Calculation of Byron D4 SG Tube Support Plate Differential Pressures during MSLB with RELAP5M2

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Abstract

The purpose of this calculation is to perform and document an independent assessment of the Westinghouse calculations generated to provide structural loadings on the steam generator tube support plates during limiting transient conditions. The Main steam line break (MSLB) event from hot zero power was determined by the vendor to yield the highest differential pressures across the support plates. The vendor utilized the TRANFLO code for the initial work, and validated their results using the MULTIFLEX computer code. This assessment utilizes the RELAP5M2 computer code to analyze the limiting transient and determine the peak differential pressures seen at the most highly loaded TSP for comparison to the vendor predictions.

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1. Introduction

During a main steam line break event, the rapid blowdown of the faulted steam generator can lead to significant loads on the tube support plates. Westinghouse has performed transient thermal hydraulic calculations on the Byron 1/Braidwood 1 Model D4 steam generators in support of structural calculations regarding the extent of tube support plate deformation. As a result of questions that arose during licensing review of the vendor methodology, it was determined that an independent assessment of the limiting TSP differential pressures be performed in-house using the RELAP5 computer code. This report documents the models created for this purpose and details the results obtained.

2. Methodology/Model Description and Assumptions

2.1 Computer Code

The RELAP5M2 cycle 36.05 computer code as implemented on the ComEd IBM mainframe was employed for this calculation. This code has been installed and verified for use in controlled analysis. This computer code has the ability to model full non-equilibrium conditions, and employs a six equation/ two fluid model. This code has been extensively tested in LOCA type calculations, and has been used for licensing applications by vendors and utilities.

2.2 RELAP5M2 Model of D4 Steam Generator

The model developed for use in this calculation is depicted in Figure 1. This model is based heavily on the TRANFLO input description provided by Westinghouse. The primary side of the model used a nodalization essentially identical to that used by Westinghouse. Key secondary side flowpaths have been checked to ensure that appropriate values of inertia and pressure drop information are being consistently applied. Calculations of fluid path inertia and loss coefficients of the principal flow paths for the TRANFLO model and the corresponding RELAP input are provided in Appendix B. As can be seen, the RELAP model uses consistent, and slightly conservative values.

2.3 Initial Conditions

The vendor calculations indicate that the limiting case occurs at hot zero power conditions with water levels at normal values. The water level is at 487" , just below the swirl vanes in the separators. The temperature of the water and steam are uniform at 557 F, and saturation conditions are assumed. The primary system is at equilibrium conditions with the steam generator. The primary system is modeled with time dependent boundary conditions that specify the hot leg temperature to be constant at 557 F. It should be noted that setting initial conditions for the partially voided volumes required some effort, since RELAP requires specification of fluid quality, but the value needed is void fraction. Inspections of resultant void fractions, and total SG mass were helpful in adjusting the model to start at the correct liquid levels.

2.4 Break Model

The break is modeled using a motor valve component with an opening rate of 1 millisecond. The generator nozzle is specifically modeled to provide appropriate treatment of fluid inertia and flow limitation. The break is assumed to occur directly outside the nozzle.

2.5 Tube Support Plate Differential Pressure Calculation

The calculation of tube support plate differential pressure was accomplished by subdividing the pipe component representing the upper section of the steam generator to include thin (.2 ft) volumes on either side of the support plate. The pressure difference between these volumes was then calculated via a control variable to provide the time dependent differential pressure. This method was applied on the uppermost support plate (P) since the vendor calculations indicated that this plate experienced the highest loads. This will lead to slight conservative overprediction of the differential pressures (about 0.12 psi) across the TSP since the elevation head is not being compensated out.

2.6 Calculation of Crossflow Resistance

A review of the Westinghouse input/output for TRANFLO indicated that a crossflow resistance across the tube bundle was accounted for. An independent approach for calculating the crossflow resistance was developed based on the Zukauskus correlation as presented in Reference 2. The results of this correlation were compared to Westinghouse at the .57 second output edit, and showed comparable pressure drops. The pressure drop information calculated in this way was then converted into K-values to be added as crossflow corrections at selected junctions. This approach was used for the upper tube region(135-5) , downcomer entrance (100), and preheater (133) areas.

3. Calculations

3.1 Base Case

The base case performed is the full MSLB from Hot Zero Power Conditions. The water level is assumed to be at normal levels (487"). Comparisons to be performed include tube support plate (TSP) P differential pressure vs time and break flow rate. The full non-equilibrium two fluid model capability is utilized for this case. The default separator performance curves are applied.

3.2 Equilibrium Conditions Calculation

This case is essentially identical to the base case with two exceptions. The equilibrium switch in the volume descriptions is set to 1 to force equilibrium temperatures between phases. The other change is to set the h flag (VCAHS) in the junction description to 2 to force the code to adopt a single momentum equation at junctions. All other input remains identical. This case tests the sensitivity of the results to the two phase fluid model used.

3.3 Sensitivity Calculations

Several additional cases were run to assess the sensitivity of the base case model to variance in input parameters.

3.3.1 Separator Performance

The first set of sensitivity runs looked at the RELAP5 separator modeling of carryover/carryunder fractions. The base case used the default separator performance values (Vover=.5, Vunder=.15). Values of Vover ranging from 0.25 to 1.0 were input with default Vunder. Then Vunder was varied from the default value of 0.15 to 0.45, while holding Vover at its 0.5 default value.

3.3.2 TSP Loss Coefficient

In order to assess the appropriateness of the differential pressure modeling of the upper support plate, the loss coefficient for the P TSP were varied plus and minus 10%. This allows the determination of whether the pressure drop is due to two-phase effects, or just the plate frictional losses by comparing the relative change in the differential pressures from the base case.

3.3.3 Flow Area/Inertia of Preheater Section

The junction flow areas of the base case preheater section ignored the bypass flow areas through the TSP for conservatism. An additional run was performed to determine the effect of adding this area to the existing model.

4. Results

4.1 Base Case

The base case was evaluated out to 10 seconds into the blowdown to ensure that the key load causing aspects of the MSLB were included. The base case resulted in a peak pressure of 1.97 psi across the P-TSP (Note that this includes an overprediction of approximately .12 psi, as do all the results presented). The results of the base case are depicted in Figures 2 through 7. The dome pressure is shown in Figure 2. As can be seen, the pressure drops rapidly initially and then moderates to rates of approximately 100 psi/sec or less within .2 seconds. Break mass flow rate is shown in Figure 3. Break flow is initially all steam, with entrained liquid reaching the break at approximately .7 seconds, causing an increase in the mass flow rate. The differential pressure across the P-TSP is shown in Figure 4. This shows a peak occurs about 0.5 to 0.8 seconds followed by a rapid decay to near steady-state conditions. The liquid velocity at the P-TSP is provided in Figure 5, and the corresponding liquid void fraction is shown in Figure 6. The liquid void fraction remains relatively high throughout the peak dynamic load period, and review of the flow regimes predicted indicates bubbly flow persists until after the peak load occurs. Figure 7 demonstrates the vapor void fractions at the P-TSP and at the J-TSP lower down in the boiling section. As can be seen, the void fractions remain relatively close to each other throughout the blowdown. This tends to support that the principal flow pattern is cocurrent, at least for these locations. A review of the liquid and vapor temperatures indicates that some non-equilibrium behavior is seen in the upper nodes of the model, with steam temperatures being approximately 10 degrees lower than the liquid in the early portions of the blowdown.

4.2 HEM Comparison Calculation

The model used for the base case, modified as described in section 3.2 to force equilibrium, single equation momentum calculation resulted in a reduction in peak pressure drop at the P-TSP location. The peak pressure reached on this case was 1.35 psi across the P-TSP. The principal value of this case is to indicate the range of sensitivity of the differential pressure with respect to two-phase fluid flow models. This supports that the two phase calculational uncertainty is bounded in the range of .5 psi or approximately 30%.

4.3 Results of Sensitivity Cases

4.3.1 Separator Model Sensitivity

The values of separator carryover and carryunder fractions were varied over a range of values to determine what impact the separator model has on the results. The values utilized and the corresponding results are displayed in Table 1. As can be seen, there is very little sensitivity to separator model inputs. This is most likely a result of early flooding of the separator, causing the separator model to shift to "same in/same out" behavior. The carryunder fraction is most likely insensitive due to flow reversal effects.

Case	Vover	Vunder	Max DP at P-TSP
3	.75	.15	2.087
4	1.0	.15	2.161
5	.25	.15	1.99
6	.5	.3	1.97
7	.5	.45	1.97

Table 1 Results of Separator Parametric Sensitivity

4.3.2 Effects of TSP Loss Coefficient

The loss coefficients for the P-TSP were varied by plus and minus 10%. The results are shown in Table 2. The results are as one would expect, with almost linear behavior of pressure drop with respect to loss coefficient.

Case	K	Max DP at P-TSP
8	1.19	2.15
9	.972	1.76
Base	1.08	1.97

Table 2 Sensitivity to TSP Loss Coefficient

4.3.3 Addition of Preheat Bypass Area

This case directly added the bypass area modeled by Westinghouse to the main flow paths in the preheater section. This bypass is not modeled in the base case, since it was felt that it represented a minor impact. The effect on peak pressure across P-TSP was a very small increase to 1.974 psi, from 1.97 psi. This confirms the initial model assumption with respect to this flow path.

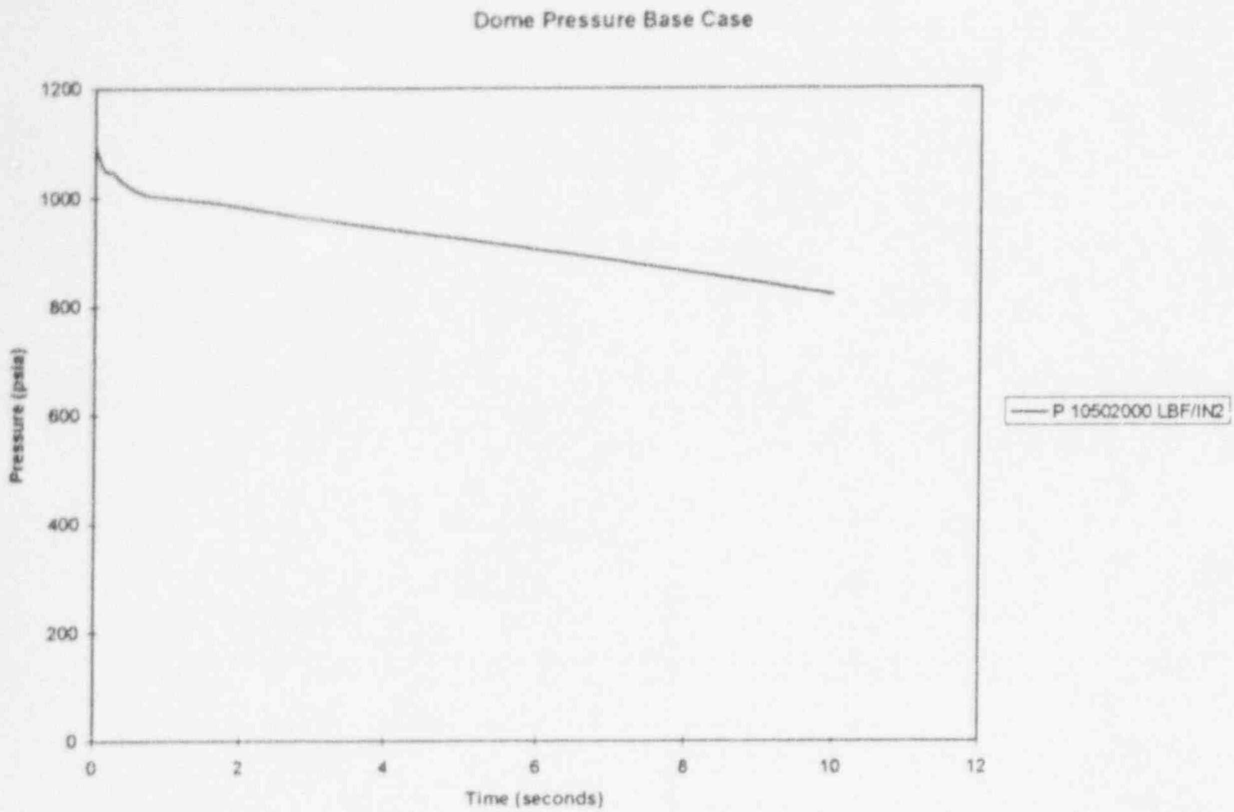

Figure 2 Dome Pressure Response Base Case

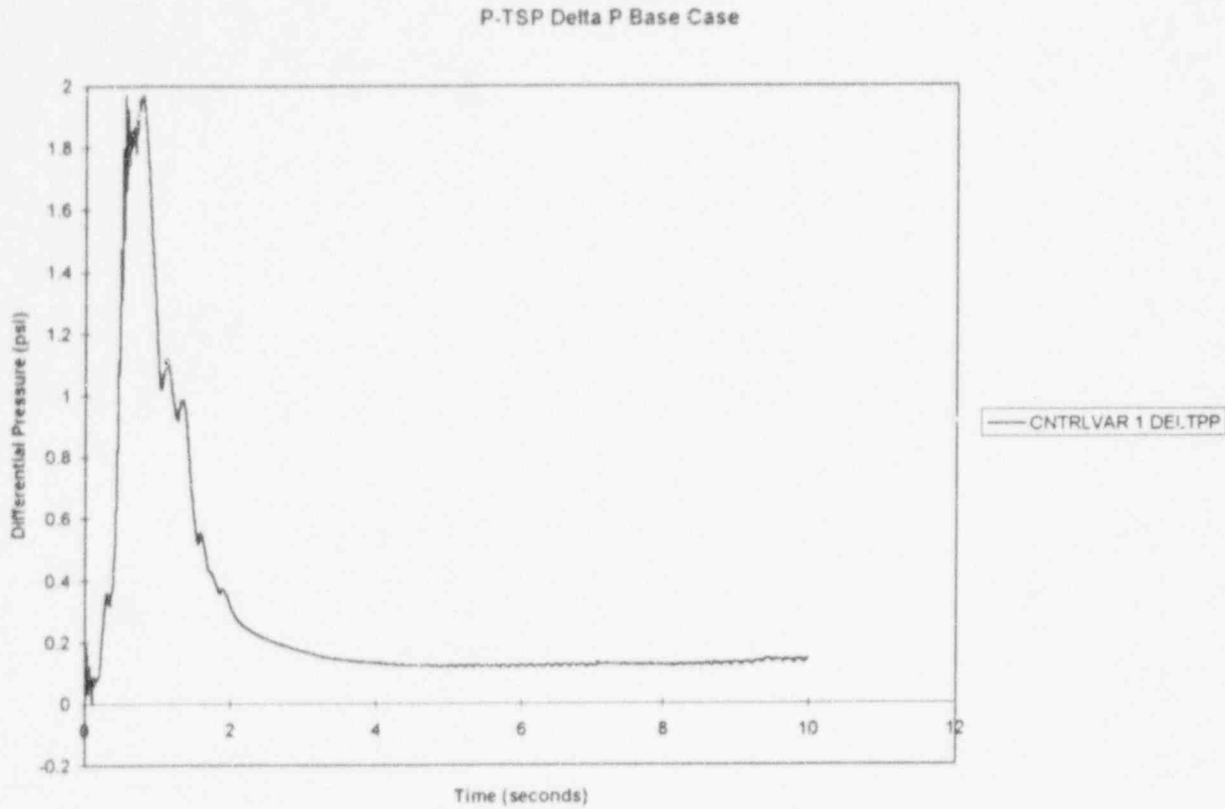

Figure 4 P-TSP Differential Pressure Base Case

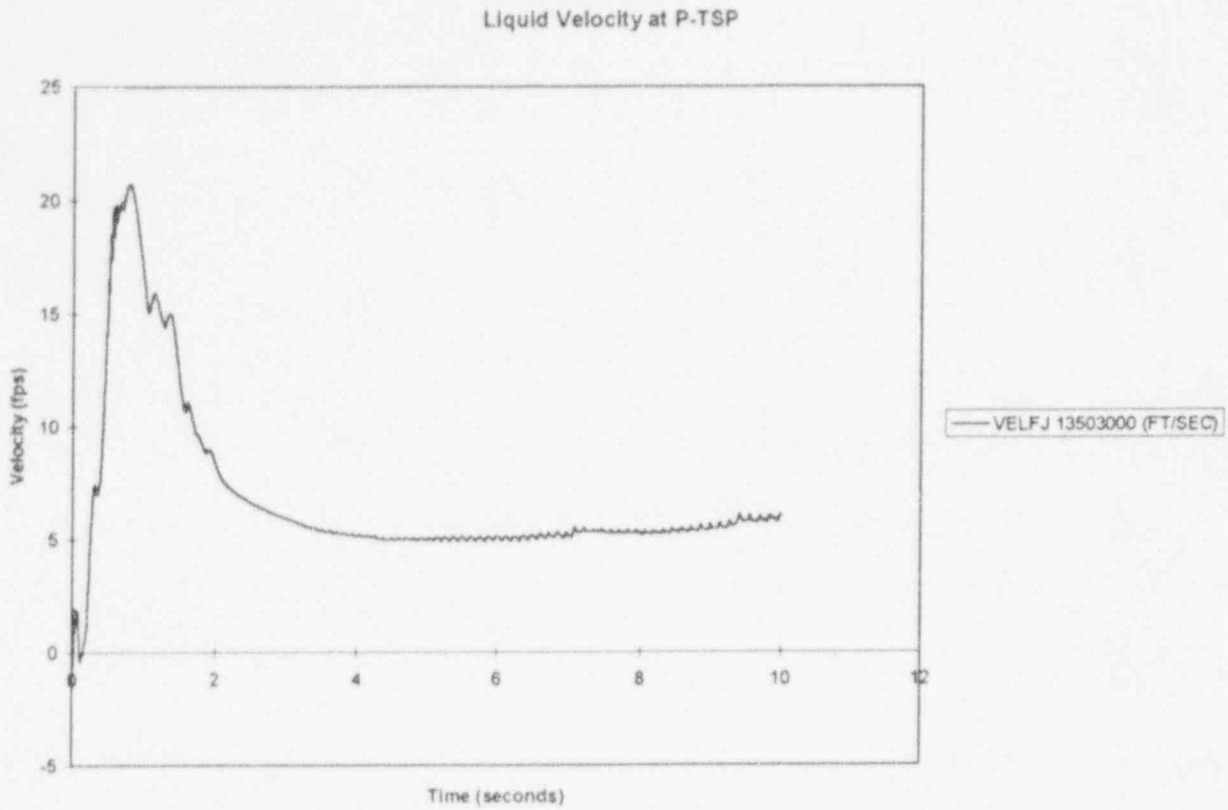

Figure 5 Liquid Velocity at P-TSP Base Case

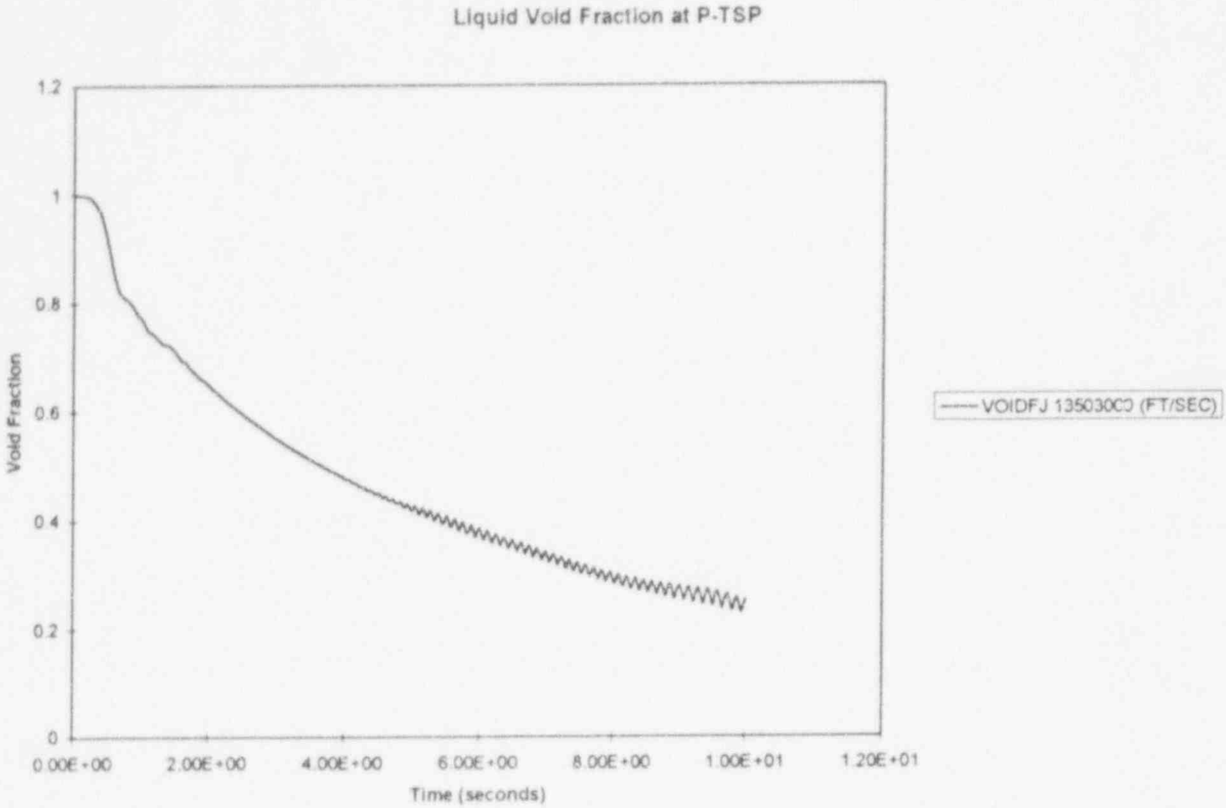

Figure 6 Liquid Void Fraction at P-TSP Base Case

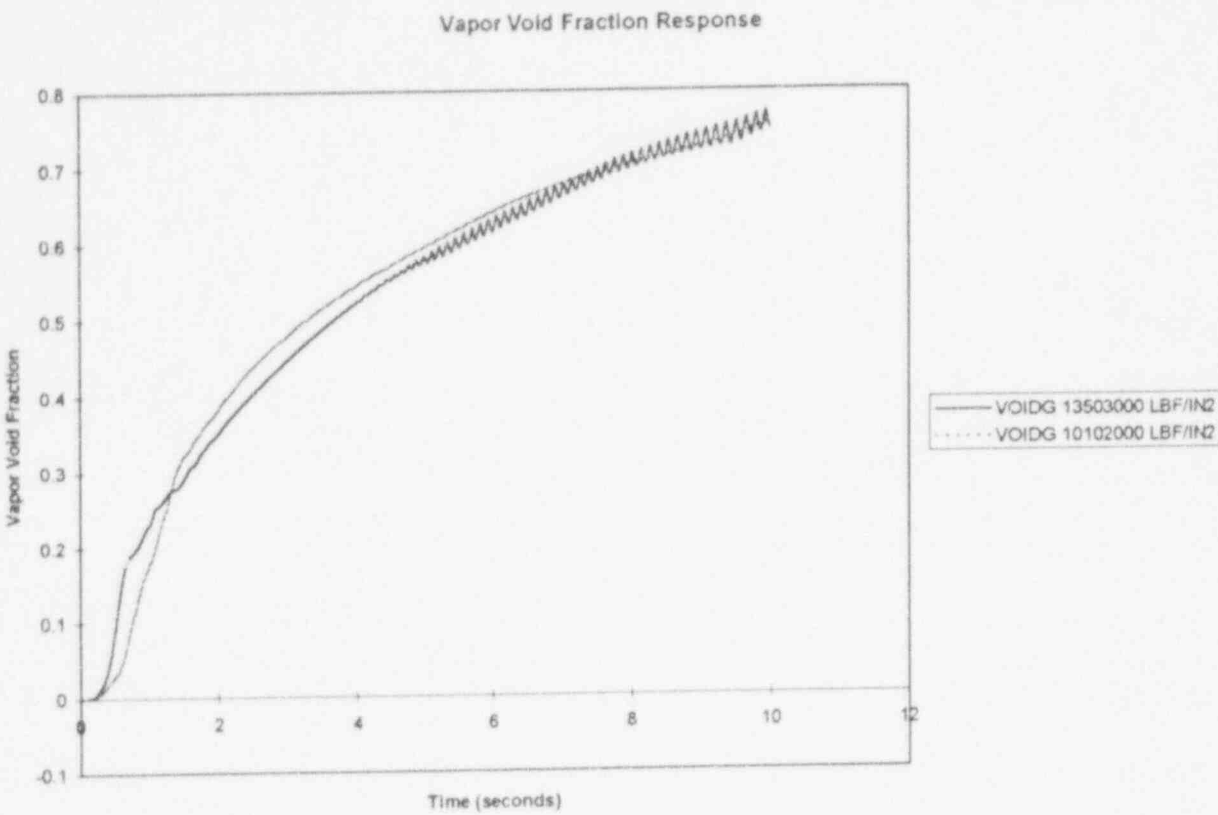

Figure 7 Vapor Void Fractions at P-TSP and J-TSP

5. Conclusions/Discussion

The peak pressure at the P-TSP has been calculated using RELAP5M2 with a model geometry comparable to that used by Westinghouse. The pressure calculated agrees fairly well with that calculated by Westinghouse (1.9 vs 1.6 psi at P-TSP). The variation between the codes can be attributed to the different constitutive models used, two-fluid by RELAP vs a drift flux formulation in TRANFLO. When a factor of two is applied to the TRANFLO results, it conservatively bounds the maximum values calculated by RELAP5M2.

6. References

1) TRANFLO Input Description for D4 Steam Generator

2) "Nuclear Systems I", N. Todreas and M. Kazimi, 1990.

Appendix A - Microfiche Index

Microfiche ID	# of fiche	Description
NFSKR1	1	Base Case
NFSKR2		HEM case
NFSKR3		Separator Sensitivity
NFSKR4		Separator Sensitivity
NFSKR5		Separator Sensitivity
NFSKR6		Separator Sensitivity
NFSKR7		Separator Sensitivity
NFSKR8		K Sensitivity
NFSKR9		K Sensitivity
NFSKR0		Preheat Bypass area

Appendix B RELAP5 Input Deck and Verification Sheets

Summary of Principal Path Nozzle to TSP Parameters for TRANFLO D4 Model								
Junction	Segment	Area	Length	K	L/A	K/A2	Hyd dia	calc hyd d
23	1	129.35	1.77625	0	0.013732122	0	12.83	12.83369
	2	1.388	1.5	0	1.080691643	0	0.5025	1.329423
	3		0.5	0	0.1	0	2.45	2.52321
24	1	74.94	3.7242	0	0.049695757	0	11.02	9.76844
	2	129.35	1.77625	0	0.013732122	0	12.83	12.83369
25	1	179.54	0.37	40	0.002060822	0.001240902	0.0417	15.1199
	2	63.49	3.725	0.5	0.058670657	0.000124039	11.02	8.99127
28	1	70.75	3.725	0.5	0.052650177	9.98889E-05	3.92	9.491429
	2	179.54	0.37	0	0.002060822	0	0.0417	15.1199
29	1	152.67	1.1146	0	0.007300714	0	14.04	13.94265
	2	77.74	3.78	0	0.048623617	0	4.07	9.949257
30	1	24.89	0.6354		0.025528325	0	1.625	5.629643
	2	11.49	0.25	0.86	0.02175805	0.00651416	1.1042	3.824973
	3	152.67	1.1146	0	0.007300714	0	14.04	13.94265
37	1	24.89	6.2148	0	0.249690639	0	1.625	5.629643
	2	22.01	0.25	13.9	0.011358473	0.028692918	1.0729	5.293932
	3	24.89	0.6979	0	0.028039373	0	1.625	5.629643
38	1	92.13	3.59375	0	0.039007381	0	10.82	10.83101
	2	24.89	6.2148	0	0.249690639	0	1.625	5.629643
39	2	16.9996	0.0625	1.08	0.003678557	0.0037372	0.0417	4.652514
	3	36.39	4.25	0	0.116790327	0	0.1234	6.807057
Totals					2.182058931	0.040409108		

Summary of Principal Path Nozzle to TSP Parameter for RELAP5M2 Model								
Volume		Area	Length	K	L/A	K/A2	hyd	
107		1.388	1.5	0	1.080692	0	0.5025	
1051		63.49	7.45	0	0.117341	0	11.02	
1052		98.79	3.55	0	0.035935	0	12.83	
124		171.4	0.708	0	0.004131	0	0.0417	
124-104		70.75		0.5		9.99E-05		
124-105		63.49		5.502		0.001365		
104		70.75	7.45	0	0.1053	0	4.07	
103		151.32	2.35	0	0.01553	0	14.04	
j102-103		11.49	0	0.86	0	0.006514		
103-104		77.74		0		0		
102		25.8121	14.1567	0	0.548452	0	1.625	
j135-102		22.01	0	13.9	0	0.028693		
135		55.25	8.1566	0	0.147631	0	.1234	
j135tsp		16.9996	0	1.08	0	0.003737		
Totals					2.055012	0.040409		

Summary of Separator drain Path Parameters for TRANFLO D4 Model								
Junction	Segment	Area	Length	K	L/A	K/A2	Hyd dia	calc hyd
23	1	129.35	1.77625	0	0.013732	0	12.83	12.83369
	2	1.388	1.5	0	1.080692	0	0.5025	1.329423
	3	5	0.5	0	0.1	0	2.45	2.52321
24	1	74.94	3.7242	0	0.049696	0	11.02	9.76844
	2	129.35	1.77625	0	0.013732	0	12.83	12.83369
25	1	179.54	0.37	40	0.002061	0.001241	0.0417	15.1199
	2	63.49	3.725	0.5	0.058671	0.000124	11.02	8.99127
28	1	70.75	3.725	0.5	0.05265	9.99E-05	3.92	9.491429
	2	179.54	0.37	0	0.002061	0	0.0417	15.1199
29	1	152.67	1.1146	0	0.007301	0	14.04	13.94265
	2	77.74	3.78	0	0.048624	0	4.07	9.949257
30	1	24.89	0.6354		0.025528	0	1.625	5.629643
	2	11.49	0.25	0.86	0.021758	0.006514	1.1042	3.824973
	3	152.67	1.1146	0	0.007301	0	14.04	13.94265
31	1	24.89	0.6979		0.028039	0	1.625	5.629643
	2	19.78	2.9167	0.5	0.147457	0.001278	0.5417	5.018588
32	1	19.78	2.9167	0.5	0.147457	0.001278	0.5417	5.018588
	2	104.07	2.9167	0	0.028026	0	3.1026	11.51148
33	1	104.07	2.9167	0	0.028026	0	3.1026	11.51148
	2	27.91	0.0625	1.28	0.002239	0.001643	0.8333	5.9614
	3	126.49	3.9635	0	0.031334	0	4.51	12.69102
64/34	1	126.5	3.935	0	0.031107	0	4.51	12.69152
	2	5.7356	15.8125	0	2.756904	0	0.3442	2.702451
36/35	1	5.7356	15.8125	0.5	2.756904	0.015199	0.3442	2.702451
	2	3.1184	1.1068	0	0.354926	0	0.1234	1.992665
Totals					7.796226	0.027377		

Summary of Separator Drain path Parameter for RELAP5M2 Model							
Volume		Area	Length	K	L/A	K/A2	hyd
107		1.388	1.5	0	1.080692	0	0.5025
1051		63.49	7.45	0	0.117341	0	11.02
1052		98.79	3.55	0	0.035935	0	12.83
124		171.4	0.708	0	0.004131	0	0.0417
124-104		70.75		0.5		9.99E-05	
124-105		63.49		5.502		0.001365	
104		70.75	7.45	0	0.1053	0	
103		151.32	2.35	0	0.01553	0	14.04
j102-103		11.49	0	0.86	0	0.006514	
103-104		77.74		0		0	
102		25.8121	14.1567	0	0.548452	0	1.625
j111-102		22.01	0	1	0	0.002064	
111		111.07	0.2202	0	0.001983	0	0
j110-111		111.07	0	0	0	0	
111-112		5.7356		0		0	
1121		5.74	2.814292	0	0.490295	0	0.3442
1122		5.74	1.001	0	0.17439	0	0.3442
1123		5.74	6.570134	0	1.144623	0	0.3442
1124		5.74	10.38443	0	1.809134	0	0.3442
1125		5.74	10.38443	0	1.809134	0	0.3442
100		56.45	0.5	0	0.008857	0	
112-100		5.7356	0	0.5	0	0.015199	
Totals					7.345797	0.025242	

Summary of Dryer Drain Path Parameters for TRANFLO D4 Model								
Junction	Segment	Area	Length	K	L/A	K/A2	Hyd dia	calc hyd
23	1	129.35	1.77625	0	0.013732	0	12.83	12.83369
	2	1.388	1.5	0	1.080692	0	0.5025	1.329423
	3	5	0.5	0	0.1	0	2.45	2.52321
24	1	74.94	3.7242	0	0.049696	0	11.02	9.76844
	2	129.35	1.77625	0	0.013732	0	12.83	12.83369
25	1	179.54	0.37	40	0.002061	0.001241	0.0417	15.1199
	2	63.49	3.725	0.5	0.058671	0.000124	11.02	8.99127
26	1	20.36	3.7242	0	0.182917	0	0.6767	5.091635
	2	2.0211	8.1925	0.5	4.053486	0.122404	1.6042	1.604214
27	1	2.0211	8.1925	0.5	4.053486	0.122404	1.6042	1.604214
	2	126.49	3.9635	0	0.031334	0	4.51	12.69102
64/34	1	126.5	3.935	0	0.031107	0	4.51	12.69152
	2	5.7356	15.8125	0	2.756904	0	0.3442	2.702451
36/35	1	5.7356	15.8125	0.5	2.756904	0.015199	0.3442	2.702451
	2	3.1184	1.1068	0	0.354926	0	0.1234	1.992665
Totals					15.53965	0.261371		

Summary of Dryer Drain Path Parameters for RELAP5M2 Model

Volume		Area	Length	K	L/A	K/A2	hyd
107		1.388	1.5	0	1.080692	0	0.5025
1051		63.49	7.45	0	0.117341	0	11.02
1052		98.79	3.55	0	0.035935	0	12.83
124		171.4	0.708	0	0.004131	0	0.0417
124-250		2.0211		0.5		0.122404	
124-105		63.49		5.502		0.001365	
250		2.02	16.5408	0	8.188515	0	
111		111.07	0.2202	0	0.001983	0	0
j250-111		2.02	0	0.5	0	0.122537	
111-112		5.7356		0		0	
1121		5.74	2.814292	0	0.490295	0	0.3442
1122		5.74	1.001	0	0.17439	0	0.3442
1123		5.74	6.570134	0	1.144623	0	0.3442
1124		5.74	10.38443	0	1.809134	0	0.3442
1125		5.74	10.38443	0	1.809134	0	0.3442
100		56.45	0.5	0	0.008857	0	
112-100		5.7356	0	0.5	0	0.015199	
Totals					14.86503	0.261504	

Summary of Principal Path through tube sheets for TRANFLO D4 Model								
Junction	Segment	Area	Length	K	L/A	K/A2	Hyd dia	calc hyd
46	1	28.225	0.25	0	0.008857396	0	0.1234	5.994947
	2	6.4488	0.0625	1.25	0.009691726	0.030057454	0.0093	2.865549
	3	27.9	1.21875	0	0.043682796	0	0.1234	5.960332
45	1	27.9	1.21875	0	0.043682796	0	0.1234	5.960332
	2	8.0485	0.0625	1.1	0.007765422	0.016980981	0.0417	3.201296
	3	27.9	1.46875	0	0.052643369	0	0.1234	5.960332
44	1	27.9	1.46875	0	0.052643369	0	0.1234	5.960332
	2	8.0485	0.0625	1.1	0.007765422	0.016980981	0.0417	3.201296
	3	27.9	1.46875	0	0.052643369	0	0.1234	5.960332
43	1	27.9	1.46875	0	0.052643369	0	0.1234	5.960332
	2	7.8717	0.0625	1.13	0.007939835	0.018236495	0.0417	3.16594
	3	27.9	1.7604	0	0.063096774	0	0.1234	5.960332
42	1	27.9	1.7604	0	0.063096774	0	0.1234	5.960332
	2	7.0398	0.0625	1.2	0.008878093	0.024213669	0.0417	2.993978
	3	27.9	1.7604	0	0.063096774	0	0.1234	5.960332
41	1	56.45	1.7604	0	0.03118512	0	0.1234	8.478135
	2	16.9996	0.0625	1.08	0.003676557	0.0037372	0.0417	4.652514
	3	56.45	1.0604	0	0.018784765	0	0.1234	8.478135
40	1	56.45	1.7604	0	0.03118512	0	0.1234	8.478135
	2	16.9996	0.0625	1.08	0.003676557	0.0037372	0.0417	4.652514
	3	56.45	1.0604	0	0.018784765	0	0.1234	8.478135
39	1	56.45	1.7604	0	0.03118512	0	0.1234	8.478135
	2	16.9996	0.0625	1.08	0.003676557	0.0037372	0.0417	4.652514
	3	36.39	4.25	0	0.116790327	0	0.1234	6.807057
Totals					0.797072172	0.117681182		

Summary of Tube Sheet Path Parameters for RELAP5M2 Model							
Volume		Area	Length	K	L/A	K/A2	hyd
100		56.45	0.5	0	0.008857	0	1.625
j 100-121		6.4488	0	1.25	0	0.030057	0
121		27.9	2.437	0	0.087348	0	1.625
121-101		8.0485		1.1		0.016981	
1011		27.9	3	0	0.107527	0	0.1234
1012		27.9	3	0	0.107527	0	0.1234
1013		27.9	3.5833	0	0.128434	0	0.1234
j12		8.0485	0	1.1	0	0.016981	0
j23		7.8717	0	1.13	0	0.018236	0
134		56.45	3.5208	0	0.06237	0	0.1234
j101-134		7.0398	0	1.2	0	0.024214	
134-135		16.9149		1.08		0.003775	
1351		56.45	3.5833	0	0.063477	0	0.1234
1352		56.45	3.3733	0	0.059757	0	0.1234
1353		56.45	0.11	0	0.001949	0	0.1234
1354		55.25	0.11	0	0.001991	0	0.1234
1355		55.25	8.1566	0	0.147631	0	0.1234
j12		16.9996	0	1.08	0	0.003737	0
j34		16.9996	0	1.08	0	0.003737	0
Totals					0.776868	0.117719	

Summary of Deck plate drain Path Parameters for TRANFLO D4 Model								
Junction	Segment	Area	Length	K	L/A	K/A2	Hyd dia	calc hyd
23	1	129.35	1.77625	0	0.013732	0	12.83	12.83369
	2	1.388	1.5	0	1.080692	0	0.5025	1.329423
	3	5	0.5	0	0.1	0	2.45	2.52321
24	1	74.94	3.7242	0	0.049696	0	11.02	9.76844
	2	129.35	1.77625	0	0.013732	0	12.83	12.83369
25	1	179.54	0.37	40	0.002061	0.001241	0.0417	15.1199
	2	63.49	3.725	0.5	0.058671	0.000124	11.02	8.99127
28	1	70.75	3.725	0.5	0.05265	9.99E-05	3.92	9.491429
	2	179.54	0.37	0	0.002061	0	0.0417	15.1199
29	1	152.67	1.1146	0	0.007301	0	14.04	13.94265
	2	77.74	3.78	0	0.048624	0	4.07	9.949257
62	1	152.67	1.177	0	0.007709	0	14.04	13.94265
	2	7.29	0.0625	1.7	0.008573	0.031988	0.1667	3.046717
	3	104.07	2.9167	0	0.028026	0	3.1026	11.51148
33	1	104.07	2.9167	0	0.028026	0	3.1026	11.51148
	2	27.91	0.0625	1.28	0.002239	0.001643	0.8333	5.9614
	3	126.49	3.9635	0	0.031334	0	4.51	12.69102
64/34	1	126.5	3.935	0	0.031107	0	4.51	12.69152
	2	5.7356	15.8125	0	2.756904	0	0.3442	2.702451
36/35	1	5.7356	15.8125	0.5	2.756904	0.015199	0.3442	2.702451
	2	3.1184	1.1068	0	0.354926	0	0.1234	1.992665
Totals					7.434969	0.050295		

Summary of Deck plate Drain Parameters for RELAP5M2 Model							
Volume		Area	Length	K	L/A	K/A2	hyd
107		1.388	1.5	0	1.080692	0	0.5025
1051		63.49	7.45	0	0.117341	0	11.02
1052		98.79	3.55	0	0.035935	0	12.83
124		171.4	0.708	0	0.004131	0	0.0417
124-104		70.75		0.5		9.99E-05	
124-105		63.49		5.502		0.001365	
104		70.75	7.45	0	0.1053	0	
103		151.32	2.35	0	0.01553	0	14.04
j103-110		11.49	7.29	1.77	0.634465	0.013407	
103-104		77.74		0		0	
110		111.07	14.1567	0	0.127457	0	0
111		111.07	0.2202	0	0.001983	0	0
j110-111		111.07	0	0	0	0	
111-112		5.7356		0		0	
1121		5.74	2.814292	0	0.490295	0	0.3442
1122		5.74	1.001	0	0.17439	0	0.3442
1123		5.74	6.570134	0	1.144623	0	0.3442
1124		5.74	10.38443	0	1.809134	0	0.3442
1125		5.74	10.38443	0	1.809134	0	0.3442
100		56.45	0.5	0	0.008857	0	
112-100		5.7356	0	0.5	0	0.015199	
Totals					7.559267	0.030071	

```
=STAND ALONE STEAM GENERATOR MODEL FOR D4 SG
* HOT STANDBY  NONEQUILIBRIUM MODELS USED
*************************************************
* THIS DECK IS BASED ON WESTINGHOUSE TRANFLOW D4  *
*MODEL USED FOR TUBE SUPPORT PLATE DP CALCULATION *
*************************************************
* This model contains more detail in dome area
*************************************************
*                                    *
*        THIS DATA IS CONTAINED IN           *
*        NFSkr.RELAP5M2.CNTL(basene)         *
* includes two more small nodes at upper tsp   *
* models upper dome with explicit W volumes    *
* Includes .2 ft slabs for P-TSP dp calc       *
* includes crossflow resistances               *
*************************************************
*
*
100 NEW TRANSNT
*
*
102  BRITISH   BRITISH
105
*
*********************************************
*------- TIME STEP CARDS
*
*    END   DTMIN    DTMAX  OPT MIN  MAJ  RSTRT
201    2.5  1.D-7    0.0005  3   5  4000 2500
202    4.0  1.D-7    0.001   3  10   4000 2500
203   10.5  1.D-7    0.001   3  20   4000 2500
*
*
*********************************************
*--------- MINOR EDIT VARIABLES
*
* VARIABLE CODE   PARAMETER   LOCATION
301   VELFJ       135030000  *veloc
302   VOIDFJ       135030000  *void fract
303   RHOFJ       135030000  *density
304   CNTRLVAR    1          *comp dp
305   MFLOWJ      300000000 *Break flow
306   P          105020000  *dome pressure
307   VOIDG       135030000  *void frac
308   VOIDG       101020000  *SG WATER MASS
*
*******************************************
*----------- TRIP INPUT DATA
*
*VARIABLE TRIP CARDS
*  VARIABLE  PARAM   RELATION  VARIABLE PARAM   CONS  LATCH
501  TIME     0      GE      NULL    0      10.0 L
502  TIME     0      GE      NULL    0       .001 L
```

```
503  TIME    0     GE     NULL    0     100.  L
*=====================================================================
*
*-------------------------
*     TRIP IDENTIFIER  |
*                      |
*   501 =>PROBLEM STOP  |
*-------------------------
*
*TRIP STOP ADVANCEMENT CARD
*  TRP NO.
600  501
*********************************************
*----------- HYDRODYNAMIC COMPONENTS
*
*--------------------------------------------
* PRIMARY SIDE MODEL                     |
* PLENUMS AND TUBES MODELLED EXPLICITLY  |
* HOT LEG AND COLD LEG REPRESENTED BY TDVS|
*--------------------------------------------
*
*=================================
0420000  INPLEN     TMDPVOL
*
*      FLOWA   L   VOL   AZI  INCL   DZ  ROUGH HYD FE
0420101  0.0   5.2183 147.64 0.0   0.0   0.0  0.0  0.0 00
0420101  0.0   5.2183 5000.  0.0   0.0   0.0  0.0  0.0 00
*
*     EBT
0420200  3
*
*      TIME  PRESS  TEMP
0420201  0.0  2250.00  557.000
0420202  1.0E6 2250.00  557.000
*=================================
0470000  OUTPLEN     TMDPVOL
*
*      FLOWA   L   VOL   AZI  INCL   DZ  ROUGH HYD FE
0470101  0.0   5.2183 147.64 0.0   0.0   0.0  0.0  0.0 00
0470101  0.0   5.2183 5000.  0.0   0.0   0.0  0.0  0.0 00
*
*     EBT
0470200  3
*
*      TIME  PRESS  TEMP
0470201  0.0  2206.77  557.
0470202  1.0E6 2206.77  557.
```

```
*================================
1510000  TUBES  PIPE
*
*      NV
1510001  21
*
*       FLOWA   NV
1510101  11.0088   21
*
*      LENGTH   NV
1510301    .5625  1
1510302  2.5     2
1510303  3.0     3
1510304  3.5833   8
1510305  3.445    10
1510306  3.5833   14
1510307  1.5      19
1510308  1.0      20
1510309   .5625   21
*
*      VOLUME    NV
1510401    0.0    21
*
*    INCLINE ANGLE    NV
1510601    90.0        8
1510602   90.0         9
1510603  -90.0         10
1510604  -90.0         21
*
*     ELEV CNG      NV
*510701    1.7525     1
*510702    2.5        2
*510703   3.0     3
*510704   3.5833   8
*510705   3.445    9
*510706  -3.445    10
*510707  -3.5833   14
*510708  -1.5      19
*510709  -1.0      20
*510710   -.5625   21
*
*      ROUGH  HYD DIA  NV
1510801   0.0   .0553333  21
*
*      FE   NV
1511001   00   21
*
*     VCAHS NJ
1511101  10000  9
1511102  00000 10
1511103  20000 20
*
*     FLAG   P     T     DUMMY DUMMY DUMMY NV
1511201   3   2250.0  557.0    0.0   0.     0.  21
```

```
*
*     FLAG=1 => (LBM/SEC)
1511300  1
*
*     LFLOW     VFLOW  INTERFACE FLOW      NJ
1511301   9763.12   0.0        0.0          20
*=================================================================
1500000  JUNCT  TMDPJUN
*
*     FROM      TO     AREA
1500101 042000000 151000000    1.0
*
*     FLAG
1500200  1
*
*     TIME   LFLOW     VFLOW   INTFLOW
1500201   0.0    9763.12     0.0    0.0
1500202   1.0E6  9763.12     0.0    0.0
*=================================================================
1590000  JUNCT  SNGLJUN
*
*     FROM      TO     AREA    FJUNF  FJUNR  VCAHS
1590101 151010000 047000000  9.823515   0.0   0.0    20000
*
*     FLAG   LFLOW    VFLOW    INTFLOW
1590201  1      9763.12   0.0      0.0
*=================================================================
*
*
*
*
*-----------------------------------------
* SECONDARY SIDE MODEL                    |
* 90% - 10% FEED FLOW SPLIT               |
* BOUND CNDS REPRESENTED BY TIME DEPENDENT|
* JUNCTIONS AND TME DEPENDENT VOLUMES     |
*-----------------------------------------
*
*=================================================================
9020000  MNFEED  TMDPVOL
*
*     FLOWA FLOWL  VOL   AZI  INCL   DZ  ROUGH HYD  FE
9020101  0.0  31.1533 147.64  0.0  0.0    0.0  0.0  0.0  00
9020101  0.0  31.1533 5000.  0.0  0.0    0.0  0.0  0.0  00
*
*     EBT
9020200  003
*
*     TIME  PRESS  TEMP
9020201  0.0   1200.0  435.0
9020202  1.0E6  1200.0  435.0
*=================================================================
3020000  FLJUN   TMDPJUN
*
```

```
*       FROM       TO      AJUN
3020101 902000000  132000000  1.0
*
*      FLAG
3020200  1
*
*      TIME  LFLOW    VFLOW    INT FLOW
3020201  0.0      0.      0.0       0.0
3020202  1.0E6    0.      0.0       0.0
*=================================================================
1000000  RISER  BRANCH
*
*      NJ   FLAG
1000001  3     1
*
*      FLOWA  FLOWL   VOL   AZI INCL  DZ    ROUGH HYD   FE
1000101  56.45    0.0   28.22  0.0  90.  .4999  .00015  .1234  00
*
*      FLAG   P    X
1000200   2   1119.15  0.00
1000200   1   557.0   0.00
*
*       FROM       TO      AJUN    FJUN  FJUNR  VCAHS
1001101 112010000  100000000  5.7356  .50   .50  00000
*add crossflow resistance
1001101 112010000  100000000  5.7356  41.1  41.1  00000
1002101 100010000  121000000  6.4488  1.25  1.25  10000
1003101 100010000  131000000  6.1798  1.28  1.28  10000
*
*      LFLOW     VFLOW  INT FLOW
1001201    0.0      0.0      0.0
1002201    0.0      0.0      0.0
1003201    0.0      0.0      0.0
*
1210000  RISER1 BRANCH
*
*      NJ   FLAG
1210001  2     1
*
*      FLOWA  FLOWL   VOL   AZI INCL  DZ    ROUGH HYD   FE
1210101  27.9     0.0   68.01  0.0  90.  2.437  .00015  .1234  00
*
*      FLAG   P    X
1210200   2   1118.67  0.00
1210200   1   557.0   0.00
*
*       FROM       TO      AJUN    FJUN  FJUNR  VCAHS
1211101 131000000  121000000  2.7297  .38   0.34  00000
1212101 121010000  101000000  8.0485  1.1    1.1   10000
*
*      LFLOW     VFLOW  INT FLOW
1211201    0.0      0.0      0.0
1212201    0.0      0.0      0.0
*
```

```
1310000  RISER2 BRANCH
*
*     NJ   FLAG
1310001  0     1
*
*     FLOWA  FLOWL   VOL   AZI INCL  DZ    ROUGH HYD   FE
1310101  28.225   0.0   26.46  0.0  90.  0.937  .00015 0.1234  00
*
*     FLAG   P    X
1310200   2  1118.67  0.00
1310200   1   557.00  0.00
*
*      FROM      TO     AJUN   FJUN  FJUNR  VCAHS
*
*     LFLOW    VFLOW  INT FLOW
*==================================
1320000  RISER3 BRANCH
*
*     NJ   FLAG
1320001  2     1
*
*     FLOWA  FLOWL   VOL   AZI INCL  DZ    ROUGH HYD   FE
1320101  27.9     0.0   40.11  0.0  90.  1.437  .00015 0.1234  00
*
*     FLAG   P    X
1320200   2  1118.67  0.00
1320200   1   557.00  0.00
*
*      FROM      TO     AJUN   FJUN  FJUNR  VCAHS
1321101 132000000  131010000  0.7975  1.80   1.80   10000
1322101 132010000  133000000  4.42    6.18   6.18   10000
*
*     LFLOW    VFLOW  INT FLOW
1321201    0.0     0.0     0.0
1322201    0.0     0.0     0.0
*==================================
*==================================
1340000  UPRSR  BRANCH
*
*     NJ   FLAG
1340001  3     1
*
*     FLOWA  FLOWL   VOL   AZI INCL  DZ    ROUGH HYD   FE
1340101  56.45    0.0   198.75  0.0  90.  3.52  .00015  0.1234  00
*
*     FLAG   P    X
1340200   2  1114.68  0.00
1340200   1   557.00  0.00
*
*      FROM      TO     AJUN   FJUN  FJUNR  VCAHS
1341101 101010000  134000000  7.0398  1.20   1.20   10000
1342101 133010000  134000000  7.0398  1.2    1.2    10000
1343101 134010000  135000000 16.9149  1.08   1.08   10000
*
```

```
*       LFLOW     VFLOW  INT FLOW
1341201    0.0     0.0     0.0
1342201    0.0     0.0     0.0
1343201    0.0     0.0     0.0
*=====================================
1010000   BOIL2-5 PIPE
*
*       NV
1010001   3
*
*       FLOWA    NV
1010101   27.9     3
*
*       JAREA    NJ
1010201   8.0485   1
1010202   7.8717   2
*
*       LENGTH   NV
1010301    3.0     2
1010302    3.5833  3
*
*       VOLUME    NV
1010401    0.0     3
*
*     INCLINE ANGLE    NV
1010601    90.0         3
*
*      ELEV CNG      NV
1010701    3.0          2
1010702    3.5833       3
*
*       ROUGH  HYD DIA  NV
1010801  .00015 0.1234    3
*
*       FJUNF    FJUNR    NJ
1010901    1.1      1.1      1
1010902    1.13     1.13     2
*
*       FE   NV
1011001   00    3
*
*      VCAHS NJ
1011101  10000 2
*
*       FLAG  P      X       DUMMY  DUMMY   DUMMY NV
1011201  2  1117.80  .0       0.    0.      0.  1
1011202  2  1116.85  .0       0.    0.      0.  2
1011203  2  1115.81  .0       0.    0.      0.  3
1011201  1   557.00  .0      0.    0.      0.  1
1011202  1   557.00  .0      0.    0.      0.  2
1011203  1   557.00  .0      0.    0.      0.  3
*
*       FLAG=0 => (LBM/SEC)
1011300   1
```

```
*
*      LFLOW      VFLOW  INTERFACE FLOW       NJ
1011301  0.0        0.0        0.0         2
*=====================================================================
*====================================
1330000  PRHEAT  PIPE
*
*      NV
1330001  5
*
*      FLOWA   NV
1330101  26.3462  3
1330101  27.9     5
*
*      JAREA   NJ
1330201  4.2478   1
1330202  4.2478   2
1330203  4.2478   3
1330204  7.0398   4
*add bypass area to flow path
*1330201  4.9938   1
*1330202  4.9938   2
*1330203  4.9938   3
*1330204  7.0398   4
*
*      LENGTH   NV
1330301   1.5    4
1330302   3.5833  5
1330302   3.6463     5
*
*      VOLUME    NV
1330401    0.0    5
*
*    INCLINE ANGLE    NV
1330601    90.0        5
*
*     ELEV CNG      NV
1330701    1.5         4
1330702    3.5833      5
1330702    3.6463      5
*
*      ROUGH  HYD DIA  NV
1330801 .00015  0.1234    5
*
*      FJUNF    FJUNR    NJ
1330901    9.16      9.16     1
1330902    5.92      5.92     2
1330903    5.48      5.48     3
1330904    1.2       1.2      4
*add crossflow resistance of 11 to first 3 junctions
1330901   20.16     20.16     1
1330902   16.92     16.92     2
1330903   16.48     16.48     3
1330904    1.2       1.2      4
```

```
*
*      FE   NV
1331001  00    5
*
*      VCAHS NJ
1331101  10000 4
*
*      FLAG  P       X       DUMMY  DUMMY   DUMMY NV
1331201   2  1118.04  .0       0.     0.       0.   1
1331202   2  1117.56  .0       0.     0.       0.   2
1331203   2  1117.09  .0       0.     0.       0.   3
1331204   2  1116.62  .0       0.     0.       0.   4
1331205   2  1115.81  .0       0.     0.       0.   5
1331201   1   557.00  .0      0.     0.       0.   1
1331202   1   557.00  .0      0.     0.       0.   2
1331203   1   557.00  .0      0.     0.       0.   3
1331204   1   557.00  .0      0.     0.       0.   4
1331205   1   557.00  .0      0.     0.       0.   5
*
*      FLAG=0 => (LBM/SEC)
1331300   1
*
*      LFLOW       VFLOW   INTERFACE FLOW       NJ
1331301   0.0          0.0          0.0           4
*==========================================================================
1350000   UPRISER PIPE
*
*      NV
1350001   5
*
*      FLOWA    NV
1350101   56.45    3
1350102   55.25    5
*
*      JAREA    NJ
1350201   16.9996  1
1350202   55.25    2
1350203   16.9996  3
1350204   55.25    4
*
*
*      LENGTH   NV
1350301    3.5833  1
1350302    3.5733  2
1350303     .01    4
1350302    3.3733  2
1350303     .11    4
1350302    3.1733  2
1350303     .21    4
*1350302    2.9733  2
*1350303     .31    4
1350304    8.1566  5
*
*      VOLUME    NV
```

```
1350401    0.0    5
*
*     INCLINE ANGLE    NV
1350601    90.0         5
*
*      ELEV CNG      NV
*1350701    3.5833      2
*1350702    8.1666      3
*
*       ROUGH  HYD DIA  NV
1350801 .00015  0.1234    5
*
*       FJUNF     FJUNR    NJ
1350901    1.08       1.08     1
1350902     .0         .0      2
1350903    1.08       1.08     3
1350904     .0         .0      4
*test sensitivity of loss coeff
*1350903     .972       .972    3
*
*       FE   NV
1351001   00    5
*
*      VCAHS NJ
1351101  10000 1
1351102  10000 2
1351103  10000 3
1351104  10000 4
*
*      FLAG   P       X       DUMMY  DUMMY   DUMMY NV
1351201   2  1113.55   .0       0.     0.       0.   1
1351202   2  1112.42   .0       0.     0.       0.   2
1351203   2  1110.59   .0       0.     0.       0.   3
1351203   2  1110.59  1.0       0.     0.       0.   3
1351201   1   557.00   .0       0.     0.       0.   1
1351202   1   557.00   .0       0.     0.       0.   2
1351203   1   557.00   .0       0.     0.       0.   5
*1351203   1   557.00  1.0       0.     0.       0.   3
*
*      FLAG=0 => (LBM/SEC)
1351300   1
*
*      LFLOW       VFLOW  INTERFACE FLOW       NJ
1351301   0.0          0.0          0.0           4
*================================================================
1020000   SEP     SEPARATR
*
*     NJ   FLAG
1020001   3     1
*
*     FLOWA   FLOWL   VOL      AZI INCL   DZ    ROUGH   HYD   FE
1020101    0.0  14.1567 365.4148  0.0 90.  14.1567 .00015 1.625  00
*
*     FLAG   P     UF         UG          VG
```

```
1020200   2 1107.31 .227
1020200   2 1107.31 1.0
1020200   1  557.00 1.0
*1020200   1  557.00  .3494
 1020200   1  557.00  .03
*1020200   1  557.00  .015
*
*       FROM       TO       AJUN  FJUN   FJUNR  VCAHS  VFLIM
1021101 102010000  103000000 22.01   13.9    13.90   10000
1022101 102000000  111000000 19.78   0.5     0.5    00000
1023101 135010000  102000000 24.8873 0.5     1.0    10000
* rearrange losses
1021101 102010000  103000000 11.49   0.86    0.86   10000
1022101 102000000  111000000 19.78   1.0     1.0    00000
1023101 135010000  102000000 22.01   13.9    13.9   10000
*add crossflow resistance term
1023101 135010000  102000000 22.01   18.12   18.12  10000
* sensitivity values of vover/vunder
*1021101 102010000  103000000 11.49   0.86    0.86   10000  .25
*1022101 102000000  111000000 19.78   1.0     1.0    00000 .15
*1023101 135010000  102000000 22.01   13.9    13.9   10000
*
*      LFLOW    VFLOW     INT FLOW
1021201    0.0      0.0        0.0
1022201    0.0      0.0        0.0
1023201    0.0      0.0        0.0
*=========================================================================
1030000  DOME   BRANCH
*
*     NJ  FLAG
1030001  2    1
*
*     FLOWA  FLOWL  VOL     AZI INCL   DZ    ROUGH   HYD   FE
1030101  123.051 5.      0.0     0.0 90.   5.    .00015 1.625  00
1030101  123.051 5.      0.0     0.0 90.   5.    .00015 0.0    00
1030101  151.32  0.     356.23   0.0 90.  2.35415 .00015 14.04  00
*
*    FLAG   P    UF       UG        VG
1030200   2 1107.31 1.0
1030200   1  557.00 1.0
*
*       FROM       TO       AJUN  FJUN   FJUNR  VCAHS  VFLIM
1031101 103000000  110010000  7.29    1.77    1.77   10000
1032101 103010000  104000000 77.74    0.      0.     10000
*1033101 103000000  110010000 19.78   0.5     0.5    10000
*
*      LFLOW    VFLOW     INT FLOW
1031201    0.0      0.0        0.0
1032201    0.0      0.0        0.0
*1033201    0.0      0.0        0.0
*=========================================================================
1040000  UDC    SNGLVOL
*
*      FLOWA   FLOWL    VOL  AZI INCL   DZ    ROUGH  HYD   FE
```

```
1040101   70.75   0.0   527.08  0.0   0.   0.0     0.00015 4.07 00
*
*     FLAG    P     X
1040200  001   557.   1.0
*=========================================================
2500000  DRYERDRN  SNGLVOL
*
*     FLOWA   FLOWL    VOL   AZI INCL  DZ    ROUGH HYD   FE
2500101   2.02    16.5108    0.0  0.0 -90.  -16.5108 0.00015  0.0  00
*
*     FLAG    P     X
2500200  001   557.    .025
************
1240000  DRYER    BRANCH
*
*    NJ  FLAG
1240001  3    1
*
*    FLOWA  FLOWL  VOL     AZI INCL  DZ   ROUGH  HYD  FE
1240101  171.4   0.     121.41   0.0 00.   0.0  .00015 .0417  00
*
*   FLAG   P    UF       UG        VG
1240200    1  557.00 1.0
*
*     FROM      TO     AJUN  FJUN   FJUNR  VCAHS  VFLIM
1241101 104010000  124000000 70.75    .5      .5     10000
1242101 124010000  105000000 63.49    5.502   5.502  10000
1243101 250000000  124000000  2.0211  0.5     0.5    10000
*
*     LFLOW    VFLOW     INT FLOW
1241201    0.0      0.0        0.0
1242201    0.0      0.0        0.0
1243201    0.0      0.0        0.0
********************************
1050000   dome PIPE
*
*     NV
1050001   2
*
*     FLOWA    NV
1050101   63.49    1
1050102   98.79    2
*
*     JAREA    NJ
1050201   74.94    1
*
*
*     LENGTH   NV
1050301    0.     2
*
*     VOLUME   NV
1050401   473.0    1
1050402   350.7    2
*
```

```
*     INCLINE ANGLE    NV
1050601    00.0         1
1050602    90.0         2
*
*
*     ROUGH  HYD DIA  NV
1050801 .00015  11.02     1
1050802 .00015  12.83     2
*
*     FJUNF    FJUNR    NJ
1050901     .0        .00    1
*
*     FE   NV
1051001   00    2
*
*     VCAHS NJ
1051101  10000 1
*
*     FLAG   P       X       DUMMY  DUMMY    DUMMY NV
1051201   1   557.00  1.0       0.     0.       0.   2
*
*     FLAG=0 => (LBM/SEC)
1051300   1
*
*     LFLOW       VFLOW  INTERFACE FLOW         NJ
1051301   0.0          0.0          0.0            1
*================================================================
*================================================================
**********
1060000   nozzle SNGLJUN
*
*     FROM        TO       AREA    FJUNF FJUNR  VCAHS
1060101 105010000 107000000  1.388     0.0     0.0  10100
*
*     FLAG   LFLOW     VFLOW     INT FLOW
1060201   1       0.0       0.0        0.0
*******
1070000   nozzle SNGLVOL
*
*     FLOWA   FLOWL     VOL   AZI INCL   DZ    ROUGH HYD    FE
1070101   1.388    1.5      0.0   0.0  90.   1.5   .00015 0.5025  00
*
*     FLAG    P      X
1070200   002   1106.     1.0
1070200   001    557.     1.0
*================================================================
3000000   BREAK   VALVE
*
*      FROM       TO      AJUN
3000101 107010000  900000000  1.388   0.0  0.0  00100
*
*
*     TIME  LFLOW    VFLOW    INTFLOW
3000201  1  0.0   0.0     0.0
```

```
3000300 MTRVLV
3000301  502  503  1000. 0.0
*3000301  502  503    2.0 0.0
*==================================================================
9000000  break  TMDPVOL
*
*     FLOWA FLOWL  VOL   AZI  INCL   DZ  ROUGH HYD  FE
9000101  0.0  31.1533 147.64  0.0  0.0    0.0  0.0  0.0  00
9000101  5.0   0.0   9999.  0.0  0.0    0.0  0.0  0.0  00
*
*    EBT
9000200  002
*
*     TIME  PRESS   X
9000201  0.0   14.7  1.0
9000202  1.0E6  14.7  1.0
*==================================================================
1110000  UDC1  BRANCH
*
*     NJ FLAG
1110001  3   1
*
*     FLOWA   FLOWL    VOL  AZI INCL  DZ  ROUGH   HYD   FE
1110101 111.07    13.76   0.0  0.0 -90. -13.76  0.00015 0.0   00
1110101 111.07     .2192  0.0  0.0 -90. -.2192  0.00015 0.0   00
1110101 111.07     .2202  0.0  0.0 -90. -.2202  0.00015 0.0   00
*
*     FLAG  P    X
1110200    2  1107.0  0.0
1110200    1   557.0  1.0
1110200    1   557.0  0.0
*
*     FROM      TO       AJUN   FJUN  FJUNR  VCAHS
1111101  111010000 112000000  5.7356   1.15   1.28   20000
1111101  111010000 112000000  5.7356   0.0   0.00   20000
1112101  111000000 110000000  5.7356   0.0   0.0    20000
1112101  111000000 110000000  111.07   0.0   0.0    20000
1113101  250010000 111000000   2.02    0.5   0.5    20000
*
*     LFLOW   VFLOW    INT FLOW
1111201     0.0   0.0       0.0
1112201     0.0   0.0       0.0
1113201     0.0   0.0       0.0
===================================================================
*==================================================================
1100000  UDC   SNGLVOL
*
*     FLOWA   FLOWL    VOL  AZI INCL  DZ    ROUGH HYD   FE
1100101   111.07 13.5408   0.0  0.0 90.  13.5408  0.0  0.0    00
1100101   111.07 14.1567   0.0  0.0 90.  14.1567  0.0  0.0    00
*
*     FLAG   P     X
1100200  002  1106.    0.22
1100200  001  557.     1.0
```

```
*1100200  001   557.    0.3494
 1100200  001   557.    0.03
*1100200  001   557.    0.015
*================================================================
1120000  LDC1-3  PIPE
*
*      NV
1120001  5
*
*      FLOWA   NV
1120101  6.99203  5
1120101  5.74     5
*
*      LENGTH    NV
1120301    2.814292  1
1120302    1.0       2
1120302    1.001     2
1120303    6.570134  3
1120304   10.384433  5
*
*      VOLUME   NV
1120401    0.0    5
*
*    INCLINE ANGLE    NV
1120601   -90.0        5
*
*      ELEV CNG    NV
1120701   -2.814292     1
1120702   -1.0         2
1120703   -6.570134     3
1120704  -10.384433     5
*
*      ROUGH  HYD DIA  NV
1120801   0.0     .4067    5
1120801   0.00015  .3442   5
*
*      FE   NV
1121001   00    5
*
*      VCAHS NJ
1121101  20000 4
*
*      FLAG  P      X      DUMMY  DUMMY   DUMMY NV
1121201   1   557.00  1.0      0.    0.      0.  2
1121202   1   557.00   .629    0.    0.      0.  3
1121202   1   557.00   .07     0.    0.      0.  3
1121203   1   557.00  0.0      0.    0.      0.  5
 1121201   1   557.00  0.0     0.    0.      0.  2
 1121202   1   557.00  0.0     0.    0.      0.  3
 1121203   1   557.00  0.0     0.    0.      0.  5
*
*      FLAG=0 => (LBM/SEC)
1121300   1
*
```

```
*     LFLOW      VFLOW  INTERFACE FLOW      NJ
1121301    0.0      0.0        0.0         4
******************************************************************************
*---------- HEAT STRUCTURE INPUT
*
*GENERAL DATA
*       NH  NP   GEO  SS    LEFT COORD
11511000  21  11    2    1    0.02766665
*=============================================
*MESH FLAGS
*       LOCATION FLG       FORMAT FLAG
11511100    0                  2
*=============================================
*MESH DATA
*       MESH INTERVAL    INT #
11511101 .000358335        10
*=============================================
*COMPOSITION DATA
*          COMP. #      INT #
11511201      1           10
*=============================================
*HEAT DISTRIBUTION DATA
*       SOURCE    INT #
11511301   0.0       10
*=============================================
*INITIAL TEMPERATURE DATA
*           TEMP.      INT #
11511401    557.0        11
*==================================================================
*LEFT BC CARDS
*          BVL     INC  TYPE  SURF     CYL HT     STRUCT #
11511501  151010000  0000 1     0      447.65        1
11511502  151020000  0000 1     0     1989.54        2
11511503  151030000 10000 1     0     2387.45        4
11511504  151050000 10000 1     0     2851.67        8
11511505  151090000 10000 1     0     2741.59       10
11511506  151110000 10000 1     0     2851.67       14
11511507  151150000 10000 1     0     1193.72       19
11511508  151200000  0000 1     0     795.82        20
11511509  151210000  0000 1     0      447.65       21
*==================================================================
*RIGHT BC CARDS
*          BVR     INC  TYPE  SURF     CYL HT     STRUCT #
11511601  100010000  0   1     0    505.62          1
11511602  121010000  0000 1     0   2247.22          2
11511603  101010000 10000 1     0   2696.66          4
11511604  101030000  0000 1     0   3221.02          5
11511605  134010000  0000 1     0   3221.02          6
11511606  135010000 10000 1     0   3221.02          8
11511607  135050000  0000 1     0   3096.67         10
11511608  135020000 -10000 1    0   3221.02         12
11511609  134010000  0000 1     0   3221.02         13
11511610  133050000  0000 1     0   3221.02         14
11511611  133040000 -10000 1    0   1348.33         18
```

```
11511612 132010000 0000 1   0   1348.33     19
11511613 131010000 0   1    0   898.89      20
11511614 100010000 0   1    0   505.62      21
*=========================================================================
*SOURCE DATA
*       SOURCE  MULT    LDH    RDH   STRUCT #
11511701  0   0.0     0.0    0.0    21
*=========================================================================
*LEFT BOUNDARY CARDS
*       CHF  HYDIAM   HED   CHN LEN  STRUCT #
11511801  0   0.0     0.0    0.0    21
*=========================================================================
*RIGHT BOUNDARY CARDS
*       CHF  HYDIAM   HED   CHN LEN  STRUCT #
11511901  0   0.0     0.0    0.0    21
**************************************************************
*----- HEAT STRUCTURE THERMAL PROPERTY DATA
*
*COMPOSITION TYPE AND DATA FORMAT
*       MATERIAL TYPE   FLAG   FLAG
20100100      TBL/FCTN    1     1    * INCONEL
*==============================================================
*
*
*--------------------------------------------------------------
* THERMAL CONDUCTIVITY DATA (BTU/SEC-FT/DEG F) AND VOLUMETRIC HEAT |
* CAPACITY  DATA (BTU/FT**3-DEG F) VERSUS TEMPERATURE FOR ABOVE    |
* COMPOSITION                                                      |
*--------------------------------------------------------------
*
*
*
*==============================================================
*INCONEL 600 THERMAL CONDUCTIVITY DATA
*       TEMPERATURE     THERMAL CONDUCTIVITY
20100101      70.0          2.3843E-03
20100102     200.0          2.5232E-03
20100103     400.0          2.8009E-03
20100104     600.0          3.0787E-03
20100105     800.0          3.3565E-03
20100106    1000.0          3.6574E-03
20100107    1200.0          3.9815E-03
20100108    1400.0          4.3056E-03
20100109    1600.0          4.6296E-03
*==============================================================
*INCONEL 600 VOLUMETRIC HEAT CAPACITY DATA
*       TEMPERATURE     HEAT CAPACITY
20100151      70.0          55.6831
20100152     200.0          55.5227
20100153     400.0          55.2607
20100154     600.0          54.9895
20100155     800.0          54.7069
20100156    1000.0          54.3982
20100157    1200.0          54.0907
```

```
20100158   1400.0          53.7516
20100159   1600.0          53.4205
20100160   1800.0          53.0796
*=================================================================
*
*--------- CONTROL SYSTEM FOR MEASURING SG LEVEL
*
*
*-----------------------------------------------------------
* NOTE: THE FOLLOWING CONTROL SYSTEM IS TO WORK IN BRITSH   |
*     UNITS ( LBM, LBF, FT, S, P=LBF/SQIN). IN RELAP5     |
*     THE QUANTITIES STORED IN ARRAYS ARE IN SI UNITS.     |
*     THEREFORE, CONVERSIONS FROM SI TO BRITISH UNITS      |
*     MUST BE MADE.                                 |
*-----------------------------------------------------------
*
*
*--------- CONTROL VARIABLE CARD TYPE
20500000     999
*
*--------- CONTROL COMPONENT CARDS
*
*
*  COMPUTE PRESSURE DIFFERENCE
*
*       NAME    TYPE   SCALE(PSI/PA) INIT     FLAG
20500100 DELTPP   SUM     1.45003E-04  0.0       1
*      A0  A1  VAR   VOL      A2  VAR   VOL
20500101 0.0 -1.0, P, 135040000   1.0, P, 135030000
*
*       NAME    TYPE   SCALE(PSI/PA) INIT     FLAG
20500200 DELTPN   SUM     1.45003E-04  0.0       1
*      A0  A1  VAR   VOL      A2  VAR   VOL
20500201 0.0 -1.0, P, 135030000   1.0, P, 135010000
*
*       NAME    TYPE   SCALE(PSI/PA) INIT     FLAG
20500300 DELTPN   SUM     1.45003E-04  0.0       1
*      A0  A1  VAR   VOL      A2  VAR   VOL
20500301 0.0 -1.0, P, 101020000   1.0, P, 101010000
*       NAME    TYPE   SCALE(PSI/PA) INIT     FLAG
*
*
*       NAME    TYPE   SCALE(PSI/PA) INIT     FLAG
20500400 DELTPP   SUM     1.45003E-04  0.0       1
*      A0  A1  VAR   VOL      A2  VAR   VOL
20500401 0.0 -1.0, P, 135030000   1.0, P, 135020000
20500402  -12.127, RHO, 135030000   -5.3517 RHO, 135020000
*
*****************************************************************
*****************************************************************
*****************************************************************
*********************************************
*                              *
* END OF INPUT DECK - PROBLEM END          *
```