Calculation Title Page

Calculation No.: **DRE97-0010**	Page 1 of 14
☒ Safety Related ☐ Regulatory Related ☐ Non-Safety Related	
Calculation Title: **Dresden LPCI/Core Spray NPSH Analysis Post-DBA LOCA: Long-Term Design Basis**	
Station/Unit: Dresden Units 2 and 3	System Abbreviation: LPCI/CS
Equipment No.: 2(3)-1502A/B/C/D 2(3)-1401A/B	Project No.:
Rev: **0** Status: QA Serial # or CHRON # NA	Date:
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Do any assumptions in this calculation require later verification?	☐ Yes ☒ No
Reviewed by: J.W. Drowley Review Method: DETAILED REVIEW	Date: 2/11/97 Comments (C, NC or CI): NC
Approved by:	Date: 2/13/97

Calculation Revision Page

Calculation No.: **DRE97-0010**			Page 2 of 14
Rev:	Status:	QA Serial # or CHRON # **NA**	Date:__________
Prepared by:______________________________			Date:__________
Revision Summary:			
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Do any assumptions in this calculation require later verification?			☐ Yes ☐ No
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Review Method:		Comments (C, NC or CI): ______	
Approved by:______________________________			Date:__________

Table of Contents

Calculation No.: **DRE97-0010**	Rev. **0**	Page 3 of 14

1.0 PURPOSE

The purpose of this calculation is to determine if sufficient Net Positive Suction Head (NPSH) is available to the Dresden LPCI and Core Spray (CS) pumps following a DBA-LOCA. This calculation examines NPSH conditions under long-term (> 600 seconds) conditions following the accident. The results of this calculation will be used to support a Dresden License Amendment request. Upon approval of this request, this calculation will represent a Design Basis Document.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

The minimum suppression pool pressure required to meet LPCI/CS pump NPSH requirements will be determined under long-term post-LOCA conditions. The minimum pool pressure required will then be compared to the suppression pool pressure available post-LOCA (Ref. 1). If the pressure available is greater than the pressure required, then adequate NPSH exists and pump protection is ensured. If the available pressure is less than the pressure required, then the potential exists for the pumps to cavitate. In these situations, LPCI pump flows will be reduced to below-nominal values and new cases will be run to establish the ability of the operator to throttle the pumps to an acceptable condition. This acceptable condition is defined by the following criteria:

1) <u>Adequate NPSH to the pumps</u> - minimum suppression pool pressure available is greater than minimum pressure required for the LPCI and CS pumps.

2) <u>Adequate containment cooling</u> - the minimum containment cooling flow analyzed is 5000 gpm total LPCI flow through a single LPCI heat exchanger.

Various LPCI/CS pump combinations will be explored to determine the bounding NPSH case for the LPCI and Core Spray pumps. It will be shown that the 4 LPCI/2 CS pump combination is the bounding NPSH case. This calculation is bounding for NPSH due to use of the following conservative inputs:

- Maximum suppression pool temperature response - Reference 1 determines maximum suppression pool temperatures post-LOCA, thus maximizing the vapor pressure and minimizing NPSH margin.
- Minimum suppression pool pressure response - Reference 1 utilizes inputs that minimize suppression pool pressures post-LOCA, thus minimizing overpressure credit and minimizing NPSH margin.
- Technical Specifications minimum suppression pool level including drawdown, minimizing elevation head and minimizing NPSH margin
- increased clean, commercial steel suction piping friction losses by 15% to account for potential aging effects, thus maximizing suction losses

3.0 ASSUMPTIONS

1. It is assumed that at 10 minutes into the accident, operator action will be taken to ensure that the LPCI and CS pumps have been throttled to their rated flows of 5000 and 4500 gpm respectively. This condition will be referred to as the "nominal flow" condition.

2. LPCI/CS pump suction piping friction losses (excluding strainer losses) were developed for a single flow case using a FLO-SERIES model of the Dresden ECCS ring header and pump suction piping (Ref. 4). This model was then run at the various LPCI/CS pump combinations and flows as required to support the cases evaluated in this calculation (Attachment A). The model that was developed uses clean, commercial steel pipe. In order to compensate for the increased loss due to the potential effects of aging, the resulting friction losses from the model were increased by 15%. This is consistent with discussions provided in References 14 and 15.

3. To account for strainer plugging, one of the four torus strainers is assumed 100% blocked, while the remaining three strainers are assumed clean. While the torus strainers are not included in the FLO-SERIES model discussed in Assumption 2, blocking a strainer translates to blocking a torus-to-ring header entrance leg. This is accomplished in the model by closing one of the torus legs (Torus 1-4). Based on previous sensitivity analyses, Torus-4 was chosen for maximum effect on both LPCI and Core Spray suction losses for all pump combinations.

4. The calculations in Reference 1 have been performed to minimize the extent of overpressure that would exist post-LOCA, and support the conclusion that overpressure would be available and can be employed to demonstrate adequate LPCI/CS NPSH performance. These calculations are more appropriate with respect to the prediction of minimum containment pressure than are the original design basis calculations. While different decay heat standards and heat exchanger performance predictions are applied in these calculations, the peak containment temperatures being predicted are consistent with the original design basis temperature predictions. The pressure response is not a function of decay heat models, but is primarily only affected by the pool temperature and heat exchanger performance. The new calculations incorporate analysis assumptions to minimize overpressure that are consistent with NRC Information Notice 96-55. The use of the Reference 1 data is thus conservative with respect to overpressure and minimizes NPSH margin.

5. NPSH Required (NPSHR) curves are provided for the LPCI and Core Spray pump on the respective vendor pump curves (Refs. 12, 13). The NPSHR curves are provided from 3000 gpm to 6000 gpm pump flow. It is assumed that the NPSHR at 2500 gpm is the same as the NPSHR given at 3000 gpm. While it is recognized that the NPSHR may rise slightly at lower flows, 2500 gpm represents a mid-range flow point for this pump and the NPSHR is expected to remain constant in this flow region.

4.0 DESIGN INPUTS

1. Initial suppression pool temperature is 95°F (Ref. 3). This is the maximum allowable suppression pool temperature under normal operating conditions. This value is used as the initial pool temperature in Reference 1 to maximize suppression pool peak temperature, and is used as a minimum temperature during the LOCA in Reference 4 to maximize piping friction losses (maximum viscosity).

2. Numerous long-term suppression pool temperature and pressure responses were generated in Reference 1 based on a containment model developed by GE. The intent of these cases was to determine the maximum pool temperatures expected post-LOCA, and to vary the inputs in such a way as to produce a coupled minimum pool pressure response. In this manner, the temperature-pressure combination that is bounding for NPSH was determined to be Case 2A1-20% mixing. A tabular representation of the suppression pool temperature/pressure responses for this case is provided in Reference 2 and is summarized in Tables 1 and 2 of this calculation.

3. LPCI and CS pump suction piping friction losses (excluding strainer losses) from the torus strainers to the pumps were developed in Reference 4 using a FLO-SERIES model of the ECCS ring header and suction piping. This piping model was then utilized for the various LPCI/CS pump combinations and flows as required to support the cases evaluated in this calculation (Attachment A).

4. The minimum torus level elevation with a maximum drawdown of 2.1 ft. is 491'5", or 491.4 ft. (Ref. 5). At the time of peak suppression pool temperature, a recovery of 1.1 ft. occurs, resulting in a net drawdown of 1 ft (Ref. 6). This represents a torus level elevation of 492.5'.

5. The torus strainers have a head loss of 5.8 ft. @ 10,000 gpm clean (Ref. 7).

6. LPCI and Core Spray pump centerline elevation is 478.1 ft. (Refs. 8, 9).

7. NPSH Available (NPSHA) is calculated using the following equation:

$$NPSHA = 144\,V\,(P_t - P_v) + Z - h_L - h_{strain} \quad \text{(based on Ref. 10, p. 2.216)}$$

where:
- P_t = suppression pool pressure in psia
- P_v = saturation pressure in psia
- V = specific volume in ft^3/lb
- h_L = suction friction losses in feet
- h_{strain} = head loss across strainer in feet
- Z = static head of water above pump inlet in feet

8. Saturation pressures and specific volumes at various temperatures are taken from Reference 11 and are included in Tables 1 and 2.

9. LPCI pump NPSHR is 30 ft. at 5000 gpm, 25 ft. at 2500 gpm (Ref. 12, Assumption 5).

10. Core Spray pump NPSHR is 27 ft. at 4500 gpm (Ref. 13).

5.0 REFERENCES

1. "Dresden Units 2 and 3 Containment Analyses of the DBA-LOCA Based on Long-Term LPCI/Containment Cooling System Configuration of One LPCI/Containment Cooling System Pump and 2 CCSW Pumps", GE report GE-NE-T2300740-2, December 1996

2. "Transmittal of Digitized Suppression Pool Temperature and Suppression Chamber Pressure Time Histories", GE letter from S. Mintz to J. Nash dated January 28, 1997

3. Dresden Unit 2 Technical Specifications, DPR-19, Section 3.7.A.1.c.1.

4. "ECCS Suction Hydraulic Analysis without the Strainers", Duke Engineering & Services Calculation Number DRE96-0241 dated December 20, 1996

5. "Submergence of LPCI Discharge Line Post LOCA - Dresden Units 2 & 3", letter from S. Eldridge to C. Schroeder dated September 29, 1992, CHRON# 0115532

6. "Dresden LPCI/Containment Cooling System," GE Nuclear Energy letter from S. Mintz to T. L. Chapman dated January 25, 1993

7. "Supporting Calculations for the ECCS Suction Strainer Modification", Nutech File No. 64.313.3119 Rev. 1, dated June 22, 1983

8. Sargent & Lundy Drawing M-547, LPCI pump suction

9. Sargent & Lundy Drawing M-549, Core Spray pump suction

10. "Pump Handbook", 2nd Edition, Karassik, Igor et. al., 1986

11. ASME Steam Tables, 1967

12. Bingham Pump Curve Nos. 25355-7, 27367-8, 27383, 25384-5 for Model 12x14x14.5 CVDS, Dresden Station LPCI pumps

13. Bingham Pump Curve Nos. 25213 (2A), 25243 (2B), 25231 (3A) and 25242 (3B) for Model 12x16x14.5 CVDS, Dresden Station Core Spray pumps.

14. Hydraulic Institute Engineering Data Book, Second Edition, 1990

15. Cameron Hydraulic Data, 17th Edition, Ingersoll-Rand Company, 1988

6.0 CALCULATIONS

The equation presented in Design Input 7 can be rewritten to solve for the minimum suppression pool pressure required to meet pump NPSH requirements by setting the NPSHA equal to the NPSHR as follows:

$$P_{t,\,min} = \frac{(NPSHR - Z + h_{total})}{144\ V} + P_v \qquad (1)$$

where h_{total}	=	friction (h_L) + strainer (h_{strain}) loss	(Attachment A)
h_{strain}	=	5.8 ft. @ 10,000 gpm clean	(Design Input 5)
Z	=	492.5 ft. - 478.1 ft. = 14.4 ft.	(Design Inputs 4, 6)
NPSHR	=	30 ft. @ 5000 gpm for LPCI	(Design Input 9)
		27 ft. @ 4500 gpm for CS	(Design Input 10)

Solving Equation 1, the minimum suppression pool pressure required to meet LPCI and CS pump NPSH requirements under a spectrum of pump combinations is calculated and the results presented in Tables 1 and 2. These results are plotted in Figures 1 and 2 along with the available suppression pool pressure (Ref. 2). All the combinations evaluated involve 2 CS pumps. These cases bound the respective single CS pump scenarios due to the higher ring header/strainer losses of the 2-pump cases and no pool temperature benefit (cooling) from the added Core Spray pump.

It can be seen that adequate NPSH is available to meet CS pump requirements post-LOCA for all pump combinations (Figure 2). However, the potential exists for the LPCI pumps to cavitate in the 4/2 and 3/2 pump nominal flow scenarios (Figure 1). For these latter cases, throttling of the LPCI pumps may be required to ensure NPSH requirements are met. Additional cases are provided to establish the ability of the operator to throttle the LPCI pumps to an acceptable condition as defined in Section 2.0 (Table 2). These results, plotted in Figures 3 (LPCI) and 4 (CS), indicate that for all pump combinations, the LPCI pumps can be throttled to ensure pump protection and adequate containment cooling.

7.0 SUMMARY AND CONCLUSIONS

An NPSH analysis was performed for the LPCI/CS pumps under long-term post-LOCA conditions as outlined in Reference 1. Selecting inputs to minimize NPSH margin, it was determined that adequate NPSH exists to meet CS pump requirements for all pump combinations. However, the potential exists for the LPCI pumps to cavitate in the 4/2 and 3/2 pump scenarios. For these cases, throttling of the LPCI pumps may be required to ensure NPSH requirements are met. Specific cases involving throttled LPCI pumps were evaluated to establish the ability of the operator to throttle the pumps to an acceptable condition. Under all post-LOCA pump combinations, positive NPSH margin could be obtained by throttling the available LPCI pumps.

CASE 2A1 - 20% MIXING						4/2 - Nominal Pump Flows 5000 gpm/LPCI - 4500 gpm/CS								4/2 - Throttled Pump Flows 2500 gpm/LPCI - 4500 gpm/CS							
Time (sec)	Pool Press (psig)	Pool Temp (F)	Specific Volume (ft3/lb)	Pv (psia)	Static Head (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)
699	4.03	149.9	0.016342	3.709	14.4	30	16.09	2.48	**3.7**	27	13.33	0.03	**9.4**	25	5.71	-4.06	**19.0**	27	7.69	-2.37	**15.1**
991	2.48	152.4	0.016355	3.945	14.4	30	16.09	2.70	**-0.5**	27	13.33	0.26	**5.2**	25	5.71	-3.83	**14.9**	27	7.69	-2.14	**10.9**
1858	2.70	156.5	0.016376	4.359	14.4	30	16.09	3.10	**-0.9**	27	13.33	0.65	**4.8**	25	5.71	-3.42	**14.4**	27	7.69	-1.74	**10.5**
3056	2.47	160.5	0.016398	4.798	14.4	30	16.09	3.52	**-2.5**	27	13.33	1.08	**3.3**	25	5.71	-2.99	**12.9**	27	7.69	-1.31	**8.9**
4010	2.34	162.9	0.016411	5.079	14.4	30	16.09	3.79	**-3.4**	27	13.33	1.35	**2.3**	25	5.71	-2.72	**12.0**	27	7.69	-1.04	**8.0**
5026	2.43	164.6	0.016421	5.286	14.4	30	16.09	3.99	**-3.7**	27	13.33	1.55	**2.1**	25	5.71	-2.52	**11.7**	27	7.69	-0.83	**7.7**
9989	2.78	169.8	0.016450	5.965	14.4	30	16.09	4.64	**-4.4**	27	13.33	2.21	**1.3**	25	5.71	-1.85	**11.0**	27	7.69	-0.17	**7.0**
11994	2.85	171.0	0.016457	6.132	14.4	30	16.09	4.80	**-4.6**	27	13.33	2.37	**1.1**	25	5.71	-1.69	**10.7**	27	7.69	-0.01	**6.8**
15020	2.95	171.9	0.016462	6.259	14.4	30	16.09	4.93	**-4.7**	27	13.33	2.50	**1.1**	25	5.71	-1.56	**10.7**	27	7.69	0.12	**6.7**
18813	2.94	172.1	0.016463	6.288	14.4	30	16.09	4.96	**-4.8**	27	13.33	2.53	**1.0**	25	5.71	-1.53	**10.6**	27	7.69	0.15	**6.6**
25129	2.89	171.2	0.016458	6.160	14.4	30	16.09	4.83	**-4.6**	27	13.33	2.40	**1.2**	25	5.71	-1.66	**10.8**	27	7.69	0.02	**6.8**
28174	2.85	170.5	0.016454	6.062	14.4	30	16.09	4.74	**-4.5**	27	13.33	2.31	**1.3**	25	5.71	-1.75	**10.9**	27	7.69	-0.07	**6.9**

						3/2 - Nominal Pump Flows 5000 gpm/LPCI - 4500 gpm/CS								3/2 - Throttled Pump Flows 2500 gpm/LPCI (5000 gpm for single LPCI)							
Time (sec)	Pool Press (psig)	Pool Temp (F)	Specific Volume (ft3/lb)	Pv (psia)	Static Head (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)
699	4.03	149.9	0.016342	3.709	14.4	30	13.02	1.17	**6.7**	27	10.14	-1.33	**12.6**	30	9.29	-0.41	**10.5**	27	7.69	-2.37	**15.1**
991	2.48	152.4	0.016355	3.945	14.4	30	13.02	1.40	**2.5**	27	10.14	-1.10	**8.4**	30	9.29	-0.19	**6.3**	27	7.69	-2.14	**10.9**
1858	2.70	156.5	0.016376	4.359	14.4	30	13.02	1.80	**2.1**	27	10.14	-0.70	**8.0**	30	9.29	0.21	**5.9**	27	7.69	-1.74	**10.5**
3056	2.47	160.5	0.016398	4.798	14.4	30	13.02	2.22	**0.6**	27	10.14	-0.27	**6.5**	30	9.29	0.64	**4.3**	27	7.69	-1.31	**8.9**
4010	2.34	162.9	0.016411	5.079	14.4	30	13.02	2.49	**-0.4**	27	10.14	0.00	**5.5**	30	9.29	0.91	**3.4**	27	7.69	-1.04	**8.0**
5026	2.43	164.6	0.016421	5.286	14.4	30	13.02	2.69	**-0.6**	27	10.14	0.20	**5.3**	30	9.29	1.11	**3.1**	27	7.69	-0.83	**7.7**
9989	2.78	169.8	0.016450	5.965	14.4	30	13.02	3.35	**-1.3**	27	10.14	0.86	**4.5**	30	9.29	1.77	**2.4**	27	7.69	-0.17	**7.0**
11994	2.85	171.0	0.016457	6.132	14.4	30	13.02	3.51	**-1.6**	27	10.14	1.03	**4.3**	30	9.29	1.93	**2.2**	27	7.69	-0.01	**6.8**
15020	2.95	171.9	0.016462	6.259	14.4	30	13.02	3.63	**-1.6**	27	10.14	1.15	**4.3**	30	9.29	2.06	**2.1**	27	7.69	0.12	**6.7**
18813	2.94	172.1	0.016463	6.288	14.4	30	13.02	3.66	**-1.7**	27	10.14	1.18	**4.2**	30	9.29	2.09	**2.0**	27	7.69	0.15	**6.6**
25129	2.89	171.2	0.016458	6.160	14.4	30	13.02	3.54	**-1.5**	27	10.14	1.06	**4.3**	30	9.29	1.96	**2.2**	27	7.69	0.02	**6.8**
28174	2.85	170.5	0.016454	6.062	14.4	30	13.02	3.44	**-1.4**	27	10.14	0.96	**4.5**	30	9.29	1.87	**2.3**	27	7.69	-0.07	**6.9**

TABLE 1

CASE 2A1 - 20% MIXING						2/2 - Nominal Pump Flows 5000 gpm/LPCI - 4500 gpm/CS								2/2 - Throttled Pump Flows 2500 gpm/LPCI - 4500 gpm/CS							
Time (sec)	Pool Press (psig)	Pool Temp (F)	Specific Volume (ft3/lb)	Pv (psia)	Static Head (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)
699	4.03	149.9	0.016342	3.709	14.4	30	10.64	0.16	**9.1**	27	7.55	-2.43	**15.2**	25	3.85	-4.85	**20.9**	27	5.72	-3.21	**17.0**
991	2.48	152.4	0.016355	3.945	14.4	30	10.64	0.39	**4.9**	27	7.55	-2.20	**11.0**	25	3.85	-4.62	**16.7**	27	5.72	-2.98	**12.9**
1858	2.70	156.5	0.016376	4.359	14.4	30	10.64	0.79	**4.5**	27	7.55	-1.80	**10.6**	25	3.85	-4.22	**16.3**	27	5.72	-2.57	**12.4**
3056	2.47	160.5	0.016398	4.798	14.4	30	10.64	1.21	**3.0**	27	7.55	-1.37	**9.1**	25	3.85	-3.78	**14.8**	27	5.72	-2.15	**10.9**
4010	2.34	162.9	0.016411	5.079	14.4	30	10.64	1.48	**2.0**	27	7.55	-1.09	**8.1**	25	3.85	-3.51	**13.8**	27	5.72	-1.87	**10.0**
5026	2.43	164.6	0.016421	5.286	14.4	30	10.64	1.68	**1.8**	27	7.55	-0.89	**7.9**	25	3.85	-3.30	**13.6**	27	5.72	-1.67	**9.7**
9989	2.78	169.8	0.016450	5.965	14.4	30	10.64	2.34	**1.0**	27	7.55	-0.23	**7.1**	25	3.85	-2.64	**12.8**	27	5.72	-1.00	**9.0**
11994	2.85	171.0	0.016457	6.132	14.4	30	10.64	2.50	**0.8**	27	7.55	-0.07	**6.9**	25	3.85	-2.47	**12.6**	27	5.72	-0.84	**8.7**
15020	2.95	171.9	0.016462	6.259	14.4	30	10.64	2.63	**0.8**	27	7.55	0.06	**6.9**	25	3.85	-2.35	**12.6**	27	5.72	-0.71	**8.7**
18813	2.94	172.1	0.016463	6.288	14.4	30	10.64	2.66	**0.7**	27	7.55	0.09	**6.8**	25	3.85	-2.32	**12.5**	27	5.72	-0.69	**8.6**
25129	2.89	171.2	0.016458	6.160	14.4	30	10.64	2.53	**0.8**	27	7.55	-0.04	**6.9**	25	3.85	-2.45	**12.6**	27	5.72	-0.81	**8.8**
28174	2.85	170.5	0.016454	6.062	14.4	30	10.64	2.44	**1.0**	27	7.55	-0.13	**7.1**	25	3.85	-2.54	**12.8**	27	5.72	-0.91	**8.9**

						1/2 - Nominal Pump Flows 5000 gpm/LPCI - 4500 gpm/CS								1/2 - Throttled Pump Flows
Time (sec)	Pool Press (psig)	Pool Temp (F)	Specific Volume (ft3/lb)	Pv (psia)	Static Head (feet)	LPCI NPSHR (feet)	LPCI Total Loss (feet)	LPCI Preqd (psig)	LPCI NPSH Margin (feet)	CS NPSHR (feet)	CS Total Loss (feet)	CS Preqd (psig)	CS NPSH Margin (feet)	For the single LPCI pump case, LPCI flow cannot be throttled below 5000 gpm. Therefore, the nominal and throttled pump cases for the 1/2 scenario are identical
699	4.03	149.9	0.016342	3.709	14.4	30	7.43	-1.20	**12.3**	27	5.72	-3.21	**17.0**	
991	2.48	152.4	0.016355	3.945	14.4	30	7.43	-0.98	**8.1**	27	5.72	-2.98	**12.8**	
1858	2.70	156.5	0.016376	4.359	14.4	30	7.43	-0.57	**7.7**	27	5.72	-2.57	**12.4**	
3056	2.47	160.5	0.016398	4.798	14.4	30	7.43	-0.15	**6.2**	27	5.72	-2.14	**10.9**	
4010	2.34	162.9	0.016411	5.079	14.4	30	7.43	0.12	**5.2**	27	5.72	-1.87	**9.9**	
5026	2.43	164.6	0.016421	5.286	14.4	30	7.43	0.33	**5.0**	27	5.72	-1.67	**9.7**	
9989	2.78	169.8	0.016450	5.965	14.4	30	7.43	0.99	**4.2**	27	5.72	-1.00	**9.0**	
11994	2.85	171.0	0.016457	6.132	14.4	30	7.43	1.15	**4.0**	27	5.72	-0.84	**8.7**	
15020	2.95	171.9	0.016462	6.259	14.4	30	7.43	1.27	**4.0**	27	5.72	-0.71	**8.7**	
18813	2.94	172.1	0.016463	6.288	14.4	30	7.43	1.30	**3.9**	27	5.72	-0.68	**8.6**	
25129	2.89	171.2	0.016458	6.160	14.4	30	7.43	1.18	**4.1**	27	5.72	-0.81	**8.8**	
28174	2.85	170.5	0.016454	6.062	14.4	30	7.43	1.08	**4.2**	27	5.72	-0.91	**8.9**	

TABLE 2

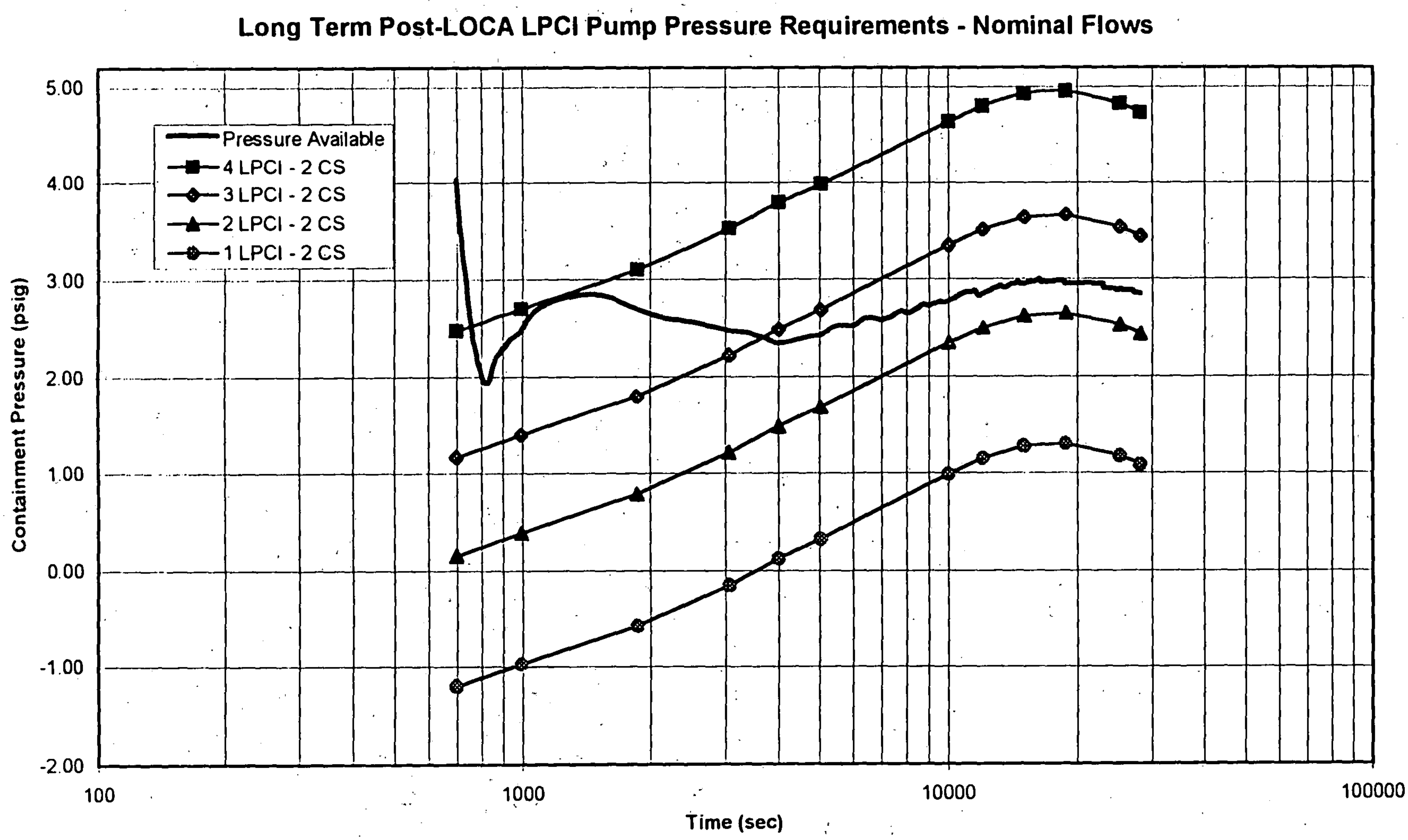
Long Term Post-LOCA LPCI Pump Pressure Requirements - Nominal Flows
Pressure Available
4 LPCI - 2 CS
3 LPCI - 2 CS
2 LPCI - 2 CS
1 LPCI - 2 CS
Containment Pressure (psig)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
100
1000
10000
100000
Time (sec)

FIGURE 1

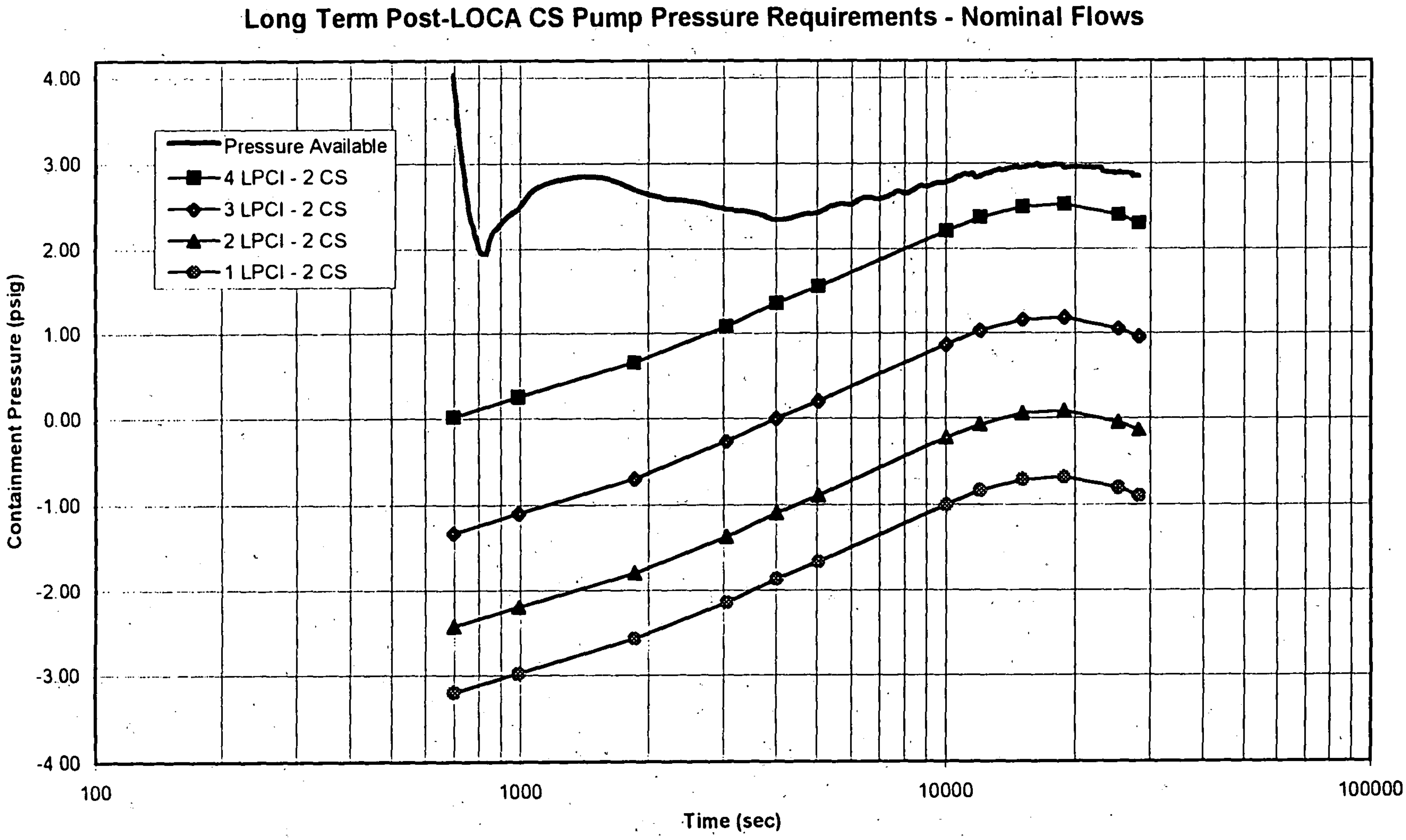
Long Term Post-LOCA CS Pump Pressure Requirements - Nominal Flows
Pressure Available
4 LPCI - 2 CS
3 LPCI - 2 CS
2 LPCI - 2 CS
1 LPCI - 2 CS
Containment Pressure (psig)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
100
1000
10000
100000
Time (sec)

FIGURE 2

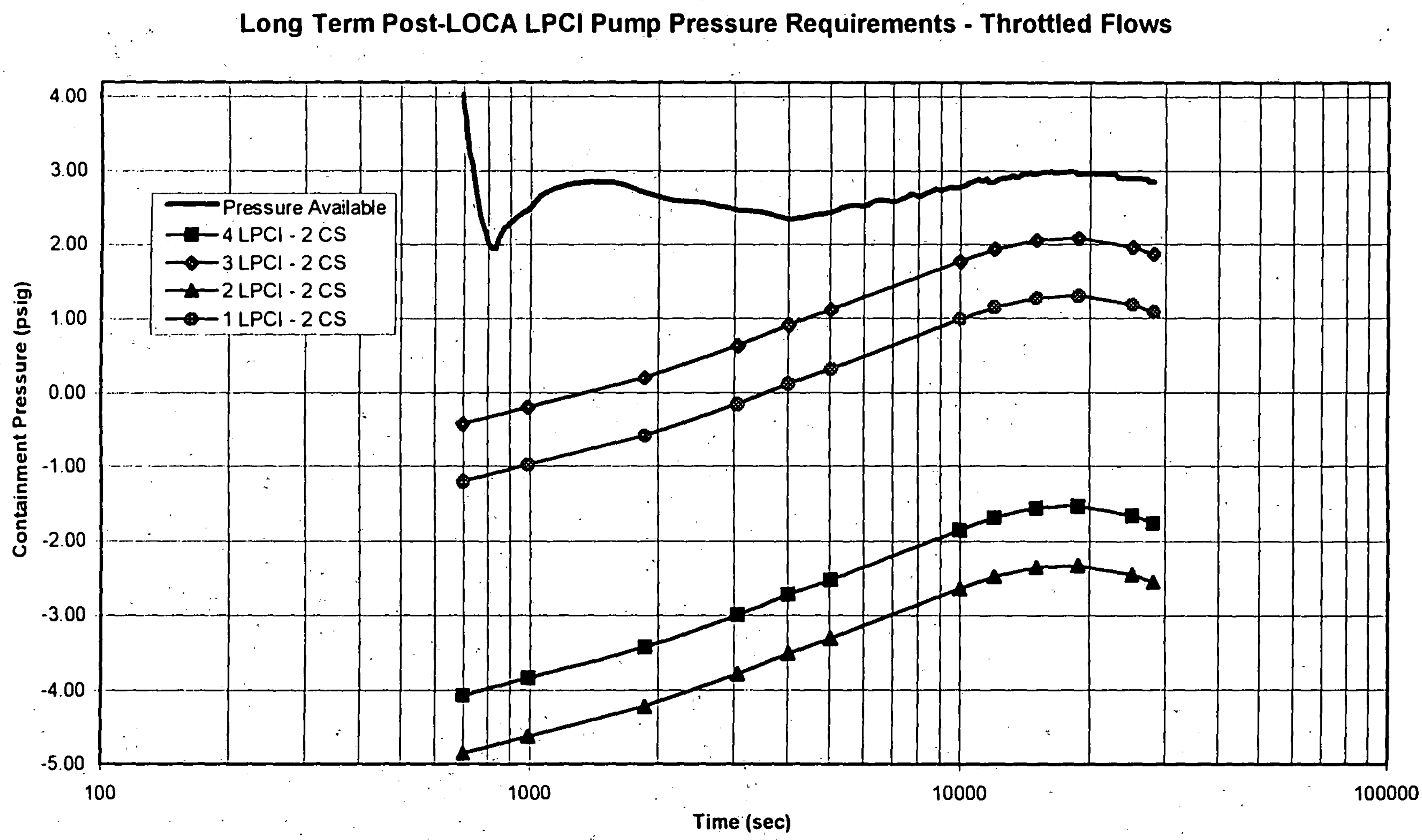
Long Term Post-LOCA LPCI Pump Pressure Requirements - Throttled Flows
Containment Pressure (psig)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
Pressure Available
4 LPCI - 2 CS
3 LPCI - 2 CS
2 LPCI - 2 CS
1 LPCI - 2 CS
100
1000
10000
100000
Time (sec)

FIGURE 3

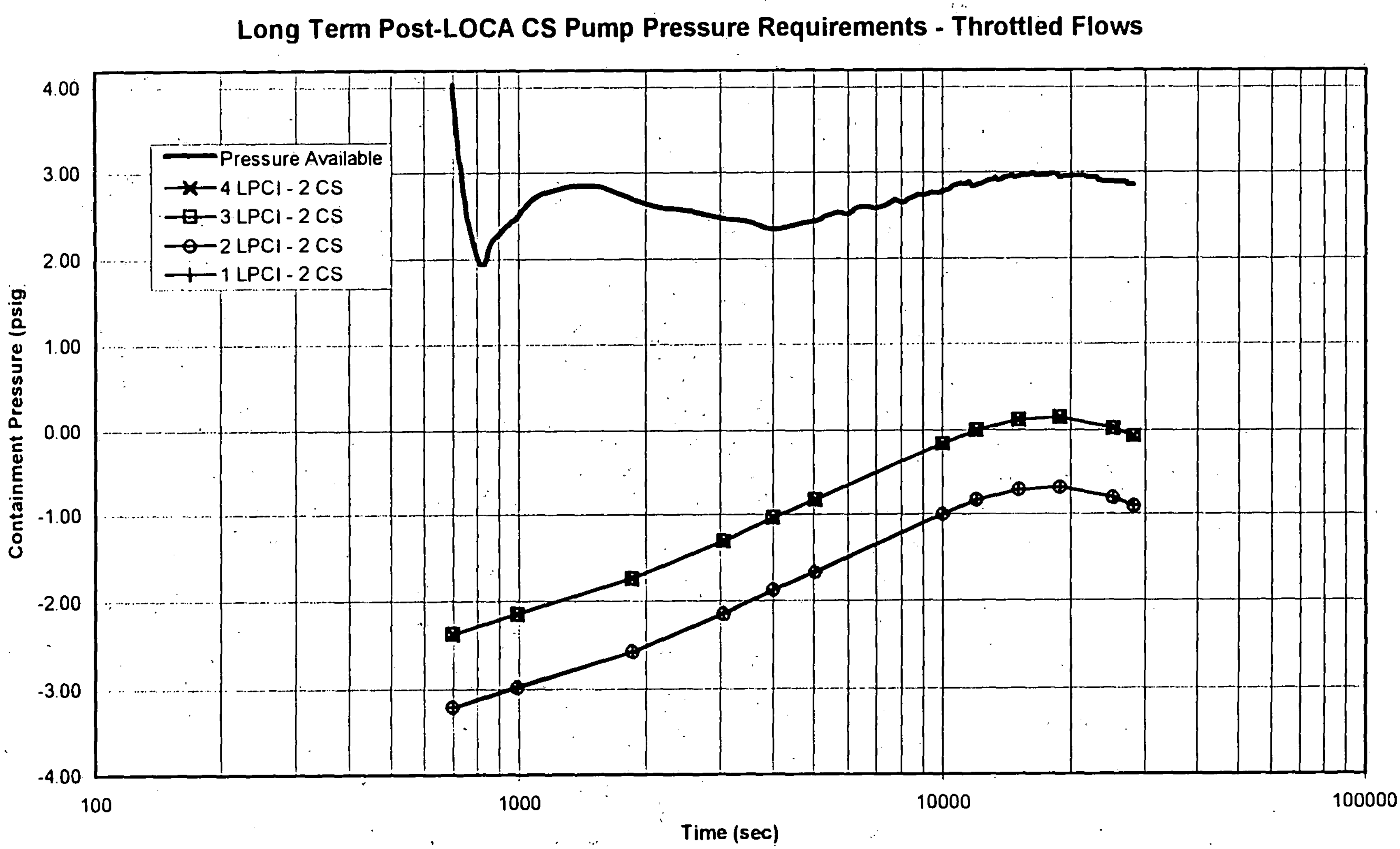
Long Term Post-LOCA CS Pump Pressure Requirements - Throttled Flows
Pressure Available
4 LPCI - 2 CS
3 LPCI - 2 CS
2 LPCI - 2 CS
1 LPCI - 2 CS
Containment Pressure (psig
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
100
1000
10000
100000
Time (sec)

FIGURE 4

ATTACHMENT A

LPCI/Core Spray Suction Friction Losses
FLO-SERIES Model

Dresden LPCI/Core Spray pump suction friction losses were developed using a FLO-SERIES model of the Dresden ECCS ring header and pump suction piping (Ref. 4). The nodal diagram of the piping model is included as Figure A1. This model was run at the various LPCI and Core Spray pump combinations and flows listed below as required to support the cases evaluated in this calculation. The FLO-SERIES runs are included in this Attachment.

LPCI Pumps	CS Pumps	LPCI/CS Flow per Pump (gpm)	Strainer Loss[#] h_{strain} (ft)	LPCI Friction Loss (ft)	LPCI Loss +15% h_L (ft)	**Total LPCI Loss* h_{total} (ft)**	CS Friction Loss (ft)	CS Loss +15% h_L (ft)	**Total CS Loss* h_{total} (ft)**	FLO-SERIES Line-up Filename
4	2	5000/4500	5.42	9.28	10.67	**16.09**	6.87	7.91	**13.33**	4L502C45.PLU
4	2	2500/4500	2.33	2.95	3.39	**5.71**	4.67	5.37	**7.69**	4L252C45.PLU
3	2	5000/4500	3.71	8.09	9.30	**13.02**	5.59	6.43	**10.14**	3L502C45.PLU
3	2	var./4500	2.33	6.06	6.96	**9.29**	4.67	5.37	**7.69**	3L_50_25.PLU
2	2	5000/4500	2.33	7.23	8.32	**10.64**	4.55	5.23	**7.55**	2L502C45.PLU
2	2	2500/4500	1.26	2.25	2.59	**3.85**	3.88	4.46	**5.72**	2L252C45.PLU
1	2	5000/4500	1.26	5.36	6.16	**7.43**	3.88	4.46	**5.72**	1L502C45.PLU

 # Strainer Loss = (Flow per strainer/10,000 gpm)^2 x 5.8 ft.
*** Total Loss = (Loss +15%) + Strainer Loss**

Table A-1

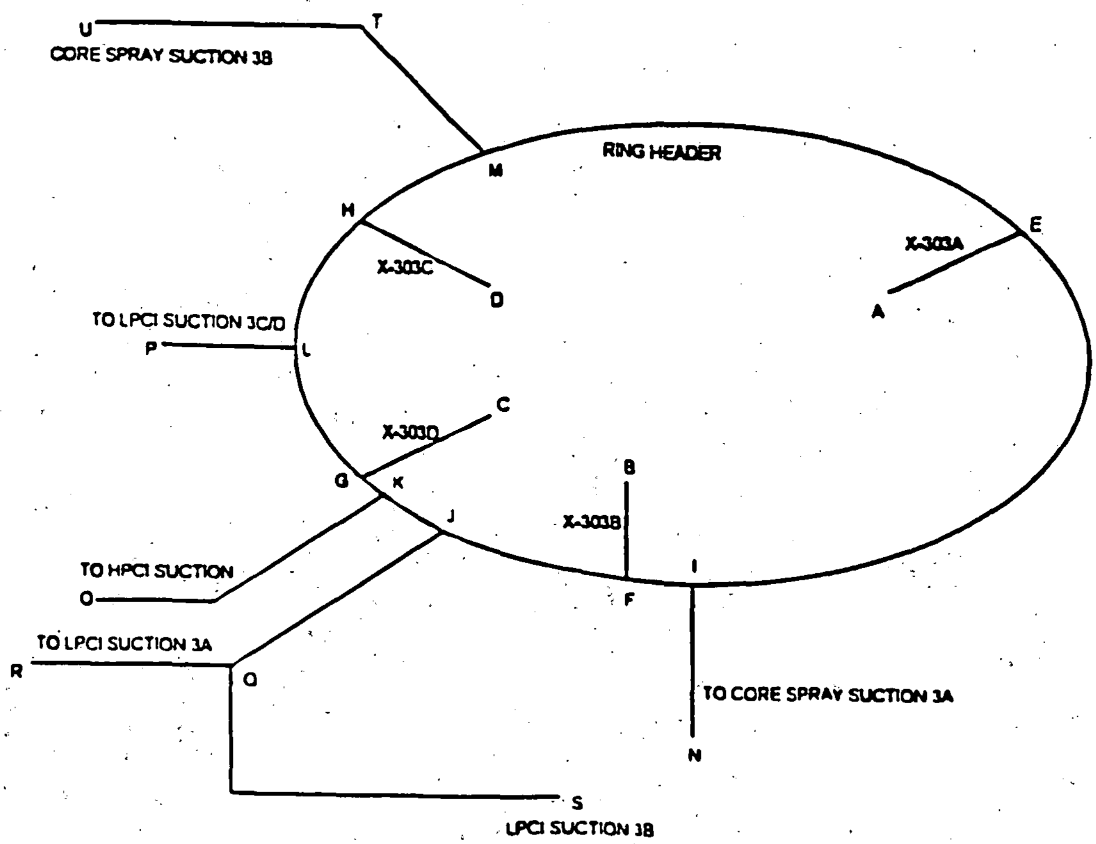

Figure A1: ECCS Suction Nodal Diagram including the Ring Header

Company: comed
Project:
by: palas

02/07/97

LINEUP REPORT rev: 02/07/97

LINELIST: RING
dated: 01/08/97

DEVIATION: 0.0157 %
after: 5 iterations

4 LPCI @5000 and 2 CS @4500 Injecting. Nearest torus leg blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	O	>>>	0.0001
P	>>>	10000	R	>>>	5000
S	>>>	5000	U	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 29000 gpm
NET FLOWS OUT: 29000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	9433	<<<	A	0
Torus-2	<<<	9552	<<<	B	0
Torus-3	<<<	10015	<<<	C	0

FLOWS IN: 29000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 29000 gpm

Calculation No. DRE97-0010
Revision 0 **Page A3**

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
A	0		p 0	0
B	0		p 0	0
C	0		p 0	0
E	0		* -1.403	-3.258
F	0		* -1.439	-3.341
G	0		* -1.582	-3.672
H	0		* -1.669	-3.874
I	0		* -1.444	-3.351
J	0		* -1.596	-3.705
K	0		* -1.591	-3.693
L	0		* -1.684	-3.909
M	0		* -1.662	-3.858
N	0	> 4500	* -1.694	-3.933
O	0	> 0.0001	* -1.591	-3.693
P	0	> 10000	* -1.948	-4.523
Q	0		* -2.208	-5.125
R	0	> 5000	* -2.75	-6.384
S	0	> 5000	* -3.996	-9.276
T	0		* -1.918	-4.451
U	0	> 4500	* -2.961	-6.874

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I	N	4500	6.274	0.251	0.582
CS3B-16	T	U	4500	7.911	1.044	2.423
CS3B-18	M	T	4500	6.274	0.255	0.593
HPCI	K	O	0	0	0	0
LPCI3A	Q	R	5000	11.64	0.543	1.259
LPCI3A/B	J	Q	10000	7.563	0.612	1.42
LPCI3B	Q	S	5000	11.64	1.789	4.152
LPCI3C/D	L	P	10000	7.563	0.264	0.614
Ring-1	E	I	2609	1.973	0.040	0.093
Ring-2	F	I	1891	1.43	0.004	0.010
Ring-3	F	J	7661	5.794	0.157	0.365
Ring-4	K	J	2339	1.769	0.005	0.012
Ring-5	G	K	2339	1.769	0.009	0.021
Ring-6	G	L	7676	5.805	0.102	0.237
Ring-7	H	L	2324	1.758	0.015	0.035
Ring-8	M	<-> H	2324	1.758	0.007	0.015
Ring-9	E	M	6824	5.161	0.259	0.601
Torus-1	A	E	9433	11.42	1.403	3.258
Torus-2	B	F	9552	11.57	1.439	3.341
Torus-3	C	G	10015	12.12	1.582	3.672
Torus-4	D	H	closed	0	0	0

LINEUP REPORT rev: 12/21/96

LINELIST: RING
dated: 12/18/96

DEVIATION: 0.0111 %
after: 6 iterations

4 LPCI @2500 and 2 CS @4500 Injecting. Nearest torus leg blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	O	>>>	0.0001
P	>>>	5000	R	>>>	2500
S	>>>	2500	U	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 19000 gpm
NET FLOWS OUT: 19000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	6218	<<<	A	0
Torus-2	<<<	6302	<<<	B	0
Torus-3	<<<	6480	<<<	C	0

FLOWS IN: 19000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 19000 gpm

Calculation No. DRE97-0010
Revision 0 **Page A6**

LINEUP NODES

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi g	H GRADE ft
A	0		p	0	0
B	0		p	0	0
C	0		p	0	0
E	0		*	-0.610	-1.416
F	0		*	-0.626	-1.454
G	0		*	-0.662	-1.538
H	0		*	-0.712	-1.652
I	0		*	-0.634	-1.472
J	0		*	-0.666	-1.547
K	0		*	-0.665	-1.544
L	0		*	-0.711	-1.651
M	0		*	-0.712	-1.652
N	0	> 4500	*	-0.885	-2.054
O	0	> 0.0001	*	-0.665	-1.544
P	0	> 5000	*	-0.778	-1.805
Q	0		*	-0.820	-1.903
R	0	> 2500	*	-0.956	-2.219
S	0	> 2500	*	-1.269	-2.945
T	0		*	-0.967	-2.245
U	0	> 4500	*	-2.011	-4.668

Calculation No. DRE97-0010
Revision 0 **Page A7**

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
[illegible]S-3A	I	N	4500	6.274	0.251	0.582
CS3B-16	T	U	4500	7.911	1.044	2.423
CS3B-18	M	T	4500	6.274	0.255	0.593
HPCI	K	O	0	0	0	0
LPCI3A	Q	R	2500	5.822	0.136	0.315
LPCI3A/B	J	Q	5000	3.781	0.154	0.357
LPCI3B	Q	S	2500	5.822	0.449	1.041
LPCI3C/D	L	P	5000	3.781	0.066	0.154
Ring-1	E	I	1999	1.512	0.024	0.056
Ring-2	F	I	2501	1.892	0.008	0.018
Ring-3	F	J	3800	2.874	0.040	0.093
Ring-4	K	J	1200	0.907	0.001	0.003
Ring-5	G	K	1200	0.907	0.002	0.006
Ring-6	G	L	5280	3.993	0.049	0.113
Ring-7	L	<-> H	280.3	0.212	0	0
Ring-8	H	M	280.3	0.212	0	0
Ring-9	E	M	4220	3.191	0.102	0.236
Torus-1	A	E	6218	7.529	0.610	1.416
Torus-2	B	F	6302	7.629	0.626	1.454
Torus-3	C	G	6480	7.845	0.662	1.538
Torus-4	D	H	closed	0	0	0

Calculation No. DRE97-0010
Revision 0 **Page A8**

Company: comed
Project:
by: palas

3L3U2C49
02/07/97

LINEUP REPORT rev: 12/21/96

LINELIST: RING
dated: 12/18/96

DEVIATION: 1.37 %
after: 3 iterations

3 LPCI @5000 and 2 CS @4500 Injecting. Nearest torus blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	P	>>>	5000
R	>>>	5000	S	>>>	5000
U	>>>	4500			

FLOWS IN: 0 gpm
FLOWS OUT: 24000 gpm
NET FLOWS OUT: 24000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	7825	<<<	A	0
Torus-2	<<<	7891	<<<	B	0
Torus-3	<<<	8284	<<<	C	0

FLOWS IN: 24000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 24000 gpm

Calculation No. DRE97-0010
Revision 0 **Page A9**

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi g	H GRADE ft
A	0		p	0	0
B	0		p	0	0
C	0		p	0	0
E	0		*	-0.966	-2.242
F	0		*	-0.982	-2.28
G	0		*	-1.082	-2.513
H	0		*	-1.109	-2.574
I	0		*	-1.012	-2.349
J	0		*	-1.086	-2.52
K	0		*	-1.106	-2.568
L	0		*	-1.118	-2.595
M	0		*	-1.108	-2.573
N	0	> 4500	*	-1.263	-2.931
P	0	> 5000	*	-1.184	-2.748
Q	0		*	-1.697	-3.939
R	0	> 5000	*	-2.24	-5.199
S	0	> 5000	*	-3.486	-8.091
T	0		*	-1.364	-3.166
U	0	> 4500	*	-2.408	-5.589

LINEUP PIPELINES

02/07/97

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
[illegible]S-3A	I	N	4500	6.274	0.251	0.582
CS3B-16	T	U	4500	7.911	1.044	2.423
CS3B-18	M	T	4500	6.274	0.255	0.593
HPCI	K	O	closed	0	0	0
LPCI3A	Q	R	5000	11.64	0.543	1.259
LPCI3A/B	J	Q	10000	7.563	0.612	1.42
LPCI3B	Q	S	5000	11.64	1.789	4.152
LPCI3C/D	L	P	5000	3.781	0.066	0.154
Ring-1	E	I	2801	2.119	0.046	0.107
Ring-2	F	I	1699	1.285	0.004	0.008
Ring-3	F	J	6192	4.683	0.103	0.240
Ring-4	K	J	3808	2.88	0.014	0.032
Ring-5	G	K	3808	2.88	0.024	0.056
Ring-6	G	L	4476	3.385	0.035	0.082
Ring-7	H	L	523.9	0.396	0	0.002
Ring-8	M	<-> H	523.9	0.396	0	0
Ring-9	E	M	5024	3.8	0.143	0.331
Torus-1	A	E	7825	9.474	0.966	2.242
Torus-2	B	F	7891	9.553	0.982	2.28
Torus-3	C	G	8284	10.03	1.082	2.513
Torus-4	D	H	closed	0	0	0

Company: comed
Project:
by: palas

02/07/97

LINEUP REPORT rev: 12/21/96

LINELIST: RING
dated: 12/18/96

DEVIATION: 0.0106 %
after: 6 iterations

2 LPCI @2500, 1 LPCI @5000 and 2 CS @4500 Injecting. Nearest torus blocked.

Volumetric flow rates require constant fluid properties in all pipelines. Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	P	>>>	5000
S	>>>	5000	U	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 19000 gpm
NET FLOWS OUT: 19000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	6218	<<<	A	0
Torus-2	<<<	6302	<<<	B	0
Torus-3	<<<	6480	<<<	C	0

FLOWS IN: 19000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 19000 gpm

Calculation No. DRE97-0010
Revision 0 **Page A12**

LINEUP NODES

02/07/97

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
A	0		p 0	0
B	0		p 0	0
C	0		p 0	0
E	0		* -0.610	-1.416
F	0		* -0.626	-1.454
G	0		* -0.662	-1.538
H	0		* -0.712	-1.652
I	0		* -0.634	-1.472
J	0		* -0.666	-1.547
K	0		* -0.665	-1.544
L	0		* -0.711	-1.651
M	0		* -0.712	-1.652
N	0	> 4500	* -0.885	-2.054
P	0	> 5000	* -0.778	-1.805
Q	0		* -0.820	-1.903
R	0		* -0.820	-1.903
S	0	> 5000	* -2.609	-6.055
T	0		* -0.967	-2.245
U	0	> 4500	* -2.011	-4.668

02/07/97

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
S-3A	I		N	4500	6.274	0.251	0.582
CS3B-16	T		U	4500	7.911	1.044	2.423
CS3B-18	M		T	4500	6.274	0.255	0.593
HPCI	K		O	closed	0	0	0
LPCI3A	Q		R	0	0	0	0
LPCI3A/B	J		Q	5000	3.781	0.154	0.357
LPCI3B	Q		S	5000	11.64	1.789	4.152
LPCI3C/D	L		P	5000	3.781	0.066	0.154
Ring-1	E		I	1999	1.512	0.024	0.056
Ring-2	F		I	2501	1.892	0.008	0.018
Ring-3	F		J	3800	2.874	0.040	0.093
Ring-4	K		J	1200	0.907	0.001	0.003
Ring-5	G		K	1200	0.907	0.002	0.006
Ring-6	G		L	5280	3.993	0.049	0.113
Ring-7	L	<->	H	280.3	0.212	0	0
Ring-8	H		M	280.3	0.212	0	0
Ring-9	E		M	4220	3.191	0.102	0.236
Torus-1	A		E	6218	7.529	0.610	1.416
Torus-2	B		F	6302	7.629	0.626	1.454
Torus-3	C		G	6480	7.845	0.662	1.538
Torus-4	D		H	closed	0	0	0

Calculation No. DRE97-0010
Revision 0 **Page A14**

Company: Comed
Project:
by: palas

02/07/97

LINEUP REPORT rev: 12/21/96

LINELIST: RING
dated: 12/18/96

DEVIATION: 1.47 %
after: 4 iterations

2 LPCI @5000 and 2 CS @4500 Injecting. Nearest torus leg blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	R	>>>	5000
S	>>>	5000	U	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 19000 gpm
NET FLOWS OUT: 19000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	6169	<<<	A	0
Torus-2	<<<	6419	<<<	B	0
Torus-3	<<<	6412	<<<	C	0

FLOWS IN: 19000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 19000 gpm

Calculation No. DRE97-0010
Revision 0 **Page A15**

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
A	0		p 0	0
B	0		p 0	0
C	0		p 0	0
E	0		* -0.600	-1.394
F	0		* -0.650	-1.509
G	0		* -0.649	-1.506
H	0		* -0.657	-1.525
I	0		* -0.653	-1.515
J	0		* -0.716	-1.662
K	0		* -0.691	-1.604
L	0		* -0.652	-1.513
M	0		* -0.659	-1.53
N	0	> 4500	* -0.904	-2.097
Q	0		* -1.327	-3.081
R	0	> 5000	* -1.87	-4.34
S	0	> 5000	* -3.116	-7.233
T	0		* -0.915	-2.123
U	0	> 4500	* -1.958	-4.546

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I		N	4500	6.274	0.251	0.582
CS3B-16	T		U	4500	7.911	1.044	2.423
CS3B-18	M		T	4500	6.274	0.255	0.593
HPCI	K		O	closed	0	0	0
LPCI3A	Q		R	5000	11.64	0.543	1.259
LPCI3A/B	J		Q	10000	7.563	0.612	1.42
LPCI3B	Q		S	5000	11.64	1.789	4.152
LPCI3C/D	L		P	closed	0	0	0
Ring-1	E		I	2991	2.262	0.052	0.121
Ring-2	F		I	1509	1.141	0.003	0.007
Ring-3	F		J	4910	3.714	0.066	0.153
Ring-4	K		J	5090	3.849	0.025	0.057
Ring-5	G		K	5090	3.849	0.042	0.098
Ring-6	G		L	1322	1.000	0.003	0.008
Ring-7	L	<->	H	1322	1.000	0.005	0.012
Ring-8	H		M	1322	1.000	0.002	0.005
Ring-9	E		M	3178	2.403	0.059	0.136
Torus-1	A		E	6169	7.469	0.600	1.394
Torus-2	B		F	6419	7.772	0.650	1.509
Torus-3	C		G	6412	7.763	0.649	1.506
Torus-4	D		H	closed	0	0	0

Company: comed
Project:
by: palas

[illegible]
02/07/97

LINEUP REPORT rev: 02/04/97

LINELIST: RING
dated: 01/08/97

DEVIATION: 0.019 %
after: 5 iterations

2 LPCI @2500 and 2 CS @4500 Injecting. Nearest torus leg blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	R	>>>	2500
S	>>>	2500	U	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 14000 gpm

NET FLOWS OUT: 14000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	4592	<<<	A	0
Torus-2	<<<	4719	<<<	B	0
Torus-3	<<<	4690	<<<	C	0

FLOWS IN: 14001 gpm
FLOWS OUT: 0 gpm

NET FLOWS IN: 14001 gpm

Calculation No. DRE97-0010
Revision 0 **Page A18**

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi g	H GRADE ft
A	0		p 0	0
B	0		p 0	0
C	0		p 0	0
E	0		* -0.333	-0.772
F	0		* -0.351	-0.816
G	0		* -0.347	-0.806
H	0		* -0.365	-0.848
I	0		* -0.359	-0.833
J	0		* -0.366	-0.850
K	0		* -0.359	-0.834
L	0		* -0.354	-0.822
M	0		* -0.370	-0.860
N	0	> 4500	* -0.610	-1.415
Q	0		* -0.520	-1.207
R	0	> 2500	* -0.656	-1.522
S	0	> 2500	* -0.969	-2.248
T	0		* -0.626	-1.452
U	0	> 4500	* -1.669	-3.875

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I		N	4500	6.274	0.251	0.582
CS3B-16	T		U	4500	7.911	1.044	2.423
CS3B-18	M		T	4500	6.274	0.255	0.593
HPCI	K		O	closed	0	0	0
LPCI3A	Q		R	2500	5.822	0.136	0.315
LPCI3A/B	J		Q	5000	3.781	0.154	0.357
LPCI3B	Q		S	2500	5.822	0.449	1.041
LPCI3C/D	L		P	closed	0	0	0
Ring-1	E		I	2074	1.569	0.026	0.060
Ring-2	F		I	2426	1.835	0.007	0.017
Ring-3	F		J	2293	1.734	0.015	0.035
Ring-4	K		J	2707	2.047	0.007	0.016
Ring-5	G		K	2707	2.047	0.012	0.028
Ring-6	G		L	1983	1.499	0.007	0.017
Ring-7	L	<->	H	1983	1.499	0.011	0.026
Ring-8	H		M	1983	1.499	0.005	0.011
Ring-9	E		M	2517	1.904	0.038	0.087
Torus-1	A		E	4592	5.559	0.333	0.772
Torus-2	B		F	4719	5.713	0.351	0.816
Torus-3	C		G	4690	5.678	0.347	0.806
Torus-4	D		H	closed	0	0	0

Calculation No. DRE97-0010
Revision 0 Page A26

LINEUP REPORT rev: 12/21/96

LINELIST: RING DEVIATION: 0.0179 %
dated: 12/18/96 after: 5 iterations

1 LPCI @5000 and 2 CS @4500 Injecting. Nearest torus leg blocked.

Volumetric flow rates require constant fluid properties in all pipelines.
Fluid properties in the first specification were used.

NODE		DEMAND gpm	NODE		DEMAND gpm
N	>>>	4500	S	>>>	5000
U	>>>	4500			

FLOWS IN: 0 gpm
FLOWS OUT: 14000 gpm
NET FLOWS OUT: 14000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	4592	<<<	A	0
Torus-2	<<<	4719	<<<	B	0
Torus-3	<<<	4690	<<<	C	0

FLOWS IN: 14001 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 14001 gpm

Calculation No. DRE97-0010
Revision 0 Page A 21

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi g	H GRADE ft
A	0		p	0	0
B	0		p	0	0
C	0		p	0	0
E	0		*	-0.333	-0.772
F	0		*	-0.351	-0.816
G	0		*	-0.347	-0.806
H	0		*	-0.365	-0.848
I	0		*	-0.359	-0.833
J	0		*	-0.366	-0.850
K	0		*	-0.359	-0.834
L	0		*	-0.354	-0.822
M	0		*	-0.370	-0.860
N	0	> 4500	*	-0.610	-1.415
Q	0		*	-0.520	-1.207
S	0	> 5000	*	-2.309	-5.359
T	0		*	-0.626	-1.452
U	0	> 4500	*	-1.669	-3.875

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I		N	4500	6.274	0.251	0.582
CS3B-16	T		U	4500	7.911	1.044	2.423
CS3B-18	M		T	4500	6.274	0.255	0.593
HPCI	K		O	closed	0	0	0
LPCI3A	Q		R	closed	0	0	0
LPCI3A/B	J		Q	5000	3.781	0.154	0.357
LPCI3B	Q		S	5000	11.64	1.789	4.152
LPCI3C/D	L		P	closed	0	0	0
Ring-1	E		I	2074	1.569	0.026	0.060
Ring-2	F		I	2426	1.835	0.007	0.017
Ring-3	F		J	2293	1.734	0.015	0.035
Ring-4	K		J	2707	2.047	0.007	0.016
Ring-5	G		K	2707	2.047	0.012	0.028
Ring-6	G		L	1983	1.499	0.007	0.017
Ring-7	L	<->	H	1983	1.499	0.011	0.026
Ring-8	H		M	1983	1.499	0.005	0.011
Ring-9	E		M	2517	1.904	0.038	0.087
Torus-1	A		E	4592	5.559	0.333	0.772
Torus-2	B		F	4719	5.713	0.351	0.816
Torus-3	C		G	4690	5.678	0.347	0.806
Torus-4	D		H	closed	0	0	0

Calculation No. DRE97-0010
Revision 0 **Page A23**