APT BLANKET SYSTEM LOSS-OF-COOLANT (LOCA) ANALYSIS BASED ON INITIAL CONCEPTUAL DESIGN -

Case 2: External HR Break at Pump Outlet with Pump Trip

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APT Blanket System Loss-of-Coolant Analysis Based on Initial Conceptual Design - Case 2: External HR Break HR Break at Pump Outlet with Pump Trip

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APT BLANKET SYSTEM LOSS-OF-COOLANT ACCIDENT (LOCA) BASED ON INITIAL CONCEPTUAL DESIGN -

Case 2: External HR Break at Pump Outlet with Pump Trip

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1 Introduction

This report is one of a series of reports that document normal operation and accident simulations for the Accelerator Production of Tritium (APT) blanket heat removal (HR) system, [1-7]. These simulations were performed for the Preliminary Safety Analysis Report. The results of simulations of a large break LOCA in the primary heat removal system piping, between the pump discharges and the heat exchanger inlets, are herein documented. The accident simulations were performed, using TRAC to model transient behavior of the heat removal system, and FLOWTRAN-TF, a computer code developed at the Savannah River Technology Center, to model detailed transient behavior in a blanket module.

2 TRAC 1-D System Model

The TRAC model of the blanket heat removal system is described in detail in Ref. [8]. It is an integrated one-dimensional system model that contains all major components, systems, and heat structures necessary to simulate transient system behavior for a wide range of accident conditions. Ref. [3] also contains background information about modeling philosophy used in the development of this model. Table 2-1 summarizes module description, thermal deposited power, and connection pipe size of each of the 6 blanket modules as modeled in the one-dimensional lumped approach.

2.1 Scenario Description

A large break LOCA external to the cavity is a design basis accident. The residual heat removal (RHR) system must be able to mitigate the accident and maintain adequate coolant flow to the blanket modules. The mitigation systems are designed with sufficient redundancy that the worst single failure does not disable the entire system. For the RHR system, this means that one of two loops can still function.

The break location, for Case 2, is in the section of 16 inch pipe between the pump discharge combining Tee and the heat exchanger inlet dividing Tee, as shown in Fig. 2.1-1. This is a 3.6 m long straight section of pipe through which all of the primary HR flow passes. A double-ended guillotine break (DEGB) is assumed. Following the break occurrence, the system will rapidly depressurize. Power to the beam and the HR pumps will be cut, and the RHR pump will be started and reach full speed in about 15 seconds.

2.2 Model Upgrades

Component action tables for the break component and check valves are updated for the Case 2 accident simulation. Component action tables for HR and RHR check valves are based on S-shaped forcing function values [8]. Constrained steady-state (CSS) capabilities are added to the TRAC normal operation system model. Signal variables and trip signals of the system model are also updated by using the control procedure for the Case 2 accident scenario described in Ref. [8].

2.3 Initial Conditions

The initial conditions for this TRAC simulation are steady-state normal operating (NO) conditions, described in Ref. [1]. Table A-2 lists the NO values of key parameters.

2.4 Transient Boundary Conditions

To initiate the LOCA, the steady-state TRAC run was restarted in transient mode with a one-cell PIPE component (component 37) replaced with two BREAK components (pressure boundary conditions) to produce a 200% double guillotine break. Figure A-1 is a TRAC component layout of the HR loop external to the cavity vessel, and PIPE component 37 is shaded to indicate that it occupies a potential break location. The TRAC layout in Fig. A-1 is modified by connecting PIPE components 36 and 38 to BREAK components, with junctions J37 and J38. This location for an external break was chosen because it is the location in the HR loop with the highest NO pressure, through which all of the HR flow passes.

The BREAK components were set to ramp from the steady-state pre-incident pressure to atmospheric pressure in 0.1 seconds. In addition to adding the BREAK components to the TRAC system model, the pressurizer boundary condition was changed from a BREAK (constant pressure boundary condition) to a zero FILL (no flow) boundary. The pressure control system for the pressurizer will be designed to preclude attempts to adjust the pressure during a severe transient, and the no flow boundary condition is consistent with this constraint.

2.5 Trips and Controls

The power to the HR pumps and the beam is tripped 0.2 seconds after the pressure in the pressurizer surge line drops 5% from the NO value of 0.72363 MPa (105 psia) to 0.68745 MPa (99.7 psia). The elapsed time for the pressurizer surge line pressure to reach this set point is about 0.1 seconds. The delay time between reaching a setpoint and tripping the beam is dominated by the response time of the transducers. A comparison with similar transducers in reactor systems put this response time at about 0.1 seconds. The delay time chosen for simulations was obtained by doubling the estimated response time for the transducers, to produce what is believed to be a conservative value. The beam trip is simulated by changing the steady-state power in the heated structures to a time dependent power decay curve. Figure 2.5-1 shows this decay curve. The RHR pump is activated, without delay, when the pressurizer surge line pressure drops 5%. The RHR pump is modeled to attain full speed (94.35 rad/sec) within 15 seconds after the accident, by using the component action table with S-shaped forcing function values [8]. Check valves on the discharge sides of the HR and RHR pumps are actuated to avoid flow reversal immediately after the initiation of the LOCA accident. If flow reversal occurs during accident conditions, HR and RHR check valves are set to be closed immediately. Table 2.5-1 lists all of the trip signals and controls used for this accident simulation.

2.6 TRAC Version

This transient model was run using TRAC-PF1/MOD2 version 5.4.28a [14]. A modified version of TRAC to generate graphics files was employed [9]. Light water properties

were used. The TRAC Case 2 LOCA model input file is listed in Appendix C, and the graphics input file is listed in Appendix D.

Table 2-1 6 lumped blanket module system model used for the present PSAR analysis.

6 Lumped Modules	Prototypic 16 Full Blanket Modules	Thermal Deposited Power Downflow / Upflow / Total Power	Pipe Size (inch)
Module 1	Front 1 st Lateral Dec. / Row 1 Module Back 1 st Lateral Dec. / Row 1 Module	8.222 MW / 15.768 MW / 23.990 MW	7.500
Module 2	Front 2 nd Lateral Row 2 / Row 3 Modules Back 2 nd Lateral Row 2 / Row 3 Modules	3.060 MW / 7.660 MW / 10.720 MW	4.750
Module 3	1 st Downstream Dec. / Row 1 Module	0.744 MW / 2.812 MW / 3.556 MW	3.750
Module 4	2 nd Downstream Row 1 / Row 2 Module	3.924 MW / 5.412 MW / 9.336 MW	5.375
Module 5	3 rd Downstream Row 2 / Row 2 Module	1.355 MW / 1.811 MW / 3.167 MW	6.000
Module 6	Low Power Modules Blanket Upstream Dec. / Row 2 Module Lower Front Dec. / Row 2 Module Lower Front Row 2 / Row 2 Module Lower Back Dec. / Row 2 Module Lower Back Row 2 / Row 2 Module Upper Front Row 2 / Row 2 Module Upper Back Row 2 / Row 2 Module	(Horizontal Flow) 0 MW / 5.712 MW / 5.712 MW	3.875
Total Deposited Power		17.305 MW / 39.175 MW / 56.480 MW	

Table 2.5-1 Trip signals used in the LOCA simulation of Case 2.

Trip Signal ID	Control Component	Signal Variables ID Number (Control Variable)	Signal Values
101	Fill boundary for secondary heat exchanger side	1 (time)	1.0e-06 sec
102	Cavity flood system valve	10 (cavity vessel pressure)	valve closed
103	RHR check valve	1 (time)	1.0e-06 sec
104	Heat structure	7 (pressurizer pressure) and time delay	0.2 sec delay after 5% reduction of pressurizer surge line pressure
105	RHR pump	7 (pressurizer pressure) and time	full speed in 15 sec. after 5% reduction of pressurizer surge line pressure
106	Primary HR pump	7 (pressurizer pressure) and time delay	0.2 sec delay after 5% reduction of pressurizer surge line pressure
107	Primary HR check valve	1 (time) and action table (S-shaped forcing function)	1.0e-06 sec
108	Cavity vessel check valve	1 (time)	valve closed
109	Cavity vessel check valve on the HR side	1 (time)	valve closed
110	Cavity vessel vent valve	7 (pressurizer pressure)	valve closed

Figure 2.1-1 Schematic of the section of the HR loop between the pumps and heat exchangers, showing the break location.

Figure 2.5-1 Decay heat power fractions of full power for various types of blanket modules.

3 TRAC Results

The TRAC system model, simulating a large break LOCA in the HR system between the pumps and heat exchangers, was run for a 600 second transient. The results are presented both graphically and in tabular form. Figures A-1 through A-6 show TRAC model component layouts of the several sub-systems associated with the blanket heat removal system. Table A-1 lists the component type, the number of cells in each

component, and briefly describes each component in the TRAC model. These figures and the table are used to interpret the graphical results. The figures in Appendix B show transient results of the TRAC simulation. The figures in Appendix B are divided into three groups: results for the plenum components (Figs. B-1a through B-7d), results for the pipe, valve, and pump components (Figs. B-8a through B-30e), and results for the heat structure components (Figs. B-31 through B-49b). The legend for each figure lists the component and cell numbers for the results shown. The component numbers are the TRAC system model component numbers that are shown in the component layout figures.

The simulation results show that the pressurizer and a single RHR system can mitigate this design basis accident without any damage to the blanket module system and structure. During the accident the liquid in the pressurizer was not drained completely so that gas inside the pressurizer is not entrained into the heat removal system loop. The temperature of the coolant water flowing through the blanket modules does not reach saturation, consequently there is no boiling. Transient phenomena in the key blanket component systems are described in detail in the following subsections.

3.1 Modules

Figure A-1 is the TRAC component layout for the six modules and the associated piping network below the two fixed headers. Figures B-1a through B-1d show respectively the pressures, temperatures, liquid subcooling temperatures, and void fractions for the two plenum components 380 and 340, that respectively represent the fixed inlet and outlet headers. There is a rapid depressurization of both headers after initiation of the accident sequence, and a transient response ensues for approximately 100 seconds. Thereafter the pressures remain constant at approximately 18 and 19 psia respectively for the inlet and outlet headers. The inlet header has a higher elevation than the outlet header, and the hydrostatic pressure difference accounts for the -1.0 psid pressure drop between the headers and across the modules. The irreversible pressure drop is very small. For the initial 40 seconds of the transient, the outlet header pressure drops below 10 psia. The outlet header temperature drops approximately by 12 C to 46 C during the initial 60 seconds, and thereafter it decreases slowly for the duration of the simulation. After 600 seconds, the temperature is approximately 42 C.

Figures B-2a through B-2d show respectively the pressures, temperatures, liquid subcooling temperatures, and void fractions for the three plenum components that represent the inlet (comp. 370), middle (comp. 350), and outlet (comp. 370) plenums for module #1. The transient pressure profiles are similar to those of the fixed headers. The module outlet plenum pressure drops below 20 psia during the initial 40 second transient. The outlet plenum fluid temperature drops quickly during the first minute, and thereafter drops very slowly. After 600 seconds, the temperature rise in the flow across module #1 is approximately 1 C. Except for module #5, the rest of the module plenums exhibit similar behavior, with lower outlet plenum temperatures. The parameters for the module #5 plenums are shown in Figs. B-6a through B-6d. The outlet plenum temperature for module #5 is approximately 46 C after 600 seconds, compared with 43 C for module #1. While this temperature is higher than that in module #1, it is decreasing at a greater rate.

Figures B-18a through B-18e show pressures, fluid temperatures, subcooling temperatures, mass flowrates, and void fractions in the first, middle, and last cells of the

upflow region of module #1 (comp. 300). The pressures and temperatures are very similar to those of the module plenums. The mass flowrate through the module drops very quickly from a pre-incident value of 545 kg/s to approximately 230 kg/s, and is close to constant for approximately 40 seconds. In the next 40 seconds, the flowrate drops to approximately 25 kg/s and holds constant for the duration of the simulation. The mass flowrates through the rest of the modules behave in a similar fashion.

Figures B-26 through B-31 show the maximum metal temperatures, in the bottom and top cells, of the heat structures associated with the upflow regions of the six lumped modules. Figures B-32 through B-37 show the heat structure surface temperatures at the same cell locations. After 600 seconds, all temperatures are less than 50 C, and are decreasing or are constant.

3.2 HR Loop and Pressurizer

Figure A-4 is the TRAC component layout for the section of the primary heat removal loop that is between the fixed headers and external to the cavity vessel, and Fig. A-6 is the component layout for the pressurizer and the surge line.

Figures B-8a through B-8e show pressures, fluid temperatures, subcooling temperatures, mass flowrates, and void fractions in several locations in the HR piping between the outlet header and the dividing Tee that splits the flow for the two pumps. The pressure transient in the hot-leg HR piping is similar to that in the fixed outlet header. The pressure in cell 7 of component 22 drops very quickly to approximately 2.0 psia, and remains essentially constant for 40 seconds. This is a high point in the system, and the -5.0 psid pressure difference between this cell and the outlet header is hydrostatic. The temperature drops slower than the pressure, and there is some voiding during the initial 15 seconds of the transient. Figure B-8b shows that the temperature drop in component 26, which is down-stream, lags that of component 22. There is a positive streamwise axial temperature gradient in the hot-leg piping. The mass flowrate drops from 600 kg/s to essentially zero between 40 and 80 seconds, and the liquid in the pipe thereafter remains stagnant. The axial temperature gradient that is present at 40 seconds is thereafter fixed as the flow becomes stagnant.

Figures B-9a through B-9e show the flow variables on the suction and discharge sides of pump 1, and Figs. B-10a through B-10e show the flow variables on the suction and discharge sides of pump 2. The behaviors of both pumps are qualitatively similar. The pump suction pressures drop quickly to approximately 2 psia, and remain there for almost 40 seconds. During this period, both pumps cavitate, and the flowrates are approximately 280 and 350 kg/s respectively for pumps 1 and 2. Cavitation ceases between 35 and 40 seconds, and thereafter the pumps spin down and the flowrate drops to zero over the next 40 seconds.

Figures B-11a through B-11e show the flow variables down-stream of the check valves. The pipe between the pump discharges and the break all has the same elevation. Once the pump flowrate drops to zero, the fluid in this section of pipe drains out through the break.

Figures B-12a through B-12e show the flow variables at the heat exchanger inlets. When the break occurs, the flow reverses, and the fluid drains out of the heat exchanger inlet piping in approximately 20 seconds. The pipe refills due to reverse flow from the fixed inlet header, at approximately 130 seconds. Figures B-13a through B-

14e show the flow variables in the heat exchanger outlets and the cold-leg piping of the HR system. This piping is lower than the break, so it does not drain. The flow in the cold-leg reverses at about 60 seconds, and drops to -200 kg/s at 80 seconds. Thereafter the flow slowly increases to approximately -30 kg/s at the end of the simulation.

Figures B-15a through B-15e show pressures, fluid temperatures, subcooling temperatures, mass flowrates, and void fractions in the bottom cell of the pressurizer and in the surge line, close to the inlet header. The pressurizer flow into the fixed inlet header goes to 280 kg/s very quickly, and then drops slowly to approximately 30 kg/s at the end of the simulation. This flow maintains the inlet header pressure at approximately 19 psia, after the initial 100 second transient.

3.3 RHR Loop

Figure A-5 is the TRAC component layout for the residual heat removal system. This pipe network goes from the fixed outlet header to the fixed inlet header, in parallel with the part of the primary HR system that is external to the cavity. The RHR pump starts when the beam is tripped, and takes 15 seconds to reach full speed. Figures B-16a through B-16e show the values of the flow variables on both the suction and discharge sides of the RHR pump. The check valve opens and flow commences approximately 10 seconds after the initiation of the accident. The mass flowrate increases, over the next 60 seconds, to 62 kg/s, approximately 4% of normal HR flow. Figures B-17a through B-17e show the flow variables on the inlet and exit sides of the heat exchanger. After the initial 40 seconds of the simulation, the temperatures decrease monotonically, and at 600 seconds, the temperature drop across the heat exchanger is 0.6 C.

3.4 Cavity Vessel and Flood System

The cavity vessel flood system and heat transfer connections between blanket modules and the cavity vessel are shown in Figs. A-2 and A-3, respectively. The cavity vessel flood system is not activated for external LOCA's, and this part of the TRAC system model does not influence the results of this simulation.

4 FLOWTRAN-TF Detailed Bin Model

The basic FLOWTRAN-TF model is described in Refs. [10,13] and was used in this version for the LOCA Case 2 analysis. The FLOWTRAN-TF model was developed to simulate the thermal-hydraulic conditions in a lateral Row 1 blanket module using the reference 1 plate-type design [15]. The areal mesh of the bin model is shown in Figure 4-1 along with the location and indexing used for the 12 discrete flow channels.

4.1 Model Upgrades

No modifications to the original model were required to for the LOCA Case 2 analysis.

4.2 Initial Conditions

Initial conditions for all of the flow transients are the normal operating conditions reported in Ref. [1]. The TRAC supplied initial conditions used in the FLOWTRAN-TF calculations are listed in Table 4.2-1.

4.3 Transient Boundary Conditions

Results from the TRAC external large-break LOCA transient were used to supply boundary conditions to the FLOWTRAN-TF code for detailed calculations of the thermal-hydraulic behavior of a single row-1 blanket plate. The TRAC transient results used in these calculations were:

1. Total coolant flow to the lateral row-1 blanket module taken from TRAC PIPE component 454.
2. Inlet cooling water temperature, pressure and void fraction taken from TRAC PLENUM component 350. The calculations used inlet flow as an applied boundary condition and inlet pressure was used only for physical property evaluations.
3. Outlet pressure taken from TRAC PLENUM component 330.

Inlet conditions derived from the TRAC system analysis are shown in Fig. 4.3-1 where the boundary conditions are plotted as transient values relative to the pre-incident conditions. The pre-incident flow to a single blanket plate is taken to be 1.488 kg/s. Since void fraction naturally falls between zero and one, absolute values of void fraction are plotted in the figure. For LOCA Case 2, no void fraction appears at the inlet to the coolant flow channels during the transient.

Table 4.2-1 Initial conditions for FLOWTRAN-TF LOCA analysis.

	Pressure (MPa)	Temperature (C)	Void
Channel Inlet	0.686	53.04	0
Channel Outlet	0.584

Figure 4-1 Finite element mesh of APT reference 1 blanket plate.

Figure 4.3-1 Inlet boundary conditions for LOCA Case 2

5 FLOWTRAN-TF Bin Model Results

A listing of the input deck used for the FLOWTRAN-TF calculations of LOCA Case 2 is given in Appendix E. Some results from the FLOWTRAN-TF calculations are shown in Fig. 5-1 where the maximum aluminum temperature found anywhere in the plate cladding is plotted as a function of time into the loss-of-coolant accident transient. The initial maximum temperature of 100.0 C is indicated on the ordinate since it is difficult to see the sudden temperature decrease that occurs within the first few seconds on the transients. Initially, the maximum aluminum temperature occurs on the side of the plate nearest the decoupler region and closest to the point of beam impact. It is assumed that the power is tripped 1.0 second after the start of the accident and that the pre-incident power is the nominal value 61.5 kW.

It is clear from the metal temperatures shown in Fig. 5-1 that surface temperatures in the flow channels following beam trip are not close to local boiling conditions. To further illustrate the safety margins, operating surface heat fluxes (q_{ohf}) were compared to the heat fluxes predicted for onset of nucleate boiling (q_{onb}), onset of significant void formation (q_{osv}) and the critical heat flux (q_{CHF}). Since each of the 12 flow channels has 20 axial cells and at each axial level the surface is composed of from 8 to 17 surface nodes there are many (2760) surface heat fluxes at any time in the calculation. To reduce the number of data points, we have taken the approach of reporting the maximum heat flux at each axial position within each channel irrespective of the particular surface node where the maximum occurs. Further we can restrict the

examination to the location of the peak axial heat fluxes. The axial power shape for the blanket module is shown in Fig. 5-2 along with the 20 cells that were used to discretize the axial dimension for the safety calculations. Highest operating surface heat fluxes were observed to occur in axial cells 10 through 15.

To show some representative results, the operating surface heat flux and the calculated limits for Case 2 are shown in Figs. 5-3 through 5-5 for all of the flow channels at axial level 11. Channels 1 and 5 are the rectangular flow channels nearest the decoupler side of the plate while channel 8 is the first annular flow channel on that side. This side of the plate absorbs the largest fraction of the deposited power but has a larger fraction of the coolant flow. Channels 4 and 7 are the rectangular flow channels nearest the cavity side of the plate where deposited power and coolant flow are lowest.

Results from other axial locations on the plate surface are similar demonstrating a substantial margin between the surface heat flux and the potentially limiting values. The closest approach of the operating heat flux to the limiting values typically occurs in flow channels 1 or 8 between 0 and 2 seconds into the transients. Near the top of the plate, the surface heat flux can even reverse as energy flows from the heated water back into the cooler metal. This condition was observed in the annular flow channels and in some of the low power rectangular channels.

Figure 5-1 Maximum aluminum temperature for LOCA Case 2.

Figure 5-2 Blanket axial power shape.

Figure 5-3 Surface heat fluxes for LOCA Case 2, axial level 11, channels 1-4.

Figure 5-4 Surface heat fluxes for LOCA Case 2, axial level 11, channels 5-8.

Figure 5-5 Surface heat fluxes for LOCA Case 2, axial level 11, channels 9-12.

6 Conclusions

6.1 Comparison to Thermal/Hydraulic Design Criteria

Simulations performed using the TRAC system model and the FLOWTRAN-TF detailed bin model show that the APT blanket modules maintain a coolable geometry during the LOCA Case 2 scenario. The thermal/hydraulic (T/H) design criteria, along with the basis for their development, is discussed in Refs. [11-12]. For LOCA the T/H onset criteria are based on meeting very strict phenomenological limits with a high degree of confidence, as follows:

- for local heated surfaces within the module components, the onset-of-significant-voids [OSV] at a three sigma confidence level; and
- for the remaining unheated piping sections of the blanket system, the onset-of-bulk-boiling [OBB] at a three sigma confidence level.

Additional (steady-state derived) material design criteria are imposed on the maximum lead and aluminum (Series 6061 - Type T6) metal temperatures acceptable for the module components. The limiting values for these parameters are 327.5 C and 115 C for lead and aluminum, respectively. These material design criteria ensure that a coolable geometry can be maintained throughout the expected lifetime of each module unit.

On a module-by-module basis, the above steady-state material and thermal onset criteria for LOCA are compared to the FLOWTRAN-TF detailed bin model results. The bin model results for the reference 1 plate-type module are tabulated in Table 6.1-1 (note that only module 1 results are currently available since the design specifications for modules 2 through 6 do not presently exist). However, module 1 should be close to the most limiting module. Additional thermal onset criteria, which are typically considered, are also provided in Table 6.1-1. Note that these are generally more stringent than the imposed design criteria chosen.

The definitions of the criteria ratios in Table 6.1-1 are listed below, as follows:

$$R_{SUB} = \max \left(\frac{T_f - T_{in}}{T_{sat} - T_{in}} \right), \text{ liquid subcooling}$$

$$R_{SUP} = \max \left(\frac{T_w - T_{in}}{T_{sat} - T_{in}} \right), \text{ wall superheating}$$

$$R_{ONB} = \max \left(\frac{q''_{OHF}}{q''_{ONB}} \right), \text{ ONB heat flux}$$

$$R_{OSV} = \max\left(\frac{q''_{OHF}}{q''_{OSV}}\right), \text{ OSV heat flux}$$

$$R_{CHF} = \max\left(\frac{q''_{OHF}}{q''_{CHF}}\right), \text{ CHF heat flux}$$

where:

- q''_{OHF} operating heat flux
- q''_{ONB} heat flux at onset of subcooled nucleate boiling
- q''_{OSV} heat flux at onset of significant void formation
- q''_{CHF} critical heat flux
- T_f fluid temperature
- T_{in} fluid temperature at inlet to flow channels, (53.05 C)
- T_{sat} local fluid saturation temperature
- T_w wall temperature

To evaluate these criteria, the maximum value corresponds to its limit spatially, as well as over the time period of the event sequence. The ratio of OHF-to-CHF is sometimes referred to as the departure from nucleate boiling ratio [DNBR]. Predicted thermal onset ratios should not exceed unity.

Confidence bounds are required to establish the acceptable level of probability of exceeding these criteria. The results presented in Table 6.1-1 represent primarily best estimate values (however, some parameters were set to their estimated upper bounds, such as power density). Quantification of overall uncertainties and then their corresponding confidence levels (i.e., operating and modeling uncertainties) have not yet been performed. Future efforts to perform a response surface analysis are planned. At that time quantification of safety margins will be determined.

The peak blanket metal temperature occurs in module #1, and it is 112.8 C, as predicted by the FLOWTRAN-TF model. This occurs in the lead plate, and it is well below the lead melting point, 327.5 C. The peak aluminum temperature also occurs in module #1, and it is 100 C, below the long term temperature limit of 115 C. Since the power decay is steeper than the flow decay the reported maximum metal temperatures are essentially the pre-incident values. Actually, maximum temperatures are reached 1 second after the start of the accident when the beam trips. However, the thermal inertia of the solid is such that this brief time delay is negligible.

6.2 Design Issues

The TRAC system model predicts a peak lead temperature in module #1 of 152 C and the detailed FLOWTRAN-TF bin model predicts a peak lead temperature of 112.8 C. The cruciform design was used in the TRAC system model, and the plate design was used in the FLOWTRAN-TF model. This points out the need for consistency between the two models. The TRAC model will be upgraded in order to provide this consistency.

6.3 Predicted Impact

Blanket conditions during LOCA Case 2 fall within all specified thermal/hydraulic design criteria. No off-site impact to people or the environment would occur as a result of LOCA Case 2. The only on-site consequence would result from the release of contaminated cooling water.

Table 6.1-1 FLOWTRAN-TF model results under LOCA Case 2 conditions.

Module #	Max Pb Temp (C)	Max AI Temp (C)	Max Subcooling Ratio	Max Superheat Ratio	Max ONB Ratio	Max OSV Ratio	Max CHR Ratio
1	112.8	100.0	0.317	0.547	0.296	0.083	0.304
2	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3	TBD	TBD	TBD	TBD	TBD	TBD	TBD
4	TBD	TBD	TBD	TBD	TBD	TBD	TBD
5	TBD	TBD	TBD	TBD	TBD	TBD	TBD
6	TBD	TBD	TBD	TBD	TBD	TBD	TBD

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Appendix A: TRAC Model Component Nomenclature

Table A-1 Blanket System Component Descriptions in TRAC Model.

System	Component Type	Comp #	No of Cells	Descriptions
HR	Fixed Header (FH)	380	1	coolant Supply FH
		340	1	coolant Return FH
	Pressurizer (Pzr)	760	1	Pzr surge line 1 connected to Supply FH 380
		761	2	Pzr surge line 2
		762	1	Pzr surge line 3
		763	1	Pzr surge line 4
		764	1	Pzr surge line 5
		765	13	Pzr surge line 6
		766	9	primary Pzr
	Hot Leg Loop	20	1	pipe connected to Return FH340
		21	1	plenum for potential break loc.
		22	7	pipe connection to external loop
		23	1	pipe connect. for potential break
		24	13	connection pipe
		25	1	connection pipe
		26	2	pipe connected to two pumps
		27	1	plenum for two pump connection
		28	2	pump#1 suction pipe
		29	7	pump#2 suction pipe
		30	2	pump located at cell face 2
		31	2	pump located at cell face 2
		32	3	check valve located at pump#1 discharge
		33	3	check valve located at pump#2 discharge
		34	1	pump outlet plenum
		36	1	connect. pipe between pump and pipe
		37	1	HX connect. pipe for potential break
		38	1	pipe connect. to two HX's inlet plenum
		40	1	plenum
	HX	48	3	HX #1 inlet pipe
		50	4	HX #1 1 st pass
		52	3	HX #1 middle header
		54	4	HX #1 2 nd pass
		49	3	HX #2 inlet pipe
		51	4	HX #2 1 st pass
		53	3	HX #2 middle header
		55	4	HX #2 2 nd pass
		710	1	HX #1 secondary side fill
		711	4	HX #1 2 nd pass secondary side
		712	3	HX #1 middle header secondary side
		713	4	HX #1 1 st pass secondary side
		714	1	HX #1 secondary side break BC
		730	1	HX #2 secondary side fill BC

Table A-1 Blanket System Component Descriptions in TRAC Model (continued).

System	Component Type	Comp #	No of Cells	Descriptions
		731	4	HX #2 2 nd pass secondary side
		732	3	HX #2 middle header secondary side
		733	4	HX #2 1 st pass secondary side
		734	1	HX #2 secondary side break BC
HR	Cold Leg Loop	56	3	HX #1 outlet pipe
		57	6	HX #2 outlet pipe
		60	3	HX outlet plenum merged after two HX's
		62	1	cold leg pipe
		63	1	cold leg pipe
		64	13	cold leg pipe located outside cavity wall
		65	1	pipe for cold leg pipe break
		66	1	horizontal cold leg pipe penetration
		67	1	plenum for internal break on HR loop
		854	2	HR isolation valve for internal break
		69	1	plenum for internal LOCA simulation
		68	5	pipe connect. to FH 340 inside cavity
Cavity Vessel	Cold Leg Loop	850	2	valve located bet. cavity vessel and HR
		852	2	valve located bet. cavity vessel and HR
			1	plenum for cavity vessel connection
		828	3	cavity vent valve
		802	1	break component for cavity vent pressure BC
		823	11	pipe for cavity lower section simulation
		824	1	plenum for cavity connection
		840	2	valve to connect cavity line to Module 1
		825	4	pipe for cavity middle section simulation
Cavity Pool	Cavity Flood Line	820	13	pipe for cavity pool connection to cavity vessel
		821	2	cavity flood line valve
		822	1	flood line pipe inside cavity vessel
	Cavity Flood Pool	801	1	break component for cavity pool BC
		810	10	pipe for top cavity pool section
		811	1	plenum for middle cavity pool section
		812	7	pipe for lower cavity pool section
		813	1	plenum for cavity pool bottom
RHR	RHR Loop	621	1	pipe located to return FH
		623	10	pipe located inside the cavity vessel
		624	1	pipe located outside the cavity vessel
		625	18	pipe bet. RHR pump and pipe comp. #624
		630	2	RHR pump located at face 2
		640	3	check valve located at pump discharge
		652	4	HX tubes
		660	16	pipe at the cold leg side
		661	1	pipe located before cavity vessel
		662	8	cold leg pipe inside cavity vessel

Table A-1 Blanket System Component Descriptions in TRAC Model (continued).

System	Component Type	Comp #	No of Cells	Descriptions
		663	1	cold leg pipe connected to supply FH
		672	1	fill for HX secondary side BC
		671	4	HX secondary shell side
		673	1	break comp. for HX secondary side BC
Module	Module 1 Flow	454	7	pipe connected to supply FH
		80	1	plenum for potential internal break simulation at Module 1
		375	5	pipe connection bet. Supply FH and Module 1 upper plenum
		370	1	upper plenum for Module 1 downcomer
		360	5	Module 1 downflow region
		350	1	middle plenum bet. Module 1 downflow and upflow regions
		300	5	Module 1 upflow region
		330	1	upper plenum for module 1 upflow region
		335	5	connection pipe after Module 1 upper plenum
		429	4	pipe connected to return FH
	Module 2 Flow	173	7	pipe connected to supply FH
		81	1	plenum for potential internal break simulation at Module 2
		82	3	pipe connection
		172	1	upper plenum for Module 2 downcomer
		158	6	Module 2 downflow region
		147	1	middle plenum bet. Module 2 downflow and upflow regions
		102	6	Module 2 upflow region
		133	1	upper plenum for module 2 upflow region
		136	7	pipe connected to return FH
	Module 3 Flow	415	7	pipe connected to supply FH
		85	1	plenum for potential internal break simulation at Module 3
		86	3	pipe connection
		479	1	upper plenum for Module 3 downcomer
		478	5	Module 3 downflow region
		418	1	middle plenum bet. Module 3 downflow and upflow regions
		409	5	Module 3 upflow region
		423	1	upper plenum for module 3 upflow region
		417	7	pipe connected to return FH
	Module 4 Flow	485	7	pipe connected to supply FH
		87	1	plenum for potential internal break simulation at Module 4
		88	3	pipe connection
		489	1	upper plenum for Module 4 downcomer

Table A-1 Blanket System Component Descriptions in TRAC Model (continued).

System	Component Type	Comp #	No of Cells	Descriptions
		480	6	Module 4 downflow region
		419	1	middle plenum bet. Module 4 downflow and upflow regions
		412	6	Module 4 upflow region
		483	1	upper plenum for module 4 upflow region
		484	7	pipe connected to return FH
Module	Module 5 Flow	513	7	pipe connected to supply FH
		89	1	plenum for potential internal break simulation at Module 5
		90	3	pipe connection
		510	1	upper plenum for Module 5 downcomer
		507	6	Module 5 downflow region
		503	1	middle plenum bet. Module 4 downflow and upflow regions
		500	6	Module 5 upflow region
		508	1	upper plenum for Module 5 upflow region
		511	7	pipe connected to return FH
	Module 6 Flow	541	7	pipe connected to supply FH
		83	1	plenum for potential internal break simulation at Module 6
		84	1	pipe connection
		538	1	upper plenum for Module 6 decoupler
		535	5	Module 6 downcomer region
		531	1	middle plenum bet. Module 6 decoupler and main heated regions
		528	5	Module 6 main heated region
		536	1	upper plenum for module 6 main heated region
		539	12	pipe connected to return FH
	Module 1 Heater Structure	901	5	Al tube structure in Row 1
		951	5	Lead zone with Al cladding in Row 1
		984	5	Al tube structure in decoupler
	Module 2 Heater Structure	905	6	Al tube structure in Row 2
		955	6	Lead zone with Al cladding in Row 2
		916	6	Al tube structure in Row 3
		966	6	Lead zone with Al cladding in Row 3
	Module 3 Heater Structure	911	5	Al tube structure in Row 1
		961	5	Lead zone with Al cladding in Row 1
		988	5	Al tube structure in decoupler
	Module 4 Heater Structure	912	6	Al tube structure in Row 1
		962	6	Lead zone with Al cladding in Row 1
		931	6	Al tube structure in Row 2

Table A-1 Blanket System Component Descriptions in TRAC Model (continued).

System	Component Type	Comp #	No of Cells	Descriptions
		978	6	Lead zone with Al cladding in Row 2
	Module 5 Heater Structure	913	6	Al tube structure in Row 2
		963	6	Lead zone with Al cladding in Row 2
		932	6	Al tube structure in Row 2
		979	6	Lead zone with Al cladding in Row 2
	Module 6 Heater Structure	915	5	Al tube structure in Row 2
		965	5	Lead zone with Al cladding in Row 2

Table A-2 Steady State Conditions.

Parameter	Units	Calculated Values
Total power deposited in blanket modules	MW	56.5
Total flow rate	kg/sec gpm	1569 25252
Pressure in cold-leg fixed header	MPa psia	0.7325 106.24
Pressure in hot-leg fixed header	MPa psia	0.4563 66.180
Pressurizer (cell #1) pressure	MPa psia	0.7311 106.03
Pump #1 suction pressure	MPa psia	0.2751 39.90
Pump #1 discharge pressure	MPa psia	1.0356 150.20
Pump #2 suction pressure	MPa psia	0.2958 42.91
Pump #2 discharge pressure	MPa psia	1.0409 150.97
Temperature in cold-leg fixed header	C F	49.43 121.0
Temperature in hot-leg fixed header	C F	58.03 136.5
Max. fluid temperature of the hottest module	C F	71.95 161.5

Figure A-1 6 blanket module layout for safety analysis.

Figure A-2 TRAC component layout for the cavity vessel and blanket module heat structures.

Figure A-4 TRAC component layout for blanket primary HR coolant loop.

Figure A-5 TRAC component layout for blanket primary RHR coolant loop.

Figure A-6 TRAC component layout for blanket primary pressurizer and surge line.

WESTINGHOUSE SAVANNAH RIVER COMPANY

Report: WSRC-TR-98-0060

Section: Appendix A

BLANKET SAFETY ANALYSES FOR LOCA

Date: 07/13/98

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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Appendix B: LOCA (Case 2) TRAC Results

Appendix B1 LOCA (Case 2) TRAC Plenum Component Figures

The following figures are from a TRAC simulation for Case 2 of a LOCA (external HR break at pump outlet with pump trip):

Figure B-1a Fixed header fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-1b Fixed header fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-1c Fixed header fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-1d Fixed header void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-2a Module 1 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-2b Module 1 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-2c Module 1 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-2d Module 1 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-3a Module 2 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-3b Module 2 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-3c Module 2 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-3d Module 2 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-4a Module 3 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-4b Module 3 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-4c Module 3 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-4d Module 3 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-5a Module 4 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-5b Module 4 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-5c Module 4 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-5d Module 4 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-6a Module 5 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-6b Module 5 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-6c Module 5 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-6d Module 5 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-7a Module 6 plenum fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-7b Module 6 plenum fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-7c Module 6 plenum fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-7d Module 6 plenum void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Appendix B2 LOCA (Case 2) TRAC Pipe, Pump, and Valve Component Figures

The following figures are from a TRAC simulation for Case 2 of a LOCA (external HR break at pump outlet with pump trip):

Figure B-8a Primary HR hot-leg piping fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-8b Primary HR hot-leg piping fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-8c Primary HR hot-leg piping fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-8d Primary HR hot-leg piping liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-8e Primary HR hot-leg piping void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-9a Primary HR pump 1 fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-9b Primary HR pump 1 fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-9c Primary HR pump 1 fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-9d Primary HR pump 1 liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-9e Primary HR pump 1 void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-10a Primary HR pump 2 fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-10b Primary HR pump 2 fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-10c Primary HR pump 2 fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-10d Primary HR pump 2 liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-10e Primary HR pump 2 void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-11a Primary HR pump discharge piping fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-11b Primary HR pump discharge piping fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-11c Primary HR pump discharge piping fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-11d Primary HR pump discharge piping liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-11e Primary HR pump discharge piping void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-12a Primary HR heat exchanger inlet piping fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-12b Primary HR heat exchanger inlet piping fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-12c Primary HR heat exchanger inlet piping fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-12d Primary HR heat exchanger inlet piping liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-12e Primary HR heat exchanger inlet piping void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-13a Primary HR heat exchanger outlet piping fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-13b Primary HR heat exchanger outlet piping fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-13c Primary HR heat exchanger outlet piping fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-13d Primary HR heat exchanger outlet piping liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-13e Primary HR heat exchanger outlet piping void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-14a Primary HR cold-leg piping fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-14b Primary HR cold-leg piping fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-14c Primary HR cold-leg piping fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-14d Primary HR cold-leg piping liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-14e Primary HR cold-leg piping void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-15a Primary HR pressurizer and surge line fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-15b Primary HR pressurizer and surge line fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-15c Primary HR pressurizer and surge line fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-15d Primary HR pressurizer and surge line liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-15e Primary HR pressurizer and surge line void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-16a Primary RHR pump fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-16b Primary RHR pump fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-16c Primary RHR pump fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-16d Primary RHR pump liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-16e Primary RHR pump void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-17a Primary RHR heat exchanger fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-17b Primary RHR heat exchanger fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-17c Primary RHR heat exchanger fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-17d Primary RHR heat exchanger liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-17e Primary RHR heat exchanger void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-18a Module 1 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-18b Module 1 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-18c Module 1 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-18d Module 1 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-8e Module 1 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-19a Module 2 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-19b Module 2 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-19c Module 2 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-19d Module 2 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-19e Module 2 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-20a Module 3 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-20b Module 3 channel Module 3 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-20c Module 3 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-20d Module 3 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-20e Module 3 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-21a Module 4 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-21b Module 4 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-21c Module 4 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-21d Module 4 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-21e Module 4 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-22a Module 5 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-22b Module 5 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-22c Module 5 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-22d Module 5 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-22e Module 5 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-23a Module 6 channel fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-23b Module 6 channel fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-23c Module 6 channel fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-23d Module 6 channel liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-23e Module 6 channel void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-24a Mid-plane module fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-24b Mid-plane module fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-24c Mid-plane module fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-24d Mid-plane module liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-24e Mid-plane module void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-25a Module inlet fluid pressures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-25b Module inlet fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-25c Module inlet fluid subcoolings for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-25d Module inlet liquid mass flowrates for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-25e Module inlet void fractions for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Appendix B3 LOCA (Case 2) TRAC Heat Structure Component Figures

The following figures are from a TRAC simulation for Case 2 of a LOCA (external HR break at pump outlet with pump trip)

Figure B-26 Module 1 upflow section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-27 Module 2 upflow section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-28 Module 3 upflow section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-29 Module 4 upflow section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-30 Module 5 upflow section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-31 Module 6 down-stream section bottom and top maximum lead metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-32 Module 1 upflow section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-33 Module 2 upflow section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-34 Module 3 upflow section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-35 Module 4 upflow section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-36 Module 5 upflow section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-37 Module 6 down-stream section bottom and top maximum aluminum metal temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-38 Module 1 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-39 Module 2 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-40 Module 3 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-41 Module 4 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-42 Module 5 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

Figure B-43 Module 6 upflow section top-plane surface and fluid temperatures for a LOCA (Case 2: external HR break between pump discharges and heat exchanger inlets; with HR pump trips).

WESTINGHOUSE SAVANNAH RIVER COMPANY

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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Appendix C: TRAC Standard Input File for LOCA Case 2 (with Beam Shutdown and Active RHR)

The file listed below represents the TRAC code "tracin" file that corresponds to the LOCA Case 2 (with beam shutdown and active RHR) for the blanket system. This input deck assumes that a TRAC restart file ("trcrst") exists based on normal operation (NO).

Input file tracin:

```

free format
*
*****
* main data *
*****
*
*          numtr          ieos          inopt          nmat          id2o
*          37             0             1             2             0
* APT Lumped Blanket Model-** LOCA Smulation for Comp 37 Break**
* 6 Module Lumped Model with Primary Coolant Loop and RHR Loop
* 6 Modules - Lateral(R1/Dec) Module, R2/R3 Module,
*             3 Backstop Modules, Low Power Module (12/18/1997)
* Hydraulic RHR Loop added as of 12/22/1997
* - This is based on check valve with flow reversal control logic.
* Number of material = 2 (Al and Pb)
* - This is single combined mod model without He comp (12/12/1997)
* - Aluminum, lead material table got from Ref. (3/5, 1997)
* - This is 1 module loop model without primary coolant and RHR loops
* - adding two upper modules (L14B-back / L14F-front) as of 7/18/1997.
* - Row2/3 power updated (4/23/1997).
* - R2/R3 axial power distribution has been updated
*   as of 4/25/1997.
* - Al and lead material properties updated already.
* - Unit cell cal. should be checked.
* - K-loss values for each comp and elevation levels need be checked.
* - Control signal variable was added (4/25/1997).
* - Module 5 6 7 8 connection to fixed header was updated (5/28/97).
* - Blanket primary loop pipe size (14 inch) was updated (5/28/1997).
* - Lower modules(module 15 16 17 18) were added/updated (5/29/1997).
* - Backstop 1st module was updated (5/29/1997).
* - Backstop 2nd and 3rd modules were updated (5/30/1997).
* - R2/R3 lateral modules were updated from 9 to 11 bins (6/3/1997).
* - Lateral module 1 to 4 decay powers were updated (6/23/1997).
* - Power for each module was updated from the 6/9/97 e-mail except
*   for snout and top modules (6/26/97).
* - Decay power fraction for each module was updated from the 6/9/97
*   e-mail except for snout and top modules (6/26/97).
* - Power for each module was updated from the 6/9/97 e-mail
*   for snout module (7/8/97).
* - Decay power fraction for each module was updated from the 6/9/97
*   e-mail for snout module (7/8/97).
* - Single loop to connect two front lateral modules was updated
*   (7/16/97).
* - Single loop to connect two back lateral modules was updated
*   (7/16/97).
*
*
*
*
*****
* namelist data *

```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

*

&inopts nrslv=1, nhtstr=25, iconht=0, iadded=10, ielv=1, ipowr=-1,
tpowr=10, igas=1, noair=0, nlt=12, ikfac=1, ithd=1, nsend=120000 &

*

dstep timet
-1 0.0000e+00

* stdyst	transi	ncomp	njun	ipak
0	1	141	120	1

* epso	epss
2.0000e-04	1.0000e-04

* oitmax	sitmax	isolut	ncontr	nccfl
50	50	0	2	0

* ntsv	ntcb	ntcf	ntrp	ntcp
7	0	0	7	1

*

* component-number data *

*

* iorder*

*

760	s	* pipe	pressurizer surge line1
761	s	* pipe	pressurizer surge line2
762	s	* pipe	pressurizer surge line3
763	s	* pipe	pressurizer surge line4
764	s	* pipe	pressurizer surge line5
765	s	* pipe	pressurizer surge line6
766	s	* pipe	primary pressurizer
767	s	* break	pressurizer boundary

*

* HR hot leg

20	s	* pipe	HR pump suction pipe
21	s	* plenum	HR pump suction pipe (bk)
22	s	* pipe	HR pump suction pipe
23	s	* pipe	HR pump suction pipe (bk)
24	s	* pipe	HR pump suction pipe
25	s	* pipe	HR pump suction pipe (bk)
26	s	* pipe	HR pump suction pipe

* HR pumps

27	s	* plenum	HR pump suction plenum
28	s	* pipe	HR pump #1 inlet pipe
30	s	* pump	HR pump #1
32	s	* pipe	HR pump #1 outlet pipe
29	s	* pipe	HR pump #2 inlet pipe
31	s	* pump	HR pump #2
33	s	* pipe	HR pump #2 outlet pipe
34	s	* plenum	HR pump discharge plenum

* HR pump-to-hx piping

36	s	* pipe	HR pump discharge pipe
----	---	--------	------------------------

* Component 37 is broken

515	s	* break	HX-1 sec. break
516	s	* break	HX-1 sec. break

*

38	s	* pipe	HR pump discharge pipe
----	---	--------	------------------------

* HR hx's

40	s	* plenum	HR hx inlet plenum
48	s	* pipe	HR hx 1 inlet pipe
50	s	* pipe	HR hx 1 tubes 1st pass
52	s	* pipe	HR hx 1 mid-header
54	s	* pipe	HR hx 1 tubes 2nd pass
56	s	* pipe	HR hx 1 outlet pipe

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

49	s	* pipe	HR hx 2 inlet pipe
51	s	* pipe	HR hx 2 tubes 1st pass
53	s	* pipe	HR hx 2 mid-header
55	s	* pipe	HR hx 2 tubes 2nd pass
57	s	* pipe	HR hx 2 outlet pipe
60	s	* plenum	HR hx outlet plenum
* HR cold leg			
62	s	* pipe	HR hx discharge pipe
63	s	* pipe	HR hx discharge pipe (bk)
64	s	* pipe	HR hx discharge pipe
*			
65	s	* pipe	HR hx discharge pipe
66	s	* pipe	HR hx discharge pipe
67	s	* plenum	HR hx discharge pipe (bk)
68	s	* pipe	HR hx discharge pipe
* HR hx Secondary Side			
710	s	* fill	HR hx Secondary Side-1
711	s	* pipe	HR hx Secondary Side-1
712	s	* pipe	HR hx Secondary Side-1
713	s	* pipe	HR hx Secondary Side-1
714	s	* break	HR hx Secondary Side-1
730	s	* fill	HR hx Secondary Side-2
731	s	* pipe	HR hx Secondary Side-2
732	s	* pipe	HR hx Secondary Side-2
733	s	* pipe	HR hx Secondary Side-2
734	s	* break	HR hx Secondary Side-2
*			
621	s	* pipe	RHR hot leg sect 1 (bk)
623	s	* pipe	RHR hot leg sect 2
624	s	* pipe	RHR hot leg sect 3 (bk)
625	s	* pipe	RHR hot leg sect 4
630	s	* pump	RHR primary pump
640	s	* valve	RHR pump discharge valve
652	s	* pipe	RHR primary heat exchanger tubes
660	s	* pipe	RHR cold leg sect 1
661	s	* pipe	RHR cold leg sect 2 (bk)
662	s	* pipe	RHR cold leg sect 3
663	s	* pipe	RHR cold leg sect 4 (bk)
* RHR hx Secondary Side			
672	s	* fill	RHR hx Secondary Side
671	s	* pipe	RHR hx Secondary Side
673	s	* break	RHR hx Secondary Side
*			
300	s	* pipe	L1 Blanket Row1
330	s	* plenum	L1 Blanket Row1 Plenum
335	s	* pipe	L1 pipe conn. 330 - 340
340	s	* plenum	L1 outlet header
350	s	* plenum	L1 lower plenum
360	s	* pipe	L1 decoupler
370	s	* plenum	L1 decoupler upper plenum
375	s	* pipe	L1 pipe conn. 370 - 380
380	s	* plenum	L1 inlet header
429	s	* pipe	L1 connect hot header-tee
454	s	* pipe	L1 connect cold header-tee
*			
173	s	* pipe	L1 Blanket Row1
172	s	* plenum	L1 Blanket Row1 Plenum
158	s	* pipe	L1 pipe conn. 330 - 340
147	s	* plenum	L1 outlet header
102	s	* pipe	L1 lower plenum
133	s	* plenum	L1 decoupler
136	s	* pipe	L1 decoupler upper plenum

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

*			
	541	s * pipe	L1 Blanket Row1
	538	s * plenum	L1 Blanket Row1 Plenum
	535	s * pipe	L1 pipe conn. 330 - 340
	531	s * plenum	L1 outlet header
	528	s * pipe	L1 lower plenum
	536	s * plenum	L1 decoupler
	539	s * pipe	L1 decoupler upper plenum
*			
	415	s * pipe	L1 Blanket Row1
	479	s * plenum	L1 Blanket Row1 Plenum
	478	s * pipe	L1 pipe conn. 330 - 340
	418	s * plenum	L1 outlet header
	409	s * pipe	L1 lower plenum
	423	s * plenum	L1 decoupler
	417	s * pipe	L1 decoupler upper plenum
*			
	485	s * pipe	2nd DNS Blanket Row1
	489	s * plenum	2nd DNS Blanket Row1 Plenum
	480	s * pipe	2nd DNS pipe conn. 330 - 340
	419	s * plenum	2nd DNS outlet header
	412	s * pipe	2nd DNS lower plenum
	483	s * plenum	2nd DNS decoupler
	484	s * pipe	2nd DNS dec upper plenum
*			
	513	s * pipe	Third DNS Blanket Row1
	510	s * plenum	Third DNS Row1 Plenum
	507	s * pipe	Third DNS pipe conn. 330-340
	503	s * plenum	Third DNS outlet header
	500	s * pipe	Third DNS lower plenum
	508	s * plenum	Third DNS decoupler
	511	s * pipe	Third DNS dec upper plenum
*			
	901	s * rod	annular aluminum rod
	951	s * rod	cylindrical lead rod
	984	s * rod	cylindrical lead rod
*			
	905	s * rod	annular aluminum rod
	955	s * rod	cylindrical lead rod
	916	s * rod	cylindrical lead rod
	966	s * rod	cylindrical lead rod
*			
	915	s * rod	annular aluminum rod
	965	s * rod	cylindrical lead rod
*			
	911	s * rod	annular aluminum rod
	961	s * rod	cylindrical lead rod
	988	s * rod	cylindrical lead rod
*			
	912	s * rod	annular aluminum rod
	962	s * rod	cylindrical lead rod
	931	s * rod	cylindrical lead rod
	978	s * rod	cylindrical lead rod
*			
	913	s * rod	annular aluminum rod
	963	s * rod	cylindrical lead rod
	932	s * rod	cylindrical lead rod
	979	s * rod	cylindrical lead rod
*			
	919	s * rod	annular ss rod
	920	s * rod	annular ss rod
	921	s * rod	annular ss rod

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

```

          922  s  * rod          annular ss rod
          971  e  * rod          annular ss rod
*
*****
* material-properties data *
*****
*
*
* matb *          51          52e
* ptbln *          2          6e
*
* lead material
*
* prptb(1,i) prptb(2,i) prptb(3,i) prptb(4,i) prptb(5,i)
* 2.7300e+02 1.1374e+04 1.2970e+02 3.4592e+01 2.8000e-01
* 1.0000e+10 1.1374e+04 8.9538e+02 3.3382e+01 2.8000e-01
e
*
* aluminum material
*
* prptb(1,i) prptb(2,i) prptb(3,i) prptb(4,i) prptb(5,i)
* 2.7300e+02 2.6990e+03 8.6985e+02 2.1046e+02 5.0000e-02
* 3.0000e+02 2.6990e+03 8.9000e+02 2.1046e+02 5.0000e-02
* 3.7300e+02 2.6990e+03 9.4140e+02 2.1046e+02 5.0000e-02
* 4.7300e+02 2.6990e+03 9.9538e+02 2.2175e+02 5.0000e-02
* 6.7300e+02 2.6990e+03 1.0900e+03 2.2845e+02 5.0000e-02
* 1.0000e+10 2.6990e+03 1.2000e+03 2.3000e+02 5.0000e-02
e
*
*****
*
* CSS data
*
*****
*
* control-parameter data *
*****
*
*****
* signal variables
*****
*
* time
* idsv isvn ilcn icn1 icn2
* 1 0 0 0 0
*
* pressure difference across RHR check valve
* idsv isvn ilcn icn1 icn2
* 2 -21 640 1 2
*
* Elapse time since RHR pump activated
* idsv isvn ilcn icn1 icn2
* 3 0 0 0 0
*
* Elapse time since HR pumps activated
* idsv isvn ilcn icn1 icn2
* 4 0 0 0 0
*
* pressure difference across HR check valve
* idsv isvn ilcn icn1 icn2
* 5 -21 32 1 2

```

BLANKET SAFETY ANALYSES FOR LOCA

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(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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```

*
* pressure difference across HR check valve
*      idsv      isvn      ilcn      icn1      icn2
*          6          -21          33          1          2
* pressure, cold leg at plenum, component 761
*      idsv      isvn      ilcn      icn1      icn2
*          7          21          761          1          1
*
*****
* control-block data *
*****
*
*****
* trips
*****
* trips from off to on at time given by setp(2), fill BC
*      ntse      ntct      ntsf      ntdp      ntsd
*          1          0          0          0          0
*      idtp      isrt      iset      itst      idsg
*         101          2          0          1          1
*      setp(1)    setp(2)
* 0.0000e+00    1.0000e-04
*      dtsp(1)    dtsp(2)
* 0.0000e+00    0.0000e+00
*      ifsp(1)    ifsp(2)
*          0          0
*
* trips from on to off at time given by setp(2)
*      idtp      isrt      iset      itst      idsg
*         102          1          1          1          1
*      setp(1)    setp(2)
* 0.0000e+00    1.0000e+04
*      dtsp(1)    dtsp(2)
* 0.0000e+00    0.0000e+00
*      ifsp(1)    ifsp(2)
*          0          0
*
* trips from off to on at time given by setp(2), trips RHR check valve
*      idtp      isrt      iset      itst      idsg
*         103          2          0          1          1
*      setp(1)    setp(2)
* 0.0000e+00    1.0000e-04
*      dtsp(1)    dtsp(2)
* 0.0000e+00    0.0000e+00
*      ifsp(1)    ifsp(2)
*          0          0
*
* trips from off to on when the cold leg 1 press. drops below setp(1)
* trips power in bundles, heat structures
*      idtp      isrt      iset      itst      idsg
*         104          1          0          1          7
*      setp(1)    setp(2)
* 6.8745e+05    6.8745e+05
*      dtsp(1)    dtsp(2)
* 2.0000e-01    2.0000e-01
*      ifsp(1)    ifsp(2)
*          0          0
*
* trips from off to on at setp(2), starts RHR pump.
*      idtp      isrt      iset      itst      idsg
*         105          1          0          1          7
*      setp(1)    setp(2)
* 6.8745e+05    6.8745e+05

```

Section: Appendix C

Date: 07/13/98

* component data *

```
*****      type              num              id              ctitle
break              516              516 $516$ break cold leg 2
*              jun1              ibty              isat              ioff
              38              1              0              0
*              ibtr              ibsv              nbtb              nbsv              nbrf
              101              1              -3              0              0
*              dxin              volin              alpin              tin              pin
              1.0000e+00              1.7936e-01              1.0000e+00              3.0000e+02              6.3543e+05
*              pain              concin              rbmx              poff              belv
              6.3543e+05              0.0000e+00              1.0000e+10              0.0000e+00              5.5560e+00
*              pscl              tlscl              tvscl              pascl              conscl
              1.0000e+00              1.0000e+00              1.0000e+00              1.0000e+00              1.0000e+00
*
* ptb *              0.0000e+00              6.35430e+05s
```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

```

* ptb * 1.0000e-01 1.01325e+05s
* ptb * 1.0000e+04 1.01325e+05e
*
*****
***** type num id ctitle
fill 767 767 $767$ pressurizer boundary
* jun1 ifty iooff
* 767 2 0
* twtold rfm concin felv
0.0000e+00 1.0000e+20 0.0000e+00 1.1100e+01
* dxin volin alpin vlin tlin
1.0000e+00 1.8639e-02 1.0000e+00 0.0000e+00 3.1315e+02
* pin pain flowin vvin tvin
6.6679e+05 6.6679e+05 0.0000e+00 0.0000e+00 3.1315e+02
*
*****
*
end
*
*****
* time-step data *
*****
*
* dtmin dtmax tend rtwfp
1.0000e-07 1.0000e-03 2.0000e-02 1.0000e+01
* edint gfint dmpint sedint
1.0000e-01 5.0000e+00 1.0000e+06 1.0000e+06
*
* dtmin dtmax tend rtwfp
1.0000e-07 5.0000e-03 1.0000e+01 1.0000e+01
* edint gfint dmpint sedint
5.0000e-01 5.0000e+00 1.0000e+06 1.0000e+06
*
* dtmin dtmax tend rtwfp
1.0000e-07 1.0000e-02 1.0000e+02 1.0000e+01
* edint gfint dmpint sedint
5.0000e+00 5.0000e+00 1.0000e+06 1.0000e+06
*
* dtmin dtmax tend rtwfp
1.0000e-07 5.0000e-02 2.0000e+02 1.0000e+01
* edint gfint dmpint sedint
10.0000e+00 5.0000e+00 1.0000e+06 1.0000e+06
*
* dtmin dtmax tend rtwfp
1.0000e-07 5.0000e-02 6.0000e+02 1.0000e+01
* edint gfint dmpint sedint
20.0000e+00 5.0000e+00 1.0000e+06 1.0000e+06
*
* endflag
-1.0000e+00

```


Appendix D: TRAC Graphics Input File for LOCA Case 2 (with Beam Shutdown and Active RHR)

The file listed below represents the TRAC code "graphin" file that corresponds to the LOCA Case 2 (with beam shutdown and active RHR) for the blanket system. This input deck contains the various graphics points selected for output to the "tecsum.grf" file.

Input file graphin:

```

/ npoints /
  95
/ component      cell      ictype      itee/
  340             1         1           1      Fixed outlet header
  380             1         1           1      Fixed inlet header

  454             2         0           1      Module 1 pipe
  173             2         0           1      Module 2 pipe
  415             2         0           1      Module 3 pipe
  485             2         0           1      Module 4 pipe
  513             2         0           1      Module 5 pipe
  541             2         0           1      Module 6 pipe

  300             1         0           1      Module 1 Row1
  102             1         0           1      Module 2 Row2
  409             1         0           1      Module 3 Row1
  412             1         0           1      Module 4 Row1
  500             1         0           1      Module 5 Row2
  528             1         0           1      Module 6 Low Power

  300             3         0           1      Module 1 Row1
  102             3         0           1      Module 2 Row2
  409             3         0           1      Module 3 Row1
  412             3         0           1      Module 4 Row1
  500             3         0           1      Module 5 Row2
  528             3         0           1      Module 6 Low Power

  300             5         0           1      Module 1 Row1
  102             6         0           1      Module 2 Row2
  409             5         0           1      Module 3 Row1
  412             6         0           1      Module 4 Row1
  500             6         0           1      Module 5 Row2
  528             5         0           1      Module 6 Low Power

  370             1         1           1      Module 1 Inlet Plenum
  350             1         1           1      Module 1 Middle Plenum
  330             1         1           1      Module 1 Outlet Plenum
  172             1         1           1      Module 2 Inlet Plenum
  147             1         1           1      Module 2 middle Plenum
  133             1         1           1      Module 2 Outlet Plenum
  479             1         1           1      Module 3 Inlet Plenum
  418             1         1           1      Module 3 Middle Plenum
  423             1         1           1      Module 3 Outlet Plenum
  489             1         1           1      Module 4 Inlet Plenum
  419             1         1           1      Module 4 Middle Plenum
  483             1         1           1      Module 4 Outlet Plenum
  510             1         1           1      Module 5 Inlet Plenum
  503             1         1           1      Module 5 Middle Plenum
  508             1         1           1      Module 5 Outlet Plenum
  538             1         1           1      Module 6 Inlet Plenum
  531             1         1           1      Module 6 Middle Plenum

```

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536	1	1	1	Module 6 Outlet Plenum
21	1	1	1	Plenum after hot leg FH
22	1	0	1	Pipe 22 near hot leg FH
22	7	0	1	Pipe 22 near hot leg FH
26	1	0	1	Hot leg pump suction line
28	1	0	1	Hot leg pump suction line
28	2	0	1	Hot leg pump suction line
29	1	0	1	Hot leg pump suction line
29	7	0	1	Hot leg pump suction line
30	1	0	1	PCL Pump 1 Suction
30	2	0	1	PCL Pump 1 Discharge
31	1	0	1	PCL Pump 2 Suction
31	2	0	1	PCL Pump 2 Discharge
32	2	0	1	PCL Pump 1 check valve
33	2	0	1	PCL Pump 2 check valve
48	2	0	1	PCL Hx 1 inlet
56	2	0	1	PCL Hx 1 outlet
49	2	0	1	PCL Hx 2 inlet
57	2	0	1	PCL Hx 2 outlet
62	1	0	1	Cold leg Hx discharge line
66	1	0	1	Cold leg Hx discharge line
625	16	0	1	Pipe 16 before RHR Pump Suct
630	1	0	1	RHR Pump Suction
630	2	0	1	RHR Pump Discharge
640	3	0	1	RHR Hx inlet
660	1	0	1	RHR Hx outlet
761	1	0	1	Pzr Pressure Signal
766	1	0	1	Pzr Bottom Pressure
951	1	3	1	Hot Module (1) upflow inside
951	5	3	1	Hot Module (1) upflow inside
951	1	3	2	Hot Module (1) upflow outside
951	5	3	2	Hot Module (1) upflow outside
955	1	3	1	Hot Module (2) upflow inside
955	6	3	1	Hot Module (2) upflow inside
955	1	3	2	Hot Module (2) upflow outside
955	6	3	2	Hot Module (2) upflow outside
961	1	3	1	Hot Module (3) upflow inside
961	5	3	1	Hot Module (3) upflow inside
961	1	3	2	Hot Module (3) upflow outside
961	5	3	2	Hot Module (3) upflow outside
962	1	3	1	Hot Module (4) upflow inside
962	6	3	1	Hot Module (4) upflow inside
962	1	3	2	Hot Module (4) upflow outside
962	6	3	2	Hot Module (4) upflow outside
963	1	3	1	Hot Module (5) upflow inside
963	6	3	1	Hot Module (5) upflow inside
963	1	3	2	Hot Module (5) upflow outside
963	6	3	2	Hot Module (5) upflow outside
965	1	3	1	Hot Module (6) upflow inside
965	5	3	1	Hot Module (6) upflow inside
965	1	3	2	Hot Module (6) upflow outside
965	5	3	2	Hot Module (6) upflow outside

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(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

INPUT NOTES:

npoints - number of locations (points) within TRAC model graphics requested
component - component id number containing specified graph point
cell - cell number with in component where graphics requested
ictype - type of component:
 (0 for fill, pipe, pressurizer, pump, tee, turb, value)
 (1 for plenum)

OUTPUT NOTES:

tsec - Time into simulation (sec)
Psia - Cell center pressure (psia)
Qf - Liquid volumetric flowrate at cell face (gpm)
tl - Liquid phase temperature (C)
tsub - Liquid subcooling (C)
tsat - Liquid saturation temperature (C)
rol - Liquid phase density (kg/m³)
vl - Liquid phasic velocity at cell face (m/s)
Pa - Cell center pressure (Pa)
qf - Liquid volumetric flowrate at cell face (m³/s)
void - Gas void fraction (-)
Qg - Gas volumetric flowrate at cell face (gpm)
qg - Gas volumetric flowrate at cell face (m³/s)
tv - Gas phase temperature (C)
rov - Gas phase density (kg/m³)
vv - Gas phasic velocity at cell face (m/s)
pair - Partial pressure of non-condensable in gas phase (psia)

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Appendix E: FLOWTRAN-TF Input File for LOCA Case 2 (with Beam Shutdown and Active RHR)

Below is an abridged listing of the FLOWTRAN-TF input deck for LOCA Case 2. The finite element input of the solid geometric parameters used in the heat conduction calculations and the fluid geometry input are identical to the values given in Ref. [6] and have been edited from this listing to save space.

Input file apt.in:

```

/*** 12-channel APT input deck for flowtran-apt code ***/
! Case 2 LOCA input deck
!
! Input Deck Description:
!
! General Comments:
!   *The solid input units are: [T] = C
!   *The fluid input units are determined by iunits as described below
!   *The working units in the fluid modules are: s, m, kg, K, Pa, J, W, ...
!   *The working units in the solid modules are: s, m, kg, C, Pa, J, W, ...
/RUN TIME, TIME STEP LIMITS, AND PRINT TIMES/
! total          minimum          maximum          minimum          maximum
! runtime fluid time step fluid time step solid time step solid time step
!-----
! runsec,          dtmin,          dtmax,          dtmin,          dtmax
! 600.0           1.0e-6           0.10           0.1           0.5           !>
!
!           printing intervals in seconds
! fluid          solid          power          plot          criteria
! dtpfld,        dtpsld,        dtpwr,        dtpplt,        dtpcrt
! 100.0          100.0          100.0          100.0          10.0           !>
!-----
/BOUNDARY CONDITION, UNITS, RESTART, AND PRINT FLAGS/
! ibond: 1 = P          (fluid and gas momentum balances at plenum)
!         2 = Qf          (prescribed Qf replaces fluid mom. bal. at plenum)
!         3 = Qg          (prescribed Qg replaces gas mom. bal. at plenum)
!         4 = Qf,Qg       (prescribed Qf, Qg replace both mom. bal. at plenum)
!        -2 = Qf          (prescribed Qf replaces fluid mom. bal. at tank bottom)
!        -3 = Qg          (prescribed Qg replaces gas mom. bal. at tank bottom)
!        -4 = Qf,Qg       (prescribed Qf, Qg replace both mom. bal. at tank bottom)
! iunits applies to the fluid input only
! iunits: 1 = SI (m, m^2, m^3, Pa, m^3/s, C)
!         2 = SRS (in, in^2, in^3, psia, gpm, C)
! istart: 0 = new
!         1 = restart (time = runsec)
!         2 = restart (time = zero)
!         3 = restart (time = tcrit0)
! isave: 0 = no restart file saved
!         1 = restart file saved and tsec set to runsec
!         2 = restart file saved and tsec set to zero
!         3 = restart file saved and tsec set to tcrit0
! iprint: 1 = short print
!         2 = long print
! icrit: 0 = no printing of criteria messages
!        1 = print criteria messages
! iscrn: 0 = no screen print
!         1 = long screen print
!         2 = short screen print

```

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```

! istdy: -1 = grid generation only
!          0 = transient from tsec to runsec
!          1 = steady state from tsec
!          2 = steady state at tsec
!          3 = steady state at tsec followed by a transient to runsec
! igpsk: 0 = no node renumbering
!          1 = optimum node renumbering using Gibbs-Poole-Stockmeyer-King
!          2 = optimum node renumbering using Gibbs-Poole-Stockmeyer-Cuthill-Mckee
! inorm: 0 = use unnormalized axial power shapes
!          1 = normalize the axial power shape
!-----
! ibond, iunits, istart, isave, iprint
! -2      1         2         2         1
! icrit, iscrn, istdy, ippu, ibpu
! 0        2         0         0         0
! igpsk inorm
! 1         0
!-----
!
! /REFERENCE PRESSURE, COMPRESSIBILITY FACTOR, .../
!   ilq: liquid identification, 1=H2O, 2=D2O
!   pref: reference pressure used in subroutine inner to compute
!         relative changes in the dp's
! factor: multiplier to drho,fluid/dP to increase fluid compressibility
! vminz: minimum absolute velocity for full donoring in z direction
!   tol: accchk parameter
!   tolss: steady state tolerance on dhmix/dt, (J/m^3-s)
!   tolts: relative tolerance on solid temperature
!   ttol: relative tolerance on solid time step change
!   dtsup: wall superheat reduction, C
!   htdamp: solid-fluid heat transfer damping factor
!   cidamp: interfacial drag damping factor
!   xa0: source/sink air mass fraction
!   dtf: perturbation to liquid temperature for derivative estimation
!   dtg: perturbation to gas temperature for derivative estimation
!   nstdy: maximum iterations for steady-state (istdy > 0)
!   nmat: maximum number of solid materials
!   delox: surface oxide layer thickness (m)
!   tkox: oxide thermal conductivity (W/m-K)
!-----
! ilq,      pref,      factor,  vminz
! 1         5.0e+5    1.0       0.05
!
! tol,      tolss,     tolts,    ttol
! 1.0       10.0       0.1       0.1
!
! dtsup,    htdamp,    cidamp,    xa0
! 0.0       1.0       0.1       0.0
!
! dtf,      dtg,      nstdy,     nmat
! 1.0       1.0       9000      9
!
! delox,    tkox
! 5.08e-5   2.16
!-----
!
! /BOILING CURVE AND INTERPHASE TRANSPORT OPTIONS/
!   iboil: 0 = use specified heat transfer coefficient
!           1 = forced convection (SRL)
!           2 = forced convection (Dittus-Boelter)
!           3 = forced convection (Sieder-Tate)

```

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```

!      4 = Mikic-Rohsenow interpolation
!      5 = Chen correlation
!  ichf: 1 = SRS correlation
!      2 = Biasi
! matgas: 1 = helium dissolved in water
!      2 = air dissolved in water
! persat: percent of saturation (0-100)
!  igami: 0 = bulk interfacial mass transport off
!      1 = bulk interfacial mass transport on
!  igamw: 0 = wall interfacial mass transport off
!      1 = wall interfacial mass transport on
!-----
!  iboil,  ichf,  matgas,  persat,  igami,  igamw
!    4      3      2      0.0      1      1      !>
!-----
!
/SOLID PARAMETERS/
! isolid: 0 = no solid calculations
!      1 = solid calculations with matrix decomposition every time step
!      2 = solid calculations with matrix decomposition first time step
! tsolid: initial solid temperature
!  beta: implicitness parameter in solid calculations
! iheat: 0 = no wall heat transfer calculation
!      1 = wall heat transfer calculations
!  qsurf: specified surface heat flux (used when iheat = 0)
!  hfix: specified heat transfer coefficient (used when iboil = 0)
! iaxcon: 0 = no axial conduction
!      1 = explicit axial conduction calculation
!-----
!  isolid,  tsolid,  beta,  iheat,  qsurf,  hfix,  iaxcon
!    2      54.9    1.0    1      0.0    1.0e4  1      !>
!-----
!
/INNER ITERATION OPTIONS & NEWTON ITERATION PARAMETERS/
! irebal: 0 = no coarse mesh rebalance
!      1 = coarse mesh rebalance on first pass
!      2 = coarse mesh rebalance on each pass
!  ncmr: number of coarse mesh rebalances when irebal = 1 or 2
!  epsin: inner iteration convergence criterion for relative dp error
! initmx: max. number of inner iterations allowed
!  epsp: newton iteration convergence criterion for absolute p error in Pa
! epsalp: newton iteration convergence criterion for absolute alp error
! epstg: newton iteration convergence criterion for absolute tg error in K
! epstf: newton iteration convergence criterion for absolute tf error in K
! epsxa: newton iteration convergence criterion for absolute xa error
! nitmax: |nitmax| = max. number of newton iterations allowed
!      If nitmax is positive and |nitmax| iterations are reached, then
!      then computations continue using the mth iterate values from the
!      |nitmax| iteration.
!      If nitmax is negative and |nitmax| iterations are reached, then
!      a new time step with a time step reduction is requested.
!-----
!  irebal,  ncmr,  epsin,  initmx
!    1      1      1.0e-5  200      !>
!      epsy,  epsf,  nitysi
!      1.0e-5  0.01  50      !>
!      epsp,  epsalp,  epstg,  epstf,  epsxa,  nitmax
!      50.0  0.0005  0.05  0.05  0.005  -100      !>
!-----
!
/NUMBER OF SPLINE PROFILES AND DATA POINTS/
! ndata: number of data groups

```

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```

! itime: number of time snapshots for axial power profiles
!-----
! ndata,  itime
! 10      2                                     !>
!-----
! npdat: number of data points per data set
! nset: number of data sets in data group
!-----
! npdat  nset
! 3       1                                     !>
! 29      1                                     !>
! 13      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
! 66      1                                     !>
!-----
!
! /GEOMETRIC DIMENSIONS:/
! nchn: number of flow channels
! nzt: number of top section axial cells (>=2)
! nz: number of middle section axial cell layers (>=3)
! nzb: number of bottom section axial cells (>=2)
!-----
! nchn,  nzt,  nz,  nzb
! 12     2    20    2                                     !>
!-----
!
! /POWER ITERATION INPUT/
! power: initial power in kW
! maxpi: maximum number of power iterations
! tolpow: tolerance on power limit
! ncrit: number of criteria used to check for power limit
!-----
! power,    maxpi,  tolpow,  ncrit
! 61.5      1       0.005    8                                     !>
!-----
!
! SENSITIVITY VARIABLES INPUT SECTION
!
! /SENSITIVITY PARAMETERS/
! cizfac: axial interfacial drag multiplying factor
!-----
! xcofh,  xreh,  xcofl,  xrel,  xkmet,  xcvmet
! 1.0     1.0    1.0     1.0    1.0     1.0                                     !>
!
! xhfi,   xhgi,   xkgi,   xphi
! 1.0     1.0    1.0     1.0                                     !>
!
! cizfac  xfri,   plnht,  cipln,  formhs,  alphas
! 1.0     1.0    8.75    1.0     5.382    0.05                                     !>
!
! alb2,   als2,   ala2,   expbs,  expsa
! 0.25    0.52    0.75    4.0     4.0                                     !>
!-----
!
! INPUT FOR SOLID FINITE ELEMENT CALCULATIONS
!

```


Solid mesh input for finite element regions, nodes and side boundary conditions is identical to that shown in reference [6]

! FLUID GEOMETRY AND MOMENTUM CLOSURE INPUT SECTION
!

Fluid geometry input is identical to that shown in reference [6]

/BOUNDARY CONDITION INPUT SECTION/
/OUTLET PLENUM (TOP)/

! pp10: multiplier to P transient profile
! ippl: P transient identifier
! alpp10: multiplier to alpha transient profile
! ialpl: alpha transient identifier
! tfp10: multiplier to Tf transient profile
! itfpl: Tf transient identifier
! tgpl0: multiplier to Tg transient profile
! itgpl: Tg transient identifier
! xap10: multiplier to Xa transient profile
! ixapl: Xa transient identifier

! pp10, ippl
583697.9 8 !>
! alpp10, ialpl
1.0 10 !>
! tfp10, itfpl
59.85 9 !>
! tgpl0, itgpl
59.85 9 !>
! xap10, ixapl
0.0 1 !>

!

/INLET PLENUM (BOTTOM)/

! ptb0: multiplier to P transient profile
! iptb: P transient identifier
! alptb0: multiplier to alpha transient profile
! ialtb: alpha transient identifier
! tftb0: multiplier to Tf transient profile
! itftb: Tf transient identifier
! tgtb0: multiplier to Tg transient profile
! itgtb: Tg transient identifier
! xatb0: multiplier to Xa transient profile
! ixatb: Xa transient identifier

! ptb0, iptb
685560.6 5 !>
! alptb0, ialtb
1.0 7 !>

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```

! tftb0,      itftb
53.05        6      !>
! tgtb0,      itgtb
53.05        6      !>
! xatb0,      ixatb
0.0          1      !>
!-----
!
/INLET FLOW DATA/
! The following inlet flow data is always used to initialize
! axial velocities and will also be used to define the
! appropriate prescribed flowrate for t > 0 if ibond = 2, 3, or 4.
! qfin0: multiplier to Qf transient profile
! iqfin: Qf transient identifier
! qgin0: multiplier to Qg transient profile
! iqgin: Qg transient identifier
! qfin0 = Nominal APT total flow 12 half channels, transient
!-----
! qfin0,      iqfin
-1.508e-3    4      ! 1  >
! qgin0,      iqgin
0.0          1      !      >
!-----
!
/INITIAL CONDITION INPUT SECTION/
! If iset0 > 0 then initial conditions are
! input for fluid parameters at each axial level
! iset0
0
!-----
!
/CRITERIA CHECKING FLAGS AND PEAKING FACTORS/
! checking flags for criteria #1 #2 #3 #4 #5 #6 #7 #8
0 0 0 0 0 0 0 0 !>
!peaking factors for criteria #1 #2 #3 #4 #5 #6 #7 #8
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 !>
/CRITERIA CHECKING TIME/
! time to begin criteria checking, sec
!-----
! tcrit0
0.0          !>
!-----
!
! POWER INPUT
!
/POWER PROFILE SPLINE POINTERS/
! DECAY HEAT TRANSIENT
3            !>
!
/AXIAL SPLINE POINTERS AND TIMES/
2 0.0        2 600.00
!
/TRANSIENT DATA SET INPUT SECTION/
!
/DATA SET NUMBER 1/
! enter data set label below
!-----
data set 1 - UNIFORM
!-----
! itype: 1 = linear spline
!       0 = cubic spline
! x, y: data pairs

```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

```
-----
!
!      itype
!      1      !>
! x(ipt), y(ipt)  ipt=1,npts
!      0.0    1.0    !>
!      60.0   1.0    !>
!      600.0  1.0    !>
!-----
```

```
!
! /DATA SET NUMBER 2/
!-----
```

data set 2 - NON-UNIFORM AXIAL POWER PROFILE

```
!      itype
!      1      !>
! x(ipt), y(ipt)  ipt=1,npts
!      0.00    0.032  !>
!      0.10    0.043  !>
!      0.20    0.049  !>
!      0.30    0.074  !>
!      0.40    0.093  !>
!      0.50    0.124  !>
!      0.60    0.165  !>
!      0.70    0.217  !>
!      0.80    0.317  !>
!      0.90    0.508  !>
!      1.00    0.943  !>
!      1.10    1.446  !>
!      1.20    1.658  !>
!      1.30    1.754  !>
!      1.40    1.783  !>
!      1.50    1.827  !>
!      1.60    1.870  !>
!      1.70    1.881  !>
!      1.80    1.915  !>
!      1.90    1.915  !>
!      2.00    1.887  !>
!      2.10    1.864  !>
!      2.20    1.790  !>
!      2.30    1.660  !>
!      2.40    1.423  !>
!      2.50    0.932  !>
!      2.60    0.506  !>
!      2.70    0.313  !>
!      2.80    0.229  !>
!-----
```

```
!
! /DATA SET NUMBER 3/
!-----
```

data set 3 - DECAY POWER CURVE (+1 second time delay)

```
!      itype
!      1      !>
! x(ipt), y(ipt)  ipt=1,npts
!      0.00    1.000000000E+00
!      1.00    1.000000000E+00
!      1.01    1.298500039E-02
!      2.00    9.929999709E-03
!      3.00    8.652999997E-03
!      6.00    7.736000232E-03
!      11.00   7.573999930E-03
!      21.00   7.437000051E-03
!      61.00   7.073000073E-03
!      121.00  6.672000047E-03
```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

301.00 5.936999805E-03
601.00 5.392999854E-03
1201.00 4.968000110E-03

!-----

!

/DATA SET NUMBER 4/

!-----

data set 4 - COOLANT FLOW TRANSIENT

! itype

1

! x(ipt), y(ipt) ipt=1,npts

0.00	1.00000E+00
0.52	8.02746E-01
1.03	6.79792E-01
1.53	6.01678E-01
2.03	5.47402E-01
2.53	5.10105E-01
3.03	4.85195E-01
3.53	4.67315E-01
4.03	4.55262E-01
4.53	4.46853E-01
5.03	4.40212E-01
5.53	4.34878E-01
6.03	4.31194E-01
6.53	4.28697E-01
7.04	4.26830E-01
7.54	4.25523E-01
8.04	4.24647E-01
8.54	3.72900E-01
9.04	3.90656E-01
9.54	4.01556E-01
15.01	4.28534E-01
20.01	4.23633E-01
25.01	4.09141E-01
30.01	3.40995E-01
35.01	2.74588E-01
40.01	2.21235E-01
45.02	1.81601E-01
50.02	1.46089E-01
55.02	1.14088E-01
60.02	9.22337E-02
65.02	7.20636E-02
70.02	5.55500E-02
75.02	4.65663E-02
80.02	4.57347E-02
85.03	4.71895E-02
90.03	4.72085E-02
95.03	4.70529E-02
110.04	4.56135E-02
120.04	4.56368E-02
130.04	4.56861E-02
140.04	4.57351E-02
150.04	4.57719E-02
160.08	4.55941E-02
170.08	4.56074E-02
180.08	4.56250E-02
190.08	4.56389E-02
220.03	4.57183E-02
240.03	4.57785E-02
260.06	4.64024E-02
280.06	4.64972E-02
300.06	4.65821E-02

BLANKET SAFETY ANALYSES FOR LOCA

Date: 07/13/98

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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320.06	4.66684E-02
340.06	4.67487E-02
360.06	4.68247E-02
380.06	4.68997E-02
400.06	4.69676E-02
420.06	4.70308E-02
440.06	4.70891E-02
460.06	4.71449E-02
480.06	4.71959E-02
500.06	4.72449E-02
520.06	4.72939E-02
540.06	4.72322E-02
560.06	4.73943E-02
580.06	4.75458E-02
600.01	4.76238E-02

!-----

!

/DATA SET NUMBER 5/

!-----

data set 5 - INLET PRESSURE TRANSIENT

```
!      itype
      1
!      x(ipt),      y(ipt)      ipt=1,npts
      0.00      1.00000E+00
      0.52      3.49539E-01
      1.03      3.06144E-01
      1.53      2.90392E-01
      2.03      2.78955E-01
      2.53      2.74261E-01
      3.03      2.70437E-01
      3.53      2.67951E-01
      4.03      2.66537E-01
      4.53      2.66120E-01
      5.03      2.64948E-01
      5.53      2.64393E-01
      6.03      2.64317E-01
      6.53      2.64012E-01
      7.04      2.63798E-01
      7.54      2.63663E-01
      8.04      2.63549E-01
      8.54      2.50762E-01
      9.04      2.28675E-01
      9.54      2.34107E-01
      15.01      2.65148E-01
      20.01      2.60462E-01
      25.01      2.63437E-01
      30.01      2.83075E-01
      35.01      2.92015E-01
      40.01      2.97217E-01
      45.02      3.02177E-01
      50.02      3.03369E-01
      55.02      3.05992E-01
      60.02      3.08101E-01
      65.02      3.10567E-01
      70.02      3.12210E-01
      75.02      3.12507E-01
      80.02      3.14473E-01
      85.03      3.16719E-01
      90.03      3.17181E-01
      95.03      3.17340E-01
      110.04      3.17525E-01
      120.04      3.17600E-01
```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

130.04	3.17707E-01
140.04	3.17551E-01
150.04	3.17369E-01
160.08	3.17189E-01
170.08	3.17072E-01
180.08	3.16954E-01
190.08	3.16827E-01
220.03	3.16774E-01
240.03	3.16763E-01
260.06	3.16547E-01
280.06	3.16368E-01
300.06	3.16176E-01
320.06	3.16009E-01
340.06	3.15874E-01
360.06	3.15707E-01
380.06	3.15551E-01
400.06	3.15405E-01
420.06	3.15281E-01
440.06	3.15142E-01
460.06	3.14964E-01
480.06	3.14883E-01
500.06	3.14773E-01
520.06	3.14754E-01
540.06	3.14783E-01
560.06	3.11432E-01
580.06	3.09296E-01
600.01	3.08004E-01

!-----
!

/DATA SET NUMBER 6/

!-----
data set 6 - INLET TEMPERATURE TRANSIENT

! itype

1

! x(ipt), y(ipt) ipt=1,npts

0.00	1.00000E+00
0.52	1.00000E+00
1.03	9.97172E-01
1.53	9.90762E-01
2.03	9.82466E-01
2.53	9.74170E-01
3.03	9.66629E-01
3.53	9.60030E-01
4.03	9.54563E-01
4.53	9.49661E-01
5.03	9.45136E-01
5.53	9.40988E-01
6.03	9.36840E-01
6.53	9.32692E-01
7.04	9.28356E-01
7.54	9.23831E-01
8.04	9.19306E-01
8.54	9.14970E-01
9.04	9.10822E-01
9.54	9.06674E-01
15.01	8.73303E-01
20.01	8.66704E-01
25.01	8.64819E-01
30.01	8.57466E-01
35.01	8.50302E-01
40.01	8.42006E-01
45.02	8.33145E-01

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

50.02	8.25226E-01
55.02	8.19004E-01
60.02	8.14668E-01
65.02	8.12029E-01
70.02	8.10332E-01
75.02	8.09389E-01
80.02	8.08635E-01
85.03	8.08258E-01
90.03	8.07881E-01
95.03	8.07692E-01
110.04	8.06750E-01
120.04	8.05430E-01
130.04	8.03922E-01
140.04	8.02413E-01
150.04	8.00716E-01
160.08	7.99208E-01
170.08	7.98077E-01
180.08	7.96946E-01
190.08	7.96192E-01
220.03	7.94495E-01
240.03	7.93929E-01
260.06	7.93552E-01
280.06	7.93175E-01
300.06	7.92798E-01
320.06	7.92232E-01
340.06	7.92044E-01
360.06	7.91667E-01
380.06	7.91290E-01
400.06	7.90724E-01
420.06	7.90347E-01
440.06	7.90158E-01
460.06	7.89781E-01
480.06	7.89404E-01
500.06	7.89216E-01
520.06	7.89027E-01
540.06	7.88650E-01
560.06	7.88462E-01
580.06	7.88273E-01
600.01	7.88273E-01

!-----
!

/DATA SET NUMBER 7/

!-----

data set 7 - INLET VOID TRANSIENT

! itype

1

!	x(ipt),	y(ipt)	ipt=1,npts
	0.00	0.00000E+00	
	0.52	0.00000E+00	
	1.03	0.00000E+00	
	1.53	0.00000E+00	
	2.03	0.00000E+00	
	2.53	0.00000E+00	
	3.03	0.00000E+00	
	3.53	0.00000E+00	
	4.03	0.00000E+00	
	4.53	0.00000E+00	
	5.03	0.00000E+00	
	5.53	0.00000E+00	
	6.03	0.00000E+00	
	6.53	0.00000E+00	
	7.04	0.00000E+00	

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

7.54	0.00000E+00
8.04	0.00000E+00
8.54	0.00000E+00
9.04	0.00000E+00
9.54	0.00000E+00
15.01	0.00000E+00
20.01	0.00000E+00
25.01	0.00000E+00
30.01	0.00000E+00
35.01	0.00000E+00
40.01	0.00000E+00
45.02	0.00000E+00
50.02	0.00000E+00
55.02	0.00000E+00
60.02	0.00000E+00
65.02	0.00000E+00
70.02	0.00000E+00
75.02	0.00000E+00
80.02	0.00000E+00
85.03	0.00000E+00
90.03	0.00000E+00
95.03	0.00000E+00
110.04	0.00000E+00
120.04	0.00000E+00
130.04	0.00000E+00
140.04	0.00000E+00
150.04	0.00000E+00
160.08	0.00000E+00
170.08	0.00000E+00
180.08	0.00000E+00
190.08	0.00000E+00
220.03	0.00000E+00
240.03	0.00000E+00
260.06	0.00000E+00
280.06	0.00000E+00
300.06	0.00000E+00
320.06	0.00000E+00
340.06	0.00000E+00
360.06	0.00000E+00
380.06	0.00000E+00
400.06	0.00000E+00
420.06	0.00000E+00
440.06	0.00000E+00
460.06	0.00000E+00
480.06	0.00000E+00
500.06	0.00000E+00
520.06	0.00000E+00
540.06	0.00000E+00
560.06	0.00000E+00
580.06	0.00000E+00
600.01	0.00000E+00

!-----

!

/DATA SET NUMBER 8/

!-----

data set 8 - OUTLET PRESSURE TRANSIENT

!

itype

1

!

x(ipt), y(ipt) ipt=1,npts

0.00 1.00000E+00

0.52 2.83608E-01

1.03 2.53111E-01

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

1.53	2.46035E-01
2.03	2.39865E-01
2.53	2.38819E-01
3.03	2.37190E-01
3.53	2.36224E-01
4.03	2.35823E-01
4.53	2.36169E-01
5.03	2.35490E-01
5.53	2.35358E-01
6.03	2.35607E-01
6.53	2.35475E-01
7.04	2.35382E-01
7.54	2.35324E-01
8.04	2.35246E-01
8.54	2.18883E-01
9.04	1.98218E-01
9.54	1.87210E-01
15.01	2.36302E-01
20.01	2.31326E-01
25.01	2.36455E-01
30.01	2.66590E-01
35.01	2.82782E-01
40.01	2.92711E-01
45.02	3.00916E-01
50.02	3.04171E-01
55.02	3.09074E-01
60.02	3.12523E-01
65.02	3.15699E-01
70.02	3.17831E-01
75.02	3.18254E-01
80.02	3.20596E-01
85.03	3.23184E-01
90.03	3.23725E-01
95.03	3.23915E-01
110.04	3.24143E-01
120.04	3.24230E-01
130.04	3.24353E-01
140.04	3.24167E-01
150.04	3.23951E-01
160.08	3.23752E-01
170.08	3.23612E-01
180.08	3.23470E-01
190.08	3.23320E-01
220.03	3.23238E-01
240.03	3.23222E-01
260.06	3.22965E-01
280.06	3.22754E-01
300.06	3.22525E-01
320.06	3.22327E-01
340.06	3.22166E-01
360.06	3.21968E-01
380.06	3.21783E-01
400.06	3.21610E-01
420.06	3.21462E-01
440.06	3.21298E-01
460.06	3.21088E-01
480.06	3.20991E-01
500.06	3.20861E-01
520.06	3.20835E-01
540.06	3.20869E-01
560.06	3.16933E-01
580.06	3.14421E-01

BLANKET SAFETY ANALYSES FOR LOCA

Date: 07/13/98

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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600.01 3.12902E-01

!-----

!

/DATA SET NUMBER 9/

!-----

data set 9 - OUTLET TEMPERATURE TRANSIENT

! itype

1

! x(ipt), y(ipt) ipt=1,npts

0.00 1.00000E+00

0.52 9.99833E-01

1.03 9.98496E-01

1.53 9.94319E-01

2.03 9.87803E-01

2.53 9.79950E-01

3.03 9.71262E-01

3.53 9.61738E-01

4.03 9.52047E-01

4.53 9.42022E-01

5.03 9.31997E-01

5.53 9.21972E-01

6.03 9.12448E-01

6.53 9.03258E-01

7.04 8.94737E-01

7.54 8.86550E-01

8.04 8.78864E-01

8.54 8.72180E-01

9.04 8.65998E-01

9.54 8.59983E-01

15.01 8.06683E-01

20.01 7.80284E-01

25.01 7.72431E-01

30.01 7.69089E-01

35.01 7.64912E-01

40.01 7.60568E-01

45.02 7.56391E-01

50.02 7.52047E-01

55.02 7.48204E-01

60.02 7.44862E-01

65.02 7.42356E-01

70.02 7.40518E-01

75.02 7.39348E-01

80.02 7.38513E-01

85.03 7.37845E-01

90.03 7.37343E-01

95.03 7.37176E-01

110.04 7.36842E-01

120.04 7.36675E-01

130.04 7.36508E-01

140.04 7.36007E-01

150.04 7.35171E-01

160.08 7.34002E-01

170.08 7.32832E-01

180.08 7.31495E-01

190.08 7.29992E-01

220.03 7.26149E-01

240.03 7.23977E-01

260.06 7.22306E-01

280.06 7.20969E-01

300.06 7.19967E-01

320.06 7.18964E-01

340.06 7.18129E-01

BLANKET SAFETY ANALYSES FOR LOCA

Date: 07/13/98

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

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360.06	7.17293E-01
380.06	7.16792E-01
400.06	7.16124E-01
420.06	7.15622E-01
440.06	7.15121E-01
460.06	7.14453E-01
480.06	7.13952E-01
500.06	7.13450E-01
520.06	7.12949E-01
540.06	7.12615E-01
560.06	7.12114E-01
580.06	7.11779E-01
600.01	7.11278E-01

!-----

!

/DATA SET NUMBER 10/

!-----

data set 10 - OUTLET VOID TRANSIENT

! itype

1

! x(ipt), y(ipt) ipt=1,npts

0.00	0.00000E+00
0.52	0.00000E+00
1.03	0.00000E+00
1.53	0.00000E+00
2.03	0.00000E+00
2.53	0.00000E+00
3.03	0.00000E+00
3.53	0.00000E+00
4.03	0.00000E+00
4.53	0.00000E+00
5.03	0.00000E+00
5.53	0.00000E+00
6.03	0.00000E+00
6.53	0.00000E+00
7.04	0.00000E+00
7.54	0.00000E+00
8.04	0.00000E+00
8.54	0.00000E+00
9.04	0.00000E+00
9.54	0.00000E+00
15.01	0.00000E+00
20.01	0.00000E+00
25.01	0.00000E+00
30.01	0.00000E+00
35.01	0.00000E+00
40.01	0.00000E+00
45.02	0.00000E+00
50.02	0.00000E+00
55.02	0.00000E+00
60.02	0.00000E+00
65.02	0.00000E+00
70.02	0.00000E+00
75.02	0.00000E+00
80.02	0.00000E+00
85.03	0.00000E+00
90.03	0.00000E+00
95.03	0.00000E+00
110.04	0.00000E+00
120.04	0.00000E+00
130.04	0.00000E+00
140.04	0.00000E+00

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 2: EXTERNAL HR BREAK AT PUMP OUTLET WITH PUMP TRIP)

150.04	0.00000E+00
160.08	0.00000E+00
170.08	0.00000E+00
180.08	0.00000E+00
190.08	0.00000E+00
220.03	0.00000E+00
240.03	0.00000E+00
260.06	0.00000E+00
280.06	0.00000E+00
300.06	0.00000E+00
320.06	0.00000E+00
340.06	0.00000E+00
360.06	0.00000E+00
380.06	0.00000E+00
400.06	0.00000E+00
420.06	0.00000E+00
440.06	0.00000E+00
460.06	0.00000E+00
480.06	0.00000E+00
500.06	0.00000E+00
520.06	0.00000E+00
540.06	0.00000E+00
560.06	0.00000E+00
580.06	0.00000E+00
600.01	0.00000E+00

!-----
/END OF INPUT FILE/