   2
3401203   2    973.1  0.13707    0.0    0   0   3
3401204   2    972.1  0.23046    0.0    0   0   4
3401205   2    971.4  0.22785    0.0    0   0   5
3401301   2.5693     4.2873  0.0   1
3401302   4.3156     6.9725  0.0   2
3401303   5.9254     9.4081  0.0   3
3401304   8.5445     10.559  0.0   4
*************************************************************
*  COMPONENT 350; INTACT STEAM GENERATOR SEPERATOR          *
*************************************************************
3500000   "ISGS SPR"   SEPARATR
3500001   3
3500101   0.0   6.69  2050.0  0.0  90.  6.69  1.5E-4  1.625   00
3500200   2   970.43   3.60460E-2
3501101   350010000   360000000   58.56  15.0 15.0 11000 0.15
```

```
3502101   350000000   330000000   8.42   0.1  0.1  21000 0.15
3503101   340010000   350000000   66.36  0.1  0.1  11000
3501201   7.1844  18.267  0.0
3502201   15.994 -24.970  0.0
3503201   14.866    18.851     0.0
*************************************************************
*  COMPONENT 360; INTACT STEAM GENERATOR STEAM DOME/DRYER      *
*************************************************************
3600000   "ISG DOME"    PIPE
3600001   3
3600101   0.0     2
3600102   9.86    3
3600201   2.8     2
3600301   9.79    1
3600302   5.29    2
3600303   137.0   3
3600401   3078.0  1
3600402   800.0   2
3600403   0.0     3
3600601   90.0    2
3600602   0.0     3
3600801   1.5E-4   14.0    2
3600802   1.5E-4   2.505   3
3600901   0.0      0.0     2
3601001   00       3
3601101   10000     2
3601201   2     968.56  0.99974   0.0     0  0  1
3601202   2     968.44  0.99954   0.0     0  0  2
3601203   2     964.81  0.99890   0.0     0  0  3
3601301   333.87       382.69   0.0   1
3601302   271.78       382.76   0.0   2
*************************************************************
*  COMPONENT 330; INTACT STEAM GENERATOR DOWNCOMER             *
*************************************************************
3300000   "ISGS DWN"   PIPE
3300001   5
3300101   0.0     5
3300201   15.54    1
3300202   13.46    2
3300203   13.98    3
3300204   12.72    4
3300301   12.22    1
3300302   6.34     2
3300303   7.20     4
3300304   5.43     5
3300401   991.2    1
3300402   99.04    2
3300403   112.44   4
3300404   84.88    5
3300601   -90.   5
```

```
3300801   1.5E-4    2.1104   1
3300802   1.5E-4    0.469    5
3301001   00   5
3301101   20000   1
3301102   20100   4
3301201   3    972.9   515.20   0.   0  0  1
3301202   3    975.3   515.21   0.   0  0  2
3301203   3    977.4   515.22   0.   0  0  3
3301204   3    979.6   515.23   0.   0  0  4
3301205   3    981.4   515.24   0.   0  0  5
3301301   11.463   11.463  0.0    1
3301302   11.406   11.406  0.0    2
3301303   11.406   11.406  0.0    4
*****************************************************************
*  COMPONENT 331; INTACT STEAM GEN DOWNCOMER TO RISER JUNCTION  *
*****************************************************************
3310000   ISGSDRSR   SNGLJUN
3310101   330010000   340000000  14.48  8.71 8.71 00100
3310201   0  11.515    14.399   0.0
*****************************************************************
*  COMPONENT 321; INTACT STEAM GENERATOR MAIN FEEDWATER JUNCTION*
*****************************************************************
3210000   "I MNFEED"   TMDPJUN
3210101   320000000   330000000   0.60
3210200   1      507
3210201   0.0  67.60    0.0      0.0
3210202   100.0    67.60   0.0   0.0
3210203   5000.00    67.60   0.0   0.0
*****************************************************************
*  COMPONENT 320; INTACT STEAM GEN MAIN FEEDWATER SOURCE VOLUME *
*****************************************************************
3200000   "I MNFEED"   TMDPVOL
3200101   2000. 1.0   0.0   0.0   0.0   0.0   0.0  50.0   00
3200200   3
3200201   0.0   1025.7   440.000
*****************************************************************
*  COMPONENT 370; INTACT LOOP STEAM LINE ( M S I V )            *
*****************************************************************
3700000   "IMAINSTM"  VALVE
3700101   360010000  565000000   9.86   0.0  0.0  00100
3700201   1   0.0     10.0        0.0
3700300   MTRVLV
3700301   507   506   0.20    1.0
*-----------------------------------------------*
*            BROKEN LOOP PIPINGS                *
*-----------------------------------------------*
*
*
*************************************************
*   COMPONENT 400 : BROKEN LOOP HOT LEG         *
```

```
**************************************************
*
4000000  B-HOTLEG   PIPE
4000001  2
4000101  0.0        2
4000301  6.4413     2
4000401  29.5286    2
4000601  0.0        2
4000801  0.00015    2.4167    2
4001001  00         2
4001101  00000      1
4001201  003        2284.4    621.270     0 0 0 2
4001300  1
4001301 10104.00   0.0       0.0       1
*
**************************************************
*   COMPONENT 405 : BROKEN LOOP JUNCTION        *
*                   BETWEEN HOT LEG SEGMENTS    *
**************************************************
*
4050000  B-HOTJUN   SNGLJUN
4050101  400010000  410000000   0.0   0.0   0.0   00000
4050201  1         10104.00    0.0   0.0
*
**************************************************
*   COMPONENT 410 : BROKEN LOOP HOT LEG         *
**************************************************
*
4100000  B-HOTLEG   PIPE
4100001  3
4100101  0.0        3
4100301  3.5499     2
4100302  3.7973     3
4100401  16.2831    2
4100402  19.9033    3
4100601  0.0        2
4100602  50.0       3
4100701  0.0        2
4100702  2.9087     3
4100801  0.00015    2.4167    2
4100802  0.00015    2.5833    3
4100901  0.0        0.0       1
4100902  0.07007    0.071929  2
4101001  00         3
4101101  00000      1
4101102  00000      2
4101201  003        2283.7    621.270     0 0 0 2
4101202  003        2283.5    621.270     0 0 0 3
4101300  1
4101301 10104.00   0.0       0.0       2
```

```
*
**************************************************
*   COMPONENT 415 : JUNCTION BETWEEN HOT LEG AND  *
*                   STEAM GENERATOR INLET PLENUM  *
**************************************************
*
4150000  B-HOT-SG   SNGLJUN
4150101  410010000  500000000  5.2414  0.7324  0.459   00000
4150201  1         10104.00   0.0     0.0
*
**************************************************
*   COMPONENT 502 : JUNCTION BETWEEN S/G OUTLET   *
*                   PLENUM AND PUMP SUCTION       *
**************************************************
*
5020000  B-SG-SUC   SNGLJUN
5020101  500010000  420000000  5.2414  0.459   0.7324  00000
5020201  1         10104.00   0.0     0.0
*
**************************************************
*   COMPONENT 420 : BROKEN LOOP PUMP SUCTION      *
*                   PIPING                        *
**************************************************
*
4200000  B-PMPSUC   PIPE
4200001  5
4200101  0.0        5
4200301  4.8392     1
4200302  4.5283     2
4200303  7.0686     3
4200304  2.5573     4
4200305  7.0686     5
4200401  25.3645    1
4200402  23.7350    2
4200403  37.0496    3
4200404  13.4039    4
4200405  37.0496    5
4200601  -60.0475   1
4200602  -90.0      2
4200603  -39.5402   3
4200604  0.0        4
4200605  39.5402    5
4200801  0.00015    2.5833     5
4200901  0.05645    0.05645    1
4200902  0.0        0.0        2
4200903  0.143      0.143      3
4200904  0.143      0.143      4
4201001  00         5
4201101  00000      2
4201102  00000      4
```

```
4201201  003        2243.8     556.6    0 0 0 5
4201300  1
4201301 10104.00   0.0        0.0      4
*
**************************************************
*   COMPONENT 425 : BROKEN LOOP RC PUMP          *
**************************************************
*
4250000  B-PUMP     PUMP
4250101  0.0        9.8458     80.0   0.0   36.182   5.8125   00
4250108  420010000  5.2414     0.0    0.0   00000
4250109  430000000  4.1247     0.0    0.0   00000
4250200  003        2289.6     557.0
4250201  1         10104.00   0.0    0.0
4250202  1         10104.00   0.0    0.0
4250301     -2     -1     -2    -1     -1     509     0
4250302  1188.0   1.0  102800.0  294.0   28000.0  190000.0  46.43  0.0
4250303  581.08   0.0  868.03    -199.83
***********************
*   COMPONENT 430 : BROKEN LOOP COLD LEG FROM    *
*                   PUMP DISCHARGE TO            *
*                   ACCUMULATOR LINE / BREAK     *
**************************************************
*
4300000  B-COLDLG   PIPE
4300001  2
4300101  4.1247     2
4300301  4.4073     2
4300401  0.0        2
4300601  0.0        2
4300801  0.00015    2.2917    2
4301001  00         2
4301101  00000      1
4301201  003        2321.60   557.00     0 0 0 2
4301300  1
4301301 10104.00   0.0       0.0        1
*
**************************************************
*   COMPONENT 440 : BROKEN LOOP COLD LEG FROM    *
*                   ACCUMULATOR LINE / BREAK     *
*                   TO SI LINE                   *
**************************************************
*
4400000  B-COLDLG   BRANCH
4400001  2          1
4400101  4.1247  3.6833  0.0   0.0   0.0   0.0   0.00015   2.2917  00
4400200  003        2321.10       557.00
4401101  430010000  440000000     4.1247    0.0   0.0   00000
4402101  440010000  452000000     4.1247    0.0   0.0   00000
4401201 10104.00   0.0           0.0
```

```
4402201 10104.00   0.0          0.0
*
**************************************************
*   COMPONENT 452 : BROKEN LOOP COLD LEG FROM    *
*                   SI LINE TO VESSEL            *
**************************************************
*
4520000  B-COLDLG   PIPE
4520001  2
4520101  0.0        2
4520301  6.5969     2
4520401  27.2102    1
4520402  32.2330    2
4520601  0.0        2
4520801  0.00015    2.2917     1
4520802  0.00015    2.4942     2
4521001  00         2
4521101  00000      1
4521201  003        2320.7     557.00    0 0 0 2
4521300  1
4521301 10104.00   0.0        0.0       1
*
*****************************************************************
*  COMPONENT 500; BROKEN STEAM GENERATOR TUBES                  *
*****************************************************************
5000000   BSGTBS   PIPE
5000001   10
5000101   0.0   01
5000102  10.776 09
5000103   0.0   10
5000301   4.0095  1
5000302   7.20    9
5000303   4.0095  10
5000401   142.26   1
5000402   0.000    9
5000403   142.26   10
5000601   90.   4
5000602   61.733  5
5000603  -61.733  6
5000604  -90.   10
5000801   0.00015 6.72127 1
5000802   0.00000 0.0505  9
5000803   0.00015 6.72127 10
5001001   00   10
5001101   00100   1
5001102   00000   8
5001103   00100   9
5001201   3   2286.30   620.64   0.0   0   0   1
5001202   3   2279.7  607.44   0.0   0 0 2
5001203   3   2273.8  593.99   0.0   0 0 3
```

```
5001204   3   2267.8  584.01   0.0   0 0 4
5001205   3   2262.0  575.96   0.0   0 0 5
5001206   3   2258.3  569.56   0.0   0 0 6
5001207   3   2256.8  564.30   0.0   0 0 7
5001208   3   2255.4  559.78   0.0   0 0 8
5001209   3   2254.1  556.71   0.0   0 0 9
5001210   3   2255.0  556.71   0.0   0 0 10
5001300   1
5001301  10104.00   0.0   0.0   9
*****************************************************************
*  COMPONENT 540; BROKEN STEAM GENERATOR RISER                  *
*****************************************************************
5400000   "BSG-RSR"  PIPE
5400001   5
5400101   0.0    5
5400201   21.97     3
5400202    0.0      4
5400301   5.43    1
5400302   7.20    3
5400303   6.34    4
5400304   12.22   5
5400401   307.56   1
5400402   393.78   3
5400403   370.48   4
5400404   774.4    5
5400601   90.     5
5400801   1.5E-4   0.0908    4
5400802   1.5E-4   10.25     5
5400901   0.5   0.5   4
5401001   00   5
5401101   10100   4
5401201   2    975.7  2.736E-2   0.0    0   0   1
5401202   2    974.4  8.294E-2   0.0    0   0   2
5401203   2    973.1  0.13707    0.0    0   0   3
5401204   2    972.1  0.23046    0.0    0   0   4
5401205   2    971.4  0.22785    0.0    0   0   5
5401301   2.5693     4.2873  0.0   1
5401302   4.3156     6.9725  0.0   2
5401303   5.9254     9.4081  0.0   3
5401304   8.5445     10.559  0.0   4
*****************************************************************
*  COMPONENT 550; BROKEN STEAM GENERATOR SEPERATOR              *
*****************************************************************
5500000   "BSGS SPR"   SEPARATR
5500001   3
5500101   0.0   6.69  1025.0  0.0  90.  6.69  1.5E-4  1.625   00
5500200   2   970.43   3.60460E-2
5501101   550010000   560000000   29.28  15.0 15.0 11000 0.15
5502101   550000000   530000000   4.21   0.1  0.1  21000 0.15
5503101   540010000   550000000   33.18  0.1  0.1  11000
```

```
5501201   7.1844  18.267  0.0
5502201   15.994 -24.970  0.0
5503201   14.866    18.851     0.0
*************************************************************
*  COMPONENT 560; BROKEN STEAM GENERATOR STEAM DOME/DRYER      *
*************************************************************
5600000   "BSG DOME"    PIPE
5600001   3
5600101   0.0     2
5600102   4.93    3
5600201   1.4     2
5600301   9.79    1
5600302   5.29    2
5600303   137.0   3
5600401   1539.0  1
5600402   400.0   2
5600403   0.0     3
5600601   90.0    2
5600602   0.0     3
5600801   1.5E-4   14.0    2
5600802   1.5E-4   2.505   3
5600901   0.0      0.0     2
5601001   00       3
5601101   10000     2
5601201   2     968.56  0.99974   0.0     0  0  1
5601202   2     968.44  0.99954   0.0     0  0  2
5601203   2     964.81  0.99890   0.0     0  0  3
5601301   333.87       382.69   0.0   1
5601302   271.78       382.76   0.0   2
*************************************************************
*  COMPONENT 530; BROKEN STEAM GENERATOR DOWNCOMER             *
*************************************************************
5300000   "BSGS DWN"   PIPE
5300001   5
5300101   0.0     5
5300201   7.77     1
5300202   6.73     2
5300203   6.99     3
5300204   6.36     4
5300301   12.22    1
5300302   6.34     2
5300303   7.20     4
5300304   5.43     5
5300401   495.6    1
5300402   49.52    2
5300403   56.22    4
5300404   42.44    5
5300601   -90.   5
5300801   1.5E-4    2.1104   1
5300802   1.5E-4    0.469    5
```

```
5301001   00   5
5301101   20000   1
5301102   20100   4
5301201   3    972.9   515.20   0.   0  0  1
5301202   3    975.3   515.21   0.   0  0  2
5301203   3    977.4   515.22   0.   0  0  3
5301204   3    979.6   515.23   0.   0  0  4
5301205   3    981.4   515.24   0.   0  0  5
5301301   11.463   11.463  0.0    1
5301302   11.406   11.406  0.0    2
5301303   11.406   11.406  0.0    4
*****************************************************************
*  COMPONENT 531; BROKEN STEAM GEN DOWNCOMER TO RISER JUNCTION  *
*****************************************************************
5310000   BSGSDRSR   SNGLJUN
5310101   530010000   540000000   7.24  8.71 8.71 00100
5310201   0  11.515    14.399   0.0
*****************************************************************
*  COMPONENT 521; BROKEN STEAM GENERATOR MAIN FEEDWATER JUNCTION*
*****************************************************************
5210000   "B MNFEED"   TMDPJUN
5210101   520000000   530000000   0.30
5210200   1     507
5210201   0.0   33.8      0.0   0.0
5210202   100.0     33.8  0.0   0.0
5210203   5000.0      33.8    0.0   0.0
*****************************************************************
*  COMPONENT 520; BROKEN STEAM GEN MAIN FEEDWATER SOURCE VOLUME *
*****************************************************************
5200000   "B MNFEED"   TMDPVOL
5200101   1000. 1.0   0.0   0.0   0.0   0.0   0.0  50.0   00
5200200   3
5200201   0.0   1025.7   440.000
*****************************************************************
*  COMPONENT 570; BROKEN LOOP STEAM LINE ( M S I V )            *
*****************************************************************
5700000   "BMAINSTM"  VALVE
5700101   560010000  565000000   4.93   0.0  0.0  00100
5700201   1    0.0    5.0         0.0
5700300   MTRVLV
5700301   507   506   0.20    1.0
*
*-----------------------------------------------*
*                 PRESSURIZER                   *
*-----------------------------------------------*
*
*
*************************************************
*   COMPONENT *620 : PRESSURIZER VESSEL         *
*************************************************
```

```
*
*200000  PZR        PIPE
*200001  8
*200101  0.0        8
*200301  5.3036     1
*200302  3.8977     2
*200303  5.1969     6
*200304  3.8977     7
*200305  5.3036     8
*200401  150.00     2
*200402  200.00     6
*200403  150.00     8
*200601  90.000     8
*200801  0.00015    6.0009     1
*200802  0.00015    7.0000     7
*200803  0.00015    6.0009     8
*200901  0.0        0.0        7
*201001  00         8
*201101  00000      7
*201201  002        2250.0     1.0   0 0 0 3
*201202  002        2250.0     0.3   0 0 0 4
*201203  002        2250.0     0.0   0 0 0 8
*201300  1
*201301  0.0        0.0        0.0       7
6200000   PZR-STDY   TMDPVOL
6200101  0.0  1.0  100.0  0.0  0.0  0.0  0.0  0.0  00
6200200  003  0
6200201  0.0  2262.45   621.271
6200202   60.0   2263.16   621.271
6200203   120.0   2263.16   621.271
6200204   180.0   2261.02   621.27
6200205   240.0   2260.31   621.27
6200206   300.0   2258.89   621.27
6200207   360.0   2255.33   621.27
6200208   420.0   2253.91   621.27
6200209   480.0   2251.07   621.27
6200210   540.0   2244.67   621.27
6200211   600.0   2237.55   621.27
6200212   660.0   2211.95   621.27
6200213   720.0   2208.39   621.27
6200214   780.0   2222.62   621.27
6200215   840.0   2224.75   621.27
6200216   900.0   2231.86   621.27
6200217   960.0   2211.24   621.27
6200218   1020.0  2212.66   621.27
6200219   1080.0  2211.95   621.27
6200220   1140.0  2214.79   621.27
6200221   1200.0  2219.79   621.27
6200222   1260.0  2223.33   621.27
6200223   1320.0  2224.75   621.27
```

```
6200224   1380.0  2226.17   621.27
6200225   1440.0  2227.60   621.27
6200226   1500.0  2223.33   621.27
6200227   1560.0  2220.48   621.27
6200228   1620.0  2217.64   621.27
6200229   1680.0  2227.60   621.27
6200230   1740.0  2230.44   621.27
*
**************************************************
*   COMPONENT 625 : JUNCTION BETWEEN PRESSURIZER  *
*                   AND SURGELINE                 *
**************************************************
*
6250000  PRZ-JUN    SNGLJUN
6250101  620000000  630000000   0.0   0.0   0.0   00100
6250201  1          0.0         0.0   0.0
*
**************************************************
*   COMPONENT 630 : PRESSURIZER SURGE-LINE       *
**************************************************
*
6300000  PZR-SUR    PIPE
6300001  3
6300101  1.0690     3
6300301  13.00      1
6300302  22.0129    3
6300601  -90.0      1
6300602  0.0        3
6300801  0.00015    1.167    3
6301001  00         3
6301101  00000      1
6301102  00000      2
6301201  003        2281.9   621.270    0 0 0 3
6301300  1
6301301  0.0        0.0      0.0      2
*
**************************************************
*   COMPONENT 635 : JUNCTION BETWEEN SURGELINE    *
*                   TO  INTACT LOOP HOT LEG       *
**************************************************
*
*6350000  SUR-HOT    SNGLJUN
*6350101  630010000  200000000   0.0   0.0   0.0   00100
*6350201  1          0.0         0.0   0.0
*
*
*************************************************************
*       HEAT STRUCTURE INPUT                                *
*************************************************************
*-----------------------------------------------------*
```

```
*  HEAT STRUCTURE 100 : REACTOR VESSEL WALL IN          *
*                       DOWNCOMDER ANNULAR REGION       *
*-------------------------------------------------------*
*
11000000  4       8       2       1       6.4792
11000100  0       1
11000101  2       6.4925
11000102  5       7.2772
11000201  5       2
11000202  6       7
11000301  0.0     7
11000400  0
11000401  557.00  8
11000501  100010000   0   1   1     1.8014    1
11000502  100020000   0   1   1     3.3114    2
11000503  102010000   0   1   1     3.6128    3
11000504  104010000   0   1   1     2.2486    4
11000601  0           0   0   1     1.8014    1
11000602  0           0   0   1     3.3114    2
11000603  0           0   0   1     3.6128    3
11000604  0           0   0   1     2.2486    4
11000701  0           0.0     0.0000    0.0   4
11000801  0           0.0     2.7895    0.0   1
11000802  0           0.0     1.6058    0.0   2
11000803  0           0.0     2.7895    0.0   3
11000804  0           0.0     2.6410    0.0   4
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 102 : CORE BARREL WALL                *
*-------------------------------------------------------*
*
11020000   11   3   2   1    5.5729
11020100   0    1
11020101   2    5.7396
11020201   5    2
11020301   0.0  2
11020400   0
11020401   557.00   3
11020501   112010000    0    1    1     4.1084    1
11020502   116010000    0    1    1     2.1060    2
11020503   116020000    0    1    1     2.1060    3
11020504   116030000    0    1    1     2.1060    4
11020505   116040000    0    1    1     2.1060    5
11020506   116050000    0    1    1     2.1060    6
11020507   116060000    0    1    1     2.1060    7
11020508   118010000    0    1    1     2.2481    8
11020509   120010000    0    1    1     3.6128    9
11020510   122010000    0    1    1     1.8064    10
11020511   0            0    0    1     3.3114    11
11020601   106070000    0    1    1     4.1084    1
```

```
11020602   106060000   0    1    1     2.1060   2
11020603   106050000   0    1    1     2.1060   3
11020604   106040000   0    1    1     2.1060   4
11020605   106030000   0    1    1     2.1060   5
11020606   106020000   0    1    1     2.1060   6
11020607   106010000   0    1    1     2.1060   7
11020608   104010000   0    1    1     2.2481   8
11020609   102010000   0    1    1     3.6128   9
11020610   100010000   0    1    1     1.8064   10
11020611   100020000   0    1    1     3.3114   11
11020701   0    0.0    0.0000   0.0     11
11020801   0    0.0   10.6784   0.0     1
11020802   0    0.0    2.1134   0.0     7
11020803   0    0.0    8.6659   0.0     10
11020804   0    0.0    0.0000   0.0     11
11020901   0    0.0    3.3545   0.0     1
11020902   0    0.0    2.7700   0.0     6
11020903   0    0.0    2.9910   0.0     7
11020904   0    0.0    3.3120   0.0     8
11020905   0    0.0    2.4540   0.0     9
11020906   0    0.0    3.1489   0.0     10
11020907   0    0.0    1.8127   0.0     11
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 106 : REACTOR VESSEL WALL IN        *
*                       THE INLET ANNULUS             *
*-----------------------------------------------------*
*
11060000   7    8    2    1    6.5417
11060100   0    1
11060101   2    6.5550
11060102   5    7.2117
11060201   5    2
11060202   6    7
11060301   0.0  7
11060400   0
11060401   557.00       8
11060501   106010000   0    1    1     2.1060   1
11060502   106020000   0    1    1     2.1060   2
11060503   106030000   0    1    1     2.1060   3
11060504   106040000   0    1    1     2.1060   4
11060505   106050000   0    1    1     2.1060   5
11060506   106060000   0    1    1     2.1060   6
11060507   106070000   0    1    1     4.1084   7
11060601   0           0    0    1     2.1060   1
11060602   0           0    0    1     2.1060   2
11060603   0           0    0    1     2.1060   3
11060604   0           0    0    1     2.1060   4
11060605   0           0    0    1     2.1060   5
11060606   0           0    0    1     2.1060   6
```

```
11060607   0            0     0    1      4.1084    7
11060701   0            0.0     0.0000    0.0       7
11060801   0            0.0     2.6243    0.0       1
11060802   0            0.0     2.4304    0.0       6
11060803   0            0.0     2.9519    0.0       7
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 107 : NEUTRON PANEL ASSEMBLY        *
*                       IN DOWNCOMER                  *
*-----------------------------------------------------*
*
11070000   6    4    1    1    0.000
11070100   0    1
11070101   3    0.3825
11070201   5    3
11070301   0.0  3
11070400   0
11070401   557.00       4
11070501   106010000    0    1    1      43.8333    1
11070502   106020000    0    1    1      65.7766    2
11070503   106030000    0    1    1      65.7766    3
11070504   106040000    0    1    1      65.7766    4
11070505   106050000    0    1    1      65.7766    5
11070506   106060000    0    1    1      65.7766    6
11070601   106010000    0    1    1      43.8333    1
11070602   106020000    0    1    1      65.7766    2
11070603   106030000    0    1    1      65.7766    3
11070604   106040000    0    1    1      65.7766    4
11070605   106050000    0    1    1      65.7766    5
11070606   106060000    0    1    1      65.7766    6
11070701   0        0.0     0.0000    0.0    6
11070801   0        0.0     3.4535    0.0    1
11070802   0        0.0     3.1983    0.0    6
11070901   0        0.0     3.4535    0.0    1
11070902   0        0.0     3.1983    0.0    6
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 108 : VESSEL WALL IN                *
*                       LOW PLENUM REGION             *
*-----------------------------------------------------*
*
11080000   2     6     3     1     6.5908
11080100   0     1
11080101   2     6.6092
11080102   3     7.0208
11080201   5     2
11080202   6     5
11080301   0.0   5
11080400   0
11080401   557.00       6
```

```
11080501   108010000    0    1    1      0.1554    1
11080502   110010000    0    1    1      0.2866    2
11080601   0            0    0    1      0.1554    1
11080602   0            0    0    1      0.2866    2
11080701   0     0.0    0.0       0.0     2
11080801   0     0.0    0.0       0.0     2
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 110 : LOWER PLENUM/CORE INLET       *
*                       VOLUME INTERNALS              *
*-----------------------------------------------------*
*
11100000   3    3    1    1    0.0000
11100100   0    1
11100101   2    0.1218
11100201   5    2
11100301   0.0  2
11100400   0
11100401   557.00      3
11100501   110010000   0    1    1    114.7142    1
11100502   108010000   0    1    1     62.2150    2
11100503   112010000   0    1    1    124.7717    3
11100601   110010000   0    1    1    114.7142    1
11100602   108010000   0    1    1     62.2150    2
11100603   112010000   0    1    1    124.7717    3
11100701   0       0.0      0.0000      0.0000    3
11100801   0       0.0      5.0274      0.0000    1
11100802   0       0.0      9.9978      0.0000    2
11100803   0       0.0      4.6385      0.0000    3
11100901   0       0.0      5.0274      0.0000    1
11100902   0       0.0      9.9978      0.0000    2
11100903   0       0.0      4.6385      0.0000    3
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 111 : LOWER CORE SUPPORT PLATE      *
*-----------------------------------------------------*
*
11110000   1    6    1    1    0.0000
11110100   0    1
11110101   5    0.4162
11110201   5    5
11110301   0.0  5
11110400   0
11110401   557.00      6
11110501   108010000   0    1    1   196.8048    1
11110601   112010000   0    1    1   196.8048    1
11110701   0         0.0     0.000      0.0000    1
11110801   0         0.0     0.7118     0.0000    1
11110901   0         0.0     0.7118     0.0000    1
*
```

```
*-------------------------------------------------------*
*  HEAT STRUCTURE 113 : LOWER CORE PLATE AND FUEL       *
*                       ASSEMBLY BOTTOM NOZZLES         *
*-------------------------------------------------------*
*
11130000   1      3      1      1      0.0000
11130100   0      1
11130101   2      0.0543
11130201   5      2
11130301   0.0    2
11130400   0
11130401   557.00        3
11130501   112010000     0    1    1    267.0491    1
11130601   112010000     0    1    1    267.0491    1
11130701   0        0.0        0.0000      0.0000    1
11130801   0        0.0        0.0513      0.0000    1
11130901   0        0.0        0.0513      0.0000    1
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 116 : CORE BAFFLE ASSEMBLY            *
*-------------------------------------------------------*
*
11160000   6      3      2      1      7.0209
11160100   0      1
11160101   2      7.1195
11160201   5      2
11160301   0.0    2
11160400   0
11160401   557.00        3
11160501   114010000     0    1    1    2.1060     1
11160502   114020000     0    1    1    2.1060     2
11160503   114030000     0    1    1    2.1060     3
11160504   114040000     0    1    1    2.1060     4
11160505   114050000     0    1    1    2.1060     5
11160506   114060000     0    1    1    2.1060     6
11160601   116010000     0    1    1    2.1060     1
11160602   116020000     0    1    1    2.1060     2
11160603   116030000     0    1    1    2.1060     3
11160604   116040000     0    1    1    2.1060     4
11160605   116050000     0    1    1    2.1060     5
11160606   116060000     0    1    1    2.1060     6
11160701   0        0.0        0.0000      0.0000    6
11160801   0        0.0        4.1593      0.0000    6
11160901   0        0.0        1.5093      0.0000    6
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 118 : UPPER CORE PLATE AND FUEL       *
*                       ASSEMBLY TOP NOZZLES            *
*-------------------------------------------------------*
*
```

```
11180000   1      3      1      1      0.0
11180100   0      1
11180101   2      0.0879
11180201   5      2
11180301   0.0    2
11180400   0
11180401   618.90        3
11180501   118010000     0     1     1     227.8132     1
11180601   118010000     0     1     1     227.8132     1
11180701   0        0.0        0.0000       0.0000     1
11180801   0        0.0        0.0913       0.0000     1
11180901   0        0.0        0.0913       0.0000     1
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 121 : UPPER CORE SUPPORT COLUMNS      *
*-------------------------------------------------------*
*
11210000   3      4      2      1      0.0
11210100   0      1
11210101   3      0.1630
11210201   5      3
11210301   0.0    3
11210400   0
11210401   618.00        4
11210501   0             0      0      1      72.2567     1
11210502   0             0      0      1     144.5133     2
11210503   0             0      0      1      62.2300     3
11210601   122010000     0      1      1      72.2567     1
11210602   120010000     0      1      1     144.5133     2
11210603   118010000     0      1      1      62.2300     3
11210701   0        0.0        0.0000       0.0000     3
11210901   0        0.0        7.4958       0.0000     3
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 122 : GUIDE TUBE LOWER ASSEMBLY WALL  *
*-------------------------------------------------------*
*
11220000   3     3     2     1     0.3216
11220100   0     1
11220101   2     0.3652
11220201   5     2
11220301   0.0   2
11220400   0
11220401   587.00        3
11220501   130010000     0     1     1      93.9337     1
11220502   130010000     0     1     1     187.8673     2
11220503   130010000     0     1     1      80.8990     3
11220601   122010000     0     1     1      93.9337     1
11220602   120010000     0     1     1     187.8673     2
11220603   118010000     0     1     1      80.8990     3
```

```
11220701   0        0.0        0.0000       0.0000    3
11220801   0        0.0        0.0000       0.0000    3
11220901   0        0.0        1.4094       0.0000    3
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 123 : SUPPORT PLATE PORTION OF UPPER  *
*                       CORE SUPPORT ASSEMBLY           *
*-------------------------------------------------------*
*
11230000   1     5     1     1     0.0
11230100   0     1
11230101   4     0.4794
11230201   5     4
11230301   0.0   4
11230400   0
11230401   587.00        5
11230501   122010000     0    1    0    138.8635    1
11230601   124010000     0    1    0    138.8635    1
11230701   0        0.0000     0.0       0.0000    1
11230801   0       11.0900     0.0       0.0000    1
11230901   0       10.6733     0.0       0.0000    1
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 124 : GUIDE TUBE UPPER ASSEMBLY WALL  *
*-------------------------------------------------------*
*
11240000   2     3     2     1     0.3166
11240100   0     1
11240101   2     0.3708
11240201   5     2
11240301   0.0   2
11240400   0
11240401   557.00        3
11240501   130010000     0    1    1    120.1720    1
11240502   130010000     0    1    1    156.6067    2
11240601   124010000     0    1    1    120.1720    1
11240602   126010000     0    1    1    156.6067    2
11240701   0        0.0        0.0000       0.0000    2
11240801   0        0.0        0.0000       0.0000    2
11240901   0        0.0        2.2122       0.0000    1
11240902   0        0.0        3.0448       0.0000    2
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 125 : CYLINDRICAL PORTION OF UPPER    *
*                       CORE SUPPORT ASSEMBLY           *
*-------------------------------------------------------*
*
11250000   1     3     2     1     5.3367
11250100   0     1
11250101   2     5.6957
```

```
11250201   5      2
11250301   0.0    2
11250400   0
11250401   557.00        3
11250501   124010000     0    1    1    2.3110    1
11250601   0             0    0    1    2.3110    1
11250701   0        0.0        0.0000    0.0000    1
11250801   0        0.0        7.9934    0.0000    1
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 128 : VESSEL CLOSURE HEAD             *
*-------------------------------------------------------*
*
11280000   3      8      3      1      6.5858
11280100   0      1
11280101   2      6.6042
11280102   5      7.1200
11280201   5      2
11280202   6      7
11280301   0.0    7
11280400   0
11280401   557.00        8
11280501   128010000     0    1    1      0.1126    1
11280502   128020000     0    1    1      0.1126    2
11280503   126010000     0    1    1      0.2286    3
11280601   0             0    0    1      0.1126    1
11280602   0             0    0    1      0.1126    2
11280603   0             0    0    1      0.2286    3
11280701   0        0.0        0.0000      0.0000    3
11280801   0        0.0        0.0000      0.0000    3
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 400 : INTACT AND BROKEN HOT LEG       *
*                       PIPING                          *
*-------------------------------------------------------*
*
14000000   10     6      2      1      1.208
14000100   0      1
14000101   5      1.417
14000201   5      5
14000301   0.0    5
14000400   0
14000401   617.00        6
14000501   400010000     0    1    1      6.4413    1
14000502   400020000     0    1    1      6.4413    2
14000503   410010000     0    1    1      3.5499    3
14000504   410020000     0    1    1      3.5499    4
14000505   410030000     0    1    1      3.7973    5
14000506   200010000     0    1    1     12.8826    6
14000507   200020000     0    1    1     12.8826    7
```

```
14000508   205010000    0    1    1      7.0998    8
14000509   210010000    0    1    1      7.0998    9
14000510   210020000    0    1    1      7.5946   10
14000601   0            0    0    1      6.4413    1
14000602   0            0    0    1      6.4413    2
14000603   0            0    0    1      3.5499    3
14000604   0            0    0    1      3.5499    4
14000605   0            0    0    1      3.7973    5
14000606   0            0    0    1     12.8826    6
14000607   0            0    0    1     12.8826    7
14000608   0            0    0    1      7.0998    8
14000609   0            0    0    1      7.0998    9
14000610   0            0    0    1      7.5946   10
14000701   0       0.0       0.0000      0.0000   10
*
14000801   0       0.0       0.0000      0.0000   10
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 420 : INTACT AND BROKEN LOOP PUMP    *
*                       SUCTION PIPING                 *
*-----------------------------------------------------*
*
14200000   10    6     2     1     1.2917
14200100   0     1
14200101   5     1.5000
14200201   5     5
14200301   0.0   5
14200400   0
14200401   557.00       6
14200501   420010000    0    1    1      4.8392    1
14200502   420020000    0    1    1      4.5283    2
14200503   420030000    0    1    1      7.0686    3
14200504   420040000    0    1    1      2.5573    4
14200505   420050000    0    1    1      7.0686    5
14200506   220010000    0    1    1      9.6785    6
14200507   220020000    0    1    1      9.0567    7
14200508   220030000    0    1    1     14.1372    8
14200509   220040000    0    1    1      5.1146    9
14200510   220050000    0    1    1     14.1372   10
14200601   0            0    0    1      4.8392    1
14200602   0            0    0    1      4.5283    2
14200603   0            0    0    1      7.0686    3
14200604   0            0    0    1      2.5573    4
14200605   0            0    0    1      7.0686    5
14200606   0            0    0    1      9.6785    6
14200607   0            0    0    1      9.0567    7
14200608   0            0    0    1     14.1372    8
14200609   0            0    0    1      5.1146    9
14200610   0            0    0    1     14.1372   10
14200701   0       0.0       0.0000      0.0000   10
```

```
14200801   0        0.0        0.0000     0.0000     10
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 425 : INTACT AND BROKEN LOOP          *
*                       PUMP CASING                     *
*-------------------------------------------------------*
*
14250000   2      9      2      1      2.346
14250100   0      1
14250101   8      3.0072
14250201   5      8
14250301   0.0    8
14250400   0
14250401   557.00        9
14250501   425010000     0      1      1      9.8460     1
14250502   225010000     0      1      1     19.6920     2
14250601   0             0      0      1      9.8460     1
14250602   0             0      0      1     19.6920     2
14250701   0        0.0        0.0000     0.0000     2
14250801   0        0.0        0.0000     0.0000     2
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 430 : INTACT AND BROKEN LOOP          *
*                       COLD LEG PIPING                 *
*-------------------------------------------------------*
*
14300000   10     5      2      1      1.1460
14300100   0      1
14300101   4      1.3330
14300201   5      4
14300301   0.0    4
14300400   0
14300401   557.00        5
14300501   430010000     0      1      1      4.4073     1
14300502   430020000     0      1      1      4.4073     2
14300503   440010000     0      1      1      3.6835     3
14300504   452010000     0      1      1      6.5969     4
14300505   452020000     0      1      1      6.5969     5
14300506   230010000     0      1      1      8.8147     6
14300507   230020000     0      1      1      8.8147     7
14300508   240010000     0      1      1      7.3665     8
14300509   252010000     0      1      1     13.1938     9
14300510   252020000     0      1      1     13.1938     10
14300601   0             0      0      1      4.4073     1
14300602   0             0      0      1      4.4073     2
14300603   0             0      0      1      3.6835     3
14300604   0             0      0      1      6.5969     4
14300605   0             0      0      1      6.5969     5
14300606   0             0      0      1      8.8147     6
14300607   0             0      0      1      8.8147     7
```

```
14300608   0            0    0    1     7.3665    8
14300609   0            0    0    1    13.1938    9
14300610   0            0    0    1    13.1938    10
14300701   0       0.0       0.0000     0.0000    10
14300801   0       0.0       0.0000     0.0000    10
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 6201 : PRESSURIZER VESSEL WALL      *
*                        (UPPER PARTIAL WALL)         *
*-----------------------------------------------------*
*
*6201000   1     8     3     1     3.5833
*6201100   0     1
*6201101   2     3.5992
*6201102   5     3.7575
*6201201   5     2
*6201202   6     7
*6201301   0.0   7
*6201400   0
*6201401   652.00       8
*6201501   620010000    0    1    1     0.3928    1
*6201601   0            0    0    1     0.3928    1
*6201701   0       0.0       0.0        0.0000    1
*6201801   0       0.0       0.0        0.0000    1
*
*-----------------------------------------------------*
*  HEAT STRUCTURE 6202 : PRESSURIZER VESSEL WALL      *
*                        (MIDDLE CYLINDRICAL VOLUME)  *
*-----------------------------------------------------*
*
*6202000   8     8     2     1     3.5000
*6202100   0     1
*6202101   2     3.5158
*6202102   5     3.6742
*6202201   5     2
*6202202   6     7
*6202301   0.0   7
*6202400   0
*6202401   652.00       8
*6202501   620010000    0    1    1     2.4886    1
*6202502   620020000    0    1    1     3.8977    2
*6202503   620030000    0    1    1     5.1969    3
*6202504   620040000    0    1    1     5.1969    4
*6202505   620050000    0    1    1     5.1969    5
*6202506   620060000    0    1    1     5.1969    6
*6202507   620070000    0    1    1     3.8977    7
*6202508   620080000    0    1    1     2.4866    8
*6202601   0            0    0    1     2.4886    1
*6202602   0            0    0    1     3.8977    2
*6202603   0            0    0    1     5.1969    3
```

```
*6202604   0            0    0    1      5.1969    4
*6202605   0            0    0    1      5.1969    5
*6202606   0            0    0    1      5.1969    6
*6202607   0            0    0    1      3.8977    7
*6202608   0            0    0    1      2.4866    8
*6202701   0       0.0       0.0         0.0000    8
*6202801   0       0.0       0.0         0.0000    8
*
*-------------------------------------------------------*
*  HEAT STRUCTURE 6203 : PRESSURIZER VESSEL WALL        *
*                        (LOWER PARTIAL VOLUME)         *
*-------------------------------------------------------*
*
*6203000   1     2     3     0     3.5833
*6203100   0     1
*6203101   1     3.7575
*6203201   5     1
*6203301   1.0   1
*6203400   0
*6203401   652.00      2
*6203501   620080000   0   2901  1     0.3928    1
*6203601   0           0    0    1     0.3928    1
*6203701   751    1.0       0.0        0.3928    1
*6203801   0      0.0       0.0        0.0000    1
*
*
*******************************************************
*              CORE FUEL PIN                          *
*******************************************************
11140000    6   17  2   1    0.0   2  1  8
11140100    0           1
11140101    6           0.0129
11140102    2           0.01316
11140103    8           0.015035
11140201    1           6
11140202    2           8
11140203    3           16
11140301    1.0         6
11140302    0.0         16
11140401    1100.       3
11140402    900.        5
11140403    620.        7
11140404    600.        9
11140405    570.        17
11140501    0           0       0       0       0.0     1
11140502    0           0       0       0       0.0     2
11140503    0           0       0       0       0.0     3
11140504    0           0       0       0       0.0     4
11140505    0           0       0       0       0.0     5
11140506    0           0       0       0       0.0     6
```

```
11140601    114010000   00000   1       1       87178.96  1
11140602    114020000   10000   1       1       87282.58  5
11140603    114060000   00000   1       1       61999.30  6
11140701   1000        0.135870   0.0     0.003630    1
11140702   1000        0.158960   0.0     0.004240    2
11140703   1000        0.163920   0.0     0.004380    3
11140704   1000        0.182110   0.0     0.004860    4
11140705   1000        0.210220   0.0     0.005610    5
11140706   1000        0.122920   0.0     0.003280    6
11140801    0           0.0     0.0     0.0     6
11140901    0           0.04250 0.0     2.0103  1
11140902    0           0.04250 0.0     2.1058  5
11140903    0           0.04250 0.0     1.4958  6
*
*****************************************************
*       HEAT STRUCTURE INPUT                        *
*****************************************************
*
*****************************************************
* HEAT STRUCTURE 500; BROKEN STEAM GENERATOR U-TUBES *
*****************************************************
15001000    8   3   2   1   0.02525
15001100   0   1
15001101   2   0.028667
15001201   4   2
15001301   0.0   2
15001401   550.  3
*5001501   500020000   0      1   1   35566.07   1
*5001502   500030000   10000  1   1   47159.44   7
*5001503   500090000   0      1   1   35566.07   8
*5001601   540010000   0      1   1   35566.07   1
*5001602   540020000   10000  1   1   47159.44   4
*5001603   540040000  -10000  1   1   47159.44   7
*5001604   540010000   0      1   1   35566.07   8
15001501   500020000   0      1   1   12803.79   1
15001502   500030000   10000  1   1   16977.40   7
15001503   500090000   0      1   1   12803.79   8
15001601   540010000   0      1   1   12803.79   1
15001602   540020000   10000  1   1   16977.40   4
15001603   540040000  -10000  1   1   16977.40   7
15001604   540010000   0      1   1   12803.79   8
15001701   0   0.0   0.0   0.0   8
15001801   0  0.0505   0.0   5.43   1
15001802   0  0.0505   0.0   7.20   7
15001803   0  0.0505   0.0   5.43   8
15001901   0  0.0908   0.0   5.43   1
15001902   0  0.0908   0.0   7.20   7
15001903   0  0.0908   0.0   5.43   8
*****************************************************
* HEAT STRUCTURE 5002; CHANNEL HEAD                 *
```

```
*****************************************************
15002000  4   6   3   1   5.234
15002100  0   1
15002101  5   5.8601
15002201  6   5
15002301  0.0    5
15002401  600.0  6
15002501  500010000   90000  1   1   0.25   2
15002502  300010000   90000  1   1   0.50   4
15002601  0           0      0   1   0.25   2
15002602  0           0      0   1   0.50   4
15002701  0    0.0   0.0   0.0   4
15002801  0    0.0   0.0   4.0095   4
15002901  0    0.0   0.0   4.0095   4
*****************************************************
* HEAT STRUCTURE 5301; S/G TRANSITION CONE SHELL     *
*****************************************************
15301000  2   6   2   1   6.205
15301100  0   1
15301101  5   6.5033
15301201  6   5
15301301  0.0   5
15301401  520.0   6
15301501  530010000   0   1   1   7.43   1
15301502  330010000   0   1   1  14.86   2
15301601  0           0   0   1   7.43   1
15301602  0           0   0   1  14.86   2
15301701  0.0   0.0   0.0   0.0     2
15301801  0     0.0   0.0   7.43    2
15301901  0     0.0   0.0   7.43    2
*****************************************************
* HEAT STRUCTURE 5302; S/G LOWER SHELL               *
*****************************************************
15302000  10   5   2   1   5.391
15302100  0     1
15302101  4     5.578
15302201  6     4
15302301  0.0   4
15302401  500.  5
15302501  530050000  0       1   1   5.43   1
15302502  530040000  -10000  1   1   7.20   3
15302503  530020000  0       1   1   6.34   4
15302504  530010000  0       1   1   4.79   5
15302505  330050000  0       1   1  10.86   6
15302506  330040000  -10000  1   1  14.40   8
15302507  330020000  0       1   1  12.68   9
15302508  330010000  0       1   1   9.58  10
15302601  0          0       0   1   5.43   1
15302602  0          0       0   1   7.20   3
15302603  0          0       0   1   6.34   4
```

```
15302604   0          0       0   1   4.79   5
15302605   0          0       0   1  10.86   6
15302606   0          0       0   1  14.40   8
15302607   0          0       0   1  12.68   9
15302608   0          0       0   1   9.58  10
15302701   0    0.0   0.0   0.0       10
15302801   0    0.0   0.0   5.43       1
15302802   0    0.0   0.0   7.20       3
15302803   0    0.0   0.0   6.34       4
15302804   0    0.0   0.0   4.79       5
15302805   0    0.0   0.0   5.43       6
15302806   0    0.0   0.0   7.20       8
15302807   0    0.0   0.0   6.34       9
15302808   0    0.0   0.0   4.79      10
15302901   0    0.0   0.0   5.43       1
15302902   0    0.0   0.0   7.20       3
15302903   0    0.0   0.0   6.34       4
15302904   0    0.0   0.0   4.79       5
15302905   0    0.0   0.0   5.43       6
15302906   0    0.0   0.0   7.20       8
15302907   0    0.0   0.0   6.34       9
15302908   0    0.0   0.0   4.79      10
*****************************************************
* HEAT STRUCTURE 5401; BROKEN S/G WRAPPER           *
*****************************************************
15401000   5   3   2   1   5.125
15401100   0   1
15401101   2   5.15625
15401201   6   2
15401301   0.0   2
15401401   535.0   3
15401501   540010000   0          1   1   5.43   1
15401502   540020000   10000      1   1   7.20   3
15401503   540040000   0          1   1   6.34   4
15401504   540050000   0          1   1   2.88   5
15401601   530050000   0          1   1   5.43   1
15401602   530040000   -10000     1   1   7.20   3
15401603   530020000   0          1   1   6.34   4
15401604   530010000   0          1   1   2.88   5
15401701   0       0.0   0.0   0.0       5
15401801   0       0.0   0.0   5.43      1
15401802   0       0.0   0.0   7.20      3
15401803   0       0.0   0.0   6.34      4
15401804   0       0.0   0.0   2.88      5
15401901   0       0.0   0.0   5.43      1
15401902   0       0.0   0.0   7.20      3
15401903   0       0.0   0.0   6.34      4
15401904   0       0.0   0.0   2.88      5
*****************************************************
* HEAT STRUCTURE 5402; BROKEN S/G WRAPPER           *
```

```
*                    TRANSITION CONE                    *
*******************************************************
15402000   1   3   2   1   6.422
15402100   0   1
15402101   2   6.453
15402201   6   2
15402301   0.0   2
15402401   530.0   3
15402501   540050000   0   1   1   4.75   1
15402601   530010000   0   1   1   4.75   1
15402701   0    0.0   0.0   0.0     1
15402801   0    0.0   0.0   4.75    1
15402901   0    0.0   0.0   4.75    1
*******************************************************
* HEAT STRUCTURE 5403; BROKEN S/G RISER BARREL        *
*******************************************************
15403000   2   3   2   1   0.8125
15403100   0       1
15403101   2       0.8333
15403201   6       2
15403301   0.0     2
15403401   538.0   3
15403501   540050000   0   1   1   73.44   1
15403502   550010000   0   1   1   106.67  2
15403601   530010000   0   1   1   73.44   1
15403602   550010000   0   1   1   106.67  2
15403701   0   0.0   0.0   0.0     2
15403801   0   0.0   0.0   4.59    1
15403802   0   0.0   0.0   6.667   2
15403901   0   0.0   0.0   4.59    1
15403902   0   0.0   0.0   6.667   2
*******************************************************
* HEAT STRUCTURE 3404; S/G TUBE SUPPORT/SPACER PLATE *
*******************************************************
15404000   8   3   1   1   0.0
15404100   0   1
15404101   2   0.09375
15404201   6   2
15404301   0.0     2
15404401   545.0   3
15404501   540010000   10000   1   1   121.6   4
15404502   340010000   10000   1   1   243.2   8
15404601   540010000   10000   1   1   121.6   4
15404602   340010000   10000   1   1   243.2   8
15404701   0   0.0   0.0   0.0     8
15404801   0   0.0   0.0   5.43    1
15404802   0   0.0   0.0   7.20    3
15404803   0   0.0   0.0   6.34    4
15404804   0   0.0   0.0   5.43    5
15404805   0   0.0   0.0   7.20    7
```

```
15404806   0   0.0   0.0   6.34     8
15404901   0   0.0   0.0   5.43     1
15404902   0   0.0   0.0   7.20     3
15404903   0   0.0   0.0   6.34     4
15404904   0   0.0   0.0   5.43     5
15404905   0   0.0   0.0   7.20     7
15404906   0   0.0   0.0   6.34     8
*****************************************************
* HEAT STRUCTURE 5601; S/G STEAM DRIER ASSEMBLY     *
*****************************************************
15601000   2   5   1   1   0.0
15601100   0   1
15601101   4   0.1667
15601201   6   4
15601301   0.0   4
15601401   545.0    5
15601501   560010000   0   1   1   277.1   1
15601502   360010000   0   1   1   554.2   2
15601601   560010000   0   1   1   277.1   1
15601602   360010000   0   1   1   554.2   2
15601701   0     0.0   0.0   0.0     2
15601801   0     0.0   0.0   9.8333  2
15601901   0     0.0   0.0   9.8333  2
*****************************************************
* HEAT STRUCTURE 5602; S/G UPPER SHELL CYLINDER     *
*****************************************************
15602000   4   5   2   1   7.0208
15602100   0   1
15602101   4   7.3500
15602201   6   4
15602301   0.0      4
15602401   545.0    5
15602501   550010000   0   1   1   6.69   1
15602502   560010000   0   1   1  12.21   2
15602503   350010000   0   1   1  13.38   3
15602504   360010000   0   1   1  24.42   4
15602601   0           0   0   1   6.69   1
15602602   0           0   0   1  12.21   2
15602603   0           0   0   1  13.38   3
15602604   0           0   0   1  24.42   4
15602701   0   0.0   0.0   0.0       4
15602801   0   0.0   0.0   6.69      1
15602802   0   0.0   0.0   12.21     2
15602803   0   0.0   0.0   13.38     3
15602804   0   0.0   0.0   24.42     4
15602901   0   0.0   0.0   6.69      1
15602902   0   0.0   0.0   12.21     2
15602903   0   0.0   0.0   13.38     3
15602904   0   0.0   0.0   24.42     4
*****************************************************
```

```
* HEAT STRUCTURE 5603; S/G STEAM DRUM HEAD                *
*******************************************************
15603000   2   5   3   1   7.0208
15603100   0   1
15603101   4   7.3541
15603201   6   4
15603301   0.0   4
15603401   540.0    5
15603501   560020000   0   1   1   0.431   1
15603502   360020000   0   1   1   0.862   2
15603601   0           0   0   1   0.431   1
15603602   0           0   0   1   0.862   2
15603701   0       0.0   0.0   0.0     2
15603801   0       0.0   0.0   5.29    2
15603901   0       0.0   0.0   5.29    2
*******************************************************
* HEAT STRUCTURE 3001; INTACT S/G U-TUBES                  *
*******************************************************
13001000    8   3   2   1   0.02525
13001100   0   1
13001101   2   0.028667
13001201   4   2
13001301   0.0   2
13001401   550.  3
*3001501   300020000   0      1   1   71132.14   1
*3001502   300030000   10000  1   1   94318.87   7
*3001503   300090000   0      1   1   71132.14   8
*3001601   340010000   0      1   1   71132.14   1
*3001602   340020000   10000  1   1   94318.87   4
*3001603   340040000  -10000  1   1   94318.87   7
*3001604   340010000   0      1   1   71132.14   8
13001501   300020000   0      1   1   25607.57   1
13001502   300030000   10000  1   1   33954.79   7
13001503   300090000   0      1   1   25607.57   8
13001601   340010000   0      1   1   25607.57   1
13001602   340020000   10000  1   1   33954.79   4
13001603   340040000  -10000  1   1   33954.79   7
13001604   340010000   0      1   1   25607.57   8
13001701   0   0.0   0.0   0.0    8
13001801   0  0.0505   0.0   5.43   1
13001802   0  0.0505   0.0   7.20   7
13001803   0  0.0505   0.0   5.43   8
13001901   0  0.0908   0.0   5.43   1
13001902   0  0.0908   0.0   7.20   7
13001903   0  0.0908   0.0   5.43   8
*******************************************************
* HEAT STRUCTURE 3401; BROKEN S/G WRAPPER                  *
*******************************************************
13401000   5   3   2   1   5.125
13401100   0   1
```

```
13401101   2   5.15625
13401201   6   2
13401301   0.0   2
13401401   535.0   3
13401501   340010000   0           1   1  10.86   1
13401502   340020000   10000       1   1  14.40   3
13401503   340040000   0           1   1  12.68   4
13401504   340050000   0           1   1   3.76   5
13401601   330050000   0           1   1  10.86   1
13401602   330040000   -10000      1   1  14.40   3
13401603   330020000   0           1   1  12.68   4
13401604   330010000   0           1   1   3.76   5
13401701   0       0.0   0.0   0.0       5
13401801   0       0.0   0.0   5.43      1
13401802   0       0.0   0.0   7.20      3
13401803   0       0.0   0.0   6.34      4
13401804   0       0.0   0.0   2.88      5
13401901   0       0.0   0.0   5.43      1
13401902   0       0.0   0.0   7.20      3
13401903   0       0.0   0.0   6.34      4
13401904   0       0.0   0.0   2.88      5
*****************************************************
* HEAT STRUCTURE 3402; INTACT S/G WRAPPER           *
*****************************************************
13402000   1   3   2   1   6.422
13402100   0   1
13402101   2   6.453
13402201   6   2
13402301   0.0   2
13402401   530.0   3
13402501   340050000   0   1   1   9.50   1
13402601   330010000   0   1   1   9.50   1
13402701   0    0.0   0.0   0.0      1
13402801   0    0.0   0.0   4.75     1
13402901   0    0.0   0.0   4.75     1
*****************************************************
* HEAT STRUCTURE 3403; BROKEN S/G RISER BARREL      *
*****************************************************
13403000   2   3   2   1   0.8125
13403100   0       1
13403101   2       0.8333
13403201   6       2
13403301   0.0     2
13403401   538.0   3
13403501   340050000   0   1   1  146.88   1
13403502   350010000   0   1   1  213.34   2
13403601   330010000   0   1   1  146.88   1
13403602   350010000   0   1   1  213.34   2
13403701   0   0.0   0.0   0.0      2
13403801   0   0.0   0.0   4.59     1
```

```
13403802   0   0.0   0.0   6.667    2
13403901   0   0.0   0.0   4.59     1
13403902   0   0.0   0.0   6.667    2
*****************************************************************
*****************************************************************
*                    CONTROL VARIABLES                          *
*****************************************************************
*****************************************************************
*
*****************************************************************
*  CONTROL VARIABLE 15; BROKEN S/G WATER LEVEL                  *
*****************************************************************
20501500  BSGLEVEL   SUM  6.286E-4   0.50   1
20501501  30.78269  62.4  VOIDF 540050000  187.6  VOIDF 530010000
20501502          1025.0  VOIDF 550010000  335.0  VOIDF 560010000
20515000  ASGLEV    SUM   1.0    0.0   1
20515001  0.0    1.0  P  530010000   -1.0    P  560010000
20515100  AH      DIV   0.10204  0.0    1
20515101  RHO  530010000    CNTRLVAR   150
20515200  LENGTH   SUM   1.0   0.0   1
20515201  -2.3282   1.0  CNTRLVAR  151
20515300  ASLEVEL   MULT  0.3076   0.0   1
20515301  CNTRLVAR  152
*****************************************************************
*  CONTROL VARIABLE 16; BROKEN S/G SECONDARY MASS INVENTORY     *
*****************************************************************
20501600  BSGSMASS   SUM  0.0624306  0.0   1
20501601 0.0 307.56  RHO 540010000  393.78  RHO 540020000
20501602     393.78  RHO 540030000  370.48  RHO 540040000
20501603     774.40  RHO 540050000  1025.0  RHO 550010000
20501604     1539.0  RHO 560010000  400.00  RHO 560020000
20501605     495.60  RHO 530010000  49.520  RHO 530020000
20501606     56.220  RHO 530030000  56.220  RHO 530040000
20501607     42.440  RHO 530050000
*****************************************************************
*  CONTROL VARIABLE 17; BROKEN S/G FEEDWATER VALVE GAIN         *
*****************************************************************
*0501700   BSFGAIN  SUM  1.0  1.0  1
*0501701   2.65    -3.3   CNTRLVAR  015
*****************************************************************
*  CONTROL VARIABLE 18; INTACT S/G WATER LEVEL                  *
*****************************************************************
20501800  ISGLEVEL   SUM  3.143E-4   0.50   1
20501801  61.56538 124.8  VOIDF 340050000  375.2  VOIDF 330010000
20501802          2050.0  VOIDF 350010000  670.0  VOIDF 360010000
*****************************************************************
*  CONTROL VARIABLE 19; INTACT S/G SECONDARY MASS INVENTORY     *
*****************************************************************
20501900  ISGSMASS   SUM  0.0624306  0.0   1
20501901 0.0 615.12  RHO 340010000  787.56  RHO 340020000
```

```
20501902     787.56  RHO 340030000  740.96  RHO 340040000
20501903    1548.80  RHO 340050000  2050.0  RHO 350010000
20501904     3078.0  RHO 360010000  800.00  RHO 360020000
20501905     991.20  RHO 330010000  99.040  RHO 330020000
20501906     112.44  RHO 330030000  112.44  RHO 330040000
20501907     84.880  RHO 330050000
*****************************************************************
*  CONTROL VARIABLE 20; INTACT S/G FEEDWATER VALVE GAIN         *
*****************************************************************
*0502000   ISFGAIN  SUM  1.0  1.0  1
*0502001   2.65    -3.3   CNTRLVAR  018
*
*********************************************************************
*                                                                   *
* HEAT STRUCTURE THERMAL PROPERTY DATA                              *
*                                                                   *
*********************************************************************
*                                                                   *
* COMPOSITION TYPE AND DATA FORMAT                                  *
*                                                                   *
*********************************************************************
*                                                                   *
20100100        TBL/FCTN        1       1     * CORE FUEL
20100200        TBL/FCTN        1       1     * CORE FUEL GAP
20100300        TBL/FCTN        1       1     * CORE FUEL CLADDING
20100400        TBL/FCTN        1       1     * INCONEL
20100500        TBL/FCTN        1       1     * STAINLESS STEEL
20100600        TBL/FCTN        1       1     * CARBON STEEL
*                                                                   *
*********************************************************************
*                                                                   *
* THERMAL CONDUCTIVITY DATA (BTU/SEC-FT/DEG F) AND VOLUMETRIC HEAT  *
* CAPACITY  DATA (BTU/FT**3-DEG F) VERSUS TEMPERATURE FOR ABOVE     *
* COMPOSITION                                                       *
*                                                                   *
*********************************************************************
*
* CORE FUEL
*
*       TEMPERATURE    THERMAL CONDUCTIVITY
*
20100101      188.6       2.284E-3
20100102      332.6       2.1235E-3
20100103      440.6       8.951E-4
20100104      500.0       8.2806E-04
20100105      650.0       6.4194E-04
20100106      800.0       5.4361E-04
20100107      950.0       5.7750E-04
20100108     1100.0       4.2278E-04
20100109     1250.0       7.7722E-04
```

```
20100110      1400.0        7.3889E-04
20100111      1500.0        8.0739E-04
20100112      1700.0        8.7789E-04
20100113      1850.0        4.5628E-04
20100114      2000.0        3.3556E-04
20100115      2150.0        5.1661E-04
20100116      2300.0        4.0472E-04
20100117      2450.0        3.5306E-04
20100118      2600.0        6.6689E-04
20100119      3100.0        5.4350E-04
20100120      3600.0        3.7228E-04
20100121      4100.0        4.6156E-04
20100122      4600.0        5.4722E-04
20100123      5100.0        2.3056E-04
*
*        TEMPERATURE      HEAT CAPACITY
*
20100151        32.0       30.45
20100152       122.0       34.35
20100153       212.0       47.75
20100154       392.0       44.55
20100155       752.0       45.70
20100156      2012.0       41.35
20100157      2732.0       32.65
20100158      3092.0       66.55
20100159      3452.0       83.05
20100160      3812.0       52.80
20100161      4352.0       69.70
20100162      4532.0       44.25
20100163      4712.0       38.15
20100164      4892.0      120.10
20100165      5144.0       96.40
20100166      8000.0      131.40
*
*
* CORE FUEL GAP
*
*        TEMPERATURE    THERMAL CONDUCTIVITY
*
20100201        32.0          2.4487788E-04
20100202      5400.0          2.4487788E-04
*
*        TEMPERATURE    HEAT CAPACITY
*
20100251        32.0          0.000065
20100252      5400.0          0.000065
*
*
* CORE FUEL CLADDING
*
```

```
*          TEMPERATURE    THERMAL CONDUCTIVITY
*
20100301       392.0          2.9267E-03
20100302       752.0          1.2478E-03
20100303      1112.0          4.7297E-03
20100304      1472.0          5.0508E-03
20100305      1832.0          6.5325E-03
20100306      2192.0          4.0142E-03
20100307      2552.0          5.8169E-03
20100308      2912.0          8.7803E-03
20100309      3272.0          1.0647E-03
20100310      3632.0          1.8311E-03
20100311      3992.0          9.0918E-02
*
*          TEMPERATURE     HEAT CAPACITY
*
20100351         0.0          26.392
20100352      1480.3          35.476
20100353      1675.0          75.176
20100354      1787.5          44.370
20100355      3500.0          24.476
*
* INCONEL
*
*          TEMPERATURE      THERMAL CONDUCTIVITY
*
20100401        32.0          2.1167E-03
20100402      1050.0          4.0394E-03
*
*          TEMPERATURE      HEAT CAPACITY
*
20100451      100.0          57.180
20100452      400.0          61.140
20100453      600.0          63.770
20100454      800.0          66.410
*
*
* STAINLESS STEEL
*
*          TEMPERATURE      THERMAL CONDUCTIVITY
*
20100501        32.0          2.0833E-03
20100502      1700.0          4.0294E-03
20100503      5000.0          4.0294E-03
*
*          TEMPERATURE      HEAT CAPACITY
*
20100551      200.0          57.114
20100552      300.0          59.118
20100553      400.0          61.122
```

```
20100554      500.0          63.126
20100555      600.0          64.629
20100556      700.0          66.130
20100557      800.0          67.134
20100558     1000.0          69.138
20100559     2000.0          80.160
20100560     5000.0          80.160
*
* CARBON STEEL
*
*        TEMPERATURE    THERMAL CONDUCTIVITY
*
20100601     80.0          0.01126
20100602     440.33        0.01009
20100603     800.33        0.00908
20100604     1160.33       0.00824
20100605     1520.33       0.00756
20100606     1880.33       0.00705
20100607     2240.33       0.00670
20100608     2600.33       0.00652
20100609     2960.33       0.00649
*
*          TEMPERATURE   HEAT CAPACITY
*
20100651     80.0          57.29
20100652     200.03        57.29
20100653     1600.07       82.04
20100654     2600.33       104.71
20100655     2960.33       112.49
*
*
*************************************************************
*
*
*
*****************************************************************
*     REACTOR KINETICS
*****************************************************************
*
30000000   POINT
30000001   GAMMA-AC   80.48E06  0.0  297.0  1.0  0.48
30000002   ANS73
*0000011     10118
*0000012     998
*0000501   44.0  0.0
30000501   44.0  0.07696   44.78   0.06964    45.52   0.04398
30000502   46.2  0.01010   46.4    0.0
30000601   557.0  0.0    653.3  -0.1789    749.6  -0.3401
30000602   845.9 -0.5043 942.2   -0.6597  1038.5   -0.8137
30000603   1134.8  -0.9529  1231.1  -1.0908  1327.4  -1.2168
```

```
30000604   1423.7  -1.3371   1520.0  -1.4514
*0000601   1600.0  0.0
30000701   114010000    0    0.1367    0.0
30000702   114020000    0    0.2229    0.0
30000703   114030000    0    0.1991    0.0
30000704   114040000    0    0.1862    0.0
30000705   114050000    0    0.1922    0.0
30000706   114060000    0    0.0629    0.0
30000801   1140001      0    0.1367    0.0
30000802   1140002      0    0.2229    0.0
30000803   1140003      0    0.1991    0.0
30000804   1140004      0    0.1862    0.0
30000805   1140005      0    0.1922    0.0
30000806   1140006      0    0.0629    0.0
*
*************************************************************************
*************************************************************************
*
*    COMPONENT 565   STEAM HEADER
*
5650000    ISTMHDR   SNGLVOL
5650101    0.0 42.38 450.97 0.0  0.0  0.0  0.0  0.0  10
5650200    2  970.0  1.0
*
*    COMPONENT 566   GOVERNOR VALVE
*
5660000   TBNVAL    TMDPJUN
5660101   565010000   569000000   1000.0
5660200   1   507
5660201  0.0   0.0      50.07  0.0
5660202  100.0  0.0  50.07    0.0
5660203  101.0  0.0  50.07   0.0
5660204  1.0E04   0.0     50.07 0.0
*660202  50.0  0.0   3381.0   0.0
*660202  1.0   0.0   2028.6   0.0
*660203   2.0  0.0   1196.7   0.0
*660204   3.0  0.0   983.87   0.0
*660205   4.0  0.0   770.87   0.0
*660206   5.0  0.0   561.24   0.0
*660207  10.0  0.0   135.24   0.0
*660208  1.E04 0.0   135.24   0.0
*660209  1000.0  0.0  3381.0  0.0
*
*     COMPONENT  569  TBN
*
5690000   TBNCON   TMDPVOL
5690101   1000.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  00
5690200   2
5690201   0.0   964.0   1.0
*
```

```
*
* STEAM DUMP SYSTEM
*****************************************************
*
20504300     RXPWR     MULT     3.59E-04     0.03     0
20504301     RKTPOW     0
*
20504400     SGPRES     MULT     1.01972E-05     77.0     0
20504401     P     360030000
*  UNIT CONVERSION
20504500   CONV1    SUM    1.0    621.3     0
20504501   -459.67    1.8    TEMPF    200010000
*
20504600    CONV2    SUM    1.0    556.99    0
20504601    -459.67     1.8    TEMPF    252020000
*
20504700    CONV3    SUM    1.0    621.3    0
20504701    -459.67    1.8    TEMPF    400010000
*
20504800    CONV4    SUM    1.0    556.99     0
20504801    -459.67    1.8    TEMPF     452020000
*
* STEAM HEADER PRESSURE
20504900    STMHDR    MULT    1.01972E-5    76.8    0
20504901   P      565010000
*
20505000    PRDIF    SUM    1.0    0.0    0
20505001    -76.8    1.0    CNTRLVAR   49
*
20505100     PINTEG     INTEGRAL     0.0056    0.0    0
20505101    CNTRLVAR    50
* TIME DEPENDENT JUNCTION
5790000    DUMP     TMDPJUN
5790101     565010000     580000000     1000.0
5790200    1    507    CNTRLVAR    51
5790201     0.0    0.0    0.0 0.0
5790202     1.0     0.0   268.0    0.0
5790203     4.0     0.0   1072.00  0.0
*
*   TEMPERATURE  CONVERSION  FROM  FHAR.  TO  CENTI.
*
*
20525000   ITEMPH   SUM   0.5556   293.5   0
20525001   -32.0   1.0   CNTRLVAR   45
*
20525100   ITEMPC   SUM   0.5556   289.8   0
20525101   -32.0   1.0   CNTRLVAR   46
*
20525200   BTEMPH   SUM   0.5556   293.0   0
20525201   -32.0   1.0   CNTRLVAR   47
```

```
*
20525300   BTEMPC   SUM   0.5556   293.0   0
20525301   -32.0   1.0   CNTRLVAR   48
*
20525400   AVGT     SUM     0.5    292.5     0
20525401   0.0    1.0    CNTRLVAR    250     1.0     CNTRLVAR     251
*
20525500     DELT     SUM     1.0     1.0     0
20525501     0.0    1.0     CNTRLVAR 250     -1.0     CNTRLVAR     251
*
*   COMPONENT   580  CONDENSER ( STM SINK )
*
5800000   CONDEN1  TMDPVOL
5800101  1000.0  1.0   0.0    0.0  0.0  0.0  0.0  0.0  00
5800200  2
5800201  0.0  14.7  1.0
*****************************************************
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10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The results of the RELAP5/MOD2 computer code simulation for the Natural Circulation Test in Yong-Gwang Unit 2 are analyzed here and compared with the plant operation data. The result of comparison reveals that the code calculation does present well the overall macroscopic behaviors of thermalhydraulic parameters in primary and secondary system compared with the plant operating data. The sensitivity study is performed to find out the effect of steam dump flow rate on the primary temperatures and it is found that the primary temperatures are very sensitive to the steam dump flow rate during the Natural Circulation. Because of the inherent uncertainties in the plant data, the assessment work is focussed on phenomena whereby the comparison between plant data and calculated data is based more on trends than on absolute values.

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

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RELAP5/MOD2
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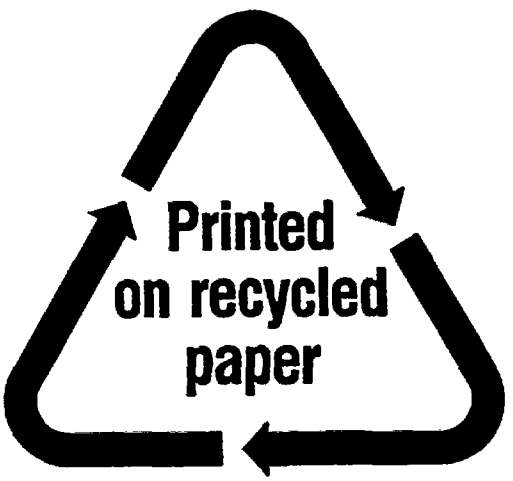

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