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RELAP5/MOD3.2 Analysis of INSC Standard Problem INSCSP-V4: Investigation of Heat Transfer for Partly Uncovered VVER-1000 Core at the Test Facility KS (RRC KI)

by
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ABSTRACT

The RELAP5/MOD3.2 computer program has been used to analyze a series of tests investigating heat-transfer from a partly uncovered VVER-1000 core in the KS test facility at the Russian Research Center "Kurchatov Institute" (RRC-KI). The analysis documented represents VVER Standard Problem 4 in Joint Project 6, which is the investigation of Computer Code Validation for Transient Analysis of RBMK and VVER Reactors, between the United States and Russian International Nuclear Safety Centers. The experiment facility and data, RELAP5 nodalization, and results are shown for one of the six tests defined in Standard Problem 4. Only part of the data was analyzed due to our conclusion that the available experimental data is not sufficient to allow the modeling of the actual experiment sequence. The experiment initial conditions were reached through a series of transient processes, about which no quantitative information was available. This has required the modeling of an arbitrary computational transient, with the goal of reaching initial conditions similar to those observed during the experiment. The use of an arbitrary transient introduces many degrees of freedom in the analysis, i.e. initial computational values that influence the entire sequence of events, including the loop behavior during the experiment time window.

Reasonable agreement between RELAP5 and the experiment data can be obtained by manipulating a number of initial computational values, including the liquid level in the fuel assembly model, the liquid level in the annular region, the quality of the saturated vapor in the voided loop regions, etc. Our study has focused on exploring the sensitivity of results to changes in these initial values which are not based on experimental information, but are selected with the goal of matching the experimentally observed behavior during the experiment time window. We have shown that changes in several initial arbitrary values can lead to similar changes in the calculated loop behavior. Other parameters exist which can directly influence the calculated results, which have been only minimally explored, or have not been explored at all due to lack of time. Because we are not modeling the entire sequence of events which led to the initial experiment conditions, it is not possible to assume that by matching a limited set of measured parameters at the beginning of the experiment time window we have reproduced all the initial actual conditions. We conclude that the analysis of these experiments, while providing a useful demonstration of the RELAP5 capabilities to describe the experimental sequence of events, cannot be used to draw quantitative conclusions about the adequacy of specific RELAP5 models.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols

Closs	=	heat loss multiplier
FA	=	fuel assembly
Hannulus(liquid)	=	liquid level in the annular space surrounding the fuel assembly, m
Hcore(liquid)	=	liquid level in the fuel assembly, m
Hdowncomer (liquid)	=	liquid level in the downcomer, m
LP	=	lower plenum
P_{out}	=	core outlet pressure, Pa
SG	=	steam generator
t0(calc)	=	RELAP calculation at the beginning of the experiment time window
t0 (exp)	=	experiment time at the beginning of the experiment time window
TF_{in}	=	water temperature in the lower plenum, K
TF_{fa}	=	coolant temperature at fuel assembly outlet, K
TF_{dc}	=	coolant temperature at the downcomer, K
TF_{up}	=	coolant temperature in the upper plenum, K
TW_{i-k}	=	heated rod wall temperature, K
UP	=	upper plenum
VVER	=	Russian Light Water Pressurized Reactor

Abbreviations

ANL	Argonne National Laboratory
RMINSC	Russian Minatom International Nuclear Safety Center
RRC KI	Russian Research Center Kurchatov Institute
SP	Standard Problem
USDOE	United States Department of Energy
USINSC	United States International Nuclear Safety Center
USNRC	United States Nuclear Regulatory Commission

1. Introduction

1.1 Objective

Validation of computer codes for use in safety analysis of VVER reactors has been identified as a topic for a joint research project between the U.S. and the Russian Minatom International Nuclear Safety Centers (USINSC/RMINSC). The goal of Joint Project 6 is to initiate the collaboration between the U.S. and Russian Minatom International Nuclear Safety Centers on the validation of computer codes related to nuclear power plant operational and safety analysis. The computer code covered in this project is RELAP5/MOD3.2 [1], which is the code in use for the in-depth safety assessment projects under the USDOE International Nuclear Safety Program.

1.2 Background

Earlier phases of Joint Project 6 included the development of a prioritization report, documenting the safety significant processes and phenomena occurring in VVER type reactors. The resulting VVER prioritization report [2] was used to develop a validation plan for ranking potential Russian tests relative to these safety significant processes and phenomena. The resulting VVER validation plan [3] identifies a number of potential standard problems that could be defined for assessing the capabilities of RELAP5/MOD3.2 in modeling VVER specific safety issues. The working basis for the code validation project is to establish standard problems based on experimental data and then perform the analysis for the standard problems with RELAP5/MOD3.2. The results of the computer analysis will be compared with the experimental results, and the adequacy of the code to model the specific phenomena will be assessed. The standard problems are defined by the RMINSC using experimental data from Russian facilities that simulate VVER behavior. The standard problems will be analyzed by U.S. and Russian analysts, and potentially by other international participants. Following the analysis of each specific standard problem by all teams involved, the results will be compared to assess the modeling capabilities of RELAP5 relative to the specific safety parameters thought to be addressed by the standard problem.

1.3 Study Description

The purpose of this report is to document the USINSC analysis for VVER standard problem 4 that has been defined in the "Standard Problem INSCSP-V4 Definition Report" [4]. This standard problem represents heat-transfer under partly uncovered core conditions.

The VVER validation plan [3] identified one phenomenon that was well covered by the data in Standard Problem 4. This phenomenon was **"heat transfer in a partially uncovered core"**. The adequacy of RELAP5/MOD3.2 to model the above phenomena is limited by the measurements available in the KS-1 facility and the facility design. As identified in [4], the test section configuration is such that heat losses to the ambient air (due to condensation dominated heat-transfer) exceed the heat injected into the coolant through the rod simulators. This leads to unsteady or quasi-steady behavior of the system resulting in a slow pressure decrease during the test measurement period and significant changes in the core liquid coolant level. Because the RELAP5 initialization does not simulate the actual sequence of events preceding the data collection window, the correct modeling of the unsteady conditions during the experiment is

difficult and must be verified carefully. The test results do not include coolant flow measurements, which adds to the difficulty in initializing the RELAP5 model.

1.4 Report Organization

Sections 2 and 3 of this report describe the KS-1 test section and the specific tests conducted, respectively. Section 4 provides a brief description of the RELAP5/MOD3.2 code as well as descriptions of the baseline input deck and sensitivity case input decks. Section 5 presents the results of the present RELAP5 analysis with comparisons to the specific test data described in the Definition Report. Conclusions from this analysis are shown in Section 6. The appendices include the RELAP model nodalization details, the base case RELAP5 input files, and peer review comments. A similar report is being prepared by the Russian analysis team. These two reports will be used to prepare a comparative analysis report covering the work of both teams.

2. Description of KS-1 Test Section

VVER Standard Problem 4 is based on heat-transfer under partly uncovered core conditions in the KS-1-VVER test section of the KS test facility at RRC Kurchatov Institute (KI). The KS test facility was designed to study thermal-hydraulic processes under normal, transient, and emergency conditions in water-cooled, water-moderated power reactors of the VVER-type, channel uranium-graphite reactors of the RBMK type, and water-cooled, water-moderated reactors of an integral layout (AST and VPBER type). The test facility was designed to investigate both separate effects and integral thermal and hydraulic processes in sections of the primary circuit

Experimental section KS-1 was developed within the KS test facility for the purpose of modeling thermal-hydraulic processes in a VVER core under postulated small break LOCA conditions. This special section used the RBMK fuel channel model as a downcomer and test section 1 as the rising section of a closed circuit to evaluate integral loop effects. Experimental section KS-1-VVER-1000 has been designed for modeling of heat transfer processes in a partly uncovered VVER-1000 core at small residual heat power under conditions of natural coolant circulation stagnation and for medium and low pressure ranges.

2.1 Description of Experimental Section Hydraulic Circuit

The KS-1-VVER-1000 test section is a semi-integral, one loop model of a VVER primary system. A schematic of the test section is shown in Fig. 2-1. The experimental section includes models of the main elements of a VVER type reactor, including a downcomer, upper plenum (UP), lower plenum (LP), hot and cold legs of the primary coolant loop and the steam generator (SG) simulator. The hydraulic circuit, depicted in Fig. 2-1, consists of the following components:

downcomer model (1),
lower plenum model (2),
core model (3),
upper plenum model (4),
loop hot leg model (5),
horizontal steam generator tube bundle simulator (6, 7),

loop cold leg model (8), and
lower pipeline (9).

The lower pipeline connects the bottom of the downcomer model and lower plenum model. The hot leg simulator and the steam generator simulators are slightly inclined to allow drainage of liquid condensate back to the upper plenum and downcomer regions of the loop. The entire loop represents a natural coolant circulation circuit which simulates a semi-integral, one loop model of a VVER primary system.

The unforced water flow rate at the core model inlet under steam-condensate circulation conditions is governed by the natural hydraulic head in the loop. This is established by the heating of the water in the core simulator, steam generation and superheating in the core model, followed by subsequent cooling and condensation of steam in the upper plenum, in the hot leg model, in the SG tube bundle simulators, in the cold leg model and also in the DC model.

The initial conditions for partly uncovered core regimes and for coolant natural circulation regimes following potential break conditions were established by a combination of the following actions:

- releasing steam from SG tube bundle simulator to expansion tank through valve 1, or
- by draining water from the lower pipeline (9) to the expansion tank through valve 2, or
- feed water connections to the lower pipeline (9) through valve 2 or valve 3.

The VVER horizontal tube bundle SG is simulated by two un-insulated piping sections with passive heat removal. The SG simulator only qualitatively simulates the hydrodynamics and heat transfer processes under steam condensation in the horizontal, steam generator tube bundle. For this reason the KS-1 experimental section is considered to be a semi-integral model of a VVER primary system. The core simulator, depicted in Fig. 2-2, incorporates a fuel assembly (FA) model consisting of 19 electrically heated tubes with a diameter of 9 mm and a heated zone height of 2.505 m. The pertinent geometrical details describing the test loop components as well as the fuel assembly simulator are incorporated into the Definition Report [4].

2.2 Description of Measurement System

The measurement scheme for the KS-1 VVER primary system model is shown in Fig. 2-3. The locations of the gauges in the downcomer model, lower plenum model, core model, upper plenum model and lower pipeline are presented on this schematic diagram. The parameters measured are summarized below:

Static pressure ***(Pout)*** of the coolant in the core model outlet was measured with a reference manometer. Pressure differences around the major loop components ***(DL13-12, DL2-4 and DL4-14)*** were measured with difmanometers. Pressure

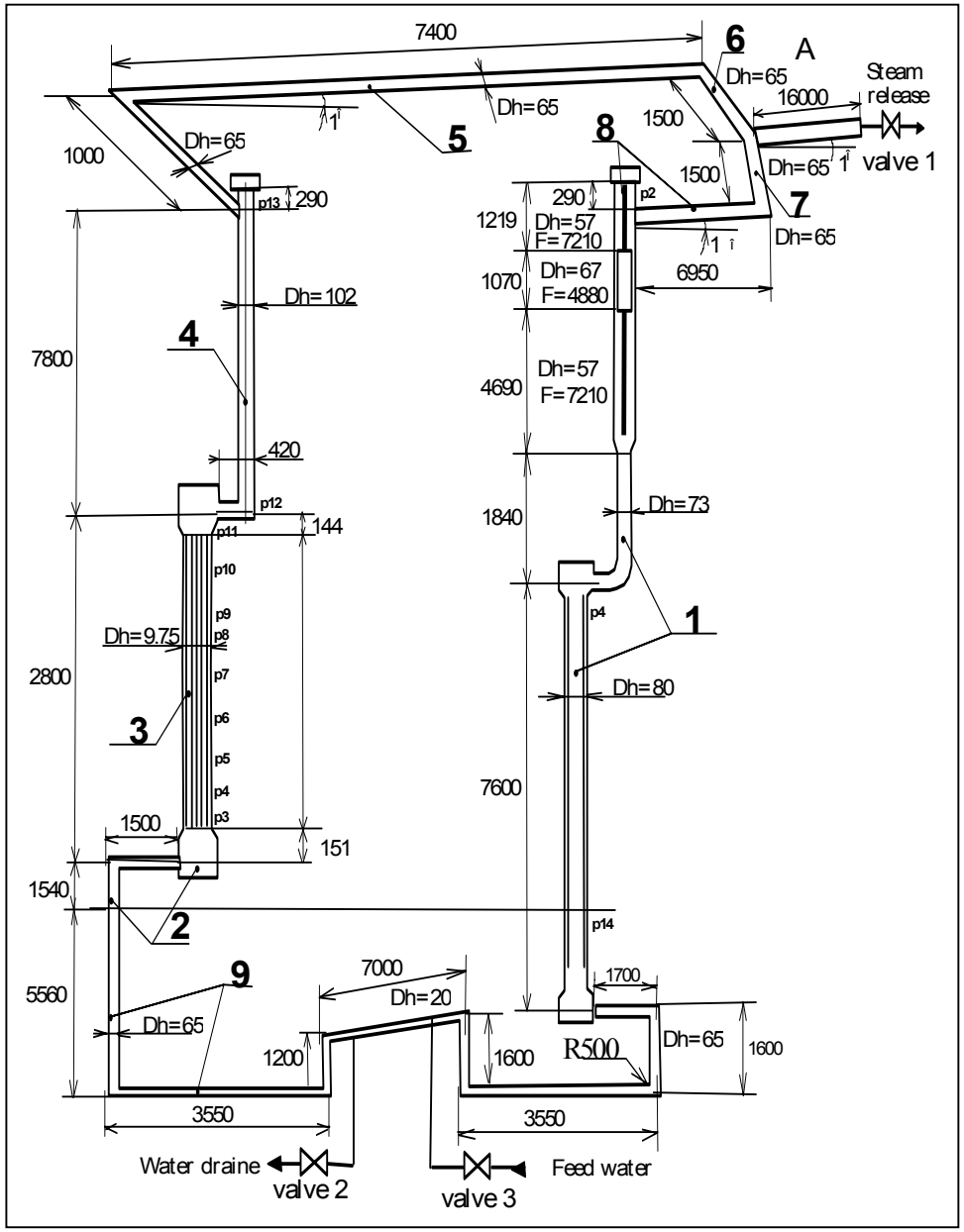

Figure 2-1. Schematic of KS-1 VVER Test Loop

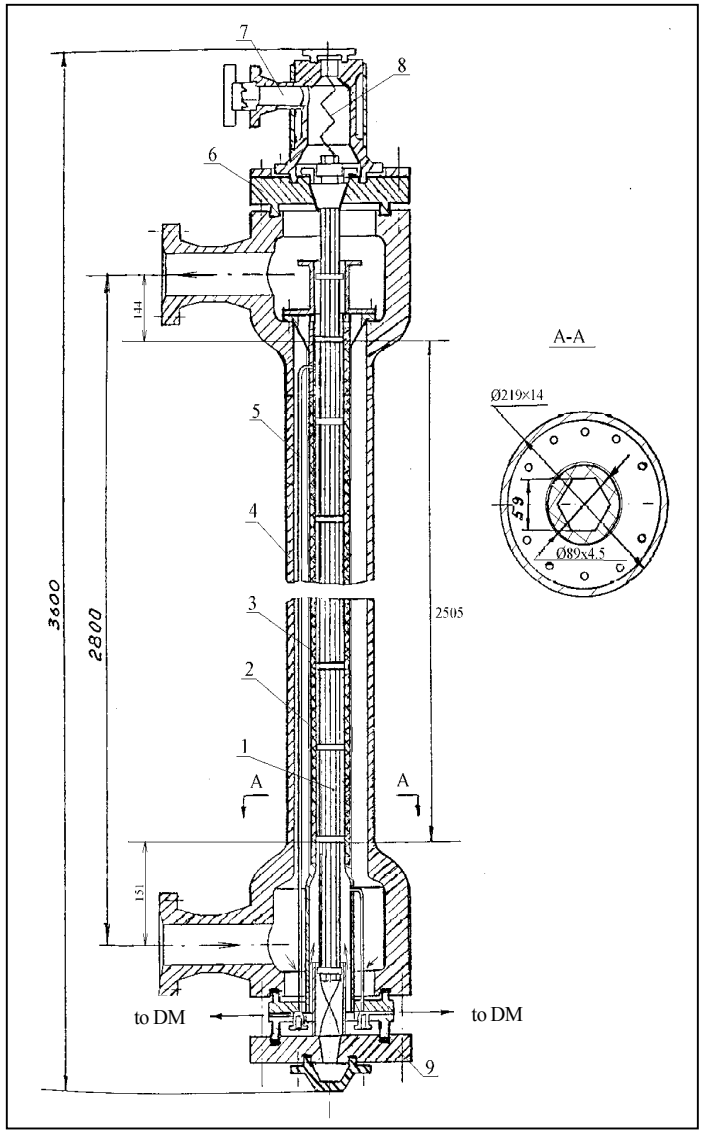

Figure 2-2. Schematic of KS-1 VVER Core Simulator

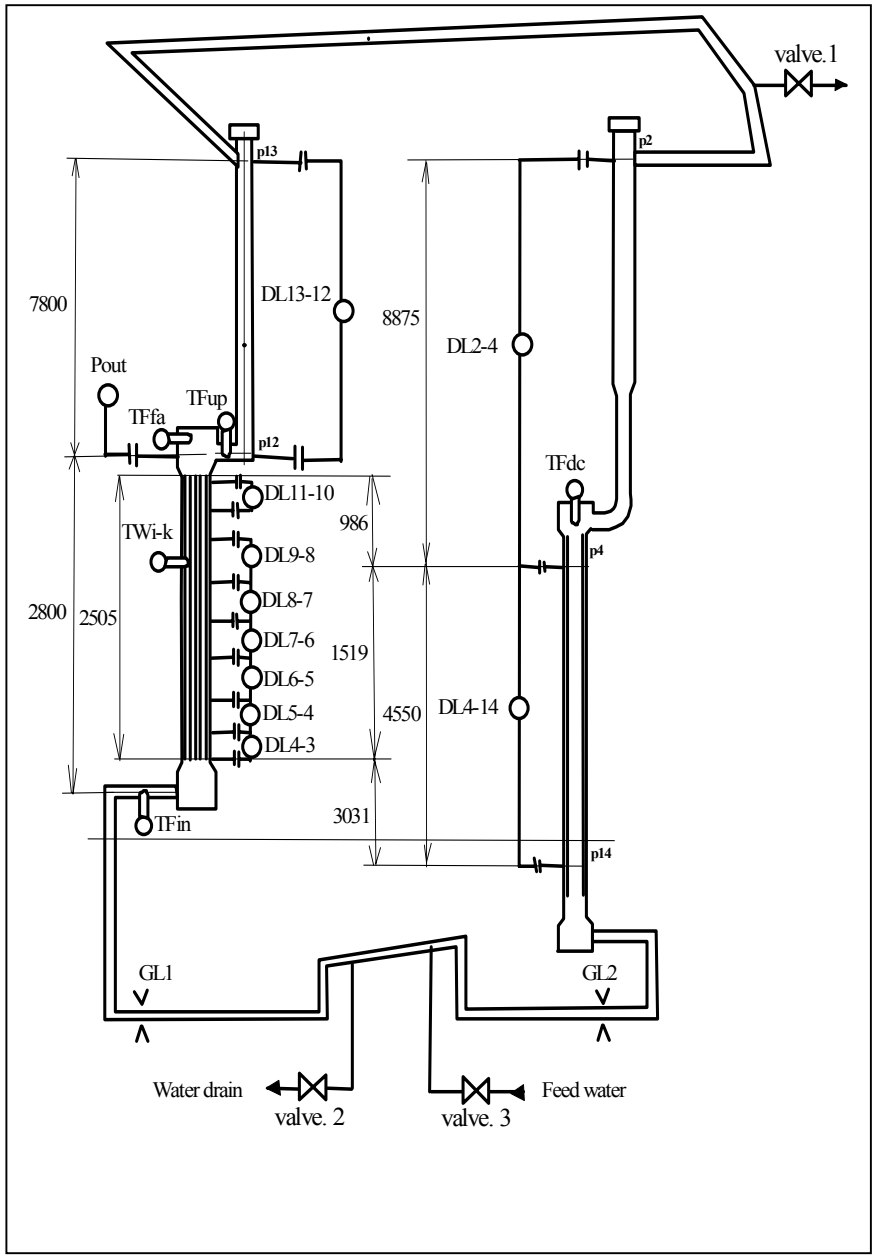

Figure 2-3. KS-1 VVER Primary System Measurement

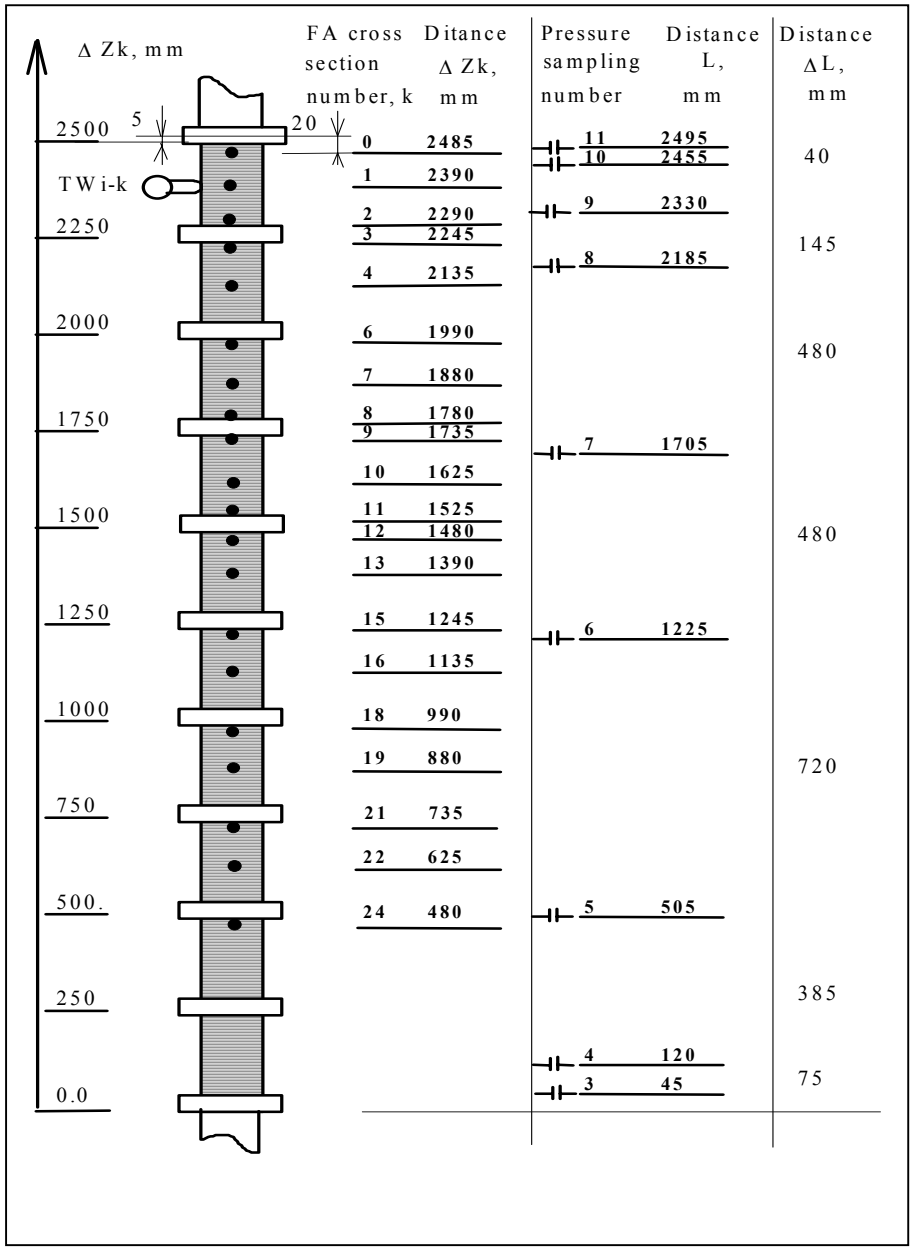

Figure 2-4. KS-1 FA Thermocouple and Pressure Sampling Points

Figure 4 KS-1 FA Thermocouple and Pressur

differences in the core model ***(DL4-3, DL5-4, DL6-5, DL7-6, DL8-7, DL9-8, and DL11-10)*** were also measured with difmanometers.

The coolant temperatures in the lower plenum model ***(TFin)***, at the FA model outlet ***(TFfa)***, at the upper plenum model inlet ***(TFup)*** and in the DC model ***(TFdc)*** were measured with chromel-copel thermocouples connected to the data acquisition computer through transducers.

The measurement scheme for the KS-1 VVER core fuel assembly model is shown in Fig. 2-4. This figure indicates the axial locations of the various fuel assembly temperature and pressure sampling locations. Measurements of axial and radial temperature distributions in the FA model were made with 33 thermocouples installed inside 14 rod simulators on 20 elevations. The temperatures of the rod simulator inner surface ***(TWi-k)*** were measured with chromel-copel and chromel-alumel thermocouples. All thermocouples were connected to the data acquisition computer through transducers.

3. Description of Tests

In 1991, investigations of unsteady boiloff, core uncovering and heat-transfer in partly uncovered FA models were conducted under quasi-steady and unsteady conditions at experimental section KS-1. Fuel pin transient temperatures were measured for a VVER-1000 FA model at small values of residual heat power under conditions of steam-condensate circulation for different levels of two-phase mixture in the core for quasi-steady flow regimes. The results of six experiments were chosen to formulate standard problem V4 to evaluate the adequacy of RELAP5 for modeling the conditions corresponding to a partly uncovered core at residual power. The tests selected (KS-1-18-1, KS-1-18-2, KS-1-19-1, KS-1-19-2, KS-1-33-1, and KS-1-34-1) represent variations in mixture level, heat flux, pressure, and steam flow rates as depicted in Table 3-1.

Table 3-1 Parameter values for the 6 experiments chosen at time t0(exp)

Experiment	Power W(t0), kW	Pressure Pout(t0), bar	Mixture level Lm(t0), m	Temperature TFin(t0), °K
KS1-18-1	20.5	67	1.62	478.15
KS1-18-2	14.5	60	1.78	479.15
KS1-19-1	21.2	35	2.29	489.15
KS1-19-2	12.9	31	1.78	488.15
KS1-33-1	9.6	31	< 0	507.15
KS1-34-1	9.4	34	0.62	511.15

Test data was recorded for the following parameters: the loop pressure at the core model outlet, differential pressures in the core region and around the primary loop, coolant temperatures at the core inlet, outlet and downcomer, 33 rod simulator wall temperatures at combinations of 14 radial and 20 axial locations, as well as the current and voltage drop across the heated channel

(representing the electrical power of the FA model). Coolant flow rates were not measured due to insufficient measurement ranges of the instrumentation.

The goals of the experiments included:

1) obtaining test data on axial and radial temperature distributions within the fuel rod simulators under various power and coolant levels in the core model,
2) determination of the influence of thermal and hydraulic processes in the primary loop component models under partly uncovered core conditions,
3) determination of the influence of loop pressure on the temperature distribution of the rod simulators under constant values of power and core mixture level for partly uncovered core conditions.

3.1 Experimental Methodology

Experiments on modeling of quasi-steady regimes of steam-condensate circulation and partly uncovering of the core were conducted under various pressures, coolant temperatures in the lower plenum model, different mixture levels in the core and various power levels. To establish the appropriate experimental conditions, preliminary heating of the coolant water and pipeline metal to the required temperature at the core model inlet was performed under forced coolant circulation. The VVER loop model was next isolated from the forced circulation circuit of the KS facility. A smooth increase of the FA power was imposed to establish a single-phase (non-boiling) natural circulation regime. Heating of the coolant water increased the coolant pressure to 80-90 bar. Coolant drainage from the SG tube bundle simulator to the expansion tank was initiated through valve 1. After the onset of boiling at the core outlet, a natural circulation, boiling regime was established in the loop under slightly greater pressure and coolant inlet temperature than specified for the test. Some steam was released from the tube bundle simulator to the expansion tank through valve 1.

Full draining of the UP model was made after the pipeline metal temperature in the upper part of the VVER circuit model reached saturation conditions near the specified values of pressure and coolant temperature at the core inlet for the individual tests. Also the core mixture level was established by draining water from the lower pipeline to the expansion tank through valve 2.

After establishment of the appropriate inlet coolant temperature and mixture level in the core model, the main test was conducted for investigating heat-transfer in the partly uncovered FA model under conditions of steam-condensate circulation with constant FA power under a quasi-steady regime. During the test measurement window, valves 1, 2, and 3 were closed. The quasi-steady behavior of these tests is due to the condensation dominance of the test loop design. The condensation dominance is the result of heat losses from the test loop exceeding the electrical power added to the core simulator rods, thereby causing a slow decrease in system pressure, core mixture level variations and variations in rod simulator wall temperatures.

4. Released Code Version and Input Deck Descriptions

The RELAP5/MOD3.2 computer program was used for the calculations reported in this report. A detailed description of RELAP5/MOD3.2 is given in Reference 1

4.1 Description of RELAP5/MOD3.2

The RELAP5 code has been developed for best-estimate transient simulation of light water reactor coolant systems during postulated accidents. The code models the coupled behavior of the reactor coolant system and the core for loss-of-coolant accidents and operational transients such as anticipated transient without scram, loss of offsite power, loss of feedwater, and loss of flow. A generic modeling approach is used that permits simulating a variety of thermal hydraulic systems. Control system and secondary system components are included to permit modeling of plant controls, turbines, condensers, and secondary feedwater systems.

The RELAP5 computer program was developed by staff at the Idaho National Engineering and Environmental Laboratory (INEEL) under funding from the U. S. Nuclear Regulatory Commission (USNRC) for the analysis of transient behavior in light water reactors. This computer program continued the development which began in 1966 with the RELAPSE code, followed by RELAP2, RELAP3, and RELAP4. The principle new feature of the RELAP5 series is the use of a two-fluid, non-equilibrium, non-homogeneous, hydrodynamic model for transient simulation of two-phase system behavior. The hydrodynamic model is a one-dimensional, transient, two-fluid model for flow of a two-phase liquid-vapor mixture which can contain noncondensable components in the vapor phase and/or a soluble component in the liquid phase. Eight field equations are solved for eight primary independent variables: pressure, two phasic (i.e., one for liquid and one for vapor) specific internal energies, vapor volume (i.e., void) fraction, two phasic velocities, noncondensable quality, and soluble component (e.g., boron) density.

The RELAP5/MOD3.2 computer program was obtained from the INEEL, which, at that time, was the RELAP5 maintenance organization for the USNRC. The program has been installed in such a way as to be accessible to a network of Sun Microsystem workstation computers running under SunOS/5.6 (a version of UNIX) in the Reactor Analysis and Engineering Division at Argonne National Laboratory. No modifications have been made to the source code.

4.2 Description of Baseline Input Deck

All of the major features of the KS-1-VVER-1000 test circuit were included in the RELAP5 input model. Figure 4-1 depicts a nodalization diagram of the baseline input model. Figure 4-2 presents a more detailed diagram of the upper core nodalization. The hydraulic model contains 182 volumes with 182 junctions. The integrated hydraulic circuit model represents a system volume of 0.448 m^3 consisting of a total system fluid mass of 125.66 kg. The zero reference elevation was specified at the bottom of the active (heated) core region for monitoring loop

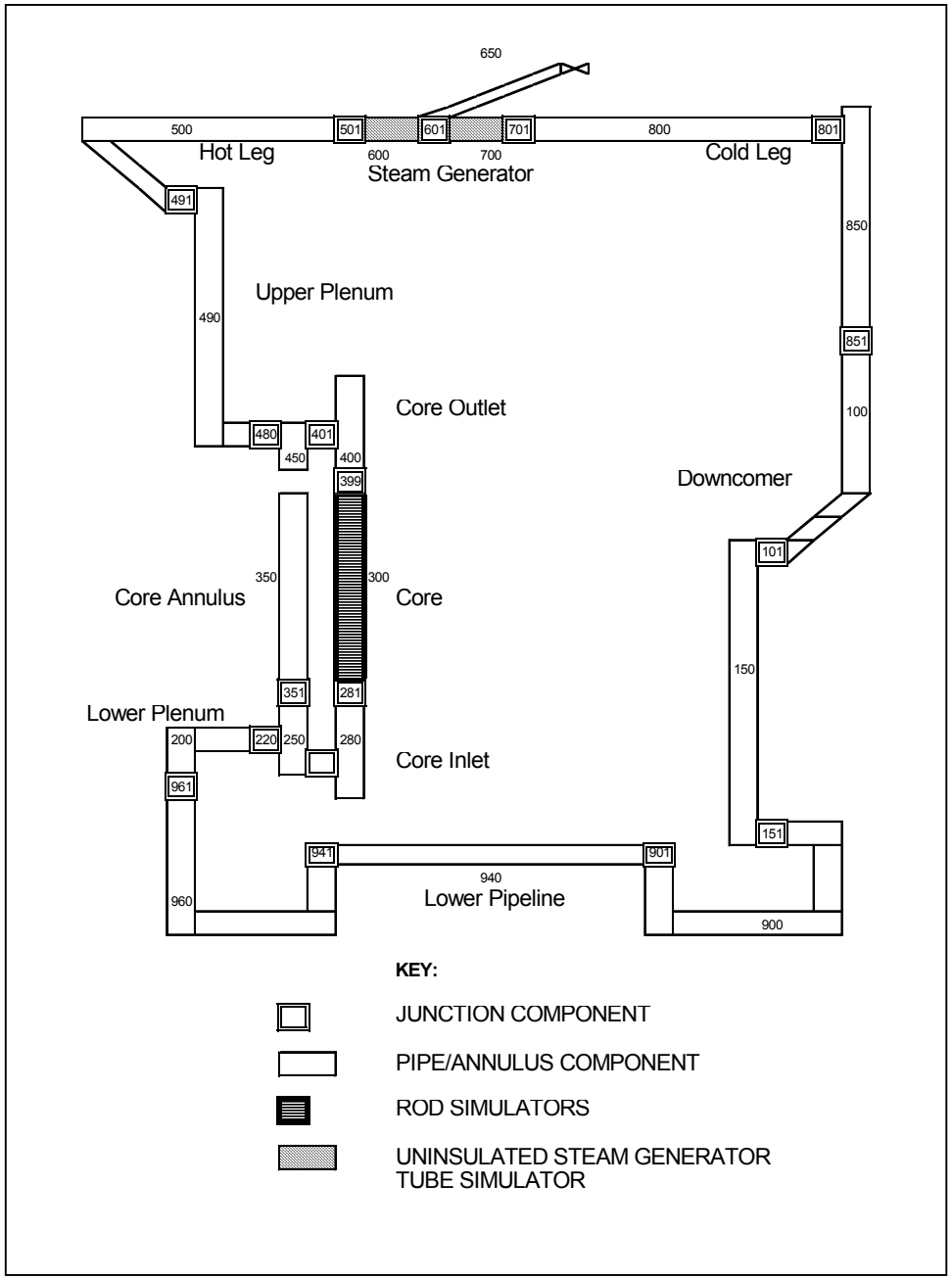

Figure 4-1. Baseline V4 RELAP5 Loop Nodalization

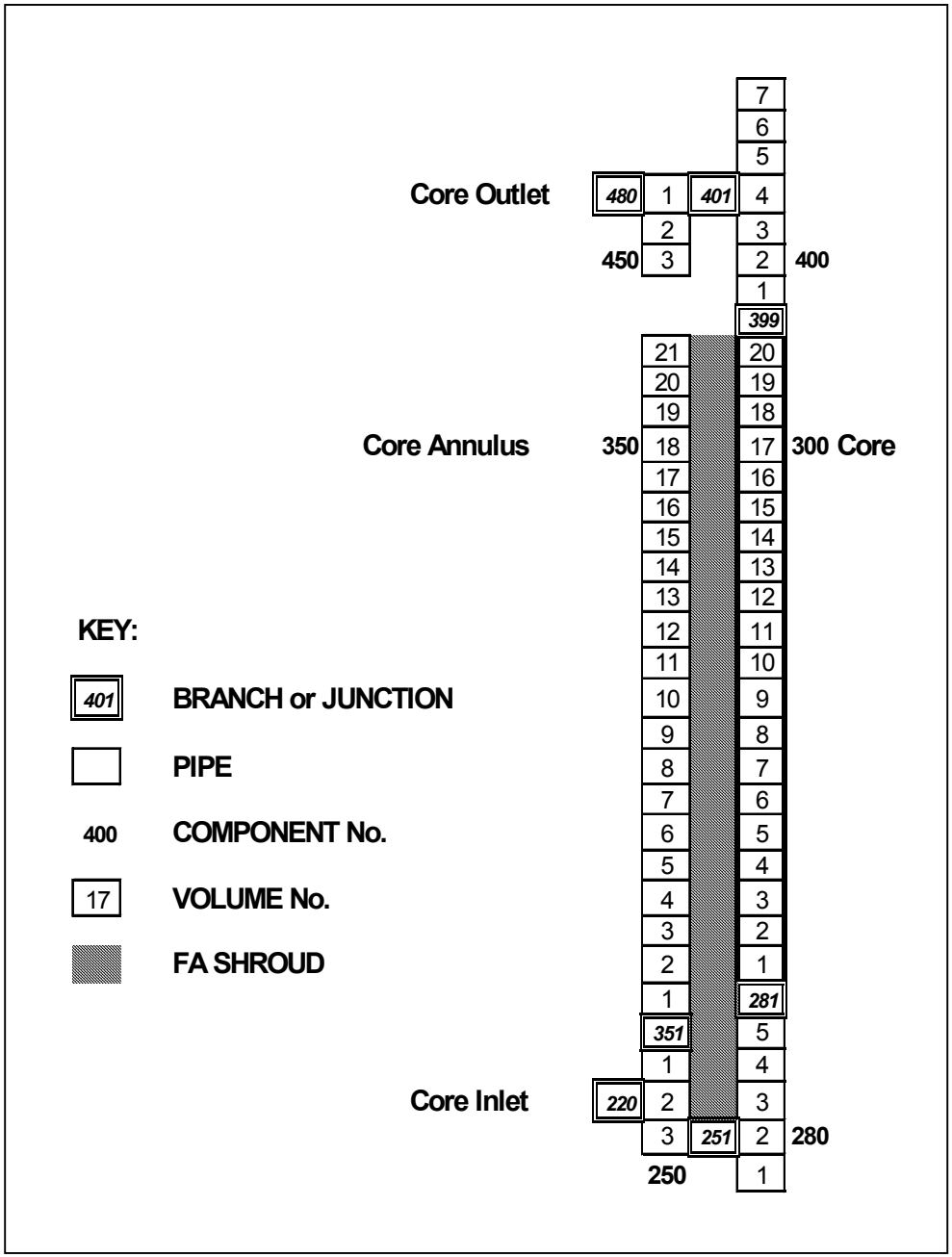

Figure 4-2. Baseline V4 RELAP5 Core Nodalization

closure calculations. Standard modeling guidelines were followed to the extent possible in developing the nodalization of the system.

The heat loss from the circuit primary and secondary system components to the ambient air was represented in the RELAP5/MOD3.2 model by entering convective boundary conditions at the exterior surfaces of all pipe volumes and other component boundaries. The definition report [4] prescribed specific constant heat transfer coefficients as a function of circuit component pipe diameter. These heat transfer coefficients were applied as constant values during the data measurement window. The code calculated the heat transferred to a constant temperature boundary condition held at the ambient room temperature (300 K). Appropriate temperature dependent material properties were input for the various piping components modeled. The external insulation surrounding the various circuit components was not modeled as separate heat structures because specific data was not provided for insulation thickness. Rather, the insulation was modeled by applying the convective heat transfer coefficients provided in the definition report. The RELAP5 heat structure model consists of 202 heat structures with 730 mesh points. The estimated total exterior circuit heat-transfer surface area of the model is approximately 25.7 m^2.

Table A1 in Appendix A provides a summary of the baseline RELAP5 model nodalization. This table describes for each major facility component the corresponding RELAP5 components which are defined to model the facility component. The description incorporates the RELAP5 component number, a brief description of the RELAP5 component, the RELAP5 component name and type, the number of volumes within each component, the hydraulic diameter, the flow area, the length, the number of associated junctions, and the connecting volume components if the component is a junction. The correspondence of the KS-1-VVER-1000 test section components with the baseline input deck numbering scheme is presented in Table 4-1 which identifies the RELAP5 component numbers and corresponding heat structures.

Table 4-1 Baseline Input Deck Numbering Scheme

KS-1 Component	RELAP5 Components	Heat Structures
Downcomer	100, 101, 150, 151	1000, 1010, 1500, 1510
Lower Pipeline	900, 901, 940, 941, 960, 961	9000, 9400, 9600
Lower Plenum	200	2000
Core Inlet	220, 250, 251, 280, 281	2200, 2500, 2501, 2800
Fuel Assembly	300	3000, 3001
Core Annulus	350, 351	3500
Core Outlet	399, 400, 401, 450, 480	4000, 4001, 4002, 4500, 4800
Upper Plenum	490, 491	4900
Loop Hot Leg	500, 501	5000, 5010
SG Tube Bundles	600, 601, 700	6000, 6010, 7000
Steam Release Pipe	650	6500
Loop Cold Leg	701, 800, 801, 850, 851	7010, 8000, 8010, 8500, 8510

The following is a brief narrative description of the RELAP5 nodalization. All volume components are numbered with even component numbers, with the exception of branch components. Typically, all junction components, including branch components, are numbered with odd component numbers.

The KS-1 downcomer is simulated by two pipe components (100, 150) and their corresponding outlet junctions represented by two branch components (101, 151). Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 1000, 1500, 1010, and 1510.

The KS-1 lower pipeline is simulated by three pipe components (900, 940, 960) and their corresponding outlet junctions represented by three single junctions (901, 941, 961). Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 9000, 9400, and 9600.

The KS-1 lower plenum is simulated by a single pipe component (200). Heat-transfer from the exterior surfaces of this component to the ambient air is simulated by corresponding heat structure 2000.

The KS-1 core simulator is represented by a core inlet section, a fuel assembly section, a core annulus section and a core outlet section as follows:

- The core inlet section is simulated by an inlet branch component (220), two annulus components (280, 250) representing the region below the fuel assembly and the surrounding annular region, and two connecting single junctions (251, 281). Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 2200, 2500, and 2501. Additionally, heat structure 2800 simulates heat-transfer between the lower, inner annulus (component 280), the surrounding annular region (component 250) and the steel separating these two regions.

- The fuel assembly section is simulated by a single pipe component (300) consisting of 20 volumes along the fuel pin axis. Heat generated within the fuel pins is simulated by a heat source (3000). Heat-transfer from the exterior surfaces of fuel pins to the coolant channel fluid is simulated by a convective boundary condition from a vertical bundle without crossflow. Heat-transfer from the coolant channel fluid to the surrounding core simulator shroud is simulated by a convective boundary condition in heat structure 3001. The shroud is modeled as a composite heat structure with steel and insulation thermal properties incorporated.

- The core annulus section is simulated by a single annulus component (350) and a single junction connecting the annulus to core inlet annulus 250. Heat-transfer from the exterior surfaces of the core simulator annulus to the ambient air is simulated by corresponding heat structure 3500.

- The core outlet section is simulated by an outlet branch component to the upper plenum (480), two annulus components (400, 450) representing the space above the fuel assembly and the surrounding annular region, and a connecting junction (401). Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by

corresponding heat structures 4800, 4500, 4001, and 4002. Additionally, heat structure 4000 simulates heat-transfer between the upper, inner annulus (component 400), the surrounding annular region (component 450) and the steel separating these two regions.

The KS-1 upper plenum is simulated by a single pipe component (490) and a corresponding outlet single junction (491). Heat-transfer from the exterior surfaces of this component to the ambient air is simulated by corresponding heat structure 4900.

The KS-1 loop hot leg is simulated by a single pipe component (500) and outlet branch component (501). Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 5000 and 5010.

The KS-1 steam generator tube bundles are simulated by two pipe components (600, 700) and a connecting tee represented by branch 601. Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 6000, 7000 and 6010. The KS-1 steam generator tube bundles are not insulated. Therefore, the enhanced heat-transfer expected from these uninsulated surfaces is modeled by specifying larger heat-transfer coefficients as indicated in the definition report [4].

The KS-1 steam release pipe is simulated by a single pipe component (650). Heat-transfer from the exterior surfaces of this component to the ambient air is simulated by corresponding heat structure 6500.

The KS-1 loop cold leg is simulated by two pipe components (800, 850), connecting outlet connections represented by single junctions (801, 851) and a branch component (701) connecting the cold leg to the steam generator tube bundle. Heat-transfer from the exterior surfaces of these components to the ambient air is simulated by corresponding heat structures 8000, 8500, and 7010.

Horizontal pipes connecting directly to vertical pipes were modeled with the momentum flux turned off at the connections to the vertical components to better simulate the effects of the change in flow direction. These modeling assumptions were applied at the hot leg connection to the upper plenum, the upper downcomer connection to the lower downcomer section, the lower pipeline connection to the lower downcomer section, and both the inlet and outlet connections to the core simulator.

The RELAP5/MOD3.2 CCFL model was applied at single junction 251, the junction between the volume beneath the core simulator and the bottom annular chamber in the core simulator. This junction was selected because it represents a location where the flow path was horizontally oriented, the flow area is reduced substantially, and it modeled a region of the flow circuit where CCFL might be expected to occur.

Choking was turned off at all junctions as recommended in the code user guidelines.

4.3 Initialization of Base Case

The test conditions were determined by both the initial conditions at the beginning of the experiment and the boundary conditions imposed on the experimental loop during the

measurements. To correctly model the experiment using RELAP5 both the initial conditions at the beginning of the experiment and the boundary conditions should match the actual values. To achieve this would require the RELAP simulation of the thermo-hydrodynamic transients which preceded the experimental window. The complex series of actions taken to initiate the experiment, combined with the lack of quantitative information (e.g. sequence and timing of events) have prevented the use of this approach. Instead, a simplified transient event was modeled, as described below, with the goal of reaching a set of reasonable initial conditions at the beginning of the experiment period.

The RELAP5 simulation was initiated at the time t0(calc) using a set of simple initial conditions. These conditions were selected to reflect a reasonable and consistent state of the loop, assuming certain liquid levels and temperatures in various loop sections. The loop pressure was initiated to the core outlet pressure Pout(t0(calc)), selected to be higher than the measured pressure Pout(t0(exp)). The lower part of the loop was assumed to contain saturated liquid up to a certain level. Above that level the loop was assumed to contain saturated wet vapor. The RELAP5 simulation was run for a time interval of 100 s, with no fuel assembly (FA) heat release and zero heat losses. This calculation allows the liquid levels around the loop to reach consistent values and the equilibration of coolant and loop structure temperatures.

The simulation was continued by a second phase, between 100-400 s, during which the both the FA power and the loop heat losses were increased from zero to the levels observed during the experiment. The FA power was increased linearly from zero to the value W(t0, experiment). The heat losses were increased by increasing the heat loss coefficient Closs from zero to a maximum value Closs(max). The coefficient Closs is used as a multipler applied to the theoretical loop heat losses calculated by RELAP, and accounts for uncertainties in the calculation of these heat losses. The value Closs(max) was selected to provide the best agreement between the calculated pressure Pout(calculated) and the corresponding measured pressure Pout(measured) during the experiment time window.

After 400 s, both the FA power and the Closs coefficient were kept constant. During this third phase, the calculation describes the quasi-steady-state phase of the experiment, during which the pressure Pout decreases gradually. The beginning time of the experiment window t0(exp) was associated with the calculation time t1(calc) at which Pout(t1(calc)) = Pout(t0(exp)). Similarly, the end time of the experiment window t1(exp) was associated with the calculation time t2(calc) at which Pout(t2(calc)) = Pout(t1(exp). Several parameters, such as the liquid level, initial pressure Pout(t0(calc)), and the quality of the vapor were varied in order to obtain a calculated FA liquid level which matches the corresponding liquid level inferred based on the experimental data, at the beginning of the experiment time window.

It is noted that this approach, which relies on an arbitrary transient to simulate the actual loop transient was dictated by the lack of information about the actual initial transient. This methodology introduces substantial uncertainties concerning the general agreement between the calculated and experimental initial loop conditions. Only a limited number of initial conditions can be matched by the calculated transient in the complex experimental loop analyzed. Because the calculations indicate that the loop is still in a transient during the third phase, and because detailed information about the experimental conditions prior to the experiment time window is limited, it is not clear that the simulated loop conditions are the same as the experimental conditions. While the comparison of the calculated results with the experimental data is

instructive, no firm conclusions can be drawn about the adequacy of RELAP models based on such comparisons.

4.4 Description of Sensitivity Cases

4.4.1 Sensitivity Cases Examining Initial Thermal-Hydraulic Conditions

A large number of parametric cases were run, with the goal of examining the influence of initial thermal hydraulic conditions on the fuel assembly temperatures during the experiment window. Parameters studied included the core water level, the annular zone water level, and the steam quality in the upper regions of the experimental loop. The results of selected cases are presented in Sections 5.2.1-5.2.3. They show that the FA temperatures during the experiment window are significantly affected by these parameters. By adjusting the values of these parameters, and other input parameters described in the next section, 4.4.2, reasonable agreement between the calculated and measured FA temperatures can be obtained. However, other combinations of input conditions could lead to similar (and possibly better) agreement between calculations and experimental data. The sensitivity of results to these unknown input parameters indicates that no firm conclusions concerning the adequacy of RELAP models can be drawn from this analysis.

4.4.2 Sensitivity to Loop Nodalization

The sensitivity of the computed results to the loop nodalization was also examined. Special attention was given to the nodalization of the FA top section which connects the FA and the upper plenum. The results of these cases, which indicate a significant sensitivity of results to the nodalization and initial conditions of this loop section, are presented in Section 5.2.4. The sensitivity of the FA temperatures to the FA exit section nodalization highlights the fact that the transient behavior of the FA temperatures during the experiment window is influenced by a combination of initial conditions and nodalization of complex loop components. Because of the experimental loop complexity, and the limited information about the initial conditions, an exhaustive study of the loop nodalization effects is impractical. This further reinforces the conclusion that the analysis of this experiment is not suitable for the evaluation of the adequacy of RELAP models.

5. Results

This section describes the results of analyses of test KS1-18-2, starting with the base case results which are presented in Section 5.1 and continuing with a number of sensitivity analyses, the results of which are presented in Section 5.2.

Substantial uncertainties about the experimental initial conditions were identified in the analysis of Test KS1-18-2. Because similar uncertainties clearly exist in the other tests, we decided to limit our analysis to the Test KS1-18-2.

5.1 Base Case Results

5.1.1 KS1-18-2 Test Data Description

During the experiment time window, texp = 0-250 s the power was kept constant at W(texp)=14.5 kW, and natural circulation was established in the closed loop circuit. A slow pressure decrease was measured, with the rate dPout / dt = -0.028 bar/s, which is attributed to the fact that the total loop heat losses Qloss(texp) were greater than the FA power W(texp), leading to a dominance of steam condensation over steam generation. The initial value of the the pressure Pout was Pout(t0exp) = 60.2 bar, and the final value was Pout(texp=250s) = 53.3 bar. The measured Pout values are shown in Fig. 5-3.

The initial value of the mixture level in the FA, based on the rod wall temperature axial distribution, was Lm(T0exp) = 1.78 m. During the experiment the mixture level increased gradually, leading to an increased wall-to-coolant heat transfer at higher FA elevations, and causing the local rod wall temperatures to decrease close to the coolant saturation temperature. This is illustrated by the measured rod wall temperatures in the upper part of the FA, shown in Fig. 5-11 - 5-13. The temperatures recorded at elevation L=2.485 m (Fig. 5-11) indicate that the mixture level reached the top of the FA channel during the experiment time window.

Because the experimental data was limited to the 250 s experiment time window, it is not possible to clearly determine how far the loop was from reaching a steady-state condition. However, the FA liquid level increase illustrated in Figs. 5-11 – 5-13 seems to indicate that the loop was still in a transient oscillatory state. The liquid level increase in the FA leads to an increase in the amount of heat transferred to the coolant and therefore to an increase in the amount of vapor formed. As the vaporization rate overtakes the condensation rate, the FA liquid level would begin to decrease, until the process reverses again.

When modeling a complex hydraulic system in a transient state it is necessary, in order to be able to evaluate the adequacy of the models, to follow the entire transient sequence. Replacing the initiating transient with an arbitrary transient introduces substantial uncertainties about the equivalence of experimental and calculated conditions at the beginning of the experiment time window. The fact that a limited set of measured parameters are matched by the calculated results at the beginning of the experiment window does not guarantee that all other relevant conditions are matched and that the modeled system is following the same transient as the experiment.

5.1.2 KS1-18-2 Test Modeling of Initial and Boundary Conditions.

The initial conditions of the RELAP simulation at the beginning of the simulation and the boundary conditions were selected with the goal of matching key experimental values at the beginning of the experiment time window t=t0(exp)=t1(calc) and other key experimental data

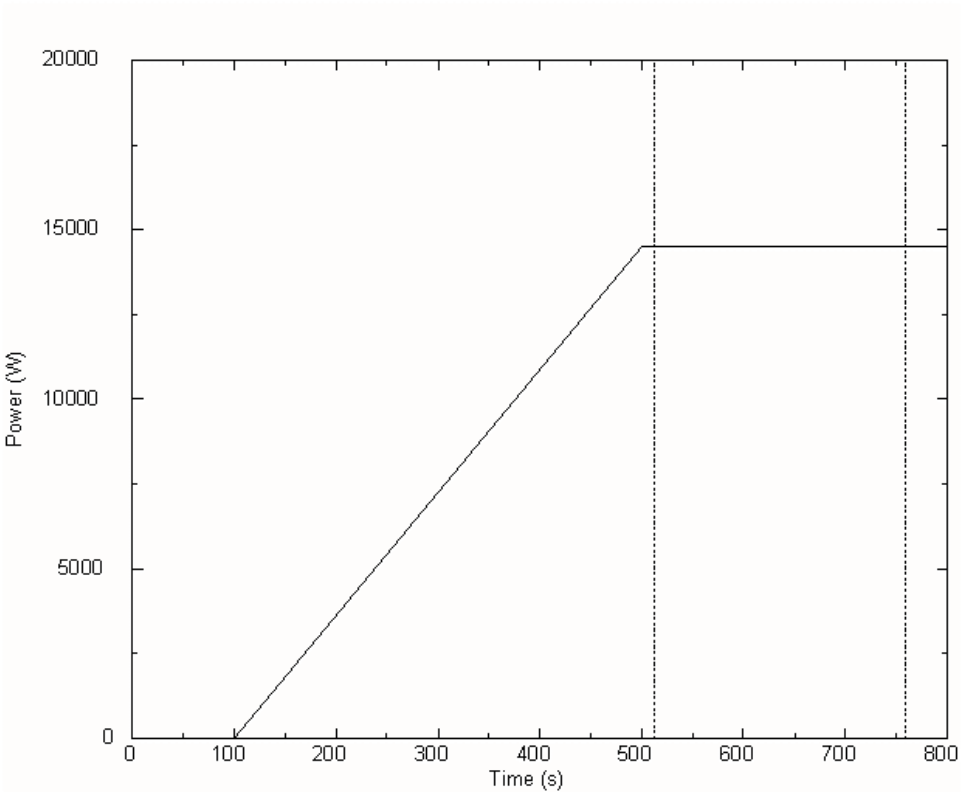

Fig. 5-1. Fuel Assembly Model Power, Test KS1-18-2.

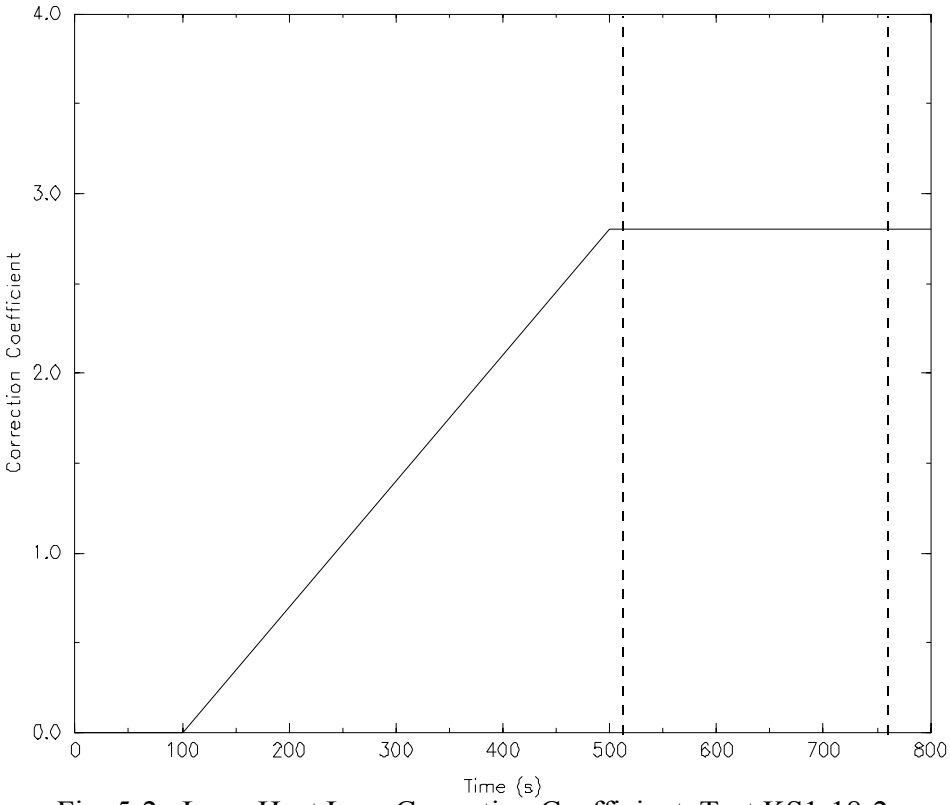

Fig. 5-2. Loop Heat Loss Correction Coefficient, Test KS1-18-2.

observed during the experiment. In particular, we were interested in matching the following experimental parameters:

- the FA heat release was constant and equal to W=14.5 kW during the experiment time window;

- the core outlet pressure was equal to Pout(t0exp) = 60.2 bar, and then decreased during the experiment to Pout(t1exp) = 53.3 bar, with the rate dPout/dt = -0.028 bar/s;

- initial coolant temperature at the core inlet was TFin(t0exp)=479 K;

- initial FA liquid level location was inferred based on the FA rod wall temperature profile to be Lm(t0exp) = 1.78 m, and then the level increased during the experiment with the rate dLm/dt ~ 4.4 mm/s.

Due to the fact that an arbitrary power and heat loss computational transient was used to arrive to the desired conditions at the beginning of the experiment time window, the initial computational conditions are not well defined, and multiple calculations were necessary to reach a quasi-optimal set of initial computational conditions. This set of initial conditions, presented below, was selected to define the base case. However, as an exhaustive exploration of all possible initial computational conditions is not practically possible, other combinations of initial computational conditions might exist which provide a better match with the experimental conditions at the beginning of the experiment window and throughout the experiment. The following initial computational conditions were used for the base case:

- FA power W(t0calc) = 0 and the heat loss coefficient Closs(t0calc) = 0;

- the initial pressure was Pout(t0calc) = 66.7 bar. This pressure, which is higher than the pressure Pout(t0exp) = 60.2 bar, was selected to allow the pressure, which deceases during the initial computational transient, to match the observed pressure Pout at the beginning of the experiment time window.

- the lower plenum and lower pipeline were assumed filled with liquid with temperature TFin(t0calc) = TFin(t0exp) = 479 K;

- the liquid level in the core Hcore(liquid = 1.25 m), core annulus Hannulus (liquid =-0.12625 m, and downcomer Hdowncomer(liquid) = 0.019 m were selected to provide optimal agreement with the experimental data mentioned above;

- the remaining parts of the loop were assumed filled with saturated wet vapor, with the pressure Pout(t0calc) and quality X(t0calc) selected to provide optimal agreement with the experimental data mentioned above;

- the temperatures of the loop components filled with liquid were assumed equal to the liquid temperature, 479 K.

- the temperatures of the loop components filled with saturated steam were assumed equal to the saturation temperature, 556 K, corresponding to the initial loop pressure Pout(t0calc).

The RELAP simulation was initiated by an initial calculation with the core power W=0 and the heat loss coefficient Closs=0 for the t = 0 - 100 s. This calculation allows the equilibration of initial loop liquid levels and temperatures. Between 100 - 500 s the FA power and the loop heat losses were increased to reach the levels observed during the experiment. During this time interval the FA power was increased linearly from zero to W = 14.5 kW and the loop heat losses were also increased by linearly increasing the heat loss coefficient Closs from zero to Closs = 2.8. After t = 500 s both the FA power W and the heat loss coefficient Closs were kept constant. The maximum value of the heat loss coefficient Closs = 2.8 was selected because it provides good agreement between the calculated and experimental pressure Pout during the experiment time window. The use of this coefficient, which reflects uncertainties in the heat loss calculations, introduces an additional degree of freedom in the analysis and increases the uncertainty in the boundary conditions adequacy. The magnitude of these uncertainties is underscored by the fact that, in order to achieve agreement between the calculated and measured values of the pressures Pout, the loop heat losses need to be approximately 3 times higher than expected based on the loop geometry and heat transfer coefficients. The values of the FA power W and the heat loss coefficient Closs are shown, as a function of time, in Figures 5-1 and 5-2.

As the heat losses are larger than the FA energy deposition, the calculated core outlet pressure Pout decreases gradually after t = 500 s. The computation time t1calc that corresponds to the beginning of the experiment window t0exp was selected such that Pout(t1calc) = Pout(t0exp) = 60.2 bar. This led to the selection of t1calc = 507 s. It is observed that at this time the FA power W and the heat loss coefficient Closs have been kept constant for only 7 seconds, which is too short a time for the loop to reach an equilibrium, or quasi-equilibrium state. Based on the computational results, we conclude that the loop was in a transient condition during the experiment time window. This increases substantially the difficulty of establishing the equivalence of initial states of the computational and experimental systems, when the computational transient used to reach the time t1calc is different from the actual sequence used in the experiment to reach the state at t0exp. To establish the equivalence of the computational and experimental systems in the presence of a transient requires not only the matching of the basic thermo-hydrodynamic variables but also the matching of many time derivatives of these variables.

5.1.3 Base Case Computational Results and Comparison to Test Data.

This section discusses first the calculated initial conditions at the beginning of the experiment time window and then the calculated transient results during the experiment.

5.1.3.1 Calculated Initial Conditions.

The computational time that corresponds to the beginning of the experimental time window t1calc = t0exp is determined by the requirement that Pout(t1calc) = Pout(t0exp). This equality is satisfied at t1calc = 507 s. The calculated values of Pout(tcalc) are shown in Figure 5-3, which

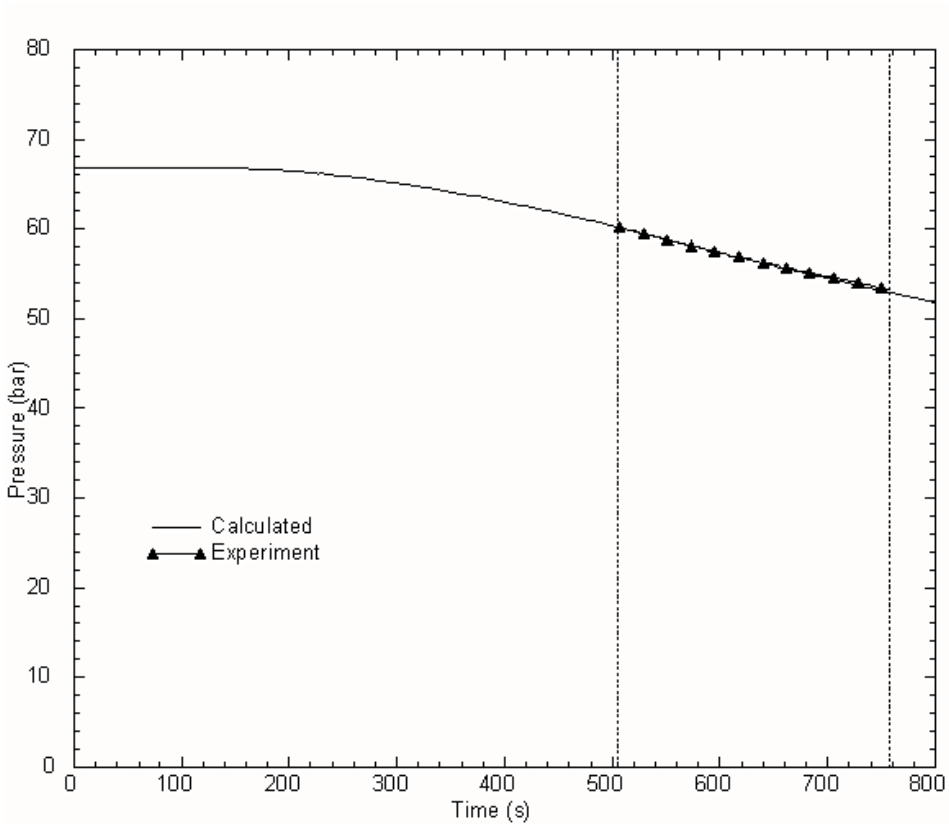

Fig. 5-3. Pressure at FA Model Outlet Pout, Test KS1-18-2.

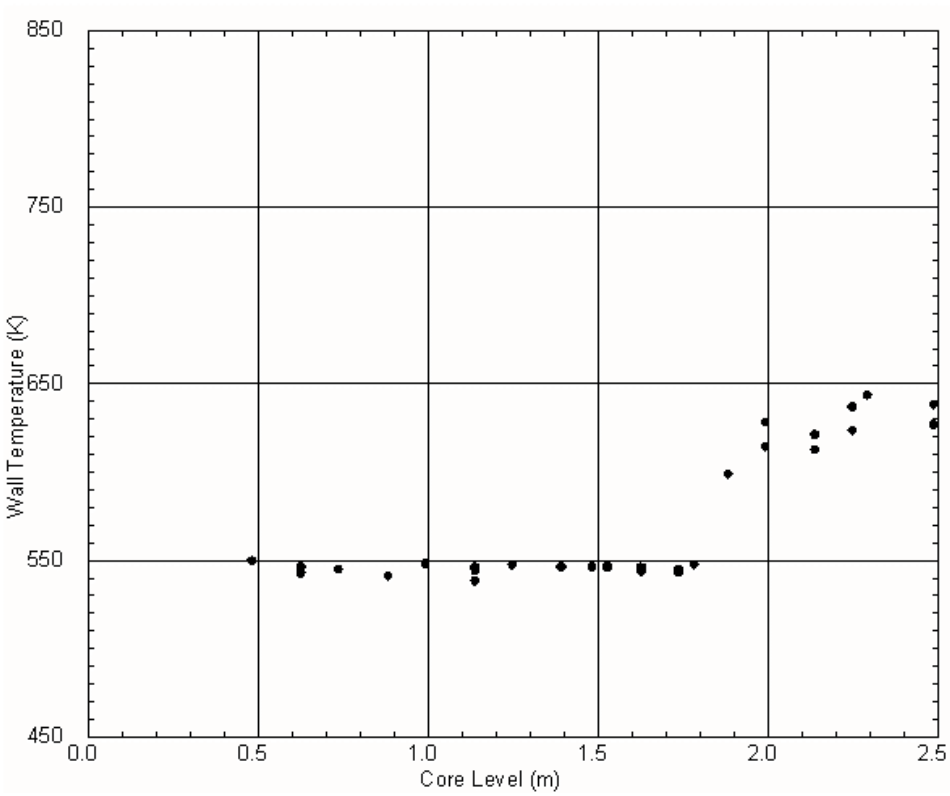

Fig. 5-4. Measured rod wall temperatures at time t0exp, Test KS1-18-2.

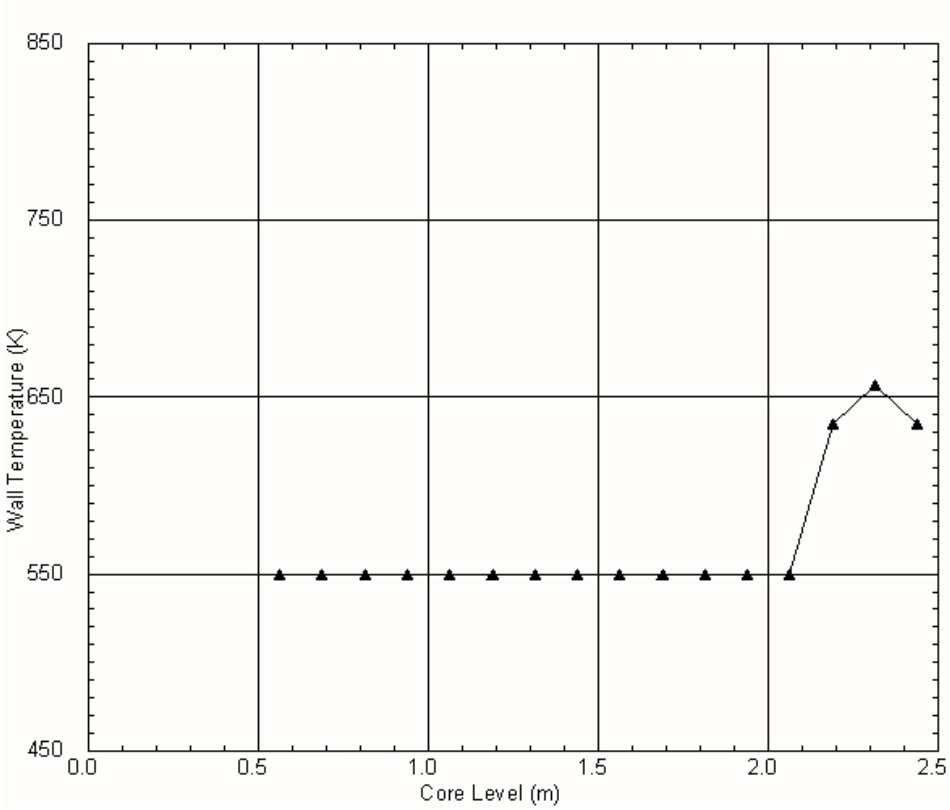

Fig. 5-5. Calculated rod wall temperatures at time t0exp, Test KS1-18-2

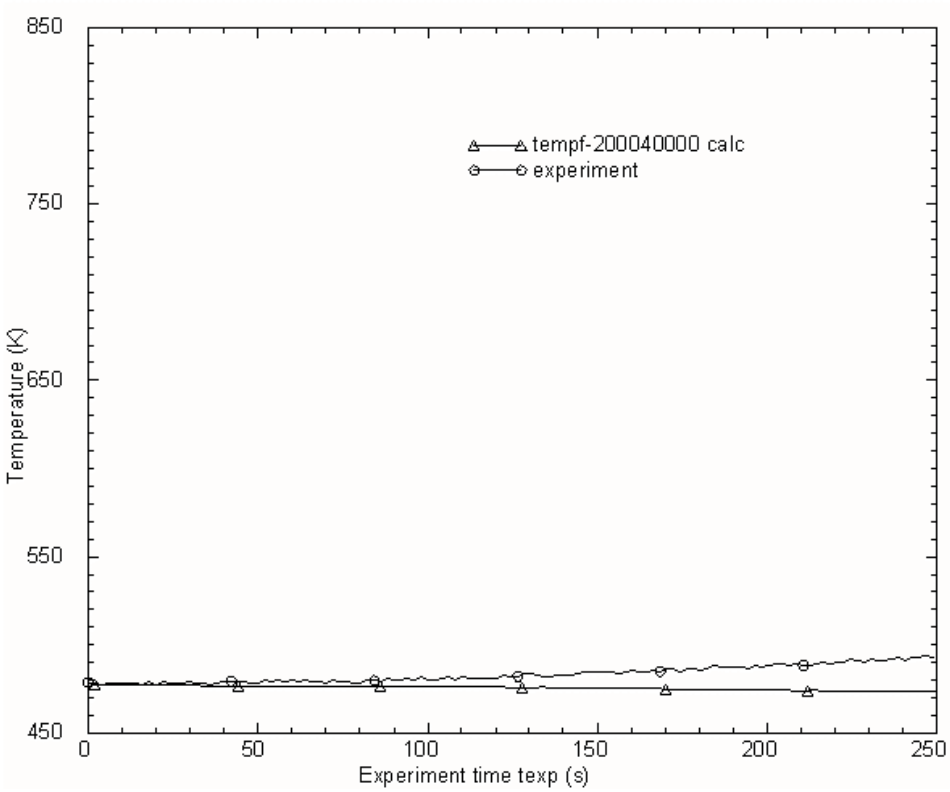

Fig. 5-6. Coolant temperature at core model inlet TFin, Test KS1-18-2.

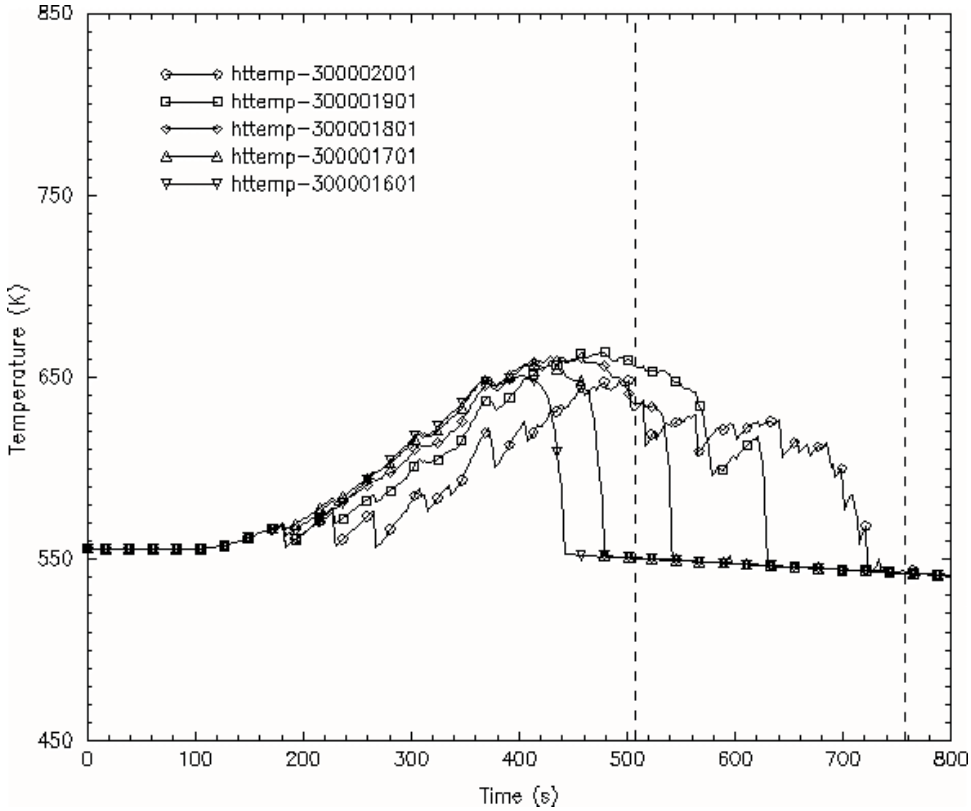

Fig. 5-7. Calculated Inner Wall Temperatures, Test KS1-18-2.

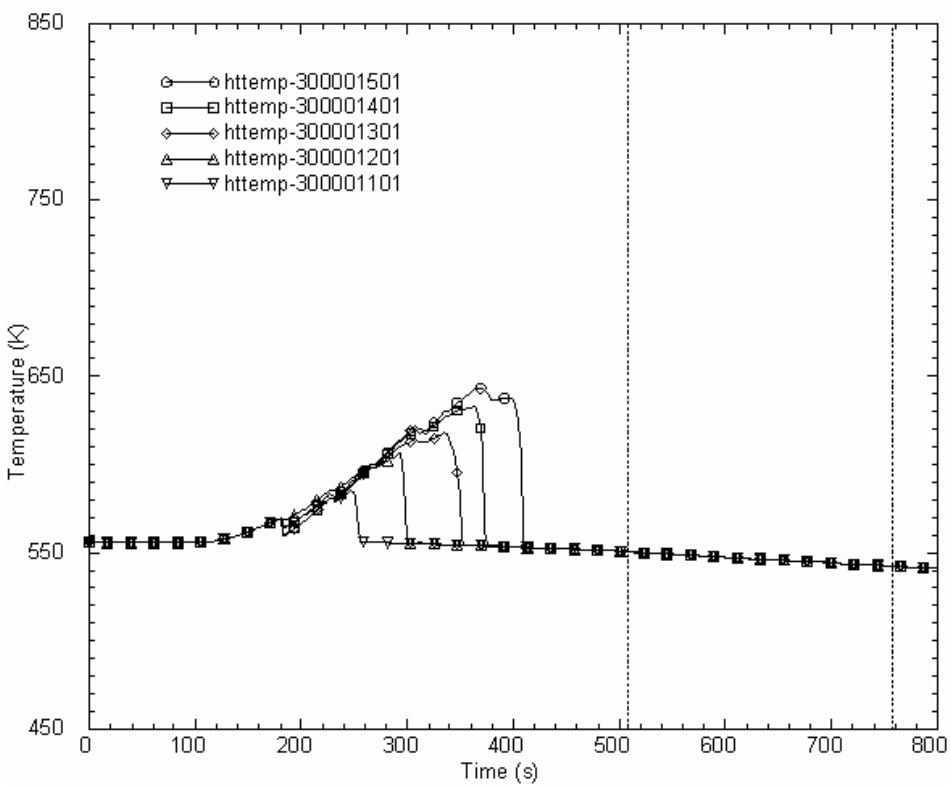

Fig. 5-8. Calculated Inner Rod Wall Temperatures, Test KS1-18-2.

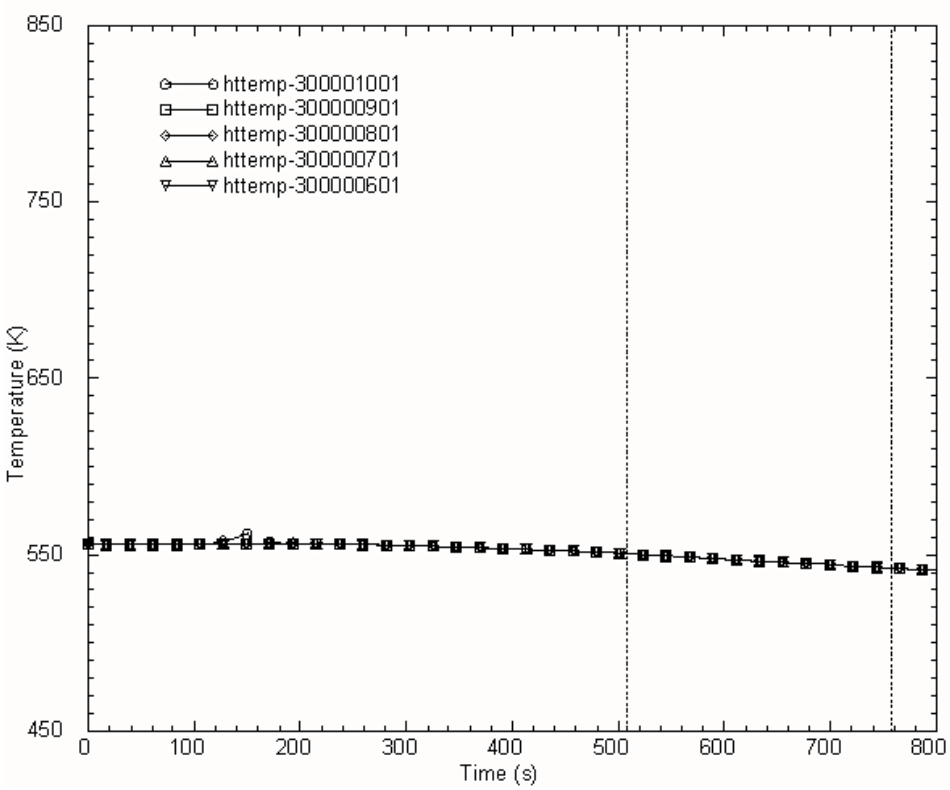

Fig. 5-9. Calculated Inner Rod Wall Temperatures, Test KS1-18-2.

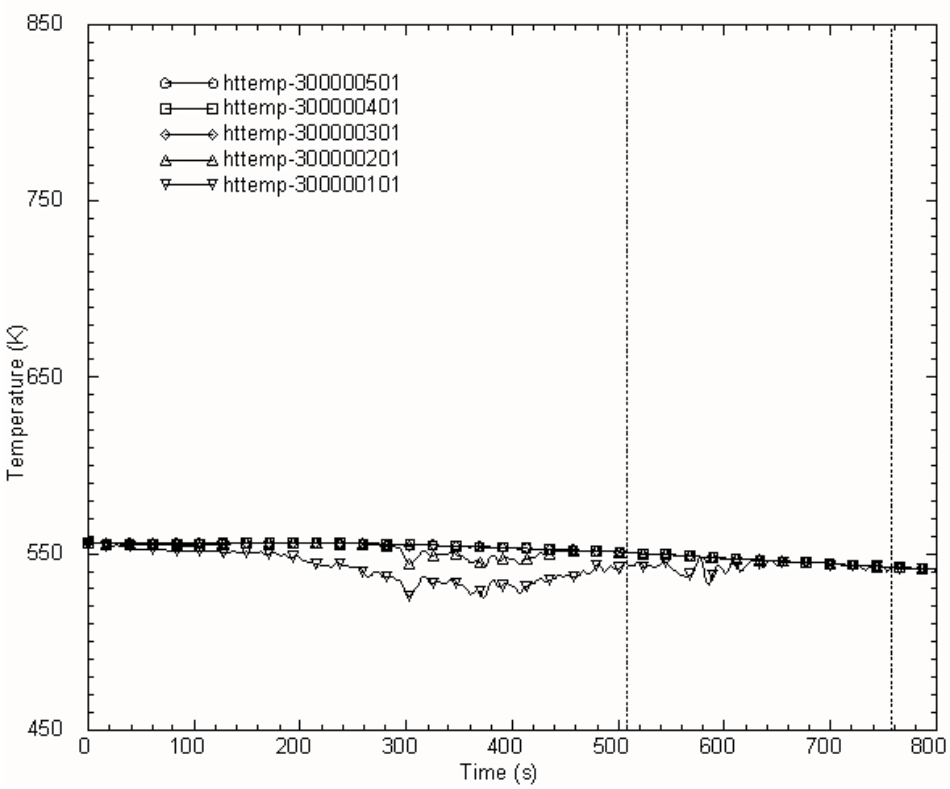

Fig. 5-10. Calculated Inner Rod Wall Temperatures, Test KS1-18-2.

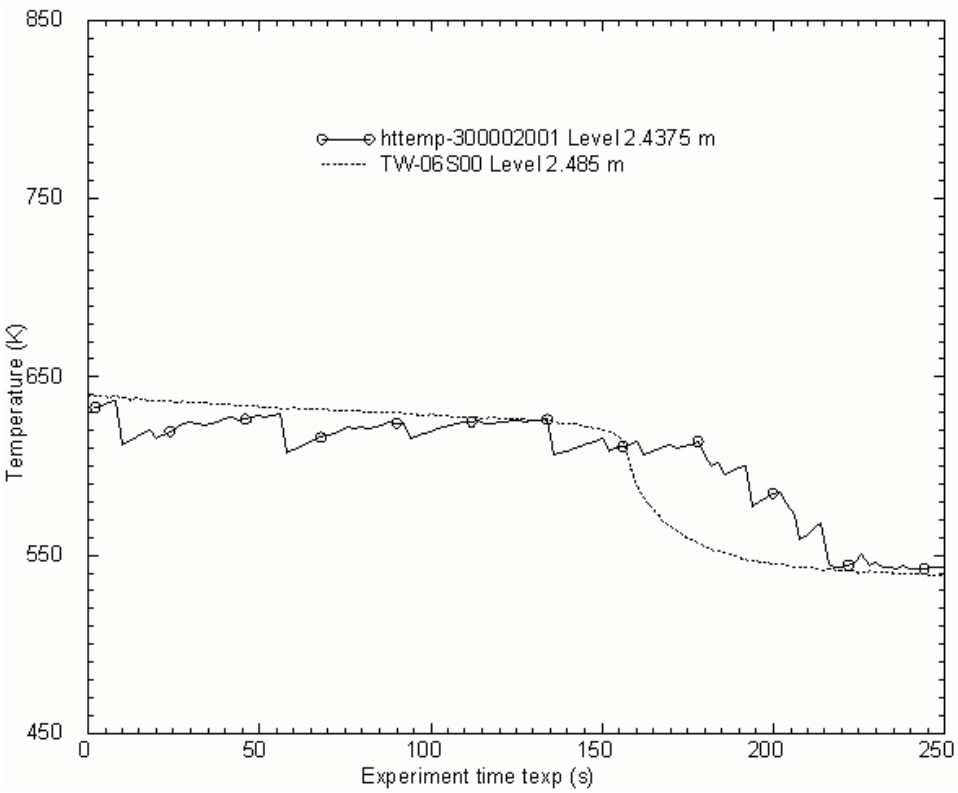

Fig. 5-11. Calculated and Measured Rod Wall Temperatures , Test KS1-18-2.

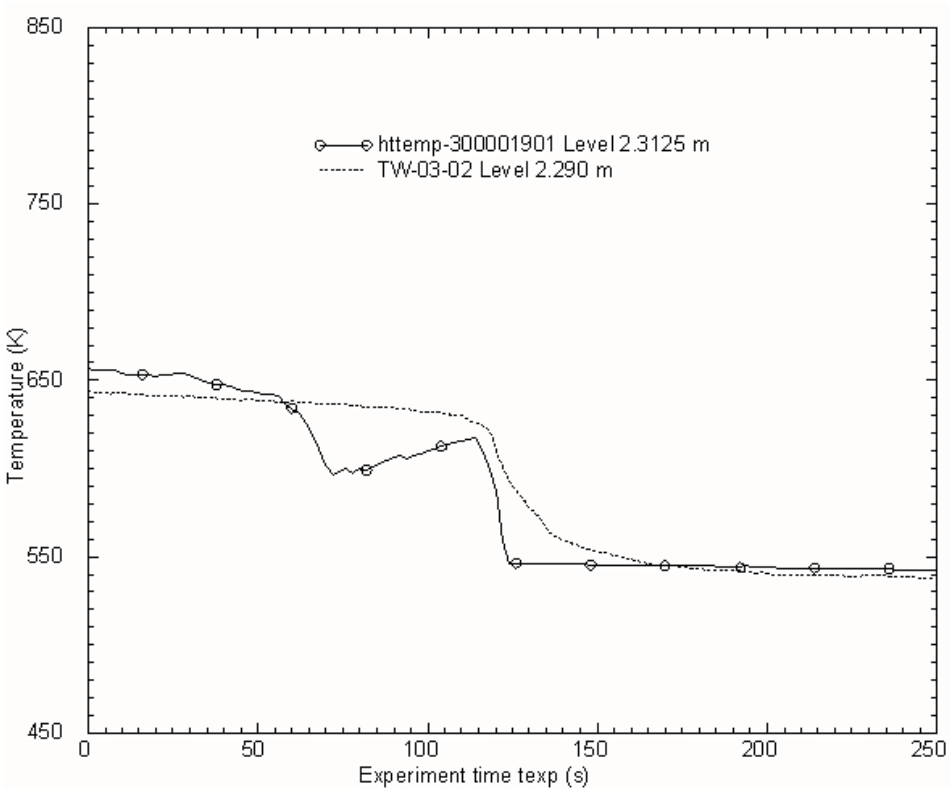

Fig. 5-12. Calculated and measured rod wall temperatures, Test KS1-18-2.

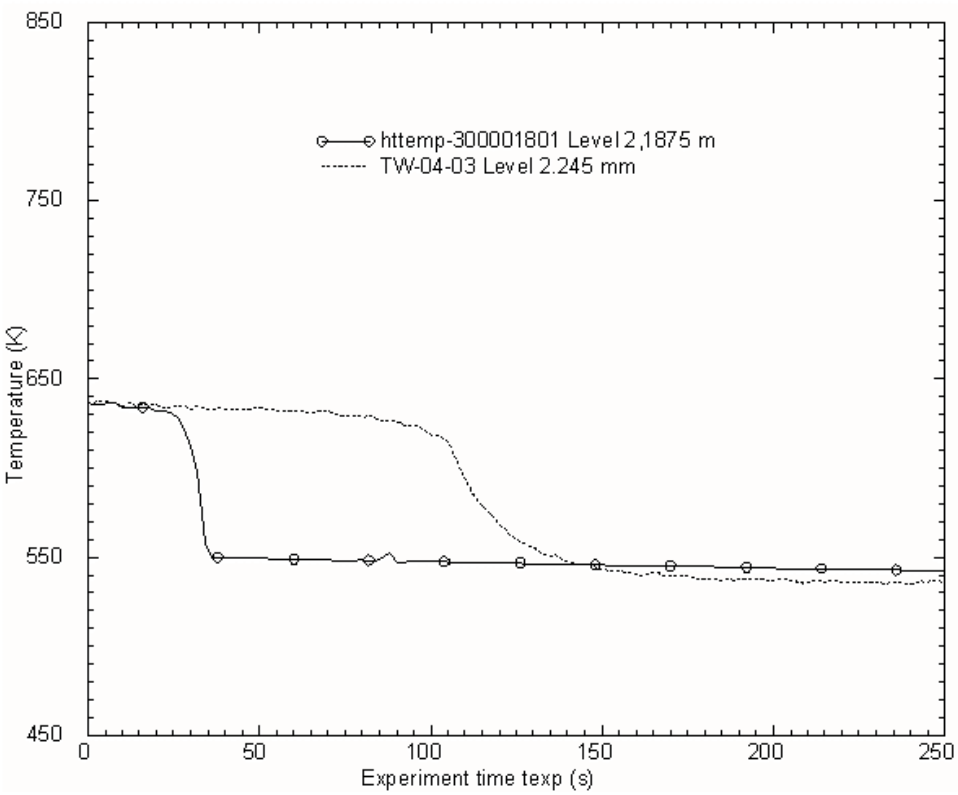

Fig. 5-13. Calculated and Measured Rod Wall Temperatures, Test KS1-18-2.

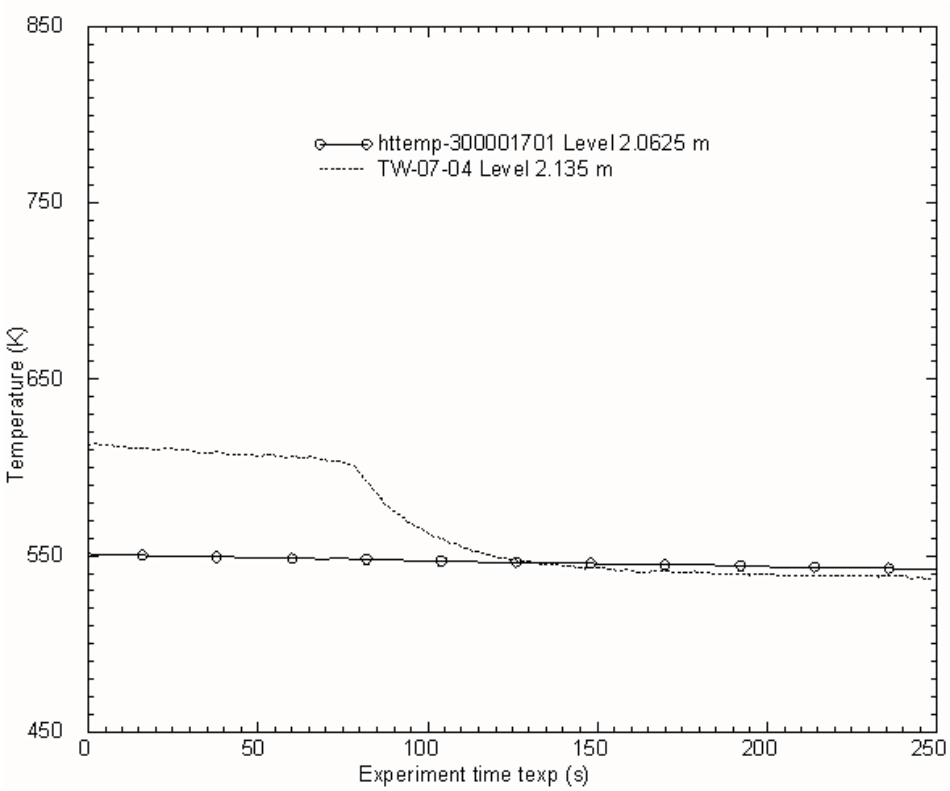

Fig. 5-14. Calculated and Measured Rod Wall Temperatures, Test KS1-18-2.

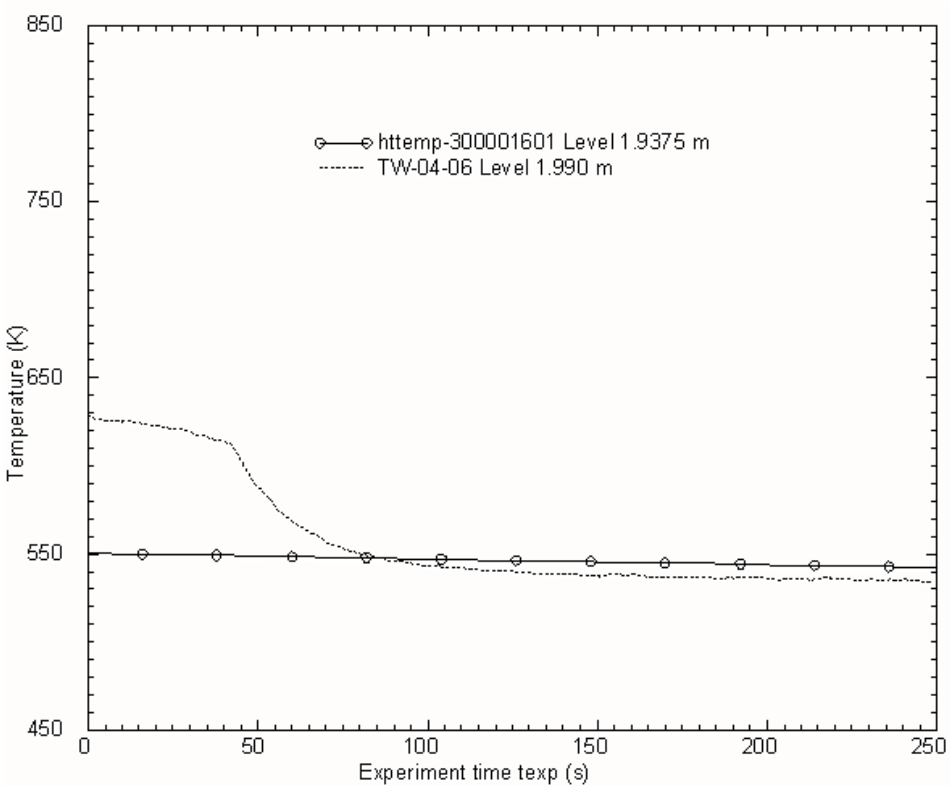

Fig. 5-15. Calculated and Measured Rod Wall Temperatures, Test KS1-18-2.

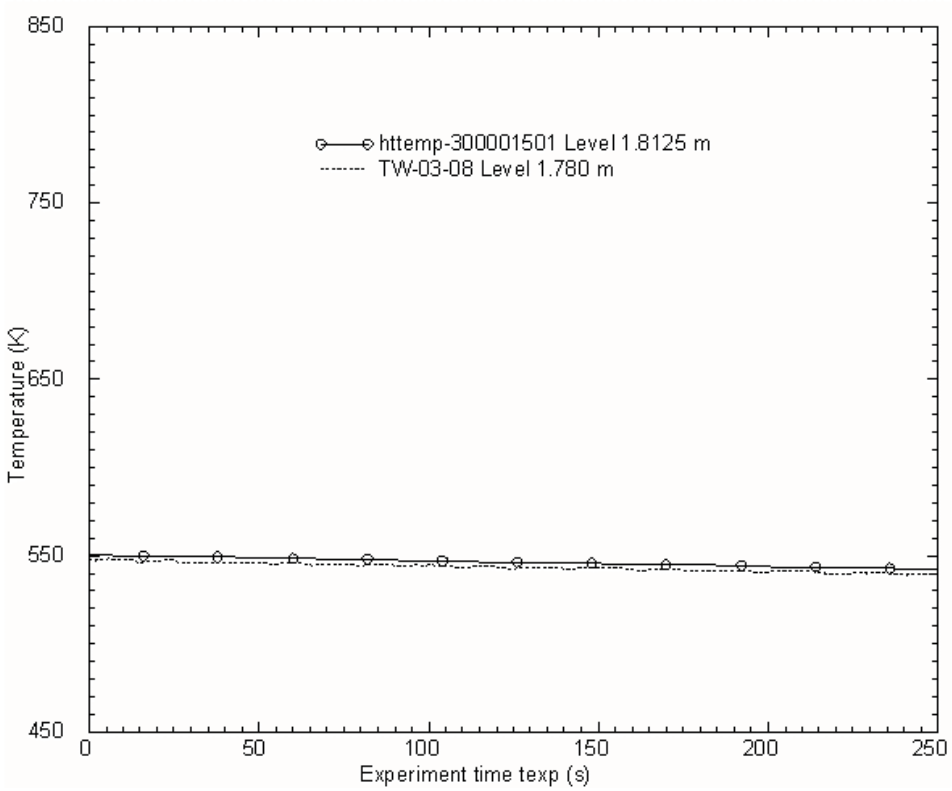

Fig. 5-16. Calculated and Measured Rod Wall Temperatures, Test KS1-18-2.

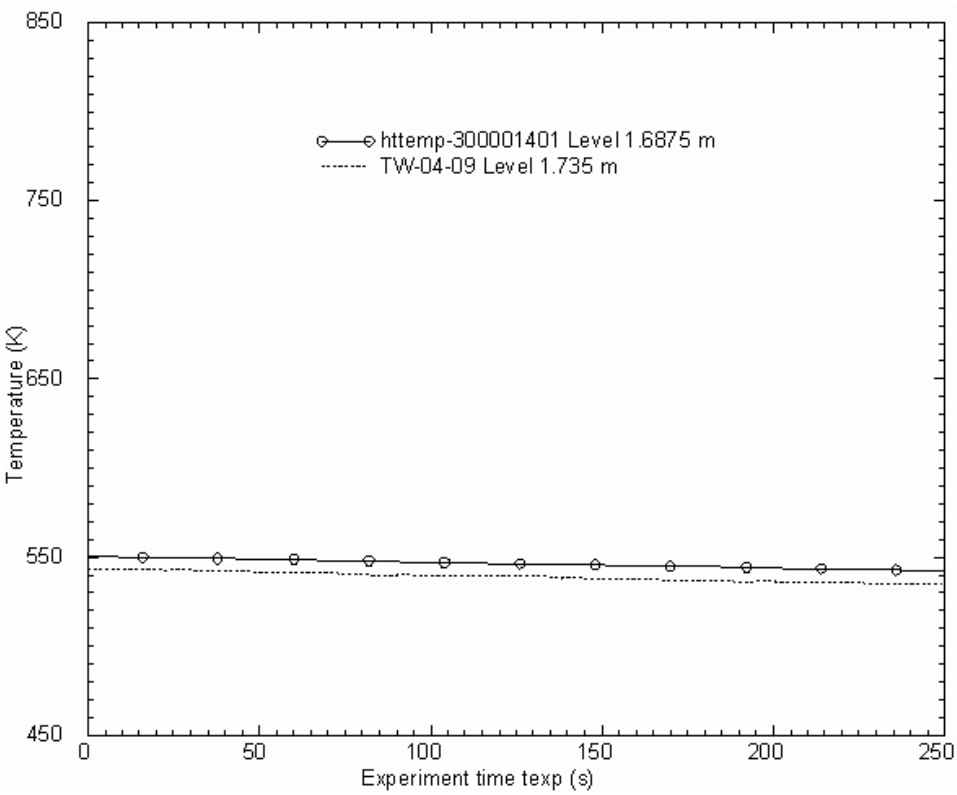

Fig. 5-17. Calculated and Measured Rod Wall Temperatures, Test KS1-18-2.

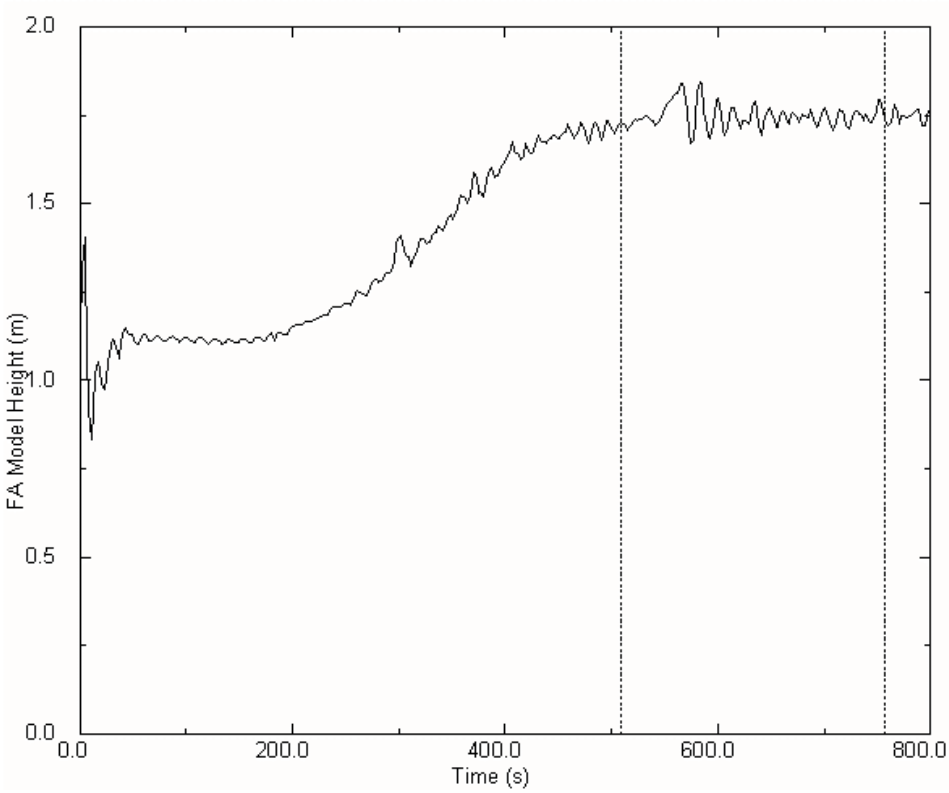

Fig. 5-18. Collapsed Liquid Level in the FA Model, Test KS1-18-2.

also indicates the beginning and end of the experimental time window. Figure 5-3 compares the calculated and measured values of Pout during the experimental window. The slope of the Pout curve is directly influenced by the magnitude of the loop heat losses, and the value of the heat loss coefficient Closs was adjusted to ensure good agreement between the calculated and measured Pout values. The value of the heat loss coefficient Closs = 2.8 was found to be adequate and was used in this analysis.

The liquid/vapor mixture level in the FA channel was determined from the analysis of experimental inner wall temperature data TW at various axial locations. The temperature data shown in Figure 5-4 indicates that at time t0exp the mixture level was Lmexp(t0exp) ≈ 1.78 m. At t0exp the wall temperature measured at level 1.78 m (TW-03-08) is still approximately 550 K, while the next higher wall temperature, measured at level 1.89 m (TW-04-06) is substantially higher, approximately 630 K, indicating a reduced heat transfer coefficient due to the presence of a larger void fraction. A similar analysis of the calculated temperatures, shown in Figure 5-5, indicates that at t0exp ≈ t1calc = 507 s the computed liquid/vapor mixture level in the FA channel was ≈ 2.06 m.

A comparison of the measured coolant temperature at the core inlet, TFin, with the corresponding calculated values is shown in Figure 5-6. The calculated TFin values are shown to be in good agreement with the measured values.

5.1.3.2 Calculated results during the experiment time window.

To assess the adequacy of the simulation, the calculated rod wall temperatures TW(tcalc) were compared with the corresponding data recorded during the experiment. The calculated rod wall temperatures in the upper, middle, and bottom parts of the heated FA model are shown in Figs. 5-7 – 5-10, respectively. These figures also show the location of the experiment time window. The calculated rod wall temperatures in the upper part of the FA model are compared with the corresponding measured temperatures in Figs. 5-11 – 5-17. Fig. 5-18 shows the time evolution of the collapsed liquid level in the FA model. This level shows the core height which would be filled with liquid if all the coolant in the core (vapor and liquid) were collapsed to liquid. It provides a measure of the coolant mass in the FA model, but is only an approximate measure of the mixture level. The mixture level is determined by both the coolant mass present in the core and the void fraction at each axial location.

An examination of Figs. 5-11 – 5-17 indicates that the calculated wall temperatures are in reasonable agreement with the experimental data, although timing discrepancies are clearly present. At time t0(exp) = t1(calc) the calculated mixture level in the FA model is approximately 2.06 m, higher than the 1.78 m inferred from the experimental data. The calculated and measured wall temperatures below the 1.78 m level are in good agreement, as shown in Figs. 5-16 and 5-17. In this region the wall temperature has decreased close to the coolant saturation temperature due to the high heat transfer between the rod wall and the coolant mixture. At levels between 1.78 m - 2.06 m, as shown in Figs. 5-14 and 5-15, the calculated rod wall temperatures have already decreased close to coolant saturation temperature, while the measured temperatures are shown to decrease to the same level during the experiment time window. This is due to the fact that the initial calculated level of the coolant mixture is higher than the level observed in the experiment at the same time. Fig. 5-13 shows both the calculated and measured wall temperatures decreasing from the same higher temperature, approximately 625 K, to a

temperature close to the coolant saturation temperature. The calculated wall temperature decrease occurs about 100 s earlier that the experimental temperature decrease. indicating an earlier arrival of the liquid mixture at that level. Figs. 5-11 and 5-12 show fairly good agreement between the calculated and measured temperatures, both in terms of magnitude and timing. This indicates that the calculated liquid mixture level is rising slower than the experimental level and by this time the calculated level, which was initially higher, is about the same as the experimental level.

The general features of the transient events analyzed can be better understood by studying the transient wall temperatures in the core during the entire calculation, i.e. including the period that preceeds the experiment time window. The calculated wall temperatures in the lower half of the FA model (Figs. 5-9 and 5-10) remain close to the liquid saturation temperature during the entire calculation, indicating a high heat transfer coefficient between the wall and the coolant, and thus the presence of a high liquid volume fraction. In the upper half of the FA model, predominantly filled with vapor, the wall temperatures begin to rise above the coolant saturation temperature starting at approximately t(calc) = 200 s (Figs. 5-7 and 5-8). This temperature increase is due to the reduced heat transfer between the fuel rod and the coolant vapor. As the mixture level in the coolant channel increases, causing the local heat transfer between the rods and the coolant to increase, the rod wall temperatures at successively higher locations decrease rapidly to the coolant saturation temperature. As shown in Fig. 5-7, the mixture level continues to increase, at decreasing rates, after t(calc) = 500 s, at which time the power and heat losses reach their maximum values. Although the power and heat losses are held constant after t(calc) = 500 s and throughout the experimental time window t(calc) = 507 s – 757 s, the mixture level in the FA model is still in a transient mode, rather than in a quasi steady state, and is strongly influenced by the transient conditions prior to t(calc)= 500 s. This is due to the small time interval between the end of the power and heat loss transient and the beginning of the experimental time window. This time interval, which is only 7 s, is not sufficient to allow the system to reach a quasi steady state.

5.2. Sensitivity Case Results

A number of initial conditions which are not known from measurements, such as the vapor quality in the voided loop regions, the initial liquid level in the FA model and the liquid level in the annular region, etc. can be changed in order to obtain better agreement between the computed and measured rod wall temperatures. These initial conditions determine the amount of coolant in the loop and the distribution of this mass at the beginning of computations. A significant number of calculations were carried out in order to evaluate the impact of these parameters on the computed results during the experiment time window. The results of some of these calculations are described in this section.

5.2.1 Effect of vapor quality in the voided loop regions.

One of the parameters influencing the transient behavior of FA model temperatures during the experimental time window is the quality of the vapor in the voided loop regions. Initial calculations, which assumed the presence of saturated dry vapor (x = 1.0) in the voided loop regions have consistently led to fuel rod temperatures higher than those observed in the experiment. The presence of wet saturated vapor in the upper parts of the loop allows the uncovered part of the fuel rods to remain at lower temperatures during the early part of the

transient, leading to transient temperatures comparable with those observed during the experiment. The vapor quality value used for the base case presented above was x = 0.7. The results of two parametric calculations using the quality values x = 0.72 and x = 0.68 are presented in Figs. 5-19 and 5-20 respectively. These results, which show the calculated transient behavior of the rod wall temperatures at various elevations are to be compared with the corresponding base case results shown in Fig. 5-7. Relatively small changes in the vapor quality are shown to have a significant effect on the transient temperature behavior. While the general temperature behavior and the maximum temperatures at various elevations remain similar, the timing of the quenching changes significantly when the initial vapor quality changes. In the case using the initial vapor quality x = 0.72, illustrated in Fig. 5-19, the coolant mixture level at the beginning of the experimental time window (t(calc) = 507 s) is approximately 1.93 m, lower than the base case corresponding level 2.06 m, and closer to the experimental value of 1.78 m. This is consistent with the presence of smaller amounts of liquid in the voided loop region and in the loop in general, leading to lower mixture level when compared with the base case. The time intervals between the occurrence of quenching at various levels are larger than those in the base case, indicating a slower rise of the mixture level. In both cases these intervals are seen to increase as the elevation increases, indicating a decelerated rise of the mixture level, but this deceleration is considerably larger in the parametric case 1 (Fig. 5-19) than in the base case. In fact, quenching at elevations 19 (H=2.3125 m) and 20 (H= 2.4375 m) which in the base case were in good agreement with the experimentally observed quenching, do not occur within the experimental time window in Fig. 5-19. Opposite trends are clearly observed in Fig. 5-20, which shows the results of a calculation using the initial vapor quality x = 0.68, instead of the x = 0.7 value used in the base case. In this case quenching at all locations occurs earlier than in the base case, and the mixture level at the beginning of the experimental time window is approximately H=2.1875, higher than the H= 2.06 m in the base case and consistent with the presence of larger amounts of liquid in the loop. The mixture level is rising faster than in the base case, as indicated by the earlier quenching times and the smaller time intervals between the quenching occurrence at successive elevations.

5.2.2 Effect of initial liquid level in the heated core region.

Another parameter influencing the transient behavior of FA model temperatures during the experimental time window is the initial liquid level in the FA model. Increasing or decreasing this level at the beginning of the calculations changes the amount of liquid in the loop and leads to a higher or lower mixture level, respectively, at the beginning of the experimental time window. The results of a sensitivity case performed with a lower initial liquid level in the FA model, Hcore (liquid) = 1.0 m instead of the value used in the base case, Hcore (liquid) = 1.25 m, is shown in Fig. 5-21. These results are compared with the corresponding transient rod wall temperatures obtained in the base case, illustrated in Fig. 5-7. The mixture level at the beginning of the experiment time window is lower than 2.0625 m, the elevation at node 17 which is just beginning to quench. This level is lower than the base level, where the quenching at node 17 occurs before the beginning of the experiment time window. The mixture level increases slower than calculated in the base case, as evidenced by the larger time intervals between the occurrence of quenching at successive elevations. As a result, the quenching at node 20, level 2.375 m, which in the base case was in good agreement with the experimental data, is now delayed and

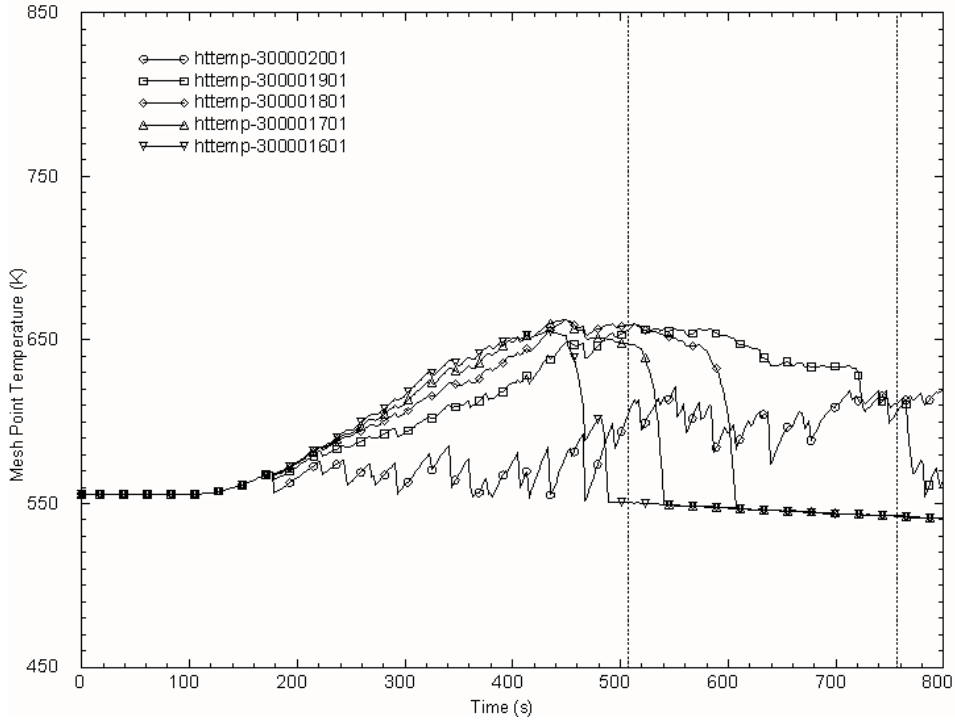

Fig. 5-19. Calculated Inner Rod Wall Temperatures, Test KS1-18-2 Parametric Case 1 (x = 0.72).

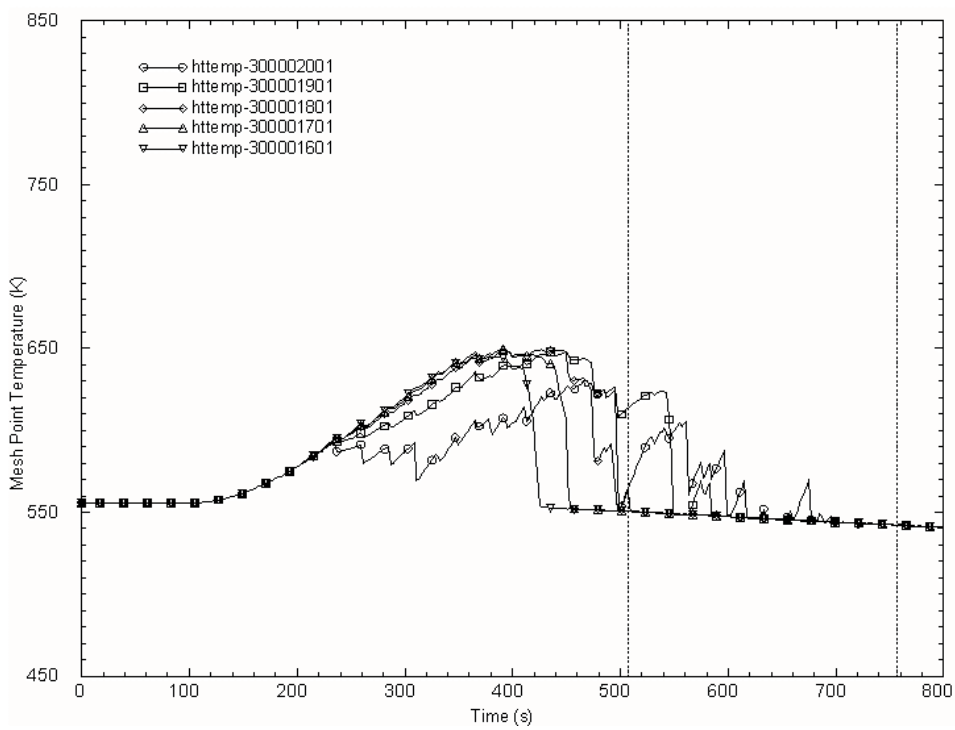

Fig. 5-20. Calculated Inner Rod Wall Temperatures, Test KS1-18-2 Parametric Case 2 (x = 0.68).

does not occur during the experiment time window. In fact, quenching at node 20 has not yet occurred at t(calc) = 800 s, when the calculation ended. As expected, the effect of decreasing the initial liquid level in the heated core region is similar to that of the increased initial vapor quality in the voided loop regions. This is evidenced by a comparison of Figs. 5.21 and 5.19. In both cases the mixture level at the beginning of the experiment window is lower than in the base case, and the mixture level increases at a lower rate than in the base case during the experiment window time interval.

5.2.3 Effect of initial liquid level in the annular region.

The transient behavior of FA model temperatures during the experimental time window is also directly influenced by the initial liquid level in the annular region surrounding the heated core region. The results appear to be particularly sensitive to changes in this level, which could be explained by the large cross sectional area of the annular region. A small increase in the initial liquid level in the annular region to 0.13125 m, instead of 0.12625 m used in the base case, leads to significant changes in the calculated rod wall temperatures, as illustrated in Fig. 5-22. A comparison of these results with the base case results shown in Fig. 5-7 indicates that the mixture level at the beginning of the experiment time window is lower than in the base case, and thus closer to the observed experiment data. However, the mixture level is rising slower than calculated in the base case, as evidenced by the longer time intervals between successive quenching events, and quenching in the upper nodes 19 and 20 does not occur during the experiment time window. These changes are not consistent with previously observed changes, as an increased level, and therefore an increased amount of coolant in the loop, was expected to lead to a faster rise of the coolant mixture. A larger increase in the annular region initial liquid level to 0.25 m leads, as expected, to a more rapid rise of the mixture level in the heated core region, and transient rod wall temperatures illustrated in Fig. 5-23. In this case, the mixture level at the beginning of the experiment time window is approximately 2.1875 m, higher than the level calculated in the base case. The coolant mixture level is rising faster than in the base case, and quenching at node 20 occurs before t(calc) = 600 s, approximately 140 s before the corresponding time calculated in the base case and illustrated in Fig. 5-7.

5.2.4 Effect of core exit nodalization and related liquid level.

Several calculations have focused on the effect of the core exit nodalization and the associated liquid level. These effects are discussed here in order to highlight the sensitivity of computed results to seemingly minor modeling assumptions. The experimental loop has a rather complex geometry and other similar sensitivities are likely to be present. It was found that the core exit nodalization and the initial liquid level in the annular outlet plenum can affect significantly the rod wall calculated temperatures. An earlier core exit nodalization (A), illustrated in Fig. 5-24 allows the communication between the annular outlet plenum and the upper shroud region (Junction 401) at a level higher than the communication between the annular outlet plenum and the core outlet nozzle. This nodalization led to maximum rod wall temperatures considerably higher than the experimentally measured values and was abandoned. The nodalization used in the base case, illustrated in Fig. 5-25, has the communication between the core outlet nozzle, the annular outlet plenum, and the upper shroud (Junction 401) region at the same level. This later nodalization facilitates the flow of condensed liquid from the upper loop regions into the core

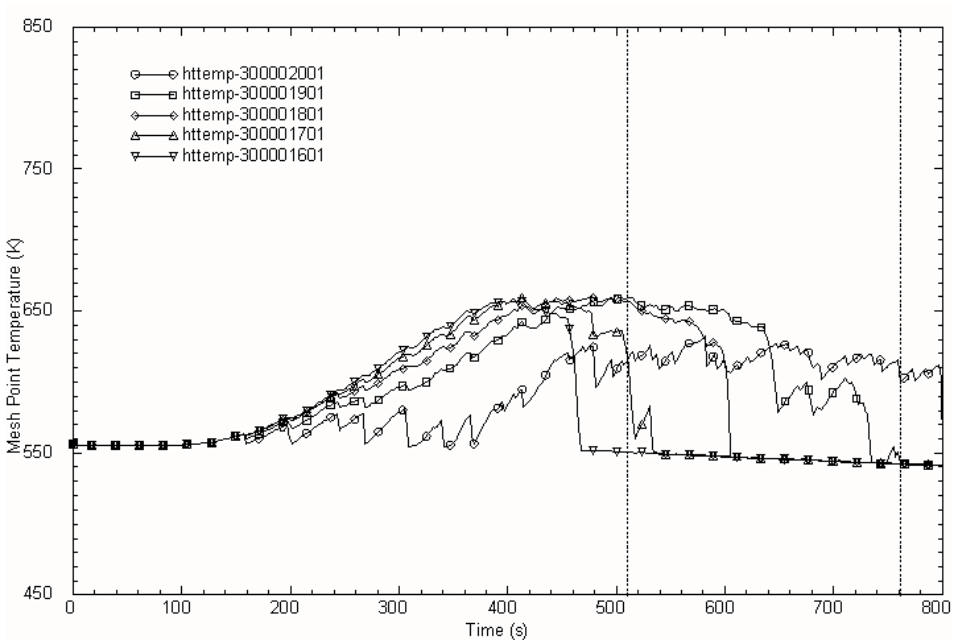

Fig. 5-21. Calculated Inner Rod Wall Temperatures, Test KS1-18-2 Parametric Case 3. (Hcore(liquid) = 1.25 m)

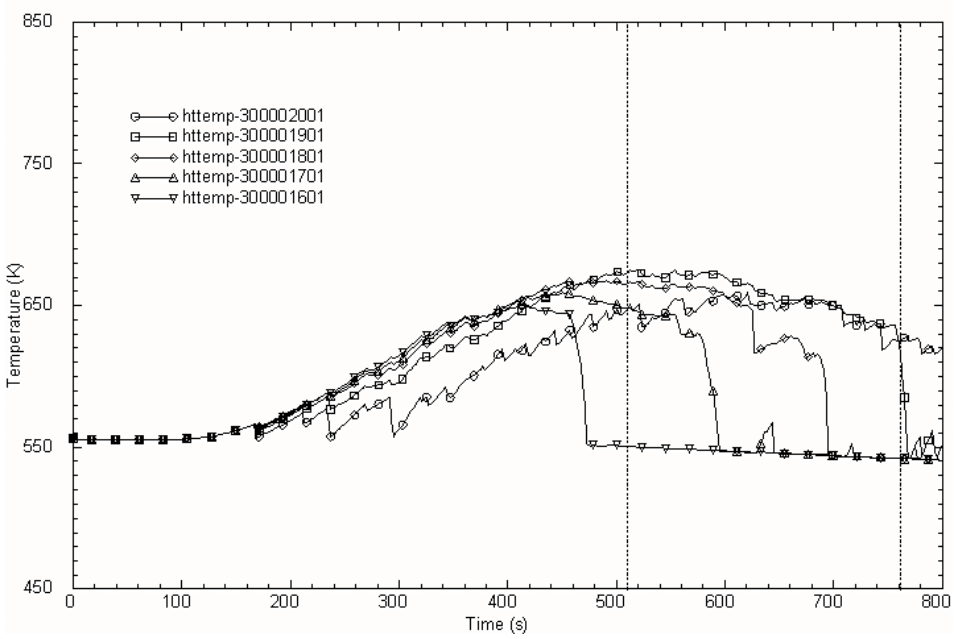

Fig. 5-22. Calculated Inner Rod Wall Temperatures, Test KS1-18-2 Parametric Case 4. (Hannulus(liquid) = 0.13125 m)

and results in lower maximum rod wall temperatures. Even more important, the initial liquid level in the annular outlet plenum has a similar impact on the rod wall temperatures. Assuming that the lower two nodes of the annular outlet plenum are initially filled with liquid, as was done in the base case, leads to considerably lower maximum rod wall temperatures (by about 55 K) than those achieved when the annular outlet plenum is assumed to be initially voided. While the presence of liquid trapped in the lower nodes of the annular outlet plenum during the experiment is possible, the fact that the rod wall temperatures are quite sensitive to this unknown level points to the uncertainties involved in the analysis of this experiment. An exhaustive analysis of the effects of various liquid levels in the annular outlet plenum and the core exit nodalization was not possible within the time frame of this analysis.

6. Conclusions

We conclude that, while a qualitative simulation of the experimental conditions was achieved by varying various computational initial conditions, the available experimental data is not sufficient to draw conclusions about the adequacy of the RELAP simulation. Additional quantitative information about the nature of the experimental transient that precedes the experimental data time window is necessary in order to allow a realistic simulation of the experiment, which would allow an evaluation of the RELAP models adequacy. While the use of an artificial transient to reach a system steady state might be acceptable, the same is not the case when trying to model a system which is still in a transient state.

Reasonable agreement between RELAP5 and the experiment data can be obtained by manipulating a number of initial computational values, including the liquid level in the fuel assembly model, the liquid level in the annular region, the quality of the saturated vapor in the voided loop regions, etc. Our study has focused on exploring the sensitivity of results to changes in these initial values, which are not based on experimental information but are selected with the

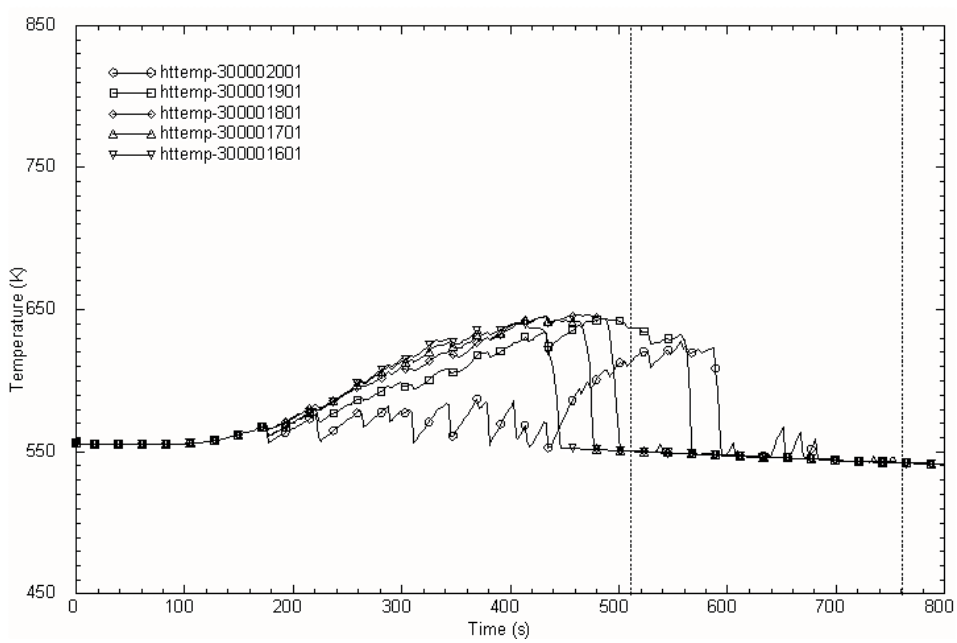

Fig. 5-23. Calculated Inner Rod Wall Temperatures, Test KS1-18-2 Parametric Case 5. (Hannulus(liquid) = 0.25 m)

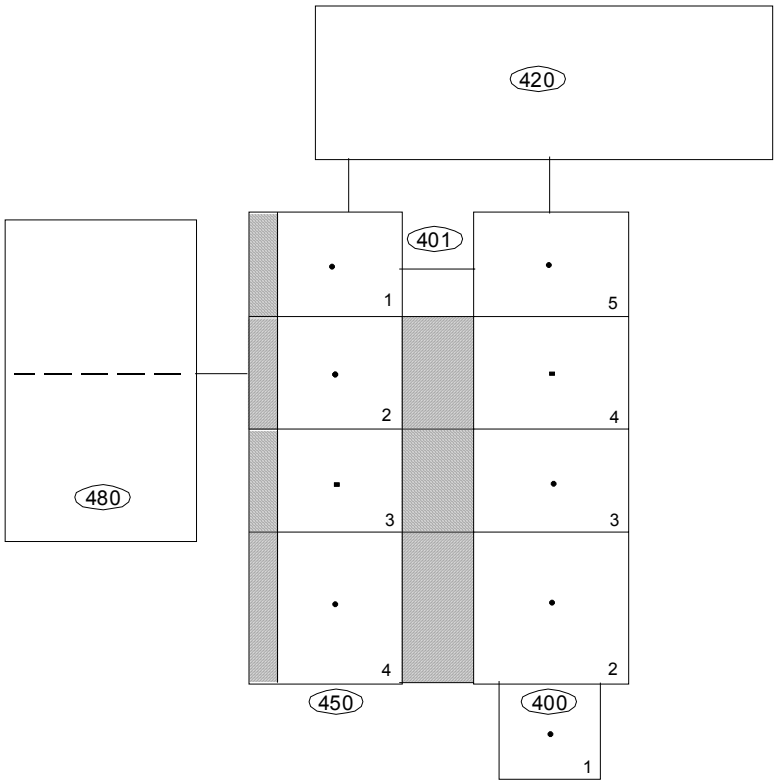

Fig. 5- 24. Core Exit Nodalization – A.

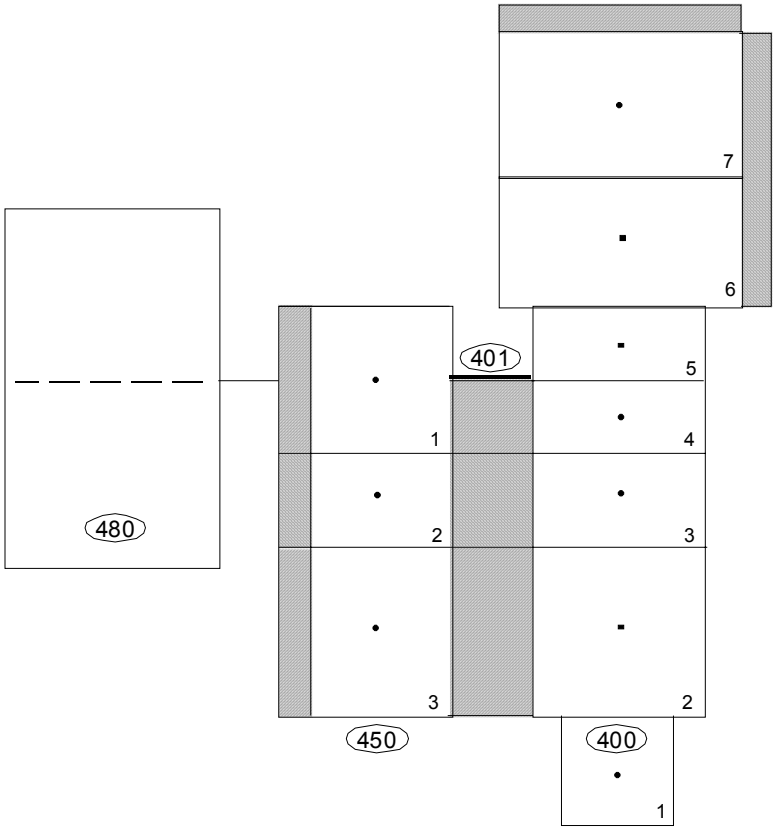

Fig. 5-25. Core Exit Nodalization - B.

goal of matching the experimentally observed behavior during the experiment time window. We have shown that changes in several initial computational values can lead to similar changes in the calculated loop behavior during the experiment time window. Other parameters exist which can directly influence the calculated results, which have been only minimally explored, or have not been explored at all due to lack of time. Because we are not modeling the entire sequence of events which led to the initial experiment conditions, it is not possible to assume that by matching a limited set of measured parameters at the beginning of the experiment time window we have reproduced all the initial actual conditions.

In view of the substantial uncertainties about the experimental initial conditions identified in the analysis of Test KS1-18-2, and because similar uncertainties clearly exist in the other tests, we decided to limit our analysis to the Test KS1-18-2. We conclude that the analysis of these experiments, while providing a useful demonstration of the RELAP5 capabilities to describe the experimental sequence of events, cannot be used to draw quantitative conclusions about the adequacy of specific RELAP5 models.

REFERENCES

1. The RELAP5 Code Development Team, "RELAP5/MOD3 Code Manual," NUREG/CR-5535 (INEL-95/0174), Volumes I-V, Idaho National Engineering Laboratory, Idaho Falls, Idaho (June 1995).

2. "Computer Code Validation for Transient Analysis of VVER and RBMK Reactors*: Validation Prioritization on VVER"*, International Nuclear Safety Center of MINATOM of Russia, deliverable 5 of Phase 1 of Joint project 6, Moscow, Russia (1998).

3. "Computer Code Validation for Transient Analysis of VVER and RBMK Reactors: A *Final RELAP5 Validation Plan for Application to VVER"*, International Nuclear Safety Center of MINATOM of Russia, deliverable 3 of Phase 2 of Joint project 6, Moscow, Russia (1998).

4. "Computer Code Validation for Transient Analysis of VVER and RBMK reactors: *Standard Problem INSCSP-V4 Definition Report"*, International Nuclear Safety Center of MINATOM of Russia, Task 2, Deliverable V4-1 of Phase 3 of Joint project 6, Moscow, Russia (2000).

Appendix A

RELAP Model Nodalization Summary

This appendix incorporates a nodalization summary of the baseline RELAP5 model (Table A-1).

Table A-1
Baseline RELAP5 Model Nodalization Summary

SYSTEM COMPONENT	RELAP Comp. No.	Description	Comp. Name	Comp. Type	No. of Vols	Deq or ID (m)	Flow Area (m^2)	Length (m)	No. Juncts	From Component	To Component
Downcomer	100	vertical pipe	upper-dc	pipe	9	0.073	0.0041854	1.9876			
	101		dc-intb	branch	1	0.073	0.0041854	0.3500	2	100-09	101-1
										101-1	150-01 (*CJ)
	150	vertical pipe	lower-dc	pipe	13	0.080	0.0050265	8.1340			
	151		dc-lpipe	branch	1	0.065	0.0033183	0.3500	2	150-13 (*CJ)	151-1
										151-1	900-01
Lower Pipeline	900	horizontal pipe	low-pipa	pipe	11	0.065	0.0033183	7.8062			
	901		dc-olj	sngljun					1	900-11	940-01
	940	slightly declined	low-pipb	pipe	10	0.020	0.0003142	7.0000			
	941		lpb-lpc	sngljun					1	940-10	960-01
	960		low-pipc	pipe	15	0.065	0.0033183	9.8808			
	961		lp-lpl-j	sngljun					1	960-15	200-01
Lower Plenum	200		lowpl-in	pipe	4	0.065	0.0033183	3.0400			
Core Inlet	220	core inlet nozzle	core-inl	branch	1	0.100	0.0078540	0.3000	2	200-04	220-1
										220-1	250-02 (*CJ)
	250	bottom annular chamber	annul-in	annulus	3	0.170	0.0574100	0.2560			
	251		lowan-jn	sngljun					1	250-03 (*CJ)	280-02 (*CJ)
	280	lower core (vert)	l-shroud	annulus	5	0.013	0.0022800	0.3140			
	281		fa-injun	sngljun					1	280-05	300-01
Fuel Assembly	300	fuel assembly	core	pipe	20	0.0098	0.0018060	2.5050			
	399		fa-outjn	sngljun					1	300-20	400-01
Core Annulus	350	Shroud annulus	core-gap	annulus	21	0.1020	0.0224310	2.5250			
	351		stag-jct	sngljun					1	250-01	350-01
Core Outlet	400	upper core (vert)	u-shroud	annulus	7	0.00974/ 0.01661/ 0.1575	0.001806/ 0.003209/ 0.05395	0.2950			
	401		cfloutjn	sngljun					1	400-04	450-01 (*CJ)
	450	upper annular chamber	annul-ot	annulus	3	0.220	0.0656600	0.1500			
	480	core outlet nozzle	core-out	branch	1	0.100	0.0078540	0.3000	2	450-01 (*CJ)	480-1
										480-1	490-01
Upper Plenum	490	vertical pipe	upper-pl	pipe	12	0.1/ 0.102	0.0078540/ 0.0081713	8.5100			
	491		upln-hlj	sngljun					1	490-12 (*CJ)	500-01
Loop Hot Leg	500	~horiz. pipe	hot-leg	pipe	11	0.065	0.0033183	7.6854			
	501		hl-elbow	branch	1	0.065	0.0033183	0.7854	2	500-11	501-1
										501-1	600-01
SG Tube Bundle 1	600	~horiz. pipe	sg-bun1	pipe	2	0.065	0.0033183	0.9675			
	601	tee	sg-tee	branch	1	0.065	0.0033183	0.0650	3	600-02	601-1
										601-1	700-01
										601-1 (*CJ)	650-01
Stm Release Pipe	650	~horiz. pipe	stm-rels	pipe	8	0.065	0.0033183	16.0000			
SG Tube Bundle 2	700	~horiz. pipe	sg-bun2	pipe	2	0.065	0.0033183	0.9675			
Loop Cold Leg	701		cl-elbow	branch	1	0.065	0.0033183	0.7854	2	700-02	701-1
										701-1	800-01
	800	~horiz. pipe	upper-cl	pipe	10	0.065	0.0033183	6.4500			
	801		low-clj	sngljun					1	800-10	850-01
	850	vertical pipe	lower-cl	pipe	9	0.057/ 0.067	0.00721/ 0.00488	6.9790			
	851		cl-outjn	sngljun					1	850-09	100-01

**CJ indicates crossflow junction*

Appendix B

Base Case RELAP Input File

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=               INSP Standard Problem V4
*         Behavior of Heated Rod Temperatures
*     in the Partially Uncovered VVER Core Model
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* The following data comprises a RELAP5 input model of the
* KS-1 Facility at RRC Kurchatov Institute, Moscow, Russia.
*
*-----------------------------------------------------------------
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* This deck is initialized for Test KS1-18-2.  Closs=2.15         *|
*           Nearly Implicit numerical scheme imposed.             *|
*           Mixture level and thermal front tracking imposed.     *|
*           Cntrlvar for Condensation Rates added.                *|
*                                                                 *|
*           Renodalization of Core from 10 to 20 volumes          *|
*           Time step sensitivity (dt=0.005:steady state)         *|
*                                 (dt=0.01: transient)            *|
*           HTC ramp turned off - first 205sec                    *|
*           Steady State Initial Temps calculated by RELAP.       *|
*           Changed surface roughness to 4.57e-5m for all         *|
*           piping except for core simulator.                     *|
*           Pressure distribution specified around loop           *|
*                                                                 *|
*           Bestion interphase friction correlation invoked       *|
*                    ( v4-18-2.i)                                 *|
*                                                                 *|
*           RENODALIZATION OF CORE EXIT 01/29/2001                *|
*                                                                 *|
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* This represnts VVER standard problem #4 of joint project #6.
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* This model was developed by Argonne National Laboratory,
*
*      AUTHOR:  John W. Ahrens
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$   This deck should be run with RELAP5/MOD3 version 3.2              $
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*  General Input Data Cards Begin Here:
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*  Developmental Model Control Card
*01        19       *  Bestion correlation for interphase friction
*
*problem     type    option
100          new    transnt
*
101          run
*101          inp-chk
*
102          si     si
*          noncondensible gas type
110         nitrogen
*
*     Ref.Vol.   elev    fluid  name
120   300010000  0.0625  h2o    primary   * Ref. Elev. is 0.0625 m below
Vol.1 center
*
*        t end    mindt   maxdt    cntrl   min    maj    res
201         5.0    1.e-7  0.005    00015   200    40000  40000    *
*202       50.0     1.e-7  0.02     00015   50     500    500     *
*203      205.0     1.e-7  0.01     00015   100    500    500    *
*204      215.0     1.e-7  0.001    00015   1000   5000   5000   *
*205      225.0     1.e-7  0.005    00015   200    2000   2000   *
*206      250.0     1.e-7  0.01     00015   100    2500   2500   *
*202      1000.0    1.e-7  0.01     00015   100    10000  10000  *
*202      1000.0    1.e-7  0.1     00015    20     5000   10000  *
202       800.0    1.e-7  0.1     00015    20     5000   10000  *
*
*201      100.0     1.e-3    0.02    00003   50    500   5000  *TTTTT
*
20800001 dt      0
20800002 dtcrnt  0
20800003 systms  1
20800004 gammai  300010000
20800005 gammai  300020000
20800006 gammai  300030000
20800007 gammai  300040000
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20800009 gammai  300060000
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20800014 gammaw  300010000
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20800028 gammac  300050000
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*     HYDRAULIC INPUT DATA
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*$=================================================================$
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**
**               area       lgh      vol     hz ang    vr ang   elv ch
*9500101           0.0       1.0      1.e6       0.0       0.0      0.0
**
**              rough    hy dia       flg
*9500102        4.57e-5      0.0        00
**
**                ctl
*9500200          003
**
**              time      pressure    temp
*9500201         0.0       6.0129e6    478.
*9500202     10000.0       6.0129e6    478.
**
**                                                                          S
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*
*
*            name       type
*9510000      td-inj    tmdpjun
*
*             from          to      jun area
*9510101    940100002    960010001      0.0
*
*           ctl      trip
*9510200       1
*
*           time    flow-f   flow-g   velj
*9510201     -1.0    0.5       0.0     0.0
*9510202      0.0    0.5       0.0     0.0
*9510203     1.e4    0.5       0.0     0.0
*
**-----------------------------------------------------------------------
*-------  DOWNCOMER MODEL  ----------------------------------------------
*-----------------------------------------------------------------------
*
*-------  upper-dc section  ---------------------------------------------
*              name          type
1000000        upper-dc      pipe
*
*             no.vol
1000001            9
*
```

```
*               area       vol no
1000101     4.185e-3         9
*
*              vol lgh    vol no
1000301         0.267        5    *Sensor P2
1000302         0.238        6
1000303         0.138209     7
1000304         0.138209     8
1000305         0.138209     9
*
*             vr ang    vol no
1000601        -90.0         6
1000602        -75.0         7
1000603        -45.0         8
1000604        -15.0         9
*
*             elv ch      vol no
1000701        -0.267        5
1000702        -0.238        6
1000703        -0.1335       7
1000704        -0.097729     8
1000705        -0.035771     9
*
*              rough    hy dia    vol no
1000801        4.57e-5    0.073       9
*
*             floss  rloss   jn.no.
1000901        0.0     0.0     5
1000902        0.078   0.078   8
*
*            tlpvbfe    vol no
1001001       110000       9
*
*               fvcahs   jn no
1001101        0001000     8
*
*         ctl   pressure    qual                  vol no
1001201   102   6.67e6      0.7    0.0  0.0  0.0  9
*
*         ctl
1001300   1
*             flow-f    flow-g   velj   jun no
1001301       0.0       0.0       0.      8
*1001301       0.5       0.0       0.      8
*
*
*-----------------------------------------------------------------------
*------------ upper dc to lower dc connection ----------------------------
*               name      type
1010000        dc-intb   branch
*
*             no jun    in ctl
1010001            2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
1010101      4.1854e-3  0.35         0.0       0.0      0.0      0.0
*
*              rough     hydia    pvbfe
```

```
1010102        4.57e-5    0.073   10000  *
*
*         ctl     pressure      qual
1010200   102     6.67e6       0.7
*
*               from        to    jun area  f loss r loss efvcahs vfrlim
1011101     100090002    101010001 4.1854e-3  0.0    0.0   001000   *
1012101     101010002    150010003  0.0       1.08   1.08 1001101   * abrupt
* exp/turn
*
*              flow-f      flow-g    velj
1011201         0.0          0.        0. *
1012201         0.0          0.        0. *
*1011201         0.5          0.        0. *
*1012201         0.5          0.        0. *

*
*-----------------------------------------------------------------------
*-------  lower-dc section  ---------------------------------------------
*               name          type
1500000         lower-dc      pipe
*
*              no.vol
1500001            13
*
*               area       vol no
1500101       5.0265e-3     13
*
*              vol lgh    vol no
1500301         0.534        1
1500302         0.158        2    * Sensor P4
1500303         0.75         7
1500304         0.50         8
1500305         0.442        9    * Sensor P14
1500306         0.75        11
1500307         0.716       12
1500308         0.534       13
*
*               vr ang    vol no
1500601        -90.0        13
*
*             elv ch      vol no
1500701        -0.534        1
1500702        -0.158        2
1500703        -0.75         7
1500704        -0.50         8
1500705        -0.442        9
1500706        -0.75        11
1500707        -0.716       12
1500708        -0.534       13
*
*              rough    hy dia    vol no
1500801        4.57e-5    0.080       13
*
*             floss  rloss   jn.no.
1500901        0.0     0.0     12
*
*            tlpvbfe    vol no
```

```
1501001      1110000        13
*
*               fvcahs   jn no
1501101        0001000     12
*
*         ctl   pressure    qual                    vol no
1501201   102   6.67e6      0.7    0.0  0.0  0.0     4
*         ctl   pressure    temp                    vol no
1501202   103   6.67e6      479.0  0.0  0.0  0.0    13
*
*         ctl
1501300   1
*             flow-f    flow-g   velj   jun no
1501301       0.0       0.0       0.      12
*1501301       0.5       0.0       0.      12
*
*
*-------------------------------------------------------------------------
*-------------------------------------------------------------------------
*------------ lower dc to lower pipeline connection ----------------------
*               name      type
1510000        dc-lpipe   branch
*
*             no jun    in ctl
1510001            2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
1510101      3.3183-3    0.35         0.0       0.0       0.0       0.0
*
*              rough     hydia    pvbfe
1510102        4.57e-5    0.065   10000  *
*
*         ctl     pressure      temp
1510200   103     6.67e6       479.0
*
*               from        to    jun area  f loss r loss vcahs vfrlim
1511101     150130004    151010001  0.0      1.08   1.08  01102  * abrupt
* contr./turn
1512101     151010002    900010001 3.3183e-3  0.0    0.0  01000  *
*
*              flow-f      flow-g    velj
1511201         0.0          0.       0. *
1512201         0.0          0.       0. *
*1511201         0.5          0.       0. *
*1512201         0.5          0.       0. *
*
*-------------------------------------------------------------------------
*
*-------------------------------------------------------------------------
*------  LOWER PIPELINE MODEL  -------------------------------------------
*-------------------------------------------------------------------------
*
*------- lower-pipeline section 'A'---------------------------------------
*
*               name          type
9000000         low-pipa      pipe
*
*              no.vol
```

```
9000001           11
*
*               area      vol no
9000101       3.3183e-3     11
*
*              vol lgh    vol no
9000301         0.85         1
9000302         0.6354       2
9000303         0.80         4
9000304         0.4954       5
9000305         0.71         8
9000306         0.4954       9
9000307         0.80        11
*
*               vr ang    vol no
9000601           0.0        2
9000602         -90.0        4
9000603           0.0        9
9000604          90.0       11
*
*             elv ch      vol no
9000701         0.00         2
9000702        -0.80         4
9000703         0.00         9
9000704         0.80        11
*
*              rough    hy dia    vol no
9000801        4.57e-5    0.065       11
*
*             floss  rloss   jn.no.
9000901        0.0     0.0      1
9000902        0.413   0.413    2   * 90 deg bend
9000903        0.0     0.0      3
9000904        0.413   0.413    4   * 90 deg bend
9000905        0.0     0.0      8
9000906        0.413   0.413    9   * 90 deg bend
9000907        0.0     0.0     10
*
*              pvbfe    vol no
9001001        10000       11
*
*               fvcahs   jn no
9001101        0001000     10
*
*         ctl   pressure    temp                    vol no
9001201   103   6.67e6     479.0  0.0  0.0  0.0     11

*
*         ctl
9001300   1
*             flow-f    flow-g   velj   jun no
9001301       0.0       0.0       0.       10
*9001301       0.5       0.0       0.       10
*-------------------------------------------------------------------------
*-------------------------------------------------------------------------
*
*               name        type
9010000        lpa-lpb      sngljun
```

```
*
*          from        to    jn area   f loss  r loss fvcahs
9010101 900110002 940010001    0.0      0.413   0.413 001100 * abrupt area
* change plus 90deg turn
*
*         ctl  flow-f      flow-g  velj
9010201    1     0.0         0.0    0. *
*9010201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*9010110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*
*------- lower-pipeline section 'B'---------------------------------------
*
*               name          type
9400000         low-pipb      pipe
*
*              no.vol
9400001           10
*
*               area      vol no
9400101       3.1416e-4      10
*
*              vol lgh    vol no
9400301         0.70         10
*
*               vr ang    vol no
9400601        -3.214809     10
*
*             elv ch      vol no
9400702       -0.0392557     10
*
*              rough    hy dia    vol no
9400801        4.57e-5    0.020       10
*
*             floss  rloss   jn.no.
9400901        0.0     0.0      1
9400902        1.5     1.5      2   * 90 deg bend
9400903        0.0     0.0      3
9400904        1.5     1.5      4   * 90 deg bend
9400905        0.0     0.0      5
9400906        1.5     1.5      6   * 90 deg bend
9400907        0.0     0.0      7
9400908        1.5     1.5      8   * 90 deg bend
9400909        0.0     0.0      9
*
*              pvbfe    vol no
9401001        10000       10
*
*               fvcahs   jn no
9401101        0001000      9
*
*         ctl   pressure    temp                    vol no
9401201   103   6.67e6     479.0  0.0  0.0  0.0     10
```

```
*
*         ctl
9401300   1
*             flow-f    flow-g   velj   jun no
9401301       0.0       0.0       0.        9
*9401301       0.5       0.0       0.        9
*
*-------------------------------------------------------------------------
*
*-------------------------------------------------------------------------
*
*               name        type
9410000        lpb-lpc    sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
9410101 940100002 960010001    0.0      0.413   0.413 001100    * abrupt area
* change plus 90deg turn
*
*         ctl  flow-f      flow-g  velj
9410201    1     0.0         0.0    0.
*9410201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*9410110   0.035     0.00      0.725     1.00
*
*--------------------------------------------------------------------------
*------- lower-pipeline section 'C'----------------------------------------
*
*               name          type
9600000         low-pipc      pipe
*
*              no.vol
9600001           15
*
*               area      vol no
9600101       3.3183e-3     15
*
*              vol lgh    vol no
9600301         0.60         2
9600302         0.4954       3
9600303         0.71         6
9600304         0.4954       7
9600305         0.695        15
*
*               vr ang    vol no
9600601         -90.0        2
9600602           0.0        7
9600603          90.0       15
*
*             elv ch      vol no
9600701        -0.60         2
9600702         0.00         7
9600703         0.695        15
*
*              rough    hy dia    vol no
9600801        4.57e-5    0.065       15
```

```
*
*             floss  rloss   jn.no.
9600901        0.0     0.0      1
9600902        0.413   0.413    2   * 90 bend
9600903        0.0     0.0      6
9600904        0.413   0.413    7   * 90 bend
9600905        0.0     0.0      14
*
*              pvbfe    vol no
9601001        10000       15
*
*               fvcahs   jn no
9601101        0001000     14
*
*         ctl   pressure    temp                   vol no
9601201   103   6.67e6      479.0 0.0  0.0  0.0      15
*
*         ctl
9601300   1
*             flow-f    flow-g   velj   jun no
9601301       0.0       0.0       0.       14
*9601301       0.5       0.0       0.       14
*
*-----------------------------------------------------------------------
*
*               name        type
9610000        lp-lpl-j    sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
9610101 960150002 200010001  3.3183e-3   0.0    0.0   001000 * no choking
*
*         ctl  flow-f      flow-g  velj
9610201    1     0.0         0.0    0.
*9610201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*9610110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*-------  LOWER PLENUM MODEL  ---------------------------------------------
*-----------------------------------------------------------------------
*
*-----------------------------------------------------------------------
*               name          type
2000000        lowpl-in       pipe
*
*              no.vol
2000001           4
*
*               area       vol no
2000101        3.3183e-3      4
*
*              vol lgh    vol no
2000301         0.770         2
2000302         0.750         4
*
```

```
*               vr ang    vol no
2000601          90.0         2
2000602           0.0         4
*
*               elv ch      vol no
2000701          0.770         2
2000702          0.0           4
*
*              rough    hy dia    vol no
2000801        4.57e-5    0.065       4
*
*             floss  rloss   jn.no.
2000901        0.0    0.0      1
2000902        1.08   1.08     2
2000903        0.0    0.0      3
*
*              pvbfe    vol no
2001001        10000       4
*
*               fvcahs   jn no
2001101         001000     3
*
*         ctl   pressure    temp                  vol no
2001201   103    6.67e6     479.0  0.0  0.0  0.0    4
*
*         ctl
2001300    1
*             flow-f    flow-g   velj   jun no
2001301        0.0       0.0       0.      3
*2001301        0.5       0.0       0.      3
*
*-------------------------------------------------------------------------
*
*------------ lower chamber of FA inlet      ------------------------------
*               name      type
2200000        core-inl   branch
*
*             no jun    in ctl
2200001          2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
2200101       7.854e-3   0.300      0.0       0.0       0.0      0.0
*
*              rough     hydia     pvbfe
2200102        4.57e-5    0.100    10000  *
*
*         ctl     pressure      temp
2200200   103      6.67e6       479.0
*
*               from        to    jun area  f loss r loss  efvcahs
2201101     200040002    220010001 7.854e-3   0.0   0.0      01000  *
2202101     220010002    250020003 7.854e-3   1.63  9.05   1001001  *
* Note for Junction #2: abrupt area change losses per K's/momentum flux off
*
*              flow-f      flow-g    velj
2201201         0.0          0.       0. *
2202201         0.0          0.       0. *
*2201201         0.5          0.       0. *
```

```
*2202201         0.5          0.       0. *
*
*-----------------------------------------------------------------------
*
*-----------------------------------------------------------------------
*               name          type
2500000        annul-in      annulus
*
*              no.vol
2500001           3
*
*               area       vol no
2500101        5.741e-2       2
2500102        3.387e-2       3
*
*              vol lgh    vol no
2500301         0.081         1
2500302         0.100         2
2500303         0.075         3
*
*               vr ang    vol no
2500601         -90.0         3
*
*               elv ch    vol no
2500701          -0.081       1
2500702          -0.100       2
2500703          -0.075       3
*
*              rough    hy dia    vol no
2500801        4.57e-5    0.17        2
2500802        4.57e-5    0.115       3
*
*             floss  rloss   jn.no.
2500901        0.0    0.0      1
2500902        0.0    0.0      2  * RELAP compute area chg losses
*
*              pvbfe    vol no
2501001        10000       3
*
*               fvcahs   jn no
2501101         001000     1
2501102         001100     2      * abrumpt area chg model invoked
*
*         ctl   pressure    temp                  vol no
2501201   103   6.67e6     479.0   0.0  0.0  0.0    3
*
*         ctl
2501300    1
*             flow-f    flow-g   velj   jun no
2501301        0.0       0.0       0.      2
*2501301        0.5       0.0       0.      2
*
*-----------------------------------------------------------------------
*
*-----------------------------------------------------------------------
*
*               name        type
2510000        lowan-jn    sngljun
```

```
*
*          from        to    jn area   f loss  r loss fvcahs
*2510101 250030004 280020003  3.06e-2    0.99    1.62  001002 * momentum flux
* off
2510101 250030004 280020003  2.14e-3    0.0     0.0   101100 * same as 18-2R
*
*         ctl  flow-f      flow-g  velj
2510201    1     0.0         0.0    0.
*2510201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*2510110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------------
*----------------------------------------------------------------------------
*               name          type
2800000        l-shroud      annulus
*
*              no.vol
2800001           5
*
*               area       vol no
2800101        2.28e-3        2
2800102        7.922e-3       4
2800103        1.806e-3       5
*
*              vol lgh    vol no
2800301         0.038         1
2800302         0.075         2
2800303         0.100         3
2800304         0.081         4
2800305         0.020         5
*
*               vr ang    vol no
2800601          90.0         5
*
*               elv ch    vol no
2800701          0.038       1
2800702          0.075       2
2800703          0.100       3
2800704          0.081       4
2800705          0.020       5
*
*              rough    hy dia    vol no
2800801        4.57e-5    0.013       2
2800802        4.57e-5    0.05605     4
2800803        4.57e-5    0.0227      5
*
*             floss  rloss   jn.no.
2800901        0.0    0.0      4
*
*              pvbfe    vol no
2801001        10000       5
*
*               fvcahs   jn no
2801101         001000     1
```

```
2801102         001100     2    * abrupt area change
2801103         001000     4    * smooth area change
*
*         ctl   pressure    temp                  vol no
2801201   103   6.67e6     479.0  0.0  0.0  0.0     5
*
*         ctl
2801300    1
*             flow-f    flow-g   velj   jun no
2801301        0.0       0.0       0.      4
*2801301        0.5       0.0       0.      4
*
*-------------------------------------------------------------------------
*
*-------------------------------------------------------------------------
*
*               name        type
2810000        fa-injun    sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
2810101 280050002 300010001  1.806e-3   0.26    0.26  001000 * no choking
*
*         ctl  flow-f      flow-g  velj
2810201    1     0.0         0.0    0.
*2810201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*2810110   0.035     0.00      0.725     1.00
*
*---------------------------------------------------------------------------
*
*-------------------------------------------------------------------------
*-------  ACTIVE CORE MODEL  ---------------------------------------------
*-------------------------------------------------------------------------
*
*-------------------------------------------------------------------------
*               name          type
3000000         core          pipe
*
*              no.vol
3000001          20
*
*               area        vol no
3000101        1.806e-3       20
*
*              vol lgh      vol no
3000301         0.125         19
3000302         0.130         20
*
*               vr ang      vol no
3000601          90.0         20
*
*               elv ch      vol no
3000701          0.125        19
3000702          0.130        20
*
```

```
*              rough    hy dia    vol no
3000801        1.5e-6    9.75e-3     20
*
*             floss  rloss   jn.no.
3000901        0.00   0.00     1
3000902        0.26   0.26     2
3000903        0.00   0.00     3
3000904        0.26   0.26     4
3000905        0.00   0.00     5
3000906        0.26   0.26     6
3000907        0.00   0.00     7
3000908        0.26   0.26     8
3000909        0.00   0.00     9
3000910        0.26   0.26    10
3000911        0.00   0.00    11
3000912        0.26   0.26    12
3000913        0.00   0.00    13
3000914        0.26   0.26    14
3000915        0.00   0.00    15
3000916        0.26   0.26    16
3000917        0.00   0.00    17
3000918        0.26   0.26    18
3000919        0.00   0.00    19
*
*            tlpvbfe    vol no
*3001001      1100000       20      * REVISED 5/17/00
3001001      0010100       20
*
*              fvcahs   jn no
3001101        001000     19
*
*         ctl   pressure    qual                    vol no
3001201   102   6.67e6     0.0      0.0  0.0  0.0     10
*
*         ctl   pressure    qual                    vol no
3001202   102   6.67e6     0.7      0.0  0.0  0.0     15
3001203   102   6.67e6     0.7      0.0  0.0  0.0     20
*
*         ctl
3001300    1
*             flow-f    flow-g   velj   jun no
3001301        0.0       0.0       0.      19
*3001301        0.5       0.0       0.      19
*
*             hy-dia                            jun no.
*3001401      9.75e-3     0.0      1.0    1.0      19
*-----------------------------------------------------------------------
*
*
*-----------------------------------------------------------------------
*-------  CORE SHROUD ANNULAR GAP   -------------------------------------
*-----------------------------------------------------------------------
*
*              name          type
3500000       core-gap       annulus
*
*              no.vol
3500001          21
```

```
*
*               area       vol no
3500101        2.2431e-2     21
*
*              vol lgh    vol no
3500301         0.020         1
3500302         0.125        20
3500303         0.130        21
*
*               vr ang    vol no
3500601          90.0        21
*
*               elv ch    vol no
3500701          0.020        1
3500702          0.125       20
3500703          0.130       21
*
*              rough    hy dia    vol no
3500801        4.57e-5    0.102       21
*
*             floss  rloss   jn.no.
3500901        0.0    0.0     20
*
*             tlpvbfe    vol no
*3501001        00000       21    * REVISED 5/17/00
3501001       1110000       21
*
*               fvcahs   jn no
3501101         001000     20
*
*         ctl   pressure    qual                    vol no
3501201   102   6.67e6     0.0      0.0  0.0  0.0     1
3501202   102   6.67e6     0.01     0.0  0.0  0.0     2
*         ctl   pressure    qual                    vol no
3501203   102   6.67e6     0.7      0.0  0.0  0.0    16
3501204   102   6.67e6     0.7      0.0  0.0  0.0    21
*
*         ctl
3501300    1
*             flow-f    flow-g   velj   jun no
3501301        0.0       0.0       0.      20
*
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*
*               name        type
3510000        stag-jct    sngljun

*
*          from        to    jn area   f loss  r loss fvcahs
3510101 250010001 350010001    0.0      0.0     0.0   001100 * abrupt area
* change
*
*         ctl  flow-f      flow-g  velj
3510201    1     0.0         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
```

```
*         hyd dia   beta      y-int     slope
*3510110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*
*               name        type
3990000        fa-outjn    sngljun
*
*          from        to    jn area   f loss  r loss   fvcahs
3990101 300200002 400010001  1.806e-3   0.26    0.26    001000 * no choking
*
*         ctl  flow-f      flow-g  velj
3990201    1     0.0         0.0    0
*3990201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*3990110   0.00974   0.00      0.725     1.00     * AMT 02/01/01
*
*-------------------------------------------------------------------------
*-----------------------------------------------------------------------
*-------  UPPER PLENUM SECTION -----------------------------------------
*-----------------------------------------------------------------------
*
*-------  upper shroud region ------------------------------------------
*               name          type
4000000        u-shroud       pipe
*
*              no.vol
4000001           7
* 4000001           2                           * MODIFIED 01/29/2001
*
*               area      vol no
4000101        1.806e-3      1
4000102        3.209e-3      5
4000103        5.395e-2      7
* 4000102        3.209e-3      2                * MODIFIED 01/29/2001
*
*              vol lgh    vol no
4000301         0.044        1
4000302         0.050        2
4000303         0.030        3
4000304         0.020        4
4000305         0.020        5
4000306         0.065        6
4000307         0.066        7
* 4000302         0.150        2                * MODIFIED 01/29/2001
*
*               vr ang    vol no
4000601           90.        7
* 4000601           90.        2                * MODIFIED 01/29/2001
*
*               elv ch    vol no
4000701         0.044        1
4000702         0.050        2
4000703         0.030        3
4000704         0.020        4
```

```
4000705         0.020        5
4000706         0.065        6
4000707         0.066        7
* 4000702         0.150        2                * MODIFIED 01/29/2001
*
*              rough    hy dia    vol no
4000801        4.57e-5   0.00974      1         * AMT 02/01/01
4000802        4.57e-5   0.01661      5
4000803        4.57e-5   0.15750      7
* 4000802        4.57e-5   0.0358       2       * MODIFIED 01/29/2001
*
*             floss  rloss   jn.no.
4000901        0.0    0.0      6
* 4000901        0.0    0.0      1              * MODIFIED 01/29/2001
*
*              pvbfe    vol no
4001001        10000       7
* 4001001        10000       2                  * MODIFIED 01/29/2001
*
*               fvcahs   jn no
4001101         001100      1  * abrupt area change
4001102         001000      4
4001103         001100      5  * abrupt area change
4001104         001000      6
* 4001101         001100      1  * abrupt area change   * MODIFIED 01/29/2001
*
*         ctl   pressure    qual                 vol no
4001201   102   6.67e6      0.7   0.0  0.0  0.0    7
* 4001201   102   6.67e6      0.7   0.0  0.0  0.0    2  * MODIFIED 01/29/2001
*
*         ctl
4001300    1
*             flow-f    flow-g   velj   jun no
4001301        0.0       0.0       0.       6
* 4001301        0.0       0.0       0.       1         * MODIFIED 01/29/2001
*4001301        0.5       0.0       0.       1
*
*            hy-dia                              jun no
*4001401      9.74e-3     0.0      1.0    1.0      1     * AMT 01/31/01
*4001402     16.61e-3     0.0      1.0    1.0      5     * AMT 01/31/01
*4001403    157.50e-3     0.0      1.0    1.0      6     * AMT 01/31/01
*-------------------------------------------------------------------------
* NEW CROSSFLOW JUNCTION ADDED 01/29/2001
*-------------------------------------------------------------------------
*
*               name        type
4010000        cf1outjn    sngljun
*
*          from        to    jn area   f loss  r loss   fvcahs
4010101 400040002 450010003  4.71e-3     0.0    0.0    001003 * no choking
*
*         ctl  flow-f      flow-g  velj
4010201    1     0.0         0.0    0
*4010201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
```

```
*4010110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*----------------------------------------------------------------------
* NEW CROSSFLOW JUNCTION ADDED 01/29/2001
*----------------------------------------------------------------------
*
*               name        type
* 4020000        cf2outjn    sngljun
*
*          from        to    jn area   f loss  r loss   fvcahs
* 4020101 400040004 450020003  9.413e-3    0.0    0.0    001003 * no choking
*
*         ctl  flow-f      flow-g  velj
* 4020201    1     0.0         0.0    0
* 4010201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
* 4010110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*------------ upper chamber of FA discharge  ----------------------------
*               name      type
* 4200000        up-chamb   branch
*
*            no jun    in ctl
* 4200001          2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
* 4200101       5.395e-2    0.101      0.0       0.0      90.0     0.101
*
*              rough     hydia     pvbfe
* 4200102        4.57e-5    0.2258   10000  *
*
*         ctl     pressure       qual
* 4200200   102     6.67e6        0.7
*
*               from        to    jun area  f loss r loss  efvcahs
* 4201101     400050002    420010001 3.209e-3   0.0    0.0   1001100  *
* abrupt area change
* 4201101     400020002    420010001 3.209e-3   0.0    0.0   1001100  *  *
* MODIFIED 01/29/2001
* 4202101     420010001    450010001 5.395e-2   0.0    0.0   1001100  *
* abrupt area change
*
*              flow-f      flow-g    velj
* 4201201         0.0          0.       0. *
* 4202201         0.0          0.       0. *
* 4201201         0.5          0.       0. *
* 4202201         0.5          0.       0. *
*
*-----------------------------------------------------------------------
*-------  annular outlet plenum ---------------------------------------
*               name          type
4500000        annul-ot      annulus
*
```

```
*              no.vol
4500001           3
*4500001           2                          * MODIFIED 01/29/2001
*
*               area      vol no
4500101        6.566e-2      3
* 4500101        6.566e-2      2               * MODIFIED 01/29/2001
*
*              vol lgh    vol no
4500301         0.040        1
4500302         0.030        2
4500303         0.050        3
* 4500301         0.100        2               * MODIFIED 01/29/2001
*
*               vr ang    vol no
4500601          -90.        3
* 4500601          -90.        2               * MODIFIED 01/29/2001
*
*               elv ch    vol no
4500701         -0.040        1
4500702         -0.030        2
4500703         -0.050        3
* 4500701         -0.10        1               * MODIFIED 01/29/2001
*
*              rough    hy dia    vol no
4500801        4.57e-5    0.220       3
* 4500801        4.57e-5    0.220       2       * MODIFIED 01/29/2001
*
*             floss  rloss   jn.no.
4500901        0.0     0.0      2
* 4500901        0.0     0.0      1             * MODIFIED 01/29/2001
*
*              pvbfe    vol no
4501001        10000       3
* 4501001        10000       2                  * MODIFIED 01/29/2001
*
*               fvcahs   jn no
4501101         001000      2
* 4501101         001000      1                 * MODIFIED 01/29/2001
*
*
*         ctl   pressure    qual                 vol no
4501201   102   6.67e6      0.7   0.0  0.0  0.0    1            * AMT
* 01/18/01
4501202   102   6.67e6      0.0   0.0  0.0  0.0    3
* 4501202   102   6.67e6      0.7   0.0  0.0  0.0    2          * MODIFIED
* 01/29/2001
*
*         ctl
4501300    1
*             flow-f    flow-g   velj   jun no
4501301        0.0       0.0       0.       2
*4501301        0.5       0.0       0.       1
* 4501301        0.0       0.0       0.       1                 * MODIFIED
* 01/29/2001
*
*-----------------------------------------------------------------------
*------------ Core outlet nozzle ---------------------------------------
```

```
*               name      type
4800000        core-out   branch
*
*             no jun    in ctl
4800001          2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
4800101      7.854e-3    0.30        0.0       0.0      0.0      0.0
*
*              rough     hydia    pvbfe
4800102        4.57e-5    0.10    10000  *
*
*         ctl     pressure       qual
4800200   102     6.67e6        0.7
*
*               from        to    jun area  f loss r loss vcahs
4801101     450010004    480010001 7.854e-3  9.05   1.63  01002
*Note for Junction 1: abrupt area change losses per K's/momentum flux off
4802101     480010002    490010001 7.854e-3  0.0    0.0   01000  * no choked
* flow/smooth area change
* 4801101     450010004    480010001 7.854e-3  9.05   1.63  01002       *
* MODIFIED 01/29/2001
*
*              flow-f      flow-g    velj
4801201         0.0          0.       0. *
4802201         0.0          0.       0.
*4801201         0.5          0.       0. *
*4802201         0.5          0.       0. *
*
*-----------------------------------------------------------------------------
*----------------------------------------------------------------------------
*               name          type
4900000         upper-pl      pipe
*
*              no.vol
4900001           12
*
*               area       vol no
4900101        7.854e-3       1
4900102        8.1713e-3      12
*
*              vol lgh    vol no
4900301         0.420         1
4900302         0.751         11
4900303         0.580         12
*
*               vr ang    vol no
4900601           0.0          1
4900602          90.0         12
*
*               elv ch      vol no
4900701           0.0          1
4900702         0.751         11
4900703         0.580         12
*
*              rough    hy dia    vol no
4900801        4.57e-5    0.100       1
4900802        4.57e-5    0.102      12
```

```
*
*             floss  rloss   jn.no.
4900901        1.02   1.02      1
4900902        0.0     0.0     11
*
*              pvbfe    vol no
4901001        10000       12
*
*               fvcahs   jn no
4901101        0001100      1  * abrupt area change
4901102        0001000     11
*
*         ctl   pressure     qual                 vol no
4901201   102   6.67e6      0.7  0.0  0.0  0.0     12
*

*         ctl
4901300   1
*             flow-f    flow-g   velj   jun no
4901301       0.0       0.0       0.       11
*4901301       0.5       0.0       0.       11
*
*-----------------------------------------------------------------------
*
*               name        type
4910000        upln-hlj    sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
4910101 490120003 500010001    0.0       2.85    1.40 001002 * momentum flux
* off
*
*         ctl  flow-f      flow-g  velj
4910201    1     0.0         0.0    0.
*4910201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*4910110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*-------  HOT LEG MODEL -------------------------------------------------
*-----------------------------------------------------------------------
*
*               name          type
5000000        hotleg         pipe
*
*              no.vol
5000001           11
*
*               area      vol no
5000101        3.3183e-3    11
*
*              vol lgh    vol no
5000301         0.500        1
5000302         0.3927       2
5000303         0.6327       3
5000304         0.770       11
```

```
*
*               vr ang    vol no
5000601          1.0         11
*
*             elv ch      vol no
5000701        0.0087262      1
5000702        0.0068536      2
5000703        0.0110421      3
5000704        0.013438      11
*
*              rough    hy dia    vol no
5000801        4.57e-5    0.065       11
*
*             floss  rloss   jn.no.
5000901        0.0     0.0      1
5000902        0.413   0.413    2
5000903        0.0     0.0     10
*
*              pvbfe    vol no
5001001        10000       11
*
*               fvcahs   jn no
5001101         001000     10
*
*         ctl   pressure    qual                 vol no
5001201   102   6.67e6     0.7  0.0  0.0  0.0     11
*
*         ctl
5001300   1
*             flow-f    flow-g   velj   jun no
5001301       0.0       0.0       0.       10
*5001301       0.5       0.0       0.       10
*
*-----------------------------------------------------------------------
*
*-------  90deg, R500mm Elbow from Comp.500 to Comp.600 ------------------
*
*               name        type
5010000        hl-elbow     branch
*
*             no jun    in ctl
5010001            2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
5010101      3.3183-3   0.7854       0.0       0.0      1.0    0.013707
*
*              rough     hydia    pvbfe
5010102        4.57e-5    0.065   10000  *
*
*         ctl     pressure       qual
5010200   102     6.67e6        0.7
*
*               from        to     jun area  f loss r loss  vcahs
5011101     500110002    501010001 3.3183e-3  0.0    0.0    01000  *
5012101     501010002    600010001 3.3183e-3  0.413  0.413  01000  *
*
*              flow-f      flow-g    velj
5011201         0.0          0.       0. *
```

```
5012201         0.0          0.       0.
*5011201         0.5          0.       0. *
*5012201         0.5          0.       0. *
*
*
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*-------  SG BUNDLE #1 MODEL ---------------------------------------------
*-----------------------------------------------------------------------
*
*-------  steam generator tube bundle #1 ---------------------------------
*               name          type
6000000        sg-bun1        pipe
*
*              no.vol
6000001           2
*
*               area       vol no
6000101        3.3183e-3     2
*
*              vol lgh    vol no
6000301         0.500        1
6000302         0.4675       2
*
*               vr ang    vol no
6000601          1.0         2
*
*             elv ch      vol no
6000701        0.0087262     1
6000702        0.008159      2
*
*              rough    hy dia    vol no
6000801        4.57e-5    0.065       2
*
*             floss  rloss   jn.no.
6000901        0.0     0.0      1
*
*              pvbfe    vol no
6001001        10000       2
*
*               fvcahs   jn no
6001101         001000     1
*
*         ctl   pressure     qual                 vol no
6001201   102   6.67e6      0.7   0.0  0.0  0.0    2
*
*         ctl
6001300   1
*             flow-f    flow-g   velj   jun no
6001301       0.0       0.0       0.       1
*6001301       0.5       0.0       0.       1
*
*-----------------------------------------------------------------------
*------------ SG bundle/steam release pipeline Tee connection ------------
*               name      type
6010000        sg-tee    branch
*
*             no jun    in ctl
```

```
6010001          3         1
*
*               area    length       vol    hz ang    vr ang    elv ch
6010101      3.3183-3    0.065        0.0       0.0       0.0       0.0
*
*              rough     hydia    pvbfe
6010102        4.57e-5    0.065   10000  *
*
*         ctl     pressure      qual
6010200   102     6.67e6        0.7
*
*               from        to     jun area  f loss r loss vcahs
6011101     600020002    601010001 3.3183e-3  0.0    0.6   01000  *
6012101     601010002    700010001 3.3183e-3  0.6    0.0   01000  *
6013101     601010004    650010001 3.3183e-3  1.0    0.24  01002  * momentum
* flux off
*
*              flow-f      flow-g    velj
6011201         0.0          0.       0. *
6012201         0.0          0.       0. *
6013201         0.0          0.       0.
*6011201         0.5          0.       0. *
*6012201         0.5          0.       0. *
*6013201         0.0          0.       0. *
*
*-----------------------------------------------------------------------------
*-------  steam release pipe  ---------------------------------------------
*               name          type
6500000        stm-rels       pipe

*
*              no.vol
6500001           8
*
*               area       vol no
6500101        3.3183e-3      8
*
*              vol lgh    vol no
6500301         2.000         8
*
*               vr ang    vol no
6500601          1.0          8
*
*             elv ch      vol no
6500701        0.0349         8
*
*              rough    hy dia    vol no
6500801        4.57e-5    0.065       8
*
*             floss  rloss   jn.no.
6500901        0.0     0.0      7
*
*              pvbfe    vol no
6501001        10000       8
*
*               fvcahs   jn no
6501101         001000     7
*
```

```
*         ctl   pressure    qual                 vol no
6501201   102   6.67e6      0.7  0.0  0.0  0.0     8
*
*         ctl
6501300   1
*             flow-f    flow-g   velj   jun no
6501301       0.0       0.0       0.       7
*
*
*-----------------------------------------------------------------------
*
*-----------------------------------------------------------------------
*-------  SG BUNDLE #2 MODEL  ---------------------------------------------
*-----------------------------------------------------------------------
*
*-------  steam generator tube bundle #2 ----------------------------------
*               name          type
7000000        sg-bun2        pipe
*
*              no.vol
7000001           2
*
*               area       vol no
7000101        3.3183e-3     2
*
*              vol lgh    vol no
7000301         0.4675       1
7000302         0.500        2
*
*               vr ang    vol no
7000601         -1.0         2
*
*             elv ch      vol no
7000701        -0.008159     1
7000702        -0.0087262    2
*
*              rough    hy dia    vol no
7000801        4.57e-5    0.065       2
*
*             floss  rloss   jn.no.
7000901        0.0     0.0      1
*
*              pvbfe    vol no
7001001        10000       2
*
*               fvcahs   jn no
7001101         001000     1
*
*         ctl   pressure    qual                vol no
7001201   102   6.67e6      0.7  0.0  0.0  0.0     2
*
*         ctl
7001300    1
*             flow-f    flow-g   velj   jun no
7001301       0.0       0.0       0.       1
*7001301       0.5       0.0       0.       1
*
*-----------------------------------------------------------------------
```

```
*
*-------  90deg, R500mm Elbow from Comp.700 to Comp.800 ------------------
*
*               name        type
7010000        cl-elbow     branch
*
*             no jun    in ctl
7010001            2         1
*
*               area    length       vol    hz ang    vr ang    elv ch
7010101      3.3183-3   0.7854       0.0       0.0     -1.0    -0.013707
*
*              rough     hydia    pvbfe
7010102        4.57e-5    0.065   10000  *
*
*         ctl     pressure      qual
7010200   102     6.67e6        0.7
*
*               from        to     jun area  f loss r loss  vcahs
7011101     700020002    701010001 3.3183e-3  0.0    0.0    01000  *
7012101     701010002    800010001 3.3183e-3  0.413  0.413  01000  *
*
*              flow-f      flow-g    velj
7011201         0.0          0.       0. *
7012201         0.0          0.       0.
*7011201         0.5          0.       0. *
*7012201         0.5          0.       0. *
*
*
*-----------------------------------------------------------------------
*
*-----------------------------------------------------------------------
*-------  COLD LEG MODEL -------------------------------------------------
*-----------------------------------------------------------------------
*
*-------  upper-cold leg section  ----------------------------------------
*               name          type
8000000         upper-cl      pipe
*
*              no.vol
8000001           10
*
*               area      vol no
8000101        3.3183e-3    10
*
*              vol lgh    vol no
8000301         0.645       10
*
*               vr ang    vol no
8000601          -1.0       10
*
*             elv ch      vol no
8000701      -0.0112569     10
*
*              rough    hy dia    vol no
8000801        4.57e-5    0.065       10
*
*             floss  rloss   jn.no.
```

```
8000901        0.0     0.0      9
*
*              pvbfe    vol no
8001001        10000       10
*
*               fvcahs   jn no
8001101         001000      9
*
*         ctl   pressure    qual                 vol no
8001201   102   6.67e6      0.7   0.0  0.0  0.0     10
*
*         ctl
8001300   1
*             flow-f    flow-g   velj   jun no
8001301       0.0       0.0       0.       9
*8001301       0.5       0.0       0.       9
*
*-----------------------------------------------------------------------
*
*               name        type
8010000        low-clj    sngljun
*
*          from        to    jn area   f loss  r loss efvcahs
8010101 800100002 850010003    0.0     1.22    1.153  1001001 * ccfl and
* momentum flux off
*
*         ctl  flow-f      flow-g  velj
8010201    1     0.0         0.0    0.
*8010201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*8010110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*
*-------  lower-cold leg section  ----------------------------------------
*               name          type
8500000         lower-cl      pipe
*
*              no.vol
8500001            9
*
*               area       vol no
8500101        7.21e-3         2
8500102        4.88e-3         4
8500103        7.21e-3         9
*
*              vol lgh    vol no
8500301         0.580        1
8500302         0.639        2
8500303         0.535        4
8500304         0.938        9

*
*               vr ang    vol no
8500601        -90.0         9
```

```
*
*             elv ch      vol no
8500701        -0.580        1
8500702        -0.639        2
8500703        -0.535        4
8500704        -0.938        9
*
*              rough    hy dia    vol no
8500801        4.57e-5    0.057        2
8500802        4.57e-5    0.067        4
8500803        4.57e-5    0.057        9
*
*             floss  rloss   jn.no.
8500901        0.0     0.0      8
*
*              pvbfe    vol no
8501001        10000        9
*
*               fvcahs   jn no
8501101         001000      8
*
*         ctl   pressure    qual                 vol no
8501201   102   6.67e6      0.7  0.0  0.0  0.0     9
*
*         ctl
8501300   1
*
*             flow-f    flow-g   velj   jun no
8501301       0.0       0.0       0.       8
*8501301       0.5       0.0       0.       8
*
*-------------------------------------------------------------------------
*
*               name        type
8510000        cl-outjn    sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
8510101 850090002 100010001    0.0      0.0     0.0    1100 * abrupt area
* change
*
*         ctl  flow-f      flow-g  velj
8510201    1     0.0         0.0    0.
*8510201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*8510110   0.035     0.00      0.725     1.00
*
*-------------------------------------------------------------------------
*
*               name        type
*9XX0000       SNG-JUN      sngljun
*
*          from        to    jn area   f loss  r loss fvcahs
*9XX0101 9XX110002 910010001  3.1416e-4  0.0     0.0    00100 * abrupt area
* change (COMPUTE K)
*
```

```
*         ctl  flow-f      flow-g  velj
*9XX0201    1     0.5         0.0    0. *
*
* use Wallis
* use the y-int for tubes with a sharp-edged entrance
*         hyd dia   beta      y-int     slope
*9XX0110   0.035     0.00      0.725     1.00
*
*-----------------------------------------------------------------------
*$=====================================================================$
**               name      type
*9100000          TDV    tmdpvol
**
**               area       lgh      vol     hz ang    vr ang   elv ch
*9100101           0.0       1.0      1.e6       0.0       0.0      0.0
**
**              rough    hy dia       flg
*9100102        4.57e-5      0.0        00
**
**                ctl
*9100200          003
**
**              time      pressure    temp
*9100201         0.0       6.0129e6    478.
*9100202     10000.0       6.0129e6    478.
**
**
$=====================================================================$
*
*
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*     HEAT STRUCTURE INPUT DATA
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Upper Downcomer Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
11000000   9    3      2          0     0.0365
*
*mesh        loc-flg   frm flg
11000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
11000101           1   0.0405         1    0.0445
*
*             cmp-no    itv-no    cmp-no    itv-no
11000201           1         1         1       2
*
*             source    itv-no    source    itv-no
11000301         0.0         1      0.0        2
*
*ini temp        flg
11000400           0
*
11000401    556.0  1   556.0   2   556.0    3
*
```

```
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11000501    100010000     0      1         1     0.267         1
11000502    100020000     0      1         1     0.267         2
11000503    100030000     0      1         1     0.267         3
11000504    100040000     0      1         1     0.267         4
11000505    100050000     0      1         1     0.267         5
11000506    100060000     0      1         1     0.238         6
11000507    100070000     0      1         1     0.1382        7
11000508    100080000     0      1         1     0.1382        8
11000509    100090000     0      1         1     0.1382        9
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11000601      -800         0     3101      1     0.267         1
11000602      -800         0     3101      1     0.267         2
11000603      -800         0     3101      1     0.267         3
11000604      -800         0     3101      1     0.267         4
11000605      -800         0     3101      1     0.267         5
11000606      -800         0     3101      1     0.238         6
11000607      -800         0     3101      1     0.1382        7
11000608      -800         0     3101      1     0.1382        8
11000609      -800         0     3101      1     0.1382        9
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
11000701           0       0.0        0.0      0.0          9
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  9
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  9
*
*---------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*   Upper/Lower Downcomer Connecting Branch
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
11010000   1    3     2          0     0.0365
*
*mesh        loc-flg   frm flg
11010100          0         1
*
*            no-itv     r-cor    no-itv    r-cor
11010101          1   0.04050         1    0.04450
*
*            cmp-no    itv-no    cmp-no    itv-no
11010201          1         1         1       2
*
*            source    itv-no    source    itv-no
11010301        0.0         1      0.0        2
*
*ini temp        flg
11010400          -1
*
11010401    556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
```

```
11010501    101010000     0      1         1     0.35          1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11010601      -800         0     3101      1     0.35          1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
11010701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11010801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11010901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Lower Downcomer Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
11500000  13    5      2          0     0.04
*
*mesh        loc-flg   frm flg
11500100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
11500101           2    0.0545         2    0.0605
*
*             cmp-no    itv-no    cmp-no    itv-no
11500201           3         2         1       4
*
*             source    itv-no    source    itv-no
11500301         0.0         4
*
*ini temp        flg
11500400          -1
*
11500401     556.0 556.0 556.0 556.0 556.0
11500402     556.0 556.0 556.0 556.0 556.0
11500403     556.0 556.0 556.0 556.0 556.0
11500404     556.0 556.0 556.0 556.0 556.0
11500405     479.0 479.0 479.0 479.0 479.0
11500406     479.0 479.0 479.0 479.0 479.0
11500407     479.0 479.0 479.0 479.0 479.0
11500408     479.0 479.0 479.0 479.0 479.0
11500409     479.0 479.0 479.0 479.0 479.0
11500410     479.0 479.0 479.0 479.0 479.0
11500411     479.0 479.0 479.0 479.0 479.0
11500412     479.0 479.0 479.0 479.0 479.0
11500413     479.0 479.0 479.0 479.0 479.0
*
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11500501    150010000     0      1         1     0.534         1
11500502    150020000     0      1         1     0.158         2
11500503    150030000     0      1         1     0.750         3
11500504    150040000     0      1         1     0.750         4
```

```
11500505    150050000     0      1         1     0.750         5
11500506    150060000     0      1         1     0.750         6
11500507    150070000     0      1         1     0.750         7
11500508    150080000     0      1         1     0.500         8
11500509    150090000     0      1         1     0.442         9
11500510    150100000     0      1         1     0.750        10
11500511    150110000     0      1         1     0.750        11
11500512    150120000     0      1         1     0.716        12
11500513    150130000     0      1         1     0.534        13
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11500601      -800         0     3102      1     0.534         1
11500602      -800         0     3102      1     0.158         2
11500603      -800         0     3102      1     0.750         3
11500604      -800         0     3102      1     0.750         4
11500605      -800         0     3102      1     0.750         5
11500606      -800         0     3102      1     0.750         6
11500607      -800         0     3102      1     0.750         7
11500608      -800         0     3102      1     0.500         8
11500609      -800         0     3102      1     0.442         9
11500610      -800         0     3102      1     0.750        10
11500611      -800         0     3102      1     0.750        11
11500612      -800         0     3102      1     0.716        12
11500613      -800         0     3102      1     0.534        13
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
11500701           0       0.0        0.0       0.0        13
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  13
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  13
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*   Lower Downcomer/Lower Pipeline Connecting Branch
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
11510000   1    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
11510100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
11510101           2    0.0375
*
*             cmp-no    itv-no    cmp-no    itv-no
11510201           1         2
*
*             source    itv-no    source    itv-no
11510301         0.0         2
*
*ini temp        flg
11510400          -1
*
```

```
11510401     479.0    479.0    479.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11510501    151010000     0      1         1     0.35          1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
11510601      -800         0     3101      1     0.35          1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
11510701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11510801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
11510901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Lower Pipeline - Section A Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
19000000  11    3      2          0      0.0325
*
*mesh        loc-flg   frm flg
19000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
19000101           2    0.0375
*
*             cmp-no    itv-no    cmp-no    itv-no
19000201           1         2
*
*             source    itv-no    source    itv-no
19000301         0.0         2
*
*ini temp        flg
19000400          0
*
19000401     479.0   1    479.0   2    479.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19000501    900010000     0      1         1     0.85          1
19000502    900020000     0      1         1     0.6354        2
19000503    900030000     0      1         1     0.80          3
19000504    900040000     0      1         1     0.80          4
19000505    900050000     0      1         1     0.4954        5
19000506    900060000     0      1         1     0.71          6
19000507    900070000     0      1         1     0.71          7
19000508    900080000     0      1         1     0.71          8
19000509    900090000     0      1         1     0.4954        9
19000510    900100000     0      1         1     0.80         10
19000511    900110000     0      1         1     0.80         11
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19000601      -800         0     3101      1     0.85          1
```

```
19000602      -800         0     3101      1     0.6354        2
19000603      -800         0     3101      1     0.80          3
19000604      -800         0     3101      1     0.80          4
19000605      -800         0     3101      1     0.4954        5
19000606      -800         0     3101      1     0.71          6
19000607      -800         0     3101      1     0.71          7
19000608      -800         0     3101      1     0.71          8
19000609      -800         0     3101      1     0.4954        9
19000610      -800         0     3101      1     0.80         10
19000611      -800         0     3101      1     0.80         11
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
19000701           0       0.0        0.0      0.0        11
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Lower Pipeline - Section B Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
19400000  10    3      2          0      0.01
*
*mesh        loc-flg   frm flg
19400100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
19400101           2    0.013
*
*             cmp-no    itv-no    cmp-no    itv-no
19400201           1         2
*
*             source    itv-no    source    itv-no
19400301         0.0         2
*
*ini temp        flg
19400400          0
*
19400401     479.0   1    479.0   2    479.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19400501    940010000     0      1         1     0.70          1
19400502    940020000     0      1         1     0.70          2
19400503    940030000     0      1         1     0.70          3
19400504    940040000     0      1         1     0.70          4
19400505    940050000     0      1         1     0.70          5
19400506    940060000     0      1         1     0.70          6
19400507    940070000     0      1         1     0.70          7
19400508    940080000     0      1         1     0.70          8
19400509    940090000     0      1         1     0.70          9
19400510    940100000     0      1         1     0.70         10
*
```

```
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19400601      -800         0     3103      1     0.70          1
19400602      -800         0     3103      1     0.70          2
19400603      -800         0     3103      1     0.70          3
19400604      -800         0     3103      1     0.70          4
19400605      -800         0     3103      1     0.70          5
19400606      -800         0     3103      1     0.70          6
19400607      -800         0     3103      1     0.70          7
19400608      -800         0     3103      1     0.70          8
19400609      -800         0     3103      1     0.70          9
19400610      -800         0     3103      1     0.70         10
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
19400701           0       0.0        0.0      0.0        10
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19400801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  10
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19400901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  10
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Lower Pipeline - Section C Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
19600000  15    3      2          0      0.0325
*
*mesh        loc-flg   frm flg
19600100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
19600101           2    0.0375
*
*             cmp-no    itv-no    cmp-no    itv-no
19600201           1         2
*
*             source    itv-no    source    itv-no
19600301         0.0         2
*
*ini temp        flg
19600400          0
*
19600401     479.0   1    479.0   2    479.0   3
*
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19600501    960010000     0      1         1     0.60          1
19600502    960020000     0      1         1     0.60          2
19600503    960030000     0      1         1     0.4954        3
19600504    960040000     0      1         1     0.71          4
19600505    960050000     0      1         1     0.71          5
19600506    960060000     0      1         1     0.71          6
19600507    960070000     0      1         1     0.4954        7
19600508    960080000     0      1         1     0.695         8
19600509    960090000     0      1         1     0.695         9
```

```
19600510    960100000     0      1         1     0.695        10
19600511    960110000     0      1         1     0.695        11
19600512    960120000     0      1         1     0.695        12
19600513    960130000     0      1         1     0.695        13
19600514    960140000     0      1         1     0.695        14
19600515    960150000     0      1         1     0.695        15
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
19600601      -800         0     3101      1     0.60          1
19600602      -800         0     3101      1     0.60          2
19600603      -800         0     3101      1     0.4954        3
19600604      -800         0     3101      1     0.71          4
19600605      -800         0     3101      1     0.71          5
19600606      -800         0     3101      1     0.71          6
19600607      -800         0     3101      1     0.4954        7
19600608      -800         0     3101      1     0.695         8
19600609      -800         0     3101      1     0.695         9
19600610      -800         0     3101      1     0.695        10
19600611      -800         0     3101      1     0.695        11
19600612      -800         0     3101      1     0.695        12
19600613      -800         0     3101      1     0.695        13
19600614      -800         0     3101      1     0.695        14
19600615      -800         0     3101      1     0.695        15
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
19600701           0       0.0        0.0       0.0        15
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19600801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  15
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
19600901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  15
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Lower Plenum Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
12000000   4    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
12000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
12000101           2    0.03750
*
*             cmp-no    itv-no    cmp-no    itv-no

12000201           1        2
*
*             source    itv-no    source    itv-no
12000301         0.0        2
*
*ini temp        flg
12000400           0
*
```

```
12000401     479.0   1    479.0   2    479.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12000501    200010000     0      1         1     0.77          1
12000502    200020000     0      1         1     0.77          2
12000503    200030000     0      1         1     0.75          3
12000504    200040000     0      1         1     0.75          4
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12000601      -800         0     3101      1     0.77          1
12000602      -800         0     3101      1     0.77          2
12000603      -800         0     3101      1     0.75          3
12000604      -800         0     3101      1     0.75          4
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
12000701           0       0.0        0.0      0.0         4
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   4
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   4
*
*-----------------------------------------------------------------------
*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Core Inlet Plenum
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
12200000   1    3      2          0      0.05
*
*mesh        loc-flg   frm flg
12200100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
12200101           2     0.062
*
*             cmp-no    itv-no    cmp-no    itv-no
12200201           1        2
*
*             source    itv-no    source    itv-no
12200301         0.0        2
*
*ini temp        flg
12200400          -1
*
12200401     479.0     479.0     479.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12200501    220010000     0      1         1     0.30          1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12200601      -800         0     3101      1     0.30          1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
12200701           0       0.0        0.0      0.0         1
```

```
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12200801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12200901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*-----------------------------------------------------------------------*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*     Lower Annulus Core Simulator Vessel
*     (heat-transfer from annulus to outer shell)
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
12500000   3    4      2          0      0.15
*
*mesh        loc-flg   frm flg
12500100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
12500101           3     0.21
*
*             cmp-no    itv-no    cmp-no    itv-no
12500201           1        3
*
*             source    itv-no    source    itv-no
12500301         0.0        3
*
*ini temp        flg
12500400           0
*
12500401     479.0   1    479.0   2    479.0   3    479.0  4
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12500501    250010000     0      1         1     0.081          1
12500502    250020000     0      1         1     0.100          2
12500503    250030000     0      1         1     0.075          3
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12500601      -800         0     3105      1     0.081         1
12500602      -800         0     3105      1     0.100         2
12500603      -800         0     3105      1     0.075         3
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
12500701           0       0.0        0.0      0.0         3
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   3
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   3
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*     Lower Core Conductor - Endcap (Slab)
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
```

```
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
12501000   1    5      1          0      0.0
*
*mesh        loc-flg   frm flg
12501100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
12501101           4     0.07
*
*             cmp-no    itv-no    cmp-no    itv-no

12501201           1        4
*
*             source    itv-no    source    itv-no
12501301         0.0        4
*
*ini temp        flg
12501400          -1
*
12501401     479.0    479.0    479.0    479.0    479.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  surf-area  ht-str-no
12501501    250030000     0      1         1     0.1385         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  surf-area  ht-str-no
12501601      -800         0     3105      1     0.1385         1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
12501701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12501801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12501901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Core Simulator Lower Shroud
*      (heat-transfer from annulus to inner shroud)
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
12800000   3    3      2          0      0.059
*
*mesh        loc-flg   frm flg
12800100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
12800101           2     0.065
*
*             cmp-no    itv-no    cmp-no    itv-no
12800201           1        2
*
*             source    itv-no    source    itv-no
12800301         0.0        2
```

```
*
*ini temp        flg
12800400           0
*
12800401     479.0   1    479.0   2    479.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12800501    280020000     0       1       1     0.075          1
12800502    280030000     0       1       1     0.100          2
12800503    280040000     0       1       1     0.081          3
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
12800601    250030000      0      1       1     0.075          1
12800602    250020000      0      1       1     0.100          2
12800603    250010000      0      1       1     0.081          3
*
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
12800701           0       0.0        0.0      0.0         3
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12800801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   3
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
12800901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   3
*
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Core Heat Source
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num

13000000  20    4      2          0     0.00297
*
*mesh        loc-flg   frm flg
13000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
13000101           3    0.0045
*
*             cmp-no    itv-no    cmp-no    itv-no
13000201           1        3
*
*             source    itv-no    source    itv-no
13000301         1.0        3
*
*ini temp        flg
13000400          -1
*
13000401  556.0   556.0   556.0   556.0
13000402  556.0   556.0   556.0   556.0
13000403  556.0   556.0   556.0   556.0
13000404  556.0   556.0   556.0   556.0
13000405  556.0   556.0   556.0   556.0
13000406  556.0   556.0   556.0   556.0
```

```
13000407  556.0   556.0   556.0   556.0
13000408  556.0   556.0   556.0   556.0
13000409  556.0   556.0   556.0   556.0
13000410  556.0   556.0   556.0   556.0
13000411  556.0   556.0   556.0   556.0
13000412  556.0   556.0   556.0   556.0
13000413  556.0   556.0   556.0   556.0
13000414  556.0   556.0   556.0   556.0
13000415  556.0   556.0   556.0   556.0
13000416  556.0   556.0   556.0   556.0
13000417  556.0   556.0   556.0   556.0
13000418  556.0   556.0   556.0   556.0
13000419  556.0   556.0   556.0   556.0
13000420  556.0   556.0   556.0   556.0
*
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
13000501          0       0      0         1      2.375         1
13000502          0       0      0         1      2.375         2
13000503          0       0      0         1      2.375         3
13000504          0       0      0         1      2.375         4
13000505          0       0      0         1      2.375         5
13000506          0       0      0         1      2.375         6
13000507          0       0      0         1      2.375         7
13000508          0       0      0         1      2.375         8
13000509          0       0      0         1      2.375         9
13000510          0       0      0         1      2.375        10
13000511          0       0      0         1      2.375        11
13000512          0       0      0         1      2.375        12
13000513          0       0      0         1      2.375        13
13000514          0       0      0         1      2.375        14
13000515          0       0      0         1      2.375        15
13000516          0       0      0         1      2.375        16
13000517          0       0      0         1      2.375        17
13000518          0       0      0         1      2.375        18
13000519          0       0      0         1      2.375        19
13000520          0       0      0         1      2.47         20
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
13000601    300010000      0     110       1      2.375         1
13000602    300020000      0     110       1      2.375         2
13000603    300030000      0     110       1      2.375         3
13000604    300040000      0     110       1      2.375         4
13000605    300050000      0     110       1      2.375         5
13000606    300060000      0     110       1      2.375         6
13000607    300070000      0     110       1      2.375         7
13000608    300080000      0     110       1      2.375         8
13000609    300090000      0     110       1      2.375         9
13000610    300100000      0     110       1      2.375        10
13000611    300110000      0     110       1      2.375        11
13000612    300120000      0     110       1      2.375        12
13000613    300130000      0     110       1      2.375        13
13000614    300140000      0     110       1      2.375        14
13000615    300150000      0     110       1      2.375        15
13000616    300160000      0     110       1      2.375        16
13000617    300170000      0     110       1      2.375        17
13000618    300180000      0     110       1      2.375        18
13000619    300190000      0     110       1      2.375        19
```

```
13000620    300200000      0     110       1      2.47         20
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
13000701         300   0.0499        0.0      0.0        19
13000702         300   0.0519        0.0      0.0        20
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
*13000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  10
*
13000900    1
*
*r-h-st   heqd   hlf    hlr     glf   glr  gkf   gkr boil  ncl   p/d  ff  #
13000901 .01345  0.0625 2.4425 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1.  1
13000902 .01345  0.1875 2.3175 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1.  2
13000903 .01345  0.3125 2.1925 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1.  3
13000904 .01345  0.4375 2.0675 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1.  4
13000905 .01345  0.5625 1.9425 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1.  5
13000906 .01345  0.6875 1.8175 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1.  6
13000907 .01345  0.8125 1.6925 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1.  7
13000908 .01345  0.9375 1.5675 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1.  8
13000909 .01345  1.0625 1.4425 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1.  9
13000910 .01345  1.1875 1.3175 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1. 10
13000911 .01345  1.3125 1.1925 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1. 11
13000912 .01345  1.4375 1.0675 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1. 12
13000913 .01345  1.5625 0.9425 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1. 13
13000914 .01345  1.6875 0.8175 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1. 14
13000915 .01345  1.8125 0.6925 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1. 15
13000916 .01345  1.9375 0.5675 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1. 16
13000917 .01345  2.0625 0.4425 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1. 17
13000918 .01345  2.1875 0.3175 0.063 0.188 0.26  0.26 1.0 2.505 1.417 1. 18
13000919 .01345  2.3125 0.1925 0.188 0.063 0.26  0.26 1.0 2.505 1.417 1. 19
13000920 .01345  2.44   0.065  0.065 0.19  0.26  0.26 1.0 2.505 1.417 1. 20
*
*
*23456789021234567890312345678904123456789051234567890612345678907234567890
*-------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Core Simulator Shroud/Insulation
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
13001000  22    6      2          0     0.030975
*
*mesh        loc-flg   frm flg
13001100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
13001101           3     0.04          2    0.0445
*
*             cmp-no    itv-no    cmp-no    itv-no
13001201           3        3          1        5
*
*             source    itv-no    source    itv-no
13001301         0.0        5
*
*ini temp        flg
13001400          -1
```

```
*
13001401      556.0  556.0  556.0  556.0  556.0  556.0
13001402      556.0  556.0  556.0  556.0  556.0  556.0
13001403      556.0  556.0  556.0  556.0  556.0  556.0
13001404      556.0  556.0  556.0  556.0  556.0  556.0
13001405      556.0  556.0  556.0  556.0  556.0  556.0
13001406      556.0  556.0  556.0  556.0  556.0  556.0
13001407      556.0  556.0  556.0  556.0  556.0  556.0
13001408      556.0  556.0  556.0  556.0  556.0  556.0
13001409      556.0  556.0  556.0  556.0  556.0  556.0
13001410      556.0  556.0  556.0  556.0  556.0  556.0
13001411      556.0  556.0  556.0  556.0  556.0  556.0
13001412      556.0  556.0  556.0  556.0  556.0  556.0
13001413      556.0  556.0  556.0  556.0  556.0  556.0
13001414      556.0  556.0  556.0  556.0  556.0  556.0
13001415      556.0  556.0  556.0  556.0  556.0  556.0
13001416      556.0  556.0  556.0  556.0  556.0  556.0
13001417      556.0  556.0  556.0  556.0  556.0  556.0
13001418      556.0  556.0  556.0  556.0  556.0  556.0
13001419      556.0  556.0  556.0  556.0  556.0  556.0
13001420      556.0  556.0  556.0  556.0  556.0  556.0
13001421      556.0  556.0  556.0  556.0  556.0  556.0
13001422      556.0  556.0  556.0  556.0  556.0  556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no

13001501     280050000    0      1         1      0.020        1
13001502     300010000    0      1         1      0.1250       2
13001503     300020000    0      1         1      0.1250       3
13001504     300030000    0      1         1      0.1250       4
13001505     300040000    0      1         1      0.1250       5
13001506     300050000    0      1         1      0.1250       6
13001507     300060000    0      1         1      0.1250       7
13001508     300070000    0      1         1      0.1250       8
13001509     300080000    0      1         1      0.1250       9
13001510     300090000    0      1         1      0.1250      10
13001511     300100000    0      1         1      0.1250      11
13001512     300110000    0      1         1      0.1250      12
13001513     300120000    0      1         1      0.1250      13
13001514     300130000    0      1         1      0.1250      14
13001515     300140000    0      1         1      0.1250      15
13001516     300150000    0      1         1      0.1250      16
13001517     300160000    0      1         1      0.1250      17
13001518     300170000    0      1         1      0.1250      18
13001519     300180000    0      1         1      0.1250      19
13001520     300190000    0      1         1      0.1250      20
13001521     300200000    0      1         1      0.130       21
13001522     400010000    0      1         1      0.044       22
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
13001601     350010000    0      1         1      0.020        1
13001602     350020000    0      1         1      0.1250       2
13001603     350030000    0      1         1      0.1250       3
13001604     350040000    0      1         1      0.1250       4
13001605     350050000    0      1         1      0.1250       5
13001606     350060000    0      1         1      0.1250       6
13001607     350070000    0      1         1      0.1250       7
13001608     350080000    0      1         1      0.1250       8
```

```
13001609     350090000    0      1         1      0.1250       9
13001610     350100000    0      1         1      0.1250      10
13001611     350110000    0      1         1      0.1250      11
13001612     350120000    0      1         1      0.1250      12
13001613     350130000    0      1         1      0.1250      13
13001614     350140000    0      1         1      0.1250      14
13001615     350150000    0      1         1      0.1250      15
13001616     350160000    0      1         1      0.1250      16
13001617     350170000    0      1         1      0.1250      17
13001618     350180000    0      1         1      0.1250      18
13001619     350190000    0      1         1      0.1250      19
13001620     350200000    0      1         1      0.1250      20
13001621     350210000    0      1         1      0.130       21
13001622     350210000    0      1         1      0.044       22
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
13001701         0       0.0        0.0       0.0         22
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
13001801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  22
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
13001901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  22
*
*------------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*      Core Simulator Pressure Vessel
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
13500000  21   3      2          0      0.0955
*
*mesh        loc-flg   frm flg
13500100          0         1
*
*             no-itv     r-cor    no-itv    r-cor
13500101          2    0.1095
*
*             cmp-no    itv-no    cmp-no    itv-no
13500201          1        2
*
*             source    itv-no    source    itv-no
13500301         0.0        2
*
*ini temp        flg
13500400         -1
*
13500401      556.0   556.0   556.0
13500402      556.0   556.0   556.0
13500403      556.0   556.0   556.0
13500404      556.0   556.0   556.0
13500405      556.0   556.0   556.0
13500406      556.0   556.0   556.0
13500407      556.0   556.0   556.0
13500408      556.0   556.0   556.0
13500409      556.0   556.0   556.0
13500410      556.0   556.0   556.0
```

```
13500411      556.0   556.0   556.0
13500412      556.0   556.0   556.0
13500413      556.0   556.0   556.0
13500414      556.0   556.0   556.0
13500415      556.0   556.0   556.0
13500416      556.0   556.0   556.0
13500417      556.0   556.0   556.0
13500418      556.0   556.0   556.0
13500419      556.0   556.0   556.0
13500420      556.0   556.0   556.0
13500421      556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
13500501     350010000    0      1         1      0.020        1
13500502     350020000    0      1         1      0.1250       2
13500503     350030000    0      1         1      0.1250       3
13500504     350040000    0      1         1      0.1250       4
13500505     350050000    0      1         1      0.1250       5
13500506     350060000    0      1         1      0.1250       6
13500507     350070000    0      1         1      0.1250       7
13500508     350080000    0      1         1      0.1250       8
13500509     350090000    0      1         1      0.1250       9
13500510     350100000    0      1         1      0.1250      10
13500511     350110000    0      1         1      0.1250      11
13500512     350120000    0      1         1      0.1250      12
13500513     350130000    0      1         1      0.1250      13
13500514     350140000    0      1         1      0.1250      14

13500515     350150000    0      1         1      0.1250      15
13500516     350160000    0      1         1      0.1250      16
13500517     350170000    0      1         1      0.1250      17
13500518     350180000    0      1         1      0.1250      18
13500519     350190000    0      1         1      0.1250      19
13500520     350200000    0      1         1      0.1250      20
13500521     350210000    0      1         1      0.13        21
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
13500601         -800     0      3105      1      0.020        1
13500602         -800     0      3105      1      0.1250       2
13500603         -800     0      3105      1      0.1250       3
13500604         -800     0      3105      1      0.1250       4
13500605         -800     0      3105      1      0.1250       5
13500606         -800     0      3105      1      0.1250       6
13500607         -800     0      3105      1      0.1250       7
13500608         -800     0      3105      1      0.1250       8
13500609         -800     0      3105      1      0.1250       9
13500610         -800     0      3105      1      0.1250      10
13500611         -800     0      3105      1      0.1250      11
13500612         -800     0      3105      1      0.1250      12
13500613         -800     0      3105      1      0.1250      13
13500614         -800     0      3105      1      0.1250      14
13500615         -800     0      3105      1      0.1250      15
13500616         -800     0      3105      1      0.1250      16
13500617         -800     0      3105      1      0.1250      17
13500618         -800     0      3105      1      0.1250      18
13500619         -800     0      3105      1      0.1250      19
13500620         -800     0      3105      1      0.1250      20
13500621         -800     0      3105      1      0.13        21
```

```
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
13500701          0       0.0        0.0      0.0        21

*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
13500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  21
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
13500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  21
*
*----------------------------------------------------------------------------
*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*     Fuel Assembly Head Simulator
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14000000   3    3      2          0      0.0375
* 14000000   2    3      2          0      0.0375                       *
* MODIFIED 01/29/2001
*
*mesh        loc-flg   frm flg
14000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14000101           2     0.045
*
*             cmp-no    itv-no    cmp-no    itv-no
14000201           1        2
*
*             source    itv-no    source    itv-no
14000301         0.0        2
*
*ini temp         flg
14000400           0
*
14000401    556.0   1   556.0  2    556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14000501    400020000     0      1         1     0.050         1
14000502    400030000     0      1         1     0.030         2
14000503    400040000     0      1         1     0.020         3
* 14000501    400020000     0      1         1     0.100         1
* MODIFIED 01/29/2001
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14000601    450030000     0      1         1     0.050         1
14000602    450020000     0      1         1     0.030         2
14000603    450010000     0      1         1     0.020         3
* 14000601    450010000     0      1         1     0.100         1
* MODIFIED 01/29/2001
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14000701           0       0.0        0.0      0.0         3
* 14000701           0       0.0        0.0      0.0         2
* MODIFIED 01/29/2001
```

```
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  3
* 14000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
* MODIFIED 01/29/2001
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  3
* 14000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
* MODIFIED 01/29/2001
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*   Upper Cavity Pressure Vessel
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14002000   2    4      2          0     0.1325
*
*mesh        loc-flg   frm flg
14002100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14002101           3     0.21
*
*             cmp-no    itv-no    cmp-no    itv-no
14002201           1        3
*
*             source    itv-no    source    itv-no
14002301         0.0        3
*
*ini temp        flg
14002400          -1
*
14002401    556.0      556.0     556.0     556.0
14002402    556.0      556.0     556.0     556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14002501    400060000     0      1         1     0.065         1
14002502    400070000     0      1         1     0.066         2
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14002601      -800         0     3105      1     0.065         1
14002602      -800         0     3105      1     0.066         2
*

*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14002701           0       0.0        0.0      0.0         2
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14002801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14002901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*-----------------------------------------------------------------------
*
```

```
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*     Upper Core Conductor - Endcap (Slab)
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14001000   1    5      1          0      0.0
*
*mesh        loc-flg   frm flg
14001100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14001101           4     0.07
*
*             cmp-no    itv-no    cmp-no    itv-no
14001201           1        4
*
*             source    itv-no    source    itv-no
14001301         0.0        4
*
*ini temp        flg
14001400          -1
*
14001401    556.0   556.0   556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  surf-area  ht-str-no
14001501    400070000     0      1         1     0.1385         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  surf-area  ht-str-no
14001601      -800         0     3105      1     0.1385         1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14001701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14001801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14001901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   1
*
*-----------------------------------------------------------------------
*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*     Core Outlet Pressure Vessel
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14500000   3    4      2          0      0.15
* 14500000   2    4      2          0      0.15                        *
* MODIFIED 01/29/2001
*
*mesh        loc-flg   frm flg
14500100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14500101           3     0.21
*
*             cmp-no    itv-no    cmp-no    itv-no
```

```
14500201           1        3

*
*             source    itv-no    source    itv-no
14500301         0.0        3
*
*ini temp        flg
14500400           0
*
14500401    556.0   1   556.0  2    556.0   3   556.0   4
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14500501    450010000     0      1         1     0.040        1
14500502    450020000     0      1         1     0.030        2
14500503    450030000     0      1         1     0.050        3
* 14500501    450010000     0      1         1     0.100        1
* MODIFIED 01/29/2001
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14500601        -800      0     3105       1     0.040        1
14500602        -800      0     3105       1     0.030        2
14500603        -800      0     3105       1     0.050        3
* 14500601        -800      0     3105       1     0.100        1
* MODIFIED 01/29/2001
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14500701           0       0.0        0.0      0.0         3
* 14500701           0       0.0        0.0      0.0         2
* MODIFIED 01/29/2001
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  3
* 14500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
* MODIFIED 01/29/2001
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  3
* 14500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
* MODIFIED 01/29/2001
*
*---------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*   Upper Plenum Model/Upper Core Simulator
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14800000   1    3      2          0      0.05
*
*mesh        loc-flg   frm flg
14800100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14800101           2    0.062
*
*             cmp-no    itv-no    cmp-no    itv-no
14800201           1        2
*
```

```
*              source    itv-no    source    itv-no
14800301         0.0        2
*
*ini temp        flg
14800400          -1
*
14800401    556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14800501    480010000     0      1         1     0.300         1

*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14800601      -800         0     3104      1     0.300         1
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14800701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14800801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14800901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*---------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*   Upper Plenum Model - Horiz. Sharp Angle
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14900000   1    3      2          0      0.05
*
*mesh        loc-flg   frm flg
14900100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14900101           2    0.062
*
*             cmp-no    itv-no    cmp-no    itv-no
14900201           1        2
*
*             source    itv-no    source    itv-no
14900301         0.0        2
*
*ini temp        flg
14900400          -1
*
14900401    556.0  556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14900501    490010000     0      1         1     0.420         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14900601      -800         0     3104      1     0.420         1
*
*source          type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14900701           0       0.0        0.0      0.0         1
```

```
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14900801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14900901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Upper Plenum Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
14901000  11    3      2          0      0.051
*
*mesh        loc-flg   frm flg
14901100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
14901101           2     0.057
*
*             cmp-no    itv-no    cmp-no    itv-no
14901201           1         2
*
*             source    itv-no    source    itv-no
14901301         0.0         2
*
*ini temp        flg
14901400           0
*
14901401    556.0  1  556.0  2   556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14901501    490020000     0      1         1     0.751         1
14901502    490030000     0      1         1     0.751         2
14901503    490040000     0      1         1     0.751         3
14901504    490050000     0      1         1     0.751         4
14901505    490060000     0      1         1     0.751         5
14901506    490070000     0      1         1     0.751         6
14901507    490080000     0      1         1     0.751         7
14901508    490090000     0      1         1     0.751         8
14901509    490100000     0      1         1     0.751         9
14901510    490110000     0      1         1     0.751        10
14901511    490120000     0      1         1     0.580        11
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
14901601      -800         0     3104      1     0.751         1
14901602      -800         0     3104      1     0.751         2
14901603      -800         0     3104      1     0.751         3
14901604      -800         0     3104      1     0.751         4
14901605      -800         0     3104      1     0.751         5
14901606      -800         0     3104      1     0.751         6
14901607      -800         0     3104      1     0.751         7
14901608      -800         0     3104      1     0.751         8
14901609      -800         0     3104      1     0.751         9
14901610      -800         0     3104      1     0.751        10
14901611      -800         0     3104      1     0.580        11
```

```
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
14901701           0       0.0        0.0       0.0        11
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14901801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11

*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
14901901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11
*
*-----------------------------------------------------------------------*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Loop Hotleg Model
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
15000000  11    3      2          0      0.0325
*
*mesh        loc-flg   frm flg
15000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
15000101           2    0.0375
*
*             cmp-no    itv-no    cmp-no    itv-no
15000201           1         2
*
*             source    itv-no    source    itv-no
15000301         0.0         2
*
*ini temp        flg
15000400           0
*
15000401    556.0  1  556.0  2   556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
15000501    500010000     0      1         1     0.50          1
15000502    500020000     0      1         1     0.3927        2
15000503    500030000     0      1         1     0.6327        3
15000504    500040000     0      1         1     0.77          4
15000505    500050000     0      1         1     0.77          5
15000506    500060000     0      1         1     0.77          6
15000507    500070000     0      1         1     0.77          7
15000508    500080000     0      1         1     0.77          8
15000509    500090000     0      1         1     0.77          9
15000510    500100000     0      1         1     0.77         10
15000511    500110000     0      1         1     0.77         11
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
15000601      -800         0     3101      1     0.50          1
15000602      -800         0     3101      1     0.3927        2
15000603      -800         0     3101      1     0.6327        3
15000604      -800         0     3101      1     0.77          4
15000605      -800         0     3101      1     0.77          5
15000606      -800         0     3101      1     0.77          6
15000607      -800         0     3101      1     0.77          7
```

```
15000608      -800         0     3101      1     0.77          8
15000609      -800         0     3101      1     0.77          9
15000610      -800         0     3101      1     0.77         10
15000611      -800         0     3101      1     0.77         11
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
15000701           0       0.0        0.0      0.0        11
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
15000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
15000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  11
*
*-----------------------------------------------------------------------*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*    Component 501 Elbow between 500/600
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
15010000   1    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
15010100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
15010101           2   0.037500
*
*             cmp-no    itv-no    cmp-no    itv-no
15010201           1         2
*
*             source    itv-no    source    itv-no
15010301         0.0         2
*
*ini temp        flg
15010400          -1
*
15010401    556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
15010501    501010000     0      1         1     0.7854         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
15010601      -800         0     3101      1     0.7854         1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
15010701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
15010801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
15010901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
```

```
*   Steam Generator Tube Bundle No. 1
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
16000000   2    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
16000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
16000101           1   0.03500         1    0.037500
*
*             cmp-no    itv-no    cmp-no    itv-no
16000201           1         1         1       2
*
*             source    itv-no    source    itv-no
16000301         0.0         1      0.0        2
*
*ini temp        flg
16000400          0
*
16000401    556.0  1  556.0  2  556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16000501    600010000     0      1         1     0.50          1
16000502    600020000     0      1         1     0.4675        2
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16000601      -800         0     3100      1     0.50          1
16000602      -800         0     3100      1     0.4675        2
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
16000701           0       0.0        0.0      0.0         2
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
16000802      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
16000902      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Steam Generator Tube Bundle TEE
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
16010000   1    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
16010100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
16010101           1   0.03500         1    0.037500
*
*             cmp-no    itv-no    cmp-no    itv-no
```

```
16010201           1         1         1       2
*
*             source    itv-no    source    itv-no
16010301         0.0         1      0.0        2
*
*ini temp        flg
16010400          -1
*
16010401    556.0   556.0   556.0
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16010501    601010000     0      1         1     0.065         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16010601      -800         0     3100      1     0.065         1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
16010701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16010801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16010901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*       Steam Release Pipe
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
16500000   8    3      2          0      0.0325
*
*mesh        loc-flg   frm flg
16500100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
16500101           2    0.0375
*
*             cmp-no    itv-no    cmp-no    itv-no
16500201           1         2
*
*             source    itv-no    source    itv-no
16500301         0.0         2
*
*ini temp        flg
16500400           0
*
16500401    556.0  1  556.0  2   556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16500501    650010000     0      1         1     2.0           1
16500502    650020000     0      1         1     2.0           2
16500503    650030000     0      1         1     2.0           3
16500504    650040000     0      1         1     2.0           4
16500505    650050000     0      1         1     2.0           5
16500506    650060000     0      1         1     2.0           6
```

```
16500507    650070000     0      1         1     2.0           7
16500508    650080000     0      1         1     2.0           8
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
16500601      -800         0     3101      1     2.0           1
16500602      -800         0     3101      1     2.0           2
16500603      -800         0     3101      1     2.0           3
16500604      -800         0     3101      1     2.0           4
16500605      -800         0     3101      1     2.0           5
16500606      -800         0     3101      1     2.0           6
16500607      -800         0     3101      1     2.0           7
16500608      -800         0     3101      1     2.0           8
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
16500701           0       0.0        0.0      0.0         8
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   8
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
16500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   8
*
*-----------------------------------------------------------------------*
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*   Steam Generator Tube Bundle No. 2
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=**
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
17000000   2    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
17000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
17000101           1   0.03500         1    0.037500
*
*             cmp-no    itv-no    cmp-no    itv-no
17000201           1         1         1       2
*
*             source    itv-no    source    itv-no
17000301         0.0         1      0.0        2
*
*ini temp        flg
17000400          0
*
17000401    556.0  1  556.0  2  556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
17000501    700010000     0      1         1     0.4675        1
17000502    700020000     0      1         1     0.50          2
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
17000601      -800         0     3100      1     0.4675        1
17000602      -800         0     3100      1     0.50          2
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
17000701           0       0.0        0.0      0.0         1
```

```
17000702           0       0.0        0.0      0.0         2
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
17000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
17000802      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
17000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
17000902      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  2
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*    Component 701 Elbow between 700/800
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
17010000   1    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
17010100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
17010101           2   0.037500
*
*             cmp-no    itv-no    cmp-no    itv-no
17010201           1         2
*
*             source    itv-no    source    itv-no
17010301         0.0         2
*
*ini temp        flg
17010400          -1
*
17010401    556.0   556.0   556.0
*

*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
17010501    701010000     0      1         1     0.7854         1
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
17010601      -800         0     3101      1     0.7854         1
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
17010701           0       0.0        0.0      0.0         1
*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
17010801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
17010901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  1
*
*-----------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*   Cold Leg Simulator - Upper ~Horiz. Section
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
```

```
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
18000000  10    3      2          0     0.0325
*
*mesh        loc-flg   frm flg
18000100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
18000101           1    0.0350        1    0.03750
*
*             cmp-no    itv-no    cmp-no    itv-no
18000201           1         1         1       2
*
*             source    itv-no    source    itv-no
18000301         0.0         1      0.0        2
*
*ini temp        flg
18000400           0
*
18000401    556.0   1   556.0   2   556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
18000501    800010000     0      1         1     0.645         1
18000502    800020000     0      1         1     0.645         2
18000503    800030000     0      1         1     0.645         3
18000504    800040000     0      1         1     0.645         4
18000505    800050000     0      1         1     0.645         5
18000506    800060000     0      1         1     0.645         6
18000507    800070000     0      1         1     0.645         7
18000508    800080000     0      1         1     0.645         8
18000509    800090000     0      1         1     0.645         9
18000510    800100000     0      1         1     0.645        10
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
18000601      -800         0     3101      1     0.645         1
18000602      -800         0     3101      1     0.645         2
18000603      -800         0     3101      1     0.645         3
18000604      -800         0     3101      1     0.645         4
18000605      -800         0     3101      1     0.645         5
18000606      -800         0     3101      1     0.645         6
18000607      -800         0     3101      1     0.645         7
18000608      -800         0     3101      1     0.645         8
18000609      -800         0     3101      1     0.645         9
18000610      -800         0     3101      1     0.645        10
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
18000701           0       0.0        0.0      0.0        10

*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
18000801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  10
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
18000901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0  10
*
*-----------------------------------------------------------------------------
*
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*   Cold Leg Simulator - Lower Vertical Section
```

```
*   *=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=***
*
*gl data  nh    np   type      s-flg     l-cor   refl b-ind itv-num
18500000   9    3      2          0     0.051
*
*mesh        loc-flg   frm flg
18500100           0         1
*
*             no-itv     r-cor    no-itv    r-cor
18500101           1    0.0540        1    0.0570
*
*             cmp-no    itv-no    cmp-no    itv-no
18500201           1         1         1       2
*
*             source    itv-no    source    itv-no
18500301         0.0         1      0.0        2
*
*ini temp        flg
18500400           0
*
18500401    556.0   1   556.0   2   556.0   3
*
*l-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
18500501    850010000     0      1         1     0.580         1
18500502    850020000     0      1         1     0.639         2
18500503    850030000     0      1         1     0.535         3
18500504    850040000     0      1         1     0.535         4
18500505    850050000     0      1         1     0.938         5
18500506    850060000     0      1         1     0.938         6
18500507    850070000     0      1         1     0.938         7
18500508    850080000     0      1         1     0.938         8
18500509    850090000     0      1         1     0.938         9
*
*r-bndy       hy-vol     inc    b-cdt   a-code  cy-length  ht-str-no
18500601      -800         0     3101      1     0.580         1
18500602      -800         0     3101      1     0.639         2
18500603      -800         0     3101      1     0.535         3
18500604      -800         0     3101      1     0.535         4
18500605      -800         0     3101      1     0.938         5
18500606      -800         0     3101      1     0.938         6
18500607      -800         0     3101      1     0.938         7
18500608      -800         0     3101      1     0.938         8
18500609      -800         0     3101      1     0.938         9
*
*source         type   is-mplr   l-dr-ht   r-dr-ht   ht-str-no
18500701           0       0.0        0.0      0.0         9

*
*l-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
18500801      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   9
*
*r-h-st  h-eq dia  h-l-f h-l-r  grd-f  grd-r  grd-l-f grd-l-r boil num
18500901      0.0  11.0  11.0   0.0     0.0      0.0     0.0   1.0   9
*
*-----------------------------------------------------------------------------
*
*-----------------------------------------------------------------------------
*
```

```
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*     MATERIAL THERMAL PROPERTY DATA
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*               type    cn flg    ca flg
*
* stainless steel (12X18H10T)
20100100    tbl/fctn         1         1  * (tables)
*
*               type    cn flg    ca flg
* stainless steel (12X18H9T)
20100200    tbl/fctn         1         1  * (tables)
*
*
* talkochlorit
20100300    tbl/fctn         1         1  * (tables)
*
*..........................................................................
*         thermal conductivity    w/(m*k)
*..........................................................................
*          *    temp   *  cond  *   temp   *  cond   *  temp   *  cond   *
*..........................................................................
*   stainless steel (12X18H10T)
*
20100101        293.0     15.0      373.0      16.0     473.0     18.0
20100102        573.0     19.0      673.0      21.0     773.0     23.0
20100103        873.0     25.0      973.0      27.0    1073.0     26.0
20100104       1273.0     26.0
*
*   stainless steel (12X18H9T)
*
20100201        293.0     16.0      373.0      16.0     473.0     18.0
20100202        573.0     20.0      673.0      21.0     773.0     23.0
20100203        873.0     25.0      973.0      26.0    1073.0     28.0
20100204       1173.0     29.0
*
*   talkochlorit
20100301        293.0     1.50      393.0     1.20      493.0     1.1
20100302        593.0     1.0       693.0     0.9       793.0     0.8
20100303        893.0     0.75
*
*..........................................................................
*         volumetric heat capacity data      j/((m**3)*k)
*..........................................................................
*               temp  *    cap    *  temp *     cap   * temp  *    cap   *
*..........................................................................
*   stainless steel (12X18H10T)
*
20100151        293.0   3649800.0   473.0   3878700.0   573.0   4022300.0
20100152        673.0   4164100.0   773.0   4229500.0   873.0   4307000.0
20100153        973.0   4370000.0  1073.0   4505800.0
*
*   stainless steel (12X18H9T)
20100251        293.0   3705100.0   473.0   3800500.0   573.0   3874400.0
20100252        673.0   3955100.0   773.0   3991100.0   873.0   4039200.0
20100253        973.0   4043200.0  1073.0   4112600.0  1173.0   4115500.0
*
*
```

```
*   talkochlorit
20100351        293.0     2.204e6   393.0      2.4854e6 493.0     2.6812e6
20100352        593.0     2.8465e6  693.0      3.0114e6 793.0     3.146e6
20100353        893.0     3.28095e6
*.......................................................................

*
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*    GENERAL TABLES
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*
* specified heat transfer coefficients on ** SG tube surfaces **
(uninsulated)
*
*                              time-fac   htc
20210000        htc-t     0    1.0        5.9
*
*                  time          htc-factor   (w/((m**2)*k)
20210001            0.0            0.0
20210002          100.0            0.0
20210003          500.0            2.8
20210004        10000.0            2.8
*
**----------------------------------------------------------------------------
**
** specified heat transfer coefficients on ** Main Circulation Loop **
**  75 mm OD (insulated)
*
*

*                              time-fac   htc
20210100        htc-t     0    1.0        3.2
*
*                  time          htc-factor   (w/((m**2)*k)
20210101            0.0            0.0
20210102          100.0            0.0
20210103          500.0            2.8
20210104        10000.0            2.8
**---------------------------------------------------------------------------
**
** specified heat transfer coefficients on ** Lower Downcomer **
**  121 mm OD (insulated)
*                              time-fac   htc
20210200        htc-t     0    1.0        3.4
**
**                 time          htc-factor   (w/((m**2)*k)
20210201            0.0              0.0
20210202          100.0              0.0
20210203          500.0              2.8
20210204        10000.0              2.8
**
**----------------------------------------------------------------------------
**
** specified heat transfer coefficients on ** Lower Pipeline **
**  26 mm OD (insulated)
*
*                              time-fac   htc
```

```
20210300        htc-t     0    1.0        5.6
**
**                 time          htc-factor   (w/((m**2)*k)
20210301            0.0              0.0
20210302          100.0              0.0
20210303          500.0              2.8
20210304        10000.0              2.8
**
**-------------------------------------------------------------------------
**
** specified heat transfer coefficients on ** Upper Plenum Model **
**  114 mm OD (insulated)
*
*                              time-fac   htc
20210400        htc-t     0    1.0        3.2
**
**                 time          htc-factor   (w/((m**2)*k)
20210401            0.0              0.0
20210402          100.0              0.0
20210403          500.0              2.8
20210404        10000.0              2.8
**
**-------------------------------------------------------------------------
**
** specified heat transfer coefficients on ** Core Simulator **
*
*
*                              time-fac   htc
20210500        htc-t     0    1.0        2.8
**
**                 time          htc-factor   (w/((m**2)*k)
20210501            0.0              0.0
20210502          100.0              0.0
20210503          500.0              2.8
20210504        10000.0              2.8
**
**-------------------------------------------------------------------------
**-------------------------------------------------------------------------
*                   Core Power Table
*-----------------------------------------------------------------------
*
*               table    trip  time coeff   power coeff
20230000        power     0       1.0           1.0         * fuel pins
*
*                   time        power (Watts)
20230001            0.0          0.e3
20230002          100.0          0.e3
20230003          500.0         14.5e3
20230004        10000.0         14.5e3
*
*-----------------------------------------------------------------------
*                   atmosphere temperature
*-----------------------------------------------------------------------
*
20280000        temp                       * ambient air temperature
*
*                   time        temp (k)
20280001            0.0         300.0
```

```
20280002        10000.0         300.0
*
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*     CONTROL VARIABLES
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=
*
*       Core water level
*
20593000     corelvl     sum     1.0     2.505         1
20593001     0.0         0.125   voidf   300010000
20593002                 0.125   voidf   300020000
20593003                 0.125   voidf   300030000
20593004                 0.125   voidf   300040000
20593005                 0.125   voidf   300050000
20593006                 0.125   voidf   300060000
20593007                 0.125   voidf   300070000
20593008                 0.125   voidf   300080000
20593009                 0.125   voidf   300090000
20593010                 0.125   voidf   300100000
20593011                 0.125   voidf   300110000
20593012                 0.125   voidf   300120000
20593013                 0.125   voidf   300130000
20593014                 0.125   voidf   300140000
20593015                 0.125   voidf   300150000
20593016                 0.125   voidf   300160000
20593017                 0.125   voidf   300170000
20593018                 0.125   voidf   300180000
20593019                 0.125   voidf   300190000
20593020                 0.13    voidf   300200000
*
*
*       Core Annulus water level
*
20593500     annlslvl    sum     1.0     2.505         1
20593501     0.0         0.125   voidf   350020000
20593502                 0.125   voidf   350030000
20593503                 0.125   voidf   350040000
20593504                 0.125   voidf   350050000
20593505                 0.125   voidf   350060000
20593506                 0.125   voidf   350070000
20593507                 0.125   voidf   350080000
20593508                 0.125   voidf   350090000
20593509                 0.125   voidf   350100000
20593510                 0.125   voidf   350110000
20593511                 0.125   voidf   350120000
20593512                 0.125   voidf   350130000
20593513                 0.125   voidf   350140000
20593514                 0.125   voidf   350150000
20593515                 0.125   voidf   350160000
20593516                 0.125   voidf   350170000
20593517                 0.125   voidf   350180000
20593518                 0.125   voidf   350190000
20593519                 0.125   voidf   350200000
20593520                 0.125   voidf   350210000
*
```

```
*       Upper Plenum water level
*
20594900     up-lvl      sum     1.0     8.08         1
20594901     0.0         0.751   voidf   490020000
20594902                 0.751   voidf   490030000
20594903                 0.751   voidf   490040000
20594904                 0.751   voidf   490050000
20594905                 0.751   voidf   490060000
20594906                 0.751   voidf   490070000
20594907                 0.751   voidf   490080000
20594908                 0.751   voidf   490090000
20594909                 0.751   voidf   490100000
20594910                 0.751   voidf   490110000
20594911                 0.580   voidf   490120000
*
*       Lower Downcomer water level
*
20591500     lwdc-lvl    sum     1.0     8.134        1
20591501     0.0         0.534   voidf   150010000
20591502                 0.158   voidf   150020000
20591503                 0.750   voidf   150030000
20591504                 0.750   voidf   150040000
20591505                 0.750   voidf   150050000
20591506                 0.750   voidf   150060000
20591507                 0.750   voidf   150070000
20591508                 0.500   voidf   150080000
20591509                 0.442   voidf   150090000
20591510                 0.750   voidf   150100000
20591511                 0.750   voidf   150110000
20591512                 0.716   voidf   150120000
20591513                 0.534   voidf   150130000
*
*
*       Lower Downcomer water level - absolute
*
20591600     lwdc-lva    sum     1.0     0.0          1
20591601     -5.925      1.000   cntrlvar      915
*
*       Upper Downcomer water level
*
20591000     updc-lvl    sum      1.0     1.84        1
20591001     0.0         0.267    voidf   100010000
20591002                 0.267    voidf   100020000
20591003                 0.267    voidf   100030000
20591004                 0.267    voidf   100040000
20591005                 0.267    voidf   100050000
20591006                 0.238    voidf   100060000
20591007                 0.1335   voidf   100070000
20591008                 0.097729 voidf   100080000
20591009                 0.035771 voidf   100090000
*
*
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*     HEAT LOSS CALCULATIONS                  *
*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
*
*       Upper Downcomer heat loss
*
```

```
20510000     udc-heat    sum        1.0     0.0         1
20510001     0.0         0.0746537  htrnr   100000101
20510002                 0.0746537  htrnr   100000201
20510003                 0.0746537  htrnr   100000301
20510004                 0.0746537  htrnr   100000401
20510005                 0.0746537  htrnr   100000501
20510006                 0.0665452  htrnr   100000601
20510007                 0.038641   htrnr   100000701
20510008                 0.038641   htrnr   100000801
20510009                 0.038641   htrnr   100000901
*
*       Lower Downcomer heat loss
*
20515000     ldc-heat    sum        1.0     0.0         1
20515001     0.0         0.09786    htrnr   101000101
20515002                 0.20299    htrnr   150000101
20515003                 0.060061   htrnr   150000201
20515004                 0.28510    htrnr   150000301
20515005                 0.28510    htrnr   150000401
20515006                 0.28510    htrnr   150000501
20515007                 0.28510    htrnr   150000601
20515008                 0.28510    htrnr   150000701
20515009                 0.19007    htrnr   150000801

20515010                 0.16802    htrnr   150000901
20515011                 0.28510    htrnr   150001001
20515012                 0.28510    htrnr   150001101
20515013                 0.27218    htrnr   150001201
20515014                 0.20299    htrnr   150001301
20515015                 0.082467   htrnr   151000101
*
*
*       Lower Pipeline Section A heat loss
*
20590000     lpa-heat    sum        1.0     0.0         1
20590001     0.0         0.20028   htrnr   900000101
20590002                 0.14971   htrnr   900000201
20590003                 0.18850   htrnr   900000301
20590004                 0.18850   htrnr   900000401
20590005                 0.11673   htrnr   900000501
20590006                 0.16729   htrnr   900000601
20590007                 0.16729   htrnr   900000701
20590008                 0.16729   htrnr   900000801
20590009                 0.11673   htrnr   900000901
20590010                 0.18850   htrnr   900001001
20590011                 0.18850   htrnr   900001101
*
*
*       Lower Pipeline Section B heat loss
*
20594000     lpb-heat    sum        1.0     0.0         1
20594001     0.0         0.057177   htrnr   940000101
20594002                 0.057177   htrnr   940000201
20594003                 0.057177   htrnr   940000301
20594004                 0.057177   htrnr   940000401
20594005                 0.057177   htrnr   940000501
20594006                 0.057177   htrnr   940000601
20594007                 0.057177   htrnr   940000701
```

```
20594008                0.057177   htrnr   940000801
20594009                0.057177   htrnr   940000901
20594010                0.057177   htrnr   940001001
*
*
*
*       Lower Pipeline Section C heat loss
*
20596000     lpc-heat    sum        1.0     0.0         1
20596001     0.0         0.14137   htrnr   960000101
20596002                 0.14137   htrnr   960000201
20596003                 0.11673   htrnr   960000301
20596004                 0.16729   htrnr   960000401
20596005                 0.16729   htrnr   960000501
20596006                 0.16729   htrnr   960000601
20596007                 0.11673   htrnr   960000701
20596008                 0.16376   htrnr   960000801
20596009                 0.16376   htrnr   960000901
20596010                 0.16376   htrnr   960001001
20596011                 0.16376   htrnr   960001101
20596012                 0.16376   htrnr   960001201
20596013                 0.16376   htrnr   960001301
20596014                 0.16376   htrnr   960001401
20596015                 0.16376   htrnr   960001501
*
*
*       Lower Plenum heat loss
*
20520000     lpl-heat    sum       1.0     0.0         1
20520001     0.0         0.18143   htrnr   200000101
20520002                 0.18143   htrnr   200000201
20520003                 0.17671   htrnr   200000301
20520004                 0.17671   htrnr   200000401
*
*       Core Simulator Cylinder heat loss
*
20535000     corcylht    sum       1.0     0.0         1
20535001     0.0         0.086     htrnr   350000201
20535002                 0.086     htrnr   350000301
20535003                 0.086     htrnr   350000401
20535004                 0.086     htrnr   350000501
20535005                 0.086     htrnr   350000601
20535006                 0.086     htrnr   350000701
20535007                 0.086     htrnr   350000801
20535008                 0.086     htrnr   350000901
20535009                 0.086     htrnr   350001001
20535010                 0.086     htrnr   350001101
20535011                 0.086     htrnr   350001201
20535012                 0.086     htrnr   350001301
20535013                 0.086     htrnr   350001401
20535014                 0.086     htrnr   350001501
20535015                 0.086     htrnr   350001601
20535016                 0.086     htrnr   350001701
20535017                 0.086     htrnr   350001801
20535018                 0.086     htrnr   350001901
20535019                 0.086     htrnr   350002001
20535020                 0.08944   htrnr   350002101
*
```

```
*       Core Simulator Inlet/Outlet heat loss
*
20535100     corendht    sum       1.0     0.0         1
20535101     0.0         0.11687   htrnr   220000101
20535102                 0.10688   htrnr   250000101
20535103                 0.13195   htrnr   250000201
20535104                 0.09896   htrnr   250000301
20535105                 0.1385    htrnr   250100101
*20535126                 0.13327   htrnr   420000101
*20535127                 0.13850   htrnr   420100101
20535128                 0.13195   htrnr   450000101
20535139                 0.065973  htrnr   450000101
20535110                 0.01376   htrnr   350000101
20535111                 0.11687   htrnr   480000101
*
*       Total Core Simulator heat loss
*
20535900     core-ht     sum       1.0       0.0         1
20535901     0.0         1.0       cntrlvar  350
20535902                 1.0       cntrlvar  351
*
*
*       Upper Plenum heat loss
*
20549000     upl-heat    sum       1.0     0.0         1
20549001     0.0         0.16361   htrnr   490000101
20549002                 0.26896   htrnr   490100101
20549003                 0.26896   htrnr   490100201
20549004                 0.26896   htrnr   490100301
20549005                 0.26896   htrnr   490100401
20549006                 0.26896   htrnr   490100501
20549007                 0.26896   htrnr   490100601
20549008                 0.26896   htrnr   490100701
20549009                 0.26896   htrnr   490100801
20549010                 0.26896   htrnr   490100901
20549011                 0.26896   htrnr   490101001
20549012                 0.20772   htrnr   490101101
*
*
*       Hot Leg heat loss
*
20550000     hl-heat    sum       1.0     0.0         1
20550001     0.0         0.11781   htrnr   500000101
20550002                 0.092528  htrnr   500000201
20550003                 0.14908   htrnr   500000301
20550004                 0.18143   htrnr   500000401
20550005                 0.18143   htrnr   500000501
20550006                 0.18143   htrnr   500000601
20550007                 0.18143   htrnr   500000701
20550008                 0.18143   htrnr   500000801
20550009                 0.18143   htrnr   500000901
20550010                 0.18143   htrnr   500001001
20550011                 0.18143   htrnr   500001101
20550012                 0.11781   htrnr   501000101
*
*
*       SG heat loss (htrnr)
*
```

```
20560000     sg-heat     sum        1.0     0.0         1
20560001     0.0         0.11781    htrnr   600000101
20560002                 0.11015    htrnr   600000201
20560003                 0.015315   htrnr   601000101
20560004                 0.11015    htrnr   700000101
20560005                 0.11781    htrnr   700000201
*
*
*       SG heat loss (q)
*
20570000     sg-heat     sum        1.0     0.0         1
20570001     0.0         1.0        q       600010000
20570002                 1.0        q       600020000
20570003                 1.0        q       601010000
20570004                 1.0        q       700010000
20570005                 1.0        q       700020000
*
*
*       Steam Release Pipe heat loss
*
20565000     stm-heat    sum        1.0     0.0         1
20565001     0.0         0.47124    htrnr   650000101
20565002                 0.47124    htrnr   650000201
20565003                 0.47124    htrnr   650000301
20565004                 0.47124    htrnr   650000401
20565005                 0.47124    htrnr   650000501
20565006                 0.47124    htrnr   650000601
20565007                 0.47124    htrnr   650000701
20565008                 0.47124    htrnr   650000801
*
*
*       Upper Cold Leg heat loss
*
20580000     ucl-heat    sum        1.0     0.0         1
20580001     0.0         0.18506    htrnr   701000101
20580002                 0.15197    htrnr   800000101
20580003                 0.15197    htrnr   800000201
20580004                 0.15197    htrnr   800000301
20580005                 0.15197    htrnr   800000401
20580006                 0.15197    htrnr   800000501
20580007                 0.15197    htrnr   800000601
20580008                 0.15197    htrnr   800000701
20580009                 0.15197    htrnr   800000801
20580010                 0.15197    htrnr   800000901
20580011                 0.15197    htrnr   800001001
*
*       Lower Cold Leg heat loss
*
20585000     lcl-heat    sum        1.0     0.0         1
20585001     0.0         0.20772    htrnr   850000101
20585002                 0.15197    htrnr   850000201
20585003                 0.15197    htrnr   850000301
20585004                 0.15197    htrnr   850000401
20585005                 0.15197    htrnr   850000501
20585006                 0.15197    htrnr   850000601
20585007                 0.15197    htrnr   850000701
20585008                 0.15197    htrnr   850000801
20585009                 0.15197    htrnr   850000901
```

```
*
*
*       TOTAL LOOP heat loss
*
20500100     tot-hlos    sum        1.0        0.0         1

20500101     0.0         1.0        cntrlvar   100
20500102                 1.0        cntrlvar   150
20500103                 1.0        cntrlvar   900
20500104                 1.0        cntrlvar   940
20500105                 1.0        cntrlvar   960
20500106                 1.0        cntrlvar   200
20500107                 1.0        cntrlvar   359
20500108                 1.0        cntrlvar   490
20500109                 1.0        cntrlvar   500
20500110                 1.0        cntrlvar   600
20500111                 1.0        cntrlvar   650
20500112                 1.0        cntrlvar   800
20500113                 1.0        cntrlvar   850
*
*
*       TOTAL Core heat source
*
20500200     corepwr     sum        1.0        0.0         1
20500201     0.0         0.06715    htrnr      300000101
20500202                 0.06715    htrnr      300000201
20500203                 0.06715    htrnr      300000301
20500204                 0.06715    htrnr      300000401
20500205                 0.06715    htrnr      300000501
20500206                 0.06715    htrnr      300000601
20500207                 0.06715    htrnr      300000701
20500208                 0.06715    htrnr      300000801
20500209                 0.06715    htrnr      300000901
20500210                 0.06715    htrnr      300001001
20500211                 0.06715    htrnr      300001101
20500212                 0.06715    htrnr      300001201
20500213                 0.06715    htrnr      300001301
20500214                 0.06715    htrnr      300001401
20500215                 0.06715    htrnr      300001501
20500216                 0.06715    htrnr      300001601
20500217                 0.06715    htrnr      300001701
20500218                 0.06715    htrnr      300001801
20500219                 0.06715    htrnr      300001901
20500220                 0.0698376  htrnr      300002001
*
*
*       NET heat input
*
20500300     net-heat    sum         1.0        0.0         1
20500301     0.0         1.0         cntrlvar   2
20500302                 -1.0        cntrlvar   1
*
*
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++*
*      Core Steam Generation Rates           *
*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++*
*
*       Core Steam Generation rate (kg/s)
```

```
*
20500400     core-sg1    sum         1.0         0.0         1
20500401     0.0         0.0002258   vapgen      300010000
20500402                 0.0002258   vapgen      300020000
20500403                 0.0002258   vapgen      300030000
20500404                 0.0002258   vapgen      300040000
20500405                 0.0002258   vapgen      300050000
20500406                 0.0002258   vapgen      300060000
20500407                 0.0002258   vapgen      300070000
20500408                 0.0002258   vapgen      300080000
20500409                 0.0002258   vapgen      300090000
20500410                 0.0002258   vapgen      300100000
20500411                 0.0002258   vapgen      300110000
20500412                 0.0002258   vapgen      300120000
20500413                 0.0002258   vapgen      300130000
20500414                 0.0002258   vapgen      300140000
20500415                 0.0002258   vapgen      300150000
20500416                 0.0002258   vapgen      300160000
20500417                 0.0002258   vapgen      300170000
20500418                 0.0002258   vapgen      300180000
20500419                 0.0002258   vapgen      300190000
20500420                 0.0002348   vapgen      300200000
*
*
*       Core Steam Generation rate (kg/s)   (volume method)
*
20500500     core-sg2    sum         1.0         0.0         1
20500501     0.0         0.0002258   gammai      300010000
20500502                 0.0002258   gammai      300020000
20500503                 0.0002258   gammai      300030000
20500504                 0.0002258   gammai      300040000
20500505                 0.0002258   gammai      300050000
20500506                 0.0002258   gammai      300060000
20500507                 0.0002258   gammai      300070000
20500508                 0.0002258   gammai      300080000
20500509                 0.0002258   gammai      300090000
20500510                 0.0002258   gammai      300100000
20500511                 0.0002258   gammai      300110000
20500512                 0.0002258   gammai      300120000
20500513                 0.0002258   gammai      300130000
20500514                 0.0002258   gammai      300140000
20500515                 0.0002258   gammai      300150000
20500516                 0.0002258   gammai      300160000
20500517                 0.0002258   gammai      300170000
20500518                 0.0002258   gammai      300180000
20500519                 0.0002258   gammai      300190000
20500520                 0.0002348   gammai      300200000
*
*
*       Core Steam Generation rate (kg/s)   (volume method)
*
20501400     core-sg3    sum         1.0         0.0         1
20501401     0.0         0.0002258   gammaw      300010000
20501402                 0.0002258   gammaw      300020000
20501403                 0.0002258   gammaw      300030000
20501404                 0.0002258   gammaw      300040000
20501405                 0.0002258   gammaw      300050000
20501406                 0.0002258   gammaw      300060000
```

```
20501407                 0.0002258   gammaw      300070000
20501408                 0.0002258   gammaw      300080000
20501409                 0.0002258   gammaw      300090000
20501410                 0.0002258   gammaw      300100000
20501411                 0.0002258   gammaw      300110000
20501412                 0.0002258   gammaw      300120000
20501413                 0.0002258   gammaw      300130000
20501414                 0.0002258   gammaw      300140000
20501415                 0.0002258   gammaw      300150000
20501416                 0.0002258   gammaw      300160000
20501417                 0.0002258   gammaw      300170000
20501418                 0.0002258   gammaw      300180000
20501419                 0.0002258   gammaw      300190000
20501420                 0.0002348   gammaw      300200000
*
*
*
*       Annulus Steam Generation rate (kg/s)   (volume method)
*
20501500     annul-sg    sum         1.0         0.0         1
20501501     0.0         0.002804    gammaw      350020000
20501502                 0.002804    gammaw      350030000
20501503                 0.002804    gammaw      350040000
20501504                 0.002804    gammaw      350050000
20501505                 0.002804    gammaw      350060000
20501506                 0.002804    gammaw      350070000
20501507                 0.002804    gammaw      350080000
20501508                 0.002804    gammaw      350090000
20501519                 0.002804    gammaw      350100000
20501510                 0.002804    gammaw      350110000
20501511                 0.002804    gammaw      350120000
20501512                 0.002804    gammaw      350130000
20501513                 0.002804    gammaw      350140000
20501514                 0.002804    gammaw      350150000
20501515                 0.002804    gammaw      350160000
20501516                 0.002804    gammaw      350170000
20501517                 0.002804    gammaw      350180000
20501518                 0.002804    gammaw      350190000
20501519                 0.002804    gammaw      350200000
20501520                 0.002916    gammaw      350210000
*
*
*       TOTAL Core Simulator Heat Generation rate (kg/s)
*
20501600     tot-sg    sum         1.0        0.0         1
20501601     0.0         1.0       cntrlvar   14
20501602                 1.0       cntrlvar   15
20501603                 0.000449  gammaw     350010000
*
*
*
**+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*
*       Steam Condensation Rates                              *
*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*
*
*       Core Condensation rate (kg/s)
*
20502100     corecond    sum         1.0         0.0         1
```

```
20502101     0.0         0.0002258   gammac      300010000
20502102                 0.0002258   gammac      300020000
20502103                 0.0002258   gammac      300030000
20502104                 0.0002258   gammac      300040000
20502105                 0.0002258   gammac      300050000
20502106                 0.0002258   gammac      300060000
20502107                 0.0002258   gammac      300070000
20502108                 0.0002258   gammac      300080000
20502109                 0.0002258   gammac      300090000
20502110                 0.0002258   gammac      300100000
20502111                 0.0002258   gammac      300110000
20502112                 0.0002258   gammac      300120000
20502113                 0.0002258   gammac      300130000
20502114                 0.0002258   gammac      300140000
20502115                 0.0002258   gammac      300150000
20502116                 0.0002258   gammac      300160000
20502117                 0.0002258   gammac      300170000
20502118                 0.0002258   gammac      300180000
20502119                 0.0002258   gammac      300190000
20502120                 0.0002348   gammac      300200000
*
*
*       Core Annulus Condensation rate (kg/s)
*
20502200     ann-cond    sum         1.0         0.0         1
20502201     0.0         0.002804   gammac      350020000
20502202                 0.002804   gammac      350030000
20502203                 0.002804   gammac      350040000
20502204                 0.002804   gammac      350050000
20502205                 0.002804   gammac      350060000
20502206                 0.002804   gammac      350070000
20502207                 0.002804   gammac      350080000
20502208                 0.002804   gammac      350090000
20502219                 0.002804   gammac      350100000
20502210                 0.002804   gammac      350110000
20502211                 0.002804   gammac      350120000
20502212                 0.002804   gammac      350130000
20502213                 0.002804   gammac      350140000
20502214                 0.002804   gammac      350150000
20502215                 0.002804   gammac      350160000
20502216                 0.002804   gammac      350170000
20502217                 0.002804   gammac      350180000
20502218                 0.002804   gammac      350190000
20502219                 0.002804   gammac      350200000
20502220                 0.002916   gammac      350210000
*
*
*       Upper Plenum Condensation rate (kg/s)
*
20502300     upl-cond    sum        1.0         0.0         1
20502301     0.0         0.000079   gammac      400010000
20502302                 0.000481   gammac      400020000
*20502303                 0.005449   gammac      420010000
20502304                 0.006566   gammac      450010000
20502305                 0.003283   gammac      450020000
20502306                 0.002356   gammac      480010000
20502307                 0.006137   gammac      490010000
20502308                 0.006137   gammac      490020000
```

```
20502309                0.006137   gammac      490030000
20502310                0.006137   gammac      490040000
20502311                0.006137   gammac      490050000
20502312                0.006137   gammac      490060000
20502313                0.006137   gammac      490070000
20502314                0.006137   gammac      490080000
20502315                0.006137   gammac      490090000
20502316                0.006137   gammac      490100000
20502317                0.006137   gammac      490110000
20502318                0.006137   gammac      490120000
*
*
*       Hot Leg Condensation rate (kg/s)
*
20502400     ann-cond    sum         1.0         0.0         1
20502401     0.0         0.001659   gammac      500010000
20502402                 0.001303   gammac      500020000
20502403                 0.002099   gammac      500030000
20502404                 0.002555   gammac      500040000
20502405                 0.002555   gammac      500050000
20502406                 0.002555   gammac      500060000
20502407                 0.002555   gammac      500070000
20502408                 0.002555   gammac      500080000
20502409                 0.002555   gammac      500090000
20502410                 0.002555   gammac      500100000
20502411                 0.002555   gammac      500110000
*
*
*       SG Condensation rate (kg/s)
*
20502500     sg-cond    sum         1.0         0.0         1
20502501     0.0         0.0026062   gammac      501010000
20502502                 0.0016592   gammac      600010000
20502503                 0.0015513   gammac      600020000
20502504                 0.00021569  gammac      601010000
20502505                 0.0015513   gammac      700010000
20502506                 0.0016592   gammac      700020000
20502507                 0.0026062   gammac      701010000
*
*
*       Stm Release Pipe Condensation rate (kg/s)
*
20502600     sr-cond     sum         1.0         0.0         1
20502601     0.0         0.006637    gammac      650010000
20502602                 0.006637    gammac      650020000
20502603                 0.006637    gammac      650030000
20502604                 0.006637    gammac      650040000
20502605                 0.006637    gammac      650050000
20502606                 0.006637    gammac      650060000
20502607                 0.006637    gammac      650070000
20502608                 0.006637    gammac      650080000
*
*
20502700     ucl-cond    sum         1.0         0.0         1
20502701     0.0         0.002140   gammac      800010000
20502702                 0.002140   gammac      800020000
20502703                 0.002140   gammac      800030000
20502704                 0.002140   gammac      800040000
```

```
20502705                0.002140   gammac      800050000
20502706                0.002140   gammac      800060000
20502707                0.002140   gammac      800070000
20502708                0.002140   gammac      800080000
20502709                0.002140   gammac      800090000
20502710                0.002140   gammac      800100000
*
*
*
20502800     lcl-cond    sum        1.0         0.0         1
20502801     0.0         0.004182   gammac      850010000
20502802                 0.004607   gammac      850020000
20502803                 0.002611   gammac      850030000
20502804                 0.002611   gammac      850040000
20502805                 0.006763   gammac      850050000
20502806                 0.006763   gammac      850060000
20502807                 0.006763   gammac      850070000
20502808                 0.006763   gammac      850080000
20502809                 0.006763   gammac      850090000
*
*
*       Upper DC Condensation rate (kg/s)
*
20502900     udc-cond    sum         1.0         0.0         1
20502901     0.0         0.0011174   gammac      100010000
20502902                 0.0011174   gammac      100020000
20502903                 0.0011174   gammac      100030000
20502904                 0.0011174   gammac      100040000
20502905                 0.0011174   gammac      100050000
20502906                 0.00099693  gammac      100060000
20502907                 0.0005784   gammac      100070000
20502908                 0.0005784   gammac      100080000
20502909                 0.0005784   gammac      100090000
*
*       Lower DC Condensation rate (kg/s)
*
20503000     ldc-cond    sum         1.0         0.0         1
20503001     0.0         0.0011174   gammac      150010000
20503002                 0.0011174   gammac      150020000
20503003                 0.0011174   gammac      150030000
20503004                 0.0011174   gammac      150040000
20503005                 0.0011174   gammac      150050000
20503006                 0.00099693  gammac      150060000
20503007                 0.0005784   gammac      150070000
20503008                 0.0005784   gammac      150080000
20503009                 0.0005784   gammac      150090000
*
*       Integrated Loop Condensation rate (kg/s)
*
20503100     tot-cond    sum         1.0         0.0         1
20503101     0.0         1.0         cntrlvar    21
20503102                 1.0         cntrlvar    22
20503103                 1.0         cntrlvar    23
20503104                 1.0         cntrlvar    24
20503105                 1.0         cntrlvar    25
20503106                 1.0         cntrlvar    26
20503107                 1.0         cntrlvar    27
20503108                 1.0         cntrlvar    28
```

```
20503109                1.0         cntrlvar    29
20503110                1.0         cntrlvar    30
20503111                0.000449    gammac      350010000
*
*
*
*-------------------------------------------------------
*
*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*
*      Pressures                                                      *
*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*+*
*
*       Core pressure drop
*
20500600     core-dp     sum         1.0         0.0         1
20500601     0.0         1.0         p           280050000
20500602                 -1.0        p           400010000
*
*
*       Pout

20500700     p-out       sum         1.0         0.0         1
20500701     0.0         1.0e-5      p           480010000
*
*
*       DL2-4
*
20500800     updc-dp     sum         1.0         0.0         1
20500801     0.0         1.0         p           150020000
20500802                 -1.0        p           850010000
*
*       DL4-14
*
20500900     ldc-dp      sum         1.0         0.0         1
20500901     0.0         1.0         p           150090000
20500902                 -1.0        p           150020000
*
*
*       DL13-12
*
20501000     uppln-dp    sum         1.0         0.0         1
20501001     0.0         1.0         p           490010000
20501002                 -1.0        p           490120000
*
*
*
.   * endcard
```

Appendix C

Peer Review of Input File

C.1 Input File Review

Review of RELAP5/MOD3.2 Input file for "RELAP5/MOD3.2 Analysis of INSC Standard Problem INSCSP-V4: Investigation of Heat Transfer for Partly Uncovered VVER-1000 Core at the Test Facility KS (RRC KI)"

R. T. Jensen ANL

I have reviewed the RELAP5 input file and the model nodalization contained in the subject report and have only minor comments and questions.

1. What is the reason or justification for setting the volume flag "p" to one for all or nearly all hydraulic volumes? This turns off the "water packing" option.

2. Components 280-01, 400-07, and 450-03 are dead ended volumes. This is contrary to INEL recommendations.

3. The from volume for single junction component 401 should specify face 3 or 4 instead of face 1.

4. The heat loss multiplier in general tables 101, 102, 103, 104, and 105 is 2.8 vs. 2.6 in the definition report.

I don't think any of these would change the analyses results.

C.2 Response to Input File Review Questions

A. M. Tentner ANL
J. W. Ahrens ANL

This memo responds to the questions about the *RELAP5/MOD3.2 Input file for* "RELAP5/MOD3.2 Analysis of INSC Standard Problem INSCSP-V4: Investigation of Heat Transfer for Partly Uncovered VVER-1000 Core at the Test Facility KS (RRC KI)" in the Input File Review presented in Appendix C.1.

1. What is the reason or justification for setting the volume flag "p" to one for all or nearly all hydraulic volumes? This turns off the "water packing" option.

A1 The volume flag "p" has been set to one for a number of hydraulic volumes to verify that no packing effect is present. No such effect was expected and none was observed.

2. Components 280-01, 400-07, and 450-03 are dead ended volumes. This is contrary to INEL recommendations.

A2 The volumes mentioned are indeed dead-end volumes and were modeled as such.

3. The from volume for single junction component 401 should specify face 3 or 4 instead of face 1.

A3 The from volume for single junction component 401 specifies face 2, not 1. This is consistent with the core exit nodalization used in the calculations, which is in Fig. 5-25, p.39. The single junction 401 connects the top face of volume 4, component 400 with the left face of volume 1, component 450. The impact of the core exit nodalization on results is discussed in Section 5.2.4.

4. The heat loss multiplier in general tables 101, 102, 103, 104, and 105 is 2.8 vs. 2.6 in the definition report.

A4 The heat loss multiplier used in our calculations was 2.8. This value was selected for our model because it provides optimal agreement between the calculated and measured pressures at the FA outlet, as discussed in Section 5.1.2, p. 23, and illustrated in Fig. 5-3. The value 2.6 mentioned in the definition report was based on the RMINSC model.