APT Blanket System Loss-of-Coolant Accident (LOCA) Based on Initial Conceptual Design - Case 1: External HR Break Near Inlet Header

by

L. L. Hamm

Westinghouse Savannah River Company

Savannah River Site

Aiken, South Carolina 29808

S. Y. Lee

M. A. Shadday

F. G. Smith, III

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Case 1: External HR Break Near Inlet Header

L. Larry Hamm
Si Young Lee
M. Andy Shadday
Frank G. Smith, III

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Reviewing
Official: William Smith MCA
(Name and Title) ENRIS
Date: 7/31/98

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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Case 1: External HR Break Near Inlet Header

SAVANNAH RIVER TECHNOLOGY CENTER

L. Larry Hamm
Si Young Lee
M. Andy Shadday
Frank G. Smith, III

Publication Date: July 1998

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

SAVANNAH RIVER SITE

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APPROVALS

L. L. Hamm Date: 7-16-98
L. Larry Hamm, Task Leader (EM&S Group/SRTC)

Si Young Lee Date: 7-20-98
Si Young Lee, Co-author (EM&S Group/SRTC)

M. Andy Shadday Date: 7/20/98
M. Andy Shadday, Co-author (EM&S Group/SRTC)

Frank G. Smith III Date: 7/20/98
Frank G. Smith, III, Co-author (PC&C Group/SRTC)

Cynthia P. Holding-Smith Date: 7/16/98
Cynthia P. Holding-Smith, Manager (EM&S Group/SRTC)

M. A. Ebra Date: 28 Jul 98
Martha A. Ebra, Manager (EDS/SRTC)

Mel R. Buckner Date: 7/21/98
Mel R. Buckner, Technical & Regulatory Lead (APT OPO)

The internal technical review function is being performed at the APT project level and is coordinated through LANL.

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1 Introduction

The APT blanket system has about 57 MW of thermal energy deposited within the blanket region under normal operating conditions from the release of neutrons and the interaction of the high energy particles with the blanket materials. This corresponds to about 48% of total thermal energy deposited in the APT target/blanket system [1]. The deposited thermal energy under normal operation conditions is an important input parameter used in the thermal-hydraulic design and accident analysis. After the APT system shutdown, decay power drops rapidly. Figure 1-1 shows transient decay power after shutdown as a fraction of steady-state power for the 1700 Mev APT design with 13 tungsten ladders [2]. Thus, it is necessary to provide an alternative means of cooling the blanket modules to prevent structural damage of the blanket system and the possible release of radioactive contamination and hazardous materials such as lead and mercury following severe accidents like the double-ended guillotine break (DEGB). Major components of a typical blanket heat removal system include heat exchangers, piping, and pumps. The blanket heat removal system is comprised of the primary heat removal (HR) system, the secondary heat removal system, the primary residual heat removal (RHR) system, and the secondary RHR system. These systems provide the heat removal function for all the thermal energy deposited within the blanket modules. The current blanket coolant system has one primary HR, one secondary HR, two 100% primary RHR, and two 100% secondary RHR. Five cases of external loss-of-coolant accident (LOCA) scenarios were simulated for large pipe breaks of the primary heat removal (HR) and residual heat removal (RHR) systems external to the cavity vessel in order to identify worst transient accident scenario [3]. In this report, Case 1, as one of the five cases of the external LOCA's, simulated the pipe break of the external HR system near the inlet fixed header using a one-dimensional TRAC system model with 6 lumped modules. The break location for Case 1 is shown in Fig.1-2. The model results are used to determine thermal-hydraulic safety margins. The results also provide boundary conditions for detailed FLOWTRAN-TF bin model calculations. The results of the accident Case 1 simulation are documented in this report.

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

Figure 1-2 Break location for the external LOCA Case 1 (External HR Break Near Inlet Header)

2 TRAC 1-D System Model

The current blanket system consists of 16 unique blanket modules based on the existing cruciform-type design components (the necessary design specifications required to develop a plate-type set of modules is currently not available but should be forthcoming in late February). Each module is separately connected to the two fixed coolant headers. A lumping strategy was developed based on module similarity, deposited power levels, and locations that resulted in a total of six separate lumped modules and reduced computational effort requirements. The six lumped modules are, respectively: the first-row lateral modules; the second-row lateral modules; the decoupler / Row 1 downstream module; the Row 1 / Row 2 downstream module; the Row 2 / Row 2 downstream module; and the remaining low-power modules, which consist of the upstream module, the four bottom modules, and the two top modules. Figure 2-1 shows a cross-sectional face map for the 6 module blanket system. 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. Figure A-1 shows the locations of all the six modules and the internal piping connections as included in the 1-D TRAC system model. The TRAC components and piping connections for the HR, pressurizer, RHR blanket coolant systems, and cavity vessel flood system are also shown in Figs. A-2 to A-6. Table A-1 lists all the blanket system components, number of cells for the components, and the component descriptions for the present one-dimensional lumped blanket system model. The present 6 lumped module blanket system model includes 170 components and 152 junctions with 10 trip control signals using for the transient LOCA accident simulations. Detailed system model descriptions are provided in Ref. [3].

2.1 Scenario Description

As one of design basis accidents, a cold-leg large break LOCA external to the cavity vessel was simulated by restarting steady-state normal operation results for the one-dimensional 6 module blanket system model in a transient mode. Normal operation conditions for the key blanket system parameters are shown in Table A-2. Detailed description of the lumped 6 module TRAC system model is provided in Ref. [3].

The current blanket coolant system has one primary HR, one secondary HR, two 100% primary RHR, and two 100% secondary RHR. Under steady-state normal operating conditions the blanket module system is connected to a single main primary loop, with three 50% pumps in parallel. Two pumps are normally operating and the remaining pump is available for immediate startup in the event of failure of a running pump. The cooling loop has two 50% heat exchangers in parallel. The two RHR primary loops are both sized to accommodate 100% of the decay heat removal requirements. Currently, the RHR components are sized for approximately 4% of the full power flow, 1569 kg/sec. Each of the RHR primary loops has one heat exchanger and one pump. The current baseline design has the RHR systems shutdown in standby mode during normal operation to enhance the system's response to some design basis accident scenarios such as LOCA's.

A large break loss-of-coolant accident (LOCA) for Case 1 was simulated as a pipe break near the inlet fixed header of the primary HR system external to the cavity vessel. The break location for accident simulation of Case 1 is component number 65 shown in Fig. 2.1-1. When pipe component 65 is broken for the Case 1 LOCA simulation, the system

will rapidly depressurize and the RHR pump will reach full speed in about 15 seconds after the accident. Two primary HR pumps are tripped off with time delay after the accident. Detailed control signals for the key component operations will be provided later.

2.2 Model Upgrades

Component action tables for the break component and check valves are updated for the Case 1 accident simulation. Component action tables for HR and RHR check valves are based on the S-shaped forcing function values. 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 1 accident scenario described in Ref. [3].

2.3 Initial Conditions

Before simulating the accident condition, steady-state results under normal operation conditions are required to provide initial input to the transient LOCA simulation model of Case 1 (see Ref. [4]). The initial steady-state normal operation (NO) conditions of the APT blanket system were obtained by specifying maximum pump rotational speeds of the two HR pumps with desired total liquid flowrate under the constrained steady-state (CSS) controller option. The initial temperatures for the pressurizer and the RHR system components are 40 C. Table A-2 shows the initial steady-state values for the key system parameters of the blanket system.

2.4 Transient Boundary Conditions

The TRAC system model is documented in the report for the steady state NO calculations [3,4]. The steady-state NO TRAC run was restarted in transient mode to initiate the LOCA simulation of Case 1. The break component was a single-cell pipe component (component 65) located just outside the cavity vessel wall. The break location was selected to be close to the cold-leg fixed header where the pressurizer surge line is connected. For the LOCA initiation, the break component 65 was replaced two break components using transient pressure boundary conditions at the both ends of the break component to simulate a double guillotine break. The break components were set to ramp down from the NO steady-state pressure to atmospheric pressure in 0.1 second after the accident. Additionally, the pressurizer boundary condition was changed from a constant pressure break boundary to a zero fill (no flow) boundary. This is done to remove the possible pressure control of the pressurizer during the LOCA accident.

2.5 Trips and Controls

Power to the two HR pumps and the beam were tripped 0.2 seconds after the pressurizer surge line pressure dropped to 0.68745 MPa (99.70 psia) corresponding to 95% of the pressurizer surge line pressure. The delay time chosen for the accident simulations was obtained by doubling the estimated response time for the signal transducers to actuate the component hardware. The beam trip was simulated by changing the steady-state NO power in the heat structure of each blanket module to the time dependent decay power curve. Figure 1-1 shows transient decay power curves for

the blanket heat structures. The beam and the two HR pump power trips actually occurred about 0.21 seconds after the initiation of the transient accident. The RHR pump power signal was set to actuate without delay after a 5% reduction of the pressurizer surge line pressure. The RHR pump was 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. 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 the trip signals and controls used for the Case 1 accident simulation.

2.6 TRAC Version

This transient model was run using TRAC-PF1/MOD2 version 5.4.28a [10]. A modified version of TRAC to generate graphics files was employed [9].

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 1.

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-08 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

The LOCA simulation model for the external cold-leg HR break near the fixed header (Case 1) was run for 600 seconds after the initiation of the accident. 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 surrounding the blanket modules does not reach saturation temperature leading to phase change inside the blanket system under any of the LOCA accident transient times. The following subsections provide descriptions of the transient

phenomena for the key blanket component systems observed in the accident simulation in more detail.

Results from the TRAC system model calculations are presented in graphical form in Appendix B. Appendix B1 shows output for the TRAC plenum components, Appendix B2 contains the output for pipe, pump and valve components while Appendix B3 shows output for the heat structures. A listing of the TRAC standard input file for LOCA Case 1 is in Appendix C and a listing of the graphics input file used to create the graphical output is given in Appendix D.

3.1 Modules

Figure A-1 shows the component layout of the internal blanket module system used in the TRAC system model. Transient results for coolant hydraulic parameters through the 6 blanket upward flow regions are graphically shown for the external LOCA Case 1 simulation in Figs. B2-24a through B2-24e. The results show rapid transient behavior for the flow channels of all the six blanket modules continuing up to about 100 seconds after initiation of the LOCA. During the first 20 seconds of rapid de-pressurization of the HR system, pump cavitation occurred at the pump suction sides, and then coolant flow decreased without flow reversal across the pump. At the same time, the RHR pump was actuated and RHR coolant water at 40 C came into the internal hot blanket module system. As a result, the fluid temperatures of the six blanket modules dropped more quickly. After recovery from the HR cavitation, the RHR pump suction side cavitated around 40 seconds after the accident, but coolant flow decreased without flow reversal across the RHR pump. This caused the module fluid temperatures to rise for about 10 seconds by which time blanket system pressure was recovered. Eventually, small liquid flowrates controlled by the gravitational hydraulic head were established to the six blanket modules.

Figure B2-24e shows channel void fractions at the mid-planes of the six modules. These results show that the module 1 channel with the largest connection pipe size (7.5 inch) to the fixed header has the largest void fraction at 22 seconds of the transient time as a result of the HR pump cavitation and then this voidage was swept away quickly.

Figs. B3-26 through B3-43b show detailed graphical results for the solid structures of the six blanket modules. Maximum lead temperature was 152 C during normal operation condition near the mid-plane of the first lateral module as shown in Fig. B3-26. Generally, solid temperatures decreased quickly up to 50 seconds and then after rising up about 2 to 3 C for about 50 seconds the solid temperatures slowly decline following the trend of the decay heat curve shown in Fig. 1-1. Maximum aluminum cladding surface temperature was 93.5 C during normal operation conditions at the mid-plane of the blanket module 1 and then it dropped to the minimum value (about 42 C) at the transient time of 50 seconds. After the HR and RHR cavitation (about 100 seconds), the aluminum surface temperatures started to approach a stabilized cooling condition.

3.2 HR Loop and Pressurizer

Figure A-2 shows the HR system component layout used for the one-dimensional TRAC system model. With the initiation of pipe break (component 65), the system pressure in the HR loop decreases rapidly. Figure B1-1a shows fixed header fluid pressures for the

Case 1 LOCA simulation. Pressures in the hot and cold legs drop steeply following initiation of the LOCA accident. The results show that the cold-leg fixed header pressure decreased to one atmospheric pressure in 3.5 seconds and hot-leg pressure dropped to less than one atmospheric pressure within a second. After pump coast-down at about 60 seconds, the hot-leg fixed header pressure rises to near one atmospheric pressure. Pressures of both fixed headers are stabilized at about 55 seconds after the accident as shown in Fig. B1-1.

Figure A-3 shows the component layout for the pressurizer system. Figs. B2-15b to B2-15e show transient behaviors of the key thermal-hydraulic parameters for the pressurizer and surge line during the LOCA Case 1 accident. From these results, the liquid in the pressurizer was not drained completely during the accident so that gas inside the pressurizer is not entrained into the heat removal system loop. Void fraction in the surge line of the pressurizer was zero during the accident to satisfy the design requirement for the pressurizer component. No void was entrained into the HR loop through the surge line of the pressurizer during the entire transient time of the accident.

3.3 RHR Loop

Figure A-4 shows layout for the RHR system. The initial temperature for the RHR system was 40 C. Maximum RHR flowrate was about 4% of total full power liquid flowrate. The RHR system has a check valve on the RHR pump discharge to prevent flow reversal during the LOCA accident. The transient responses of the RHR system to the LOCA Case 1 scenario are shown in Figs. B2-16a to B2-16e and B2-17a to B2-17e. Figure B2-16a shows pressures for the RHR pump suction and discharge sides. Void in the RHR pump suction side was initiated at the pump suction side at about 9 seconds from the pump cavitation as shown in Fig. B2-16e. At that time the RHR check valve was activated to avoid backflow in the RHR system, and consequently the RHR flowrate was rapidly reduced. After water in the pressurizer reached the RHR pump at about 150 seconds after the accident, liquid flowrate was established in the RHR system.

Figure B2-17c shows the RHR primary heat exchanger inlet and outlet temperatures. The current Conceptual Design Report has the two 100% RHR systems shutdown in standby mode during normal operation. Initial inlet temperature is the same as the steady-state stagnant RHR temperature of 40 C, and the RHR water temperature quickly increases as soon as the RHR pump circulates the water through the blanket modules internal to the cavity vessel.

3.4 Cavity Vessel and Flood System

Figure A-5 shows the TRAC component layout for the heat transfer connections between the blanket module heat structures and the cavity vessel. Figure A-6 shows the TRAC component layout for the cavity vessel and flood system. During the external LOCA Case 1 accident the cavity flood system pool is stagnant with an ambient temperature of 40 C. The cavity vessel has no liquid phase with an ambient temperature saturated at about 5 psia during the external LOCA accident.

4 FLOWTRAN-TF Detailed Bin Model

The basic FLOWTRAN-TF model is described in Refs. [6,7] and was used in this version for the LOCA Case 1 analyses. 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 [5]. 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 1 analysis.

4.2 Initial Conditions

Initial conditions for all of the flow transients are the normal operating conditions reported in Ref. [4]. 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 1, a small amount of void fraction appears at the inlet to the coolant flow channels early in the transient. The TRAC system analysis also predicts a brief episode of flow reversal at about 80 seconds into 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 1.

5 FLOWTRAN-TF Bin Model Results

A listing of the input deck used for the FLOWTRAN-TF calculations of LOCA Case 1 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 1 are shown in Figs. 5-3 through 5-5 from all of the flow channels at axial level 11. Case 1 had slightly higher metal temperatures than the other LOCA cases. 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 1.

Figure 5-2 Blanket axial power shape.

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

Figure 5-4 Surface heat fluxes for LOCA Case 1, axial level 11, channels 5-8.

Figure 5-5 Surface heat fluxes for LOCA Case 1, axial level 11, channels 9-12.

6 Conclusions

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 1 scenario. The thermal/hydraulic (T/H) design criteria, along with the basis for their development, is discussed in Refs. [1,8]. 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 1 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 1. 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 1 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	0.348	0.597	0.315	0.099	0.309
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

7 References

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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
	HX	40	1	plenum
		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	1569
	gpm	25252
Pressure in cold-leg fixed header	MPa	0.7325
	psia	106.24
Pressure in hot-leg fixed header	MPa	0.4563
	psia	66.180
Pressurizer (cell #1) pressure	MPa	0.7311
	psia	106.03
Pump #1 suction pressure	MPa	0.2751
	psia	39.90
Pump #1 discharge pressure	MPa	1.0356
	psia	150.20
Pump #2 suction pressure	MPa	0.2958
	psia	42.91
Pump #2 discharge pressure	MPa	1.0409
	psia	150.97
Temperature in cold-leg fixed header	C	49.43
	F	121.0
Temperature in hot-leg fixed header	C	58.03
	F	136.5
Max. fluid temperature of the hottest module	C	71.95
	F	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-3 TRAC component layout for the cavity vessel and cavity flood system.

BLANKET SAFETY ANALYSES FOR LOCA

Section: Appendix A

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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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.

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BLANKET SAFETY ANALYSES FOR LOCA

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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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Appendix B: LOCA (Case 1) TRAC Results

Appendix B1 LOCA (Case 1) TRAC Plenum Component Figures

The following figures are from a TRAC simulation for Case 1 of a LOCA (external HR break near inlet header):

Figure B-1a Fixed header fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-1b Fixed header fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-1c Fixed header fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-1d Fixed header void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-2a Module 1 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-2b Module 1 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-2c Module 1 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-2d Module 1 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-3a Module 2 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-3b Module 2 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-3c Module 2 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-3d Module 2 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-4a Module 3 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-4b Module 3 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-4c Module 3 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-4d Module 3 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-5a Module 4 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-5b Module 4 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-5c Module 4 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-5d Module 4 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-6a Module 5 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-6b Module 5 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-6c Module 5 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-6d Module 5 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-7a Module 6 plenum fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-7b Module 6 plenum fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-7c Module 6 plenum fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-7d Module 6 plenum void fractions for a LOCA (Case 1: external HR break near inlet header).

Appendix B2 LOCA (Case 1) TRAC Pipe, Pump, and Valve Component Figures

The following figures are from a TRAC simulation for Case 1 of a LOCA (external HR break near inlet header):

Figure B-8a Primary HR hot-leg piping fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-8b Primary HR hot-leg piping fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-8c Primary HR hot-leg piping fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-8d Primary HR hot-leg piping liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-8e Primary HR hot-leg piping void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-9a Primary HR pump 1 fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-9b Primary HR pump 1 fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-9c Primary HR pump 1 fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-9d Primary HR pump 1 liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-9e Primary HR pump 1 void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-10a Primary HR pump 2 fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-10b Primary HR pump 2 fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-10c Primary HR pump 2 fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-10d Primary HR pump 2 liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-10e Primary HR pump 2 void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-11a Primary HR pump discharge piping fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-11b Primary HR pump discharge piping fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-11c Primary HR pump discharge piping fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-11d Primary HR pump discharge piping liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-11e Primary HR pump discharge piping void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-12a Primary HR heat exchanger inlet piping fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-12b Primary HR heat exchanger inlet piping fluid temperatures for a LOCA
(Case 1: external HR break near inlet header).

Figure B-12c Primary HR heat exchanger inlet piping fluid subcoolings for a LOCA
(Case 1: external HR break near inlet header).

Figure B-12d Primary HR heat exchanger inlet piping liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-12e Primary HR heat exchanger inlet piping void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-13a Primary HR heat exchanger outlet piping fluid pressures for a LOCA
(Case 1: external HR break near inlet header).

Figure B-13b Primary HR heat exchanger outlet piping fluid temperatures for a LOCA
(Case 1: external HR break near inlet header).

Figure B-13c Primary HR heat exchanger outlet piping fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-13d Primary HR heat exchanger outlet piping liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-13e Primary HR heat exchanger outlet piping void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-14a Primary HR cold-leg piping fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-14b Primary HR cold-leg piping fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-14c Primary HR cold-leg piping fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-14d Primary HR cold-leg piping liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-14e Primary HR cold-leg piping void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-15a Primary HR pressurizer and surge line fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-15b Primary HR pressurizer and surge line fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-15c Primary HR pressurizer and surge line fluid subcoolings for a LOCA
(Case 1: external HR break near inlet header).

Figure B-15d Primary HR pressurizer and surge line liquid mass flowrates for a LOCA
(Case 1: external HR break near inlet header).

Figure B-15e Primary HR pressurizer and surge line void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-16a Primary RHR pump fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-16b Primary RHR pump fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-16c Primary RHR pump fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-16d Primary RHR pump liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-16e Primary RHR pump void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-17a Primary RHR heat exchanger fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-17b Primary RHR heat exchanger fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-17c Primary RHR heat exchanger fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-17d Primary RHR heat exchanger liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-17e Primary RHR heat exchanger void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-18a Module 1 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-18b Module 1 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-18c Module 1 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-18d Module 1 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-8e Module 1 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-19a Module 2 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-19b Module 2 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-19c Module 2 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-19d Module 2 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-19e Module 2 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-20a Module 3 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-20b Module 3 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-20c Module 3 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-20d Module 3 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-20e Module 3 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-21a Module 4 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-21b Module 4 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-21c Module 4 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-21d Module 4 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-21e Module 4 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-22a Module 5 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-22b Module 5 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-22c Module 5 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-22d Module 5 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-22e Module 5 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-23a Module 6 channel fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-23b Module 6 channel fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-23c Module 6 channel fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-23d Module 6 channel liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-23e Module 6 channel void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-24a Mid-plane module fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-24b Mid-plane module fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-24c Mid-plane module fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-24d Mid-plane module liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-24e Mid-plane module void fractions for a LOCA (Case 1: external HR break near inlet header).

Figure B-25a Module inlet fluid pressures for a LOCA (Case 1: external HR break near inlet header).

Figure B-25b Module inlet fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-25c Module inlet fluid subcoolings for a LOCA (Case 1: external HR break near inlet header).

Figure B-25d Module inlet liquid mass flowrates for a LOCA (Case 1: external HR break near inlet header).

Figure B-25e Module inlet void fractions for a LOCA (Case 1: external HR break near inlet header).

Appendix B3 LOCA (Case 1) TRAC Heat Structure Component Figures

The following figures are from a TRAC simulation for Case 1 of a LOCA (external HR break near inlet header):

Figure B-26 Module 1 upflow section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-27 Module 2 upflow section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-28 Module 3 upflow section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-29 Module 4 upflow section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-30 Module 5 upflow section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-31 Module 6 down-stream section bottom, mid-plane, and top maximum lead metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-32 Module 1 upflow section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-33 Module 2 upflow section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-34 Module 3 upflow section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-35 Module 4 upflow section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-36 Module 5 upflow section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-37 Module 6 down-stream section bottom, mid-plane, and top maximum aluminum metal temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-38 Module 1 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-39 Module 2 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-40 Module 3 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-41 Module 4 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-42 Module 5 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-43 Module 6 upflow section mid-plane surface and fluid temperatures for a LOCA (Case 1: external HR break near inlet header).

Figure B-44a Metal temperatures for various module outer aluminum surfaces at their mid-plane for a LOCA (Case 1: external HR break near inlet header).

Figure B-44b Metal temperatures for various module outer aluminum surfaces at their mid-plane for a LOCA (Case 1: external HR break near inlet header).

Appendix C: TRAC Standard Input File for LOCA Case 1 (with Beam Shutdown and Active RHR)

The file listed below represents the TRAC code "tracin" file that corresponds to the LOCA Case 1 (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 *
*****
*
*      numctr      ieos      inopt      nmat      id2o
*      37          0          1          2          0
* APT Lumped Blanket Model **** Component 65 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 1: EXTERNAL HR BREAK NEAR INLET HEADER)

*

&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
37	s	* pipe	HR pump discharge pipe (bk)
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
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

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET 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
* Component 65 is broken			
515	s	* break	HX-1 sec. break
516	s	* break	HX-1 sec. break
*			
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 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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
922	s	* rod	annular ss rod

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```

          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

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```

* 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
*      dtsp(1)   dtsp(2)

```


BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```

0.0000e+00 0.0000e+00
* ifsp(1) ifsp(2)
0 0
*
* trips from off to on at time given by setp(2), trips Primary HR pumps
* idtp isrt iset itst idsg
106 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 time given by setp(2), trips HR check valves
* idtp isrt iset itst idsg
107 2 0 1 1
* setp(1) setp(2)
0.0000e+00 1.0000e-06
* dtsp(1) dtsp(2)
0.0000e+00 0.0000e+00
* ifsp(1) ifsp(2)
0 0
*
*****
* component data *
*****
*****
***** type num id ctitle
break 515 515 $515$ break cold leg 1
* jun1 ibty isat ioff
65 1 0 0
* ibtr ibsv nbtr 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 5.0227e+00
* pscl tlsc1 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
* ptb * 1.0000e-01 1.01325e+05s
* ptb * 1.0000e+04 1.01325e+05e
*
*****
***** type num id ctitle
break 516 516 $516$ break cold leg 2
* jun1 ibty isat ioff
66 1 0 0
* ibtr ibsv nbtr 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 tlsc1 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
* ptb * 1.0000e-01 1.01325e+05s

```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
* ptb * 1.0000e+04 1.01325e+05e
*
*****
***** type num id ctitle
fill 767 767 $767$ pressurizer boundary
* jun1 ifty ioff
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 6.0000e+02 1.0000e+01
* edint gfint dmpint sedint
10.0000e+00 5.0000e+00 1.0000e+06 1.0000e+06
*
* endflag
-1.0000e+00
```

Appendix D: TRAC Graphics Input File for LOCA Case 1 (with Beam Shutdown and Active RHR)

The file listed below represents the TRAC code "graphin" file that corresponds to the LOCA Case 1 (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 /
  143
/ 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 before break
  173             2         0           1      Module 2 pipe before break
  415             2         0           1      Module 3 pipe before break
  485             2         0           1      Module 4 pipe before break
  513             2         0           1      Module 5 pipe before break
  541             2         0           1      Module 6 pipe before break

  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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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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536	1	1	1	Module 6 Outlet Plenum
26	1	0	1	Hot leg pump suction line
22	7	0	1	Hot leg pump suction line near break
20	1	0	1	Hot leg pump suction line near break
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
37	1	0	1	PCL Pump to HX
48	3	0	1	PCL Hx 1 inlet
52	2	0	1	PCL Hx 1 middle
56	1	0	1	PCL Hx 1 outlet
49	2	0	1	PCL Hx 2 inlet
53	2	0	1	PCL Hx 2 middle
57	3	0	1	PCL Hx 2 outlet
713	4	0	1	PCL Hx 1 secondary side outlet
710	1	0	1	PCL Hx 1 secondary side inlet fill
733	4	0	1	PCL Hx 2 secondary side outlet
730	1	0	1	PCL Hx 2 secondary side inlet fill
62	1	0	1	Cold leg Hx discharge line
66	6	0	1	Cold leg Hx discharge line near break
68	1	0	1	Cold leg Hx discharge line near break
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
671	4	0	1	RHR Hx secondary side outlet
672	1	0	1	RHR Hx secondary side inlet fill
761	1	0	1	Pzr Pressure Signal
765	1	0	1	Pzr Bottom Pressure
765	5	0	1	Pzr Bottom Pressure
766	1	0	1	Pzr Bottom Pressure
951	1	3	1	Hot Module (1) upflow inside
951	3	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	3	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	3	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	3	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	3	3	1	Hot Module (3) upflow inside
961	5	3	1	Hot Module (3) upflow outside
961	1	3	2	Hot Module (3) upflow outside
961	3	3	2	Hot Module (3) upflow outside
961	5	3	2	Hot Module (3) upflow outside

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962	1	3	1	Hot Module (4) upflow inside
962	3	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	3	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	3	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	3	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	3	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	3	3	2	Hot Module (6) upflow outside
965	5	3	2	Hot Module (6) upflow outside
984	1	3	2	Module 1 downflow Al 1
984	3	3	2	Module 1 downflow Al 3
984	5	3	2	Module 1 downflow Al 5
901	1	3	2	Module 1 upflow Al 1
901	3	3	2	Module 1 upflow Al 3
901	5	3	2	Module 1 upflow Al 5
916	1	3	2	Module 2 downflow Al 1
916	3	3	2	Module 2 downflow Al 3
916	6	3	2	Module 2 downflow Al 6
905	1	3	2	Module 2 upflow Al 1
905	3	3	2	Module 2 upflow Al 3
905	6	3	2	Module 2 upflow Al 6
988	1	3	2	Module 3 downflow Al 1
988	3	3	2	Module 3 downflow Al 3
988	5	3	2	Module 3 downflow Al 5
911	1	3	2	Module 3 upflow Al 1
911	3	3	2	Module 3 upflow Al 3
911	5	3	2	Module 3 upflow Al 5
931	1	3	2	Module 4 downflow Al 1
931	3	3	2	Module 4 downflow Al 3
931	6	3	2	Module 4 downflow Al 6
912	1	3	2	Module 4 upflow Al 1
912	3	3	2	Module 4 upflow Al 3
912	6	3	2	Module 4 upflow Al 6
932	1	3	2	Module 5 downflow Al 1
932	3	3	2	Module 5 downflow Al 3
932	6	3	2	Module 5 downflow Al 6
913	1	3	2	Module 5 upflow Al 1
913	3	3	2	Module 5 upflow Al 3
913	6	3	2	Module 5 upflow Al 6

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)

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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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/m ³)
vl	- Liquid phasic velocity at cell face (m/s)
Pa	- Cell center pressure (Pa)
qf	- Liquid volumetric flowrate at cell face (m ³ /s)
void	- Gas void fraction (-)
Qg	- Gas volumetric flowrate at cell face (gpm)
qg	- Gas volumetric flowrate at cell face (m ³ /s)
tv	- Gas phase temperature (C)
rov	- Gas phase density (kg/m ³)
vv	- Gas phasic velocity at cell face (m/s)
pair	- Partial pressure of non-condensable in gas phase (psia)

Appendix E: FLOWTRAN-TF Input File for LOCA Case 1 (with Beam Shutdown and Active RHR)

Below is an abridged listing of the FLOWTRAN-TF input deck for LOCA Case 1. 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 1 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,      dtsmin,      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,    dtprt
! 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)
! istory: 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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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```

! 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)

```


BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```

!      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                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      1                                     !>
! 53      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  xfric,  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)/
! ppl0: multiplier to P transient profile
! ippl: P transient identifier
! alpp10: multiplier to alpha transient profile
! ialp1: alpha transient identifier
! tfpl0: multiplier to Tf transient profile
! itfpl: Tf transient identifier
! tgpl0: multiplier to Tg transient profile
! itgpl: Tg transient identifier
! xapl0: multiplier to Xa transient profile
! ixapl: Xa transient identifier

! ppl0, ippl
584133.9 8 !>
! alpp10, ialp1
1.0 10 !>
! tfpl0, itfpl
59.85 9 !>
! tgpl0, itgpl
59.85 9 !>
! xapl0, 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
685997.1 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

```

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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
!-----
!      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
```

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(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

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	7.37075E-01
1.02	5.72705E-01
1.52	4.40728E-01
2.02	3.63497E-01
2.52	3.06184E-01
3.02	2.61426E-01
3.52	2.03020E-01
4.02	1.79780E-01
4.52	1.59863E-01
5.02	1.30665E-01
5.52	1.25023E-01
6.02	1.29952E-01
6.52	1.33560E-01
7.02	1.36582E-01
7.52	1.37488E-01
8.02	1.34386E-01
8.52	1.29507E-01
9.02	1.31412E-01
9.53	1.26434E-01
20.01	2.64245E-01
30.01	2.86157E-01
40.02	2.71281E-01
50.02	1.89285E-01
60.02	1.08393E-01
70.02	4.13263E-02
80.02	-1.12396E-01
90.03	1.49038E-03
120.00	1.74915E-02
140.04	2.20894E-02
160.06	1.73916E-02
180.07	3.28674E-02
200.09	3.25850E-02
220.10	3.76668E-02
240.14	3.70127E-02
260.14	3.74400E-02
280.17	3.57250E-02
300.19	3.34945E-02
320.23	3.50223E-02
340.26	3.58246E-02
360.29	3.80585E-02
380.31	3.48329E-02
400.34	3.07494E-02
420.35	3.13773E-02
440.36	3.58999E-02
460.37	3.79180E-02
480.39	3.86266E-02
500.42	3.91022E-02
520.46	3.89507E-02
540.48	3.92542E-02
560.49	3.69746E-02

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

580.51 3.91763E-02
600.03 4.03917E-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	3.13006E-01
1.02	2.69423E-01
1.52	2.58280E-01
2.02	2.47588E-01
2.52	2.45093E-01
3.02	2.42694E-01
3.52	2.41161E-01
4.02	2.36852E-01
4.52	2.33622E-01
5.02	2.30332E-01
5.52	2.27153E-01
6.02	2.24667E-01
6.52	2.21809E-01
7.02	2.19068E-01
7.52	2.16493E-01
8.02	2.14207E-01
8.52	2.11586E-01
9.02	2.10323E-01
9.53	2.07822E-01
20.01	2.23118E-01
30.01	2.19285E-01
40.02	2.28741E-01
50.02	2.84879E-01
60.02	3.05118E-01
70.02	3.10892E-01
80.02	2.99240E-01
90.03	3.00311E-01
120.00	3.11879E-01
140.04	3.13513E-01
160.06	3.14246E-01
180.07	3.15426E-01
200.09	3.15361E-01
220.10	3.15948E-01
240.14	3.15458E-01
260.14	3.14933E-01
280.17	3.15613E-01
300.19	3.16148E-01
320.23	3.16002E-01
340.26	3.16008E-01
360.29	3.15969E-01
380.31	3.15699E-01
400.34	3.15499E-01
420.35	3.15530E-01
440.36	3.15530E-01
460.37	3.15476E-01
480.39	3.15465E-01
500.42	3.15408E-01
520.46	3.15321E-01
540.48	3.15315E-01
560.49	3.14242E-01
580.51	3.10917E-01

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
600.03      3.08995E-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      9.99812E-01
1.02      9.97549E-01
1.52      9.92271E-01
2.02      9.85674E-01
2.52      9.78888E-01
3.02      9.72667E-01
3.52      9.67012E-01
4.02      9.61923E-01
4.52      9.57399E-01
5.02      9.53629E-01
5.52      9.50236E-01
6.02      9.47031E-01
6.52      9.44015E-01
7.02      9.41188E-01
7.52      9.38549E-01
8.02      9.35721E-01
8.52      9.33082E-01
9.02      9.30443E-01
9.53      9.27804E-01
20.01     8.52592E-01
30.01     7.72667E-01
40.02     7.56833E-01
50.02     7.56456E-01
60.02     7.60226E-01
70.02     7.66070E-01
80.02     7.70217E-01
90.03     7.77945E-01
120.00    7.80019E-01
140.04    7.85674E-01
160.06    7.94156E-01
180.07    8.02639E-01
200.09    8.05844E-01
220.10    8.08294E-01
240.14    8.11310E-01
260.14    8.12441E-01
280.17    8.10933E-01
300.19    8.08483E-01
320.23    8.06032E-01
340.26    8.03582E-01
360.29    8.01131E-01
380.31    7.98869E-01
400.34    7.97550E-01
420.35    7.96795E-01
440.36    7.96230E-01
460.37    7.95099E-01
480.39    7.93591E-01
500.42    7.92271E-01
520.46    7.91329E-01
540.48    7.90575E-01
560.49    7.90198E-01
580.51    7.89821E-01
600.03    7.89255E-01
```


BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
!-----
!  
/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  
!      1.02      0.00000E+00  
!      1.52      0.00000E+00  
!      2.02      0.00000E+00  
!      2.52      0.00000E+00  
!      3.02      0.00000E+00  
!      3.52      0.00000E+00  
!      4.02      0.00000E+00  
!      4.52      0.00000E+00  
!      5.02      0.00000E+00  
!      5.52      0.00000E+00  
!      6.02      0.00000E+00  
!      6.52      0.00000E+00  
!      7.02      0.00000E+00  
!      7.52      0.00000E+00  
!      8.02      0.00000E+00  
!      8.52      1.00000E-04  
!      9.02      2.00000E-04  
!      9.53      3.00000E-04  
!      20.01      3.00000E-04  
!      30.01      1.24400E-01  
!      40.02      9.03000E-02  
!      50.02      5.38000E-02  
!      60.02      1.00000E-04  
!      70.02      0.00000E+00  
!      80.02      0.00000E+00  
!      90.03      0.00000E+00  
!      120.00      0.00000E+00  
!      140.04      0.00000E+00  
!      160.06      0.00000E+00  
!      180.07      1.00000E-04  
!      200.09      3.00000E-04  
!      220.10      4.00000E-04  
!      240.14      1.00000E-04  
!      260.14      1.00000E-04  
!      280.17      1.00000E-04  
!      300.19      2.00000E-04  
!      320.23      2.00000E-04  
!      340.26      1.00000E-04  
!      360.29      0.00000E+00  
!      380.31      0.00000E+00  
!      400.34      0.00000E+00  
!      420.35      0.00000E+00  
!      440.36      0.00000E+00  
!      460.37      0.00000E+00  
!      480.39      0.00000E+00  
!      500.42      0.00000E+00  
!      520.46      0.00000E+00  
!      540.48      0.00000E+00  
!      560.49      0.00000E+00  
!      580.51      0.00000E+00  
!      600.03      0.00000E+00  
!-----
```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
!
/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      2.50861E-01
!      1.02      2.22476E-01
!      1.52      2.20327E-01
!      2.02      2.14822E-01
!      2.52      2.15736E-01
!      3.02      2.15683E-01
!      3.52      2.15508E-01
!      4.02      2.12236E-01
!      4.52      2.09993E-01
!      5.02      2.07579E-01
!      5.52      2.05103E-01
!      6.02      2.03405E-01
!      6.52      2.01191E-01
!      7.02      1.99066E-01
!      7.52      1.97105E-01
!      8.02      1.95400E-01
!      8.52      1.93301E-01
!      9.02      1.92488E-01
!      9.53      1.90516E-01
!      20.01     2.05297E-01
!      30.01     2.00961E-01
!      40.02     2.14693E-01
!      50.02     2.84857E-01
!      60.02     3.08627E-01
!      70.02     3.16326E-01
!      80.02     3.04782E-01
!      90.03     3.04218E-01
!      120.00    3.17855E-01
!      140.04    3.19678E-01
!      160.06    3.20636E-01
!      180.07    3.21853E-01
!      200.09    3.21763E-01
!      220.10    3.22400E-01
!      240.14    3.21837E-01
!      260.14    3.21201E-01
!      280.17    3.22027E-01
!      300.19    3.22690E-01
!      320.23    3.22489E-01
!      340.26    3.22475E-01
!      360.29    3.22411E-01
!      380.31    3.22135E-01
!      400.34    3.21936E-01
!      420.35    3.21959E-01
!      440.36    3.21907E-01
!      460.37    3.21816E-01
!      480.39    3.21787E-01
!      500.42    3.21713E-01
!      520.46    3.21610E-01
!      540.48    3.21593E-01
!      560.49    3.20371E-01
!      580.51    3.16426E-01
!      600.03    3.14162E-01
!-----
!
```

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

/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
1.02	9.98830E-01
1.52	9.95656E-01
2.02	9.91145E-01
2.52	9.85631E-01
3.02	9.79616E-01
3.52	9.72932E-01
4.02	9.65915E-01
4.52	9.58897E-01
5.02	9.51880E-01
5.52	9.44862E-01
6.02	9.38179E-01
6.52	9.31830E-01
7.02	9.25815E-01
7.52	9.20134E-01
8.02	9.15121E-01
8.52	9.10276E-01
9.02	9.06099E-01
9.53	9.02089E-01
20.01	8.45113E-01
30.01	7.36174E-01
40.02	6.83041E-01
50.02	6.76692E-01
60.02	6.76859E-01
70.02	6.78363E-01
80.02	6.79198E-01
90.03	6.92063E-01
120.00	6.91395E-01
140.04	6.96909E-01
160.06	7.06266E-01
180.07	7.18630E-01
200.09	7.27151E-01
220.10	7.32665E-01
240.14	7.35840E-01
260.14	7.37678E-01
280.17	7.38847E-01
300.19	7.39515E-01
320.23	7.39348E-01
340.26	7.38346E-01
360.29	7.36174E-01
380.31	7.33667E-01
400.34	7.31495E-01
420.35	7.29992E-01
440.36	7.28989E-01
460.37	7.27485E-01
480.39	7.25480E-01
500.42	7.23308E-01
520.46	7.21303E-01
540.48	7.19465E-01
560.49	7.18129E-01
580.51	7.17126E-01
600.03	7.16291E-01

!-----

!

/DATA SET NUMBER 10/

BLANKET SAFETY ANALYSES FOR LOCA

(CASE 1: EXTERNAL HR BREAK NEAR INLET HEADER)

```
!-----
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
!      1.02      0.00000E+00
!      1.52      0.00000E+00
!      2.02      0.00000E+00
!      2.52      0.00000E+00
!      3.02      0.00000E+00
!      3.52      0.00000E+00
!      4.02      0.00000E+00
!      4.52      0.00000E+00
!      5.02      0.00000E+00
!      5.52      0.00000E+00
!      6.02      0.00000E+00
!      6.52      0.00000E+00
!      7.02      0.00000E+00
!      7.52      0.00000E+00
!      8.02      0.00000E+00
!      8.52      0.00000E+00
!      9.02      0.00000E+00
!      9.53      0.00000E+00
!      20.01      4.00000E-04
!      30.01      2.76400E-01
!      40.02      1.48400E-01
!      50.02      1.33600E-01
!      60.02      4.51000E-02
!      70.02      1.11000E-02
!      80.02      6.50000E-03
!      90.03      8.50000E-03
!      120.00      1.70000E-03
!      140.04      8.00000E-04
!      160.06      4.00000E-04
!      180.07      2.00000E-04
!      200.09      1.00000E-04
!      220.10      2.00000E-04
!      240.14      4.00000E-04
!      260.14      3.00000E-04
!      280.17      2.00000E-04
!      300.19      1.00000E-04
!      320.23      1.00000E-04
!      340.26      2.00000E-04
!      360.29      2.00000E-04
!      380.31      1.00000E-04
!      400.34      1.00000E-04
!      420.35      0.00000E+00
!      440.36      0.00000E+00
!      460.37      0.00000E+00
!      480.39      0.00000E+00
!      500.42      0.00000E+00
!      520.46      0.00000E+00
!      540.48      0.00000E+00
!      560.49      0.00000E+00
!      580.51      0.00000E+00
!      600.03      0.00000E+00
!-----
/END OF INPUT FILE/
```