Calculation Title Page

Calculation No.: **DRE97-0002**	Page 1 of 11
☒ Safety Related ☐ Regulatory Related ☐ Non-Safety Related	
Calculation Title: **Dresden LPCI/Core Spray NPSH Analysis Post-DBA LOCA: GE SIL 151 Case Short-Term**	
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:
Prepared by: [signature] HARRY PALAS	Date: 1/8/97
Revision Summary:	
Electronic Calculation Data Files Revised: RING.PLL 4L512C58.PLU RING.PLU 4L512C55.PLU 4L512C50.PLU	
Do any assumptions in this calculation require later verification?	☐ Yes ☒ No
Reviewed by: J. W. Drowley	Date: 1/8/97
Review Method: DETAILED REVIEW	Comments (C, NC or CI): NC
Approved by: [signature]	Date: 1/9/97

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Calculation Revision Page

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Rev: **0** Status: QA Serial # or CHRON # **NA** Date:__________

Prepared by:____ Date:__________

Revision Summary:

Electronic Calculation Data Files Revised:

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:__________

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1.0 PURPOSE/OBJECTIVE

This calculation examines the Net Positive Suction Head (NPSH) available to the Dresden LPCI and Core Spray (CS) pumps in the first 600 seconds following a DBA-LOCA. Specifically, the GE SIL 151 case will be evaluated, which postulates a failure of the LPCI Loop Select logic. This case is bounding since it results in all 4 LPCI and 2 CS pumps operating at above rated flows (maximizing pump suction losses), with the LPCI pumps injecting into a broken reactor recirculation loop (minimizing flow to reactor for Peak Clad Temperature considerations). Due to the high flows anticipated, the Core Spray pumps may cavitate, resulting in reduced system flow. This reduced flow will be calculated and compared to the minimum flow required of the CS system. This calculation will be performed using a reduced initial torus temperature of 75°F and a torus pressure of 2 psig. The results of this calculation will be used to support a Dresden Exigent License Amendment.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

The minimum suppression pool pressure required to satisfy LPCI and CS pump NPSH requirements will be determined under short-term post-LOCA conditions. If the pool pressure required is greater than the pressure available, then the potential exists for the pumps to cavitate, resulting in reduced flows. A minimum Core Spray system flow of 10,552 gpm (5276 gpm per pump) is required for the first 200 seconds post-accident to ensure the Peak Clad Temperature (PCT) remains below 2200°F, while a nominal Core Spray flow of 4500 gpm per pump is acceptable beyond 200 seconds (Ref. 19).

NPSH Required (NPSHR) curves for the LPCI/CS pumps are provided on the original vendor pump curves (Refs. 12, 13). These NPSHR curves represent the point at which a 3% reduction in pump developed head has occurred. Cavitation tests were performed on this pump model by the vendor at various flow rates (Ref. 16). The test data indicates that the pump remains stable for several feet below the NPSHR value, which is expected, before the pump head collapses (full cavitation). Based on the flow rates at which the pumps were tested, it is possible to develop a reduced NPSHR curve that represents the point at which full cavitation has been achieved, as shown in Figure 1 (Refs. 17, 18). Thus, given a known set of conditions (temperature, pressure, level), the reduced flows at which the pumps will operate can be determined as follows:

1. Assume initial operating pump flow rate (maximum pump flow).
2. Determine the suppression pool pressure required to satisfy the pump's reduced NPSH requirements (Fig. 1) using the assumed pump flow and the expected torus temperature at 200 seconds post-LOCA (Ref. 1).
3. Reduce pump flow estimate until the pool pressure required equals the minimum pool pressure available (Assumption 5). It is at this flow that the pump will be in full cavitation and the total developed head (TDH) will drop off. Since this drop-off is essentially vertical, the pump curve will intersect the system curve at this flow, i.e., this is the flow at which the system will operate.

3.0 ASSUMPTIONS

1. LPCI/CS pump 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. 5). 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 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.

2. 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 1, 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 is chosen for maximum effect on LPCI and Core Spray suction losses.

3. Reference 3 developed LPCI system resistance curves and expected maximum operating flows for Unit 2. It is assumed that the Unit 3 results are similar based on identical pumps and elevations, and similar discharge piping layouts.

4. Reference 2 developed Core Spray system resistance curves and expected maximum operating flows utilizing actual Core Spray pump performance. For the Core Spray loop with the least system resistance, the original vendor pump curve was plotted with the system curve developed in Reference 2. The operating point was determined to be the same as that developed in the calculation. Therefore, the maximum Core Spray system flow of 5800 gpm used in Design Input 1 is appropriate.

5. For the purposes of this calculation, a suppression pool pressure of 2 psig will be assumed. This is consistent with the discussion provided in Dresden UFSAR Section 6.3.3.4.3, in which the presence of 2 psig in the drywell is expected since this is one of the signals which initiates the ECCS. This assumption is conservative based on the following:

   - The Dresden post-LOCA containment pressure response (Dresden UFSAR Figure 6.2-19) indicates an expected suppression pool pressure of >15 psig at 200 seconds, and >10 psig at 600 seconds.
   - The Quad Cities post-LOCA expected suppression pool pressure is >20 psig at 200 seconds and 600 seconds (Quad Cities UFSAR Figure 6.2-16).
   - Reference 1 indicates a minimum expected pool pressure of approximately 20 psig at 200 seconds, and 5.5 psig at 600 seconds.

6. While no Dresden-specific short-term containment temperature response exists, a reasonable estimate can be made using the following existing analyses:

   - In Reference 1, the Dresden post-LOCA suppression pool temperature at 200 seconds is 138°F, and at 600 seconds is 150°F, based on a 95°F initial pool temperature. These values were developed using modern analysis techniques, including ANS 5.1 decay heat model, feedwater flow and addition of pump heat.

   - The temperature profiles for Quad Cities are available and are considered representative for use at Dresden, based on plant similarities with respect to containment size, core power, and reactor operating parameters. The Quad Cities containment response (Quad Cities UFSAR Figure 6.2-18) indicates the pool temperature at 200 seconds is 144°F, and at 600 seconds is 147°F, based on a 90°F initial pool temperature. These values were developed using original analysis techniques, including the May-Witt decay heat model, no feedwater flow and no pump heat added. If corrected to a 95°F initial pool temperature (assuming a one-to-one short-term temperature relationship), these values conservatively bound the Reference 1 values listed above.

   Therefore, for the purposes of this calculation, the more conservative Quad Cities temperatures will be used.

7. It is assumed that a reduction in initial suppression pool temperature will result in a corresponding linear reduction in the short-term pool temperature response, since pool cooling is not active. Given this assumption, therefore, for a reduced initial pool temperature of 75°F (15°F reduction from Quad Cities values based on 90°F initial torus temperature), the pool temperature at 200 seconds post-LOCA is 129°F, and at 600 seconds is 132°F.

8. GE SIL 151 includes a case of all 4 LPCI pumps injecting into both reactor recirculation loops simultaneously, with one loop broken. While it is expected that this case may result in slightly higher LPCI pump flow rates, a significant amount of water will be injected into the reactor through the intact loop. Therefore, any reduction in Core Spray system flow due to cavitation below the minimum required flow will be made up by the LPCI flow injecting into the reactor. Therefore, it is expected that the PCT will not be challenged in this case.

4.0 DESIGN INPUTS

1. Maximum LPCI and Core Spray pump flows used are as follows:

Core Spray 1-Pump Maximum Injection Flow	5800 gpm	(Ref. 2)
LPCI 4-Pump Maximum Injection Flow to broken loop	20,600 gpm	(Ref. 3, Att. S)

2. The maximum allowable suppression pool temperature under normal operating conditions is 95°F (Ref. 4). For the purposes of this calculation, the effects of an initial pool temperature of 75°F on LPCI/CS pumps NPSH margin will be examined.

3. The NPSH Required for the LPCI and Core Spray pumps is 31.5 ft. at 5150 gpm, 38.5 ft. at 5800 gpm (Refs. 12, 13).

4. LPCI/CS pump suction piping friction losses (excluding strainer losses) were developed for a single flow case using a FLO-SERIES Version 4.11 model of the Dresden ECCS ring header and pump suction piping (Ref. 5). 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).

5. The minimum suppression pool level elevation using a maximum drawdown of 2.1 ft. is 491' 5", or 491.4 ft. (Ref. 6).

6. The suppression pool strainers have a 100% clean head loss of 5.8 ft. @10,000 gpm (Ref. 7).

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

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

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

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

9. Saturation pressure of water at 129°F is 2.164 psia, at 132°F is 2.345 psia (Ref. 11).

10. Specific volume of water at 129°F is 0.016243 ft^3/lb, at 132°F is 0.016256 ft^3/lb (Ref. 11).

5.0 REFERENCES

1. "Dresden Containment Analysis for Limiting DBA-LOCA", GE letter from S. Mintz to J. Nash dated November 18, 1996, Project No. DRF T23-00740
2. "Evaluation of Core Spray Capabilities and Surveillance Basis", Dresden Calculation No. DRE96-0207, dated December 17, 1996
3. "LPCI System Derivation of System Resistance Curves, Pump Curves, and Comparison to LOCA Analysis - Unit 2", Dresden Calculation No. DRE96-0211, Rev. 1, December 17, 1996
4. Dresden Unit 2 Technical Specifications, DPR-19, Section 3.7.A.1.c.1
5. "ECCS Suction Hydraulic Analysis without the Strainers", Duke Engineering & Services Calculation Number DRE96-0241 dated December 20, 1996
6. "Submergence of LPCI Discharge Line Post LOCA - Dresden Units 2 & 3", letter from S. Eldridge to C. Schroeder dated September 29, 1992, CHRON# 0115532
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
16. "Cavitation Test Report - 12x14x14-1/2 CVDS Pump", Bingham Pump Co., May 22, 1969
17. "S/B Pumps 12x14x14.5 (LPCI) and 12x16x14.5 (CS) CVDS - Flow Delivery Under Full Cavitation Conditions", letter from H. Palas to D. Spencer dated November 1, 1996
18. "Comments to Quad Cities LPCS/CS Pump NPSH Position", letter from D. Spencer to H. Palas dated November 1, 1996
19. "Dresden LOCA PCT Impact of NPSH Limiting ECCS Flow", letter NFS:BSA:96-165 from R. Tsai to R. Freeman dated December 20, 1996

6.0 CALCULATIONS

The equation presented in Design Input 8 can be rewritten to solve for the minimum suppression pool pressure required for pump protection by setting NPSHA equal to NPSHR as follows:

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

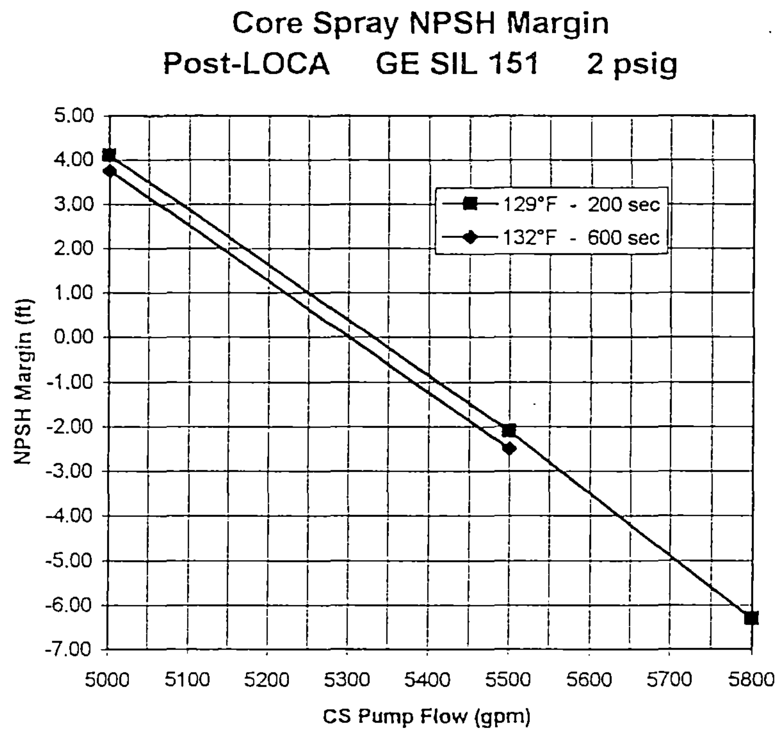
where P_v	=	2.164 psia @129°F	(Design Input 9)
		2.345 psia @132°F	(Design Input 9)
V	=	0.016243 ft^3/lb @129°F	(Design Input 10)
		0.016256 ft^3/lb @132°F	(Design Input 10)
h_{total}	=	friction (h_L) + strainer (h_{strain}) loss	(Attachment A)
h_{strain}	=	5.8 ft. @ 10,000 gpm clean	(Design Input 6)
Z	=	491.4 ft. - 478.1 ft. = 13.3 ft.	(Design Inputs 5, 7)
NPSHR	=	31.5 ft. @ 5150 gpm	(Design Input 3)
		38.5 ft. @ 5800 gpm	(Design Input 3)

Solving Equation 1, the minimum suppression pool pressure required to satisfy LPCI and Core Spray pump NPSH requirements is determined to be:

LPCI/CS Pumps	LPCI/CS Flow per Pump (gpm)	Torus Temp (°F)	Total LPCI Suction Loss, h_{total} (ft)	Total CS Suction Loss, h_{total} (ft)	Minimum Required Torus Pressure for LPCI (psia)	Minimum Required Torus Pressure for CS (psia)	Minimum Available Torus Pressure (psia)	LPCI NPSH Margin (ft)	CS NPSH Margin (ft)
4/2	5150/5800	129	18.7	17.9	17.9	20.6	16.7	-2.9	-9.1
4/2	5150/5800	132	18.7	17.9	18.1	20.8	16.7	-3.3	-9.5

As shown above, when all six ECCS pumps are running the potential exists for both the LPCI and Core Spray pumps to cavitate. The LPCI pumps NPSH deficit is relatively small and will result in a negligible reduction in flow due to cavitation (< 100 gpm per pump). The reduced flow at which the CS pumps will operate can be determined using the methodology presented in Section 2.0. Note: Reduction in LPCI flow is conservatively ignored for CS pump reduced flow determination.

CS Flow Per Pump (gpm)	Temp (°F)	Total CS Suction Losses (ft)	LPCI Flow Per Pump (gpm)	Static Head (ft)	Vapor Pressure (psia)	Specific Volume (ft^3/lb)	[Fig. 1] Reduced NPSHR (ft)	Required Torus Pressure (psia)	Available Torus Pressure (psia)	CS NPSH Margin (ft)
5800	129	17.9	5150	13.3	2.164	0.016243	35.7	19.4	16.7	-6.3
5500	129	16.9	5150	13.3	2.164	0.016243	32.5	17.6	16.7	-2.1
5000	129	15.3	5150	13.3	2.164	0.016243	27.9	14.9	16.7	4.1
5500	132	16.9	5150	13.3	2.345	0.016256	32.5	17.8	16.7	-2.5
5000	132	15.3	5150	13.3	2.345	0.016256	27.9	15.1	16.7	3.8



As shown above, it is expected that the Core Spray pump reduced flow due to cavitation would be greater than 5300 gpm per pump within the first 200 seconds post-LOCA. This is greater than the 5276 gpm per pump required in the first 200 seconds post-LOCA to ensure the PCT remains below 2200°F. The Core Spray pump reduced flow beyond 200 seconds would be at least 5300 gpm per pump, greater than the nominal 4500 gpm per pump that is required.

7.0 SUMMARY AND CONCLUSIONS

An NPSH analysis was performed for the LPCI/CS pumps bounding the first 600 seconds following a DBA-LOCA. Specifically, the GE SIL 151 case was evaluated, postulating a failure of the LPCI Loop Select logic. The calculation was performed using a reduced initial torus temperature of 75°F and a torus pressure of 2 psig. It was determined that when all six ECCS pumps are running, the potential exists for the LPCI and Core Spray pumps to cavitate. The LPCI pump NPSH deficit is relatively small and will result in a negligible reduction in flow due to cavitation (< 100 gpm per pump). The reduced flow at which the Core Spray pumps will operate in the first 200 seconds was estimated to be greater than 5300 gpm per pump, which is adequate to ensure the PCT remains below 2200°F. The Core Spray pump reduced flow beyond 200 seconds would be at least 5300 gpm per pump, which is greater than the nominal 4500 gpm per pump required. Therefore, it is concluded that adequate NPSH exists to ensure the LPCI/CS pumps can perform their safety function using a reduced initial torus temperature of 75°F and a torus pressure of 2 psig.

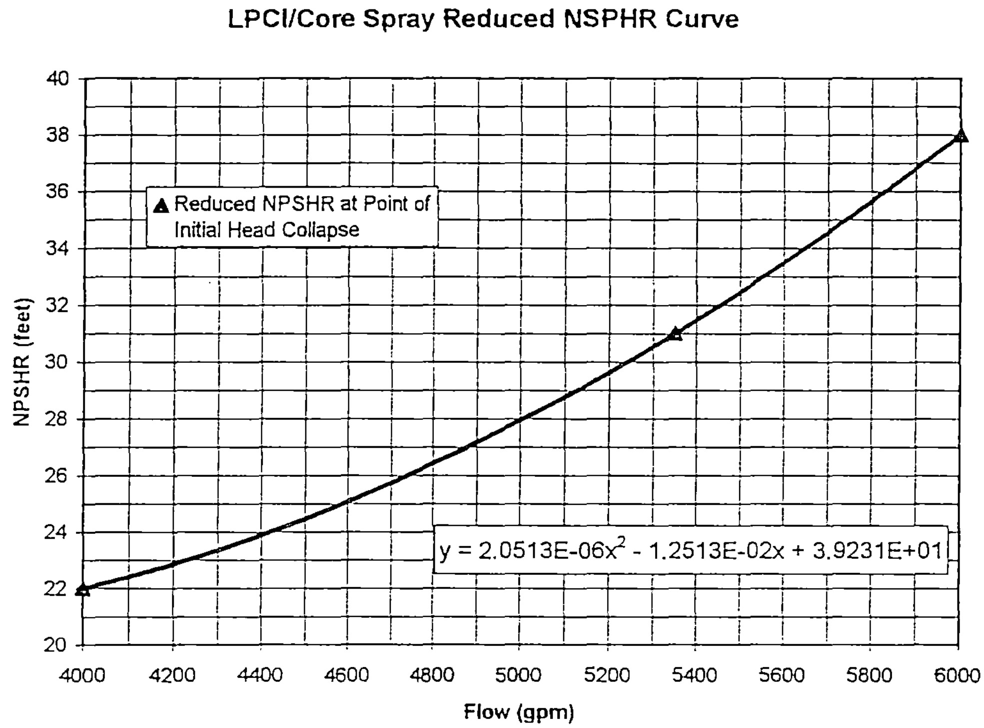


Figure 1 (Refs. 17, 18)

ATTACHMENT A

LPCI/Core Spray Suction Friction Losses
FLO-SERIES Model

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. 5). The model was run at the various LPCI and Core Spray pump flows listed below as required to support the cases evaluated in this calculation. The input and output of the FLO-SERIES runs are included in this Attachment.

LPCI Pumps	Flow Per LPCI (gpm)	CS Pumps	Flow Per CS (gpm)	Strainer Loss[#] h_{strain} (ft)	LPCI Friction Loss (ft)	LPCI Loss +15% h_L (ft)	Total LPCI Suction Loss* h_{total} (ft)	CS Friction Loss (ft)	CS Loss +15% h_L (ft)	Total CS Suction Loss* h_{total} (ft)	FLO-SERIES Line-up Filename
4	5150	2	5800	6.7	10.4	12.0	**18.7**	9.8	11.2	**17.9**	4L512C58.PLU
4	5150	2	5500	6.4	10.3	11.8	**18.2**	9.1	10.4	**16.9**	4L512C55.PLU
4	5150	2	5000	6.0	10.0	11.5	**17.6**	8.0	9.2	**15.3**	4L512C50.PLU

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

Table A-1

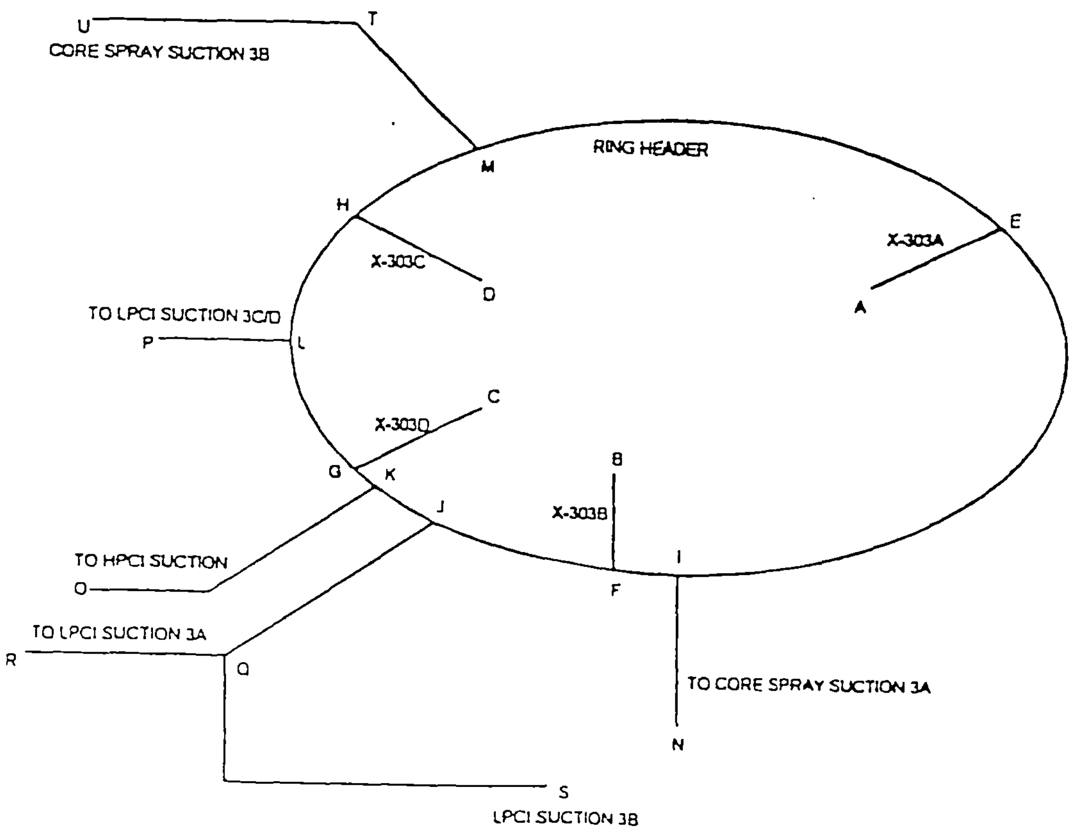


Figure A1: ECCS Suction Nodal Diagram including the Ring Header

Company: comed
Project: Dresden GE SIL 151 Case
by: palas

4L512C58
01/03/97

LINEUP REPORT rev: 01/03/97

LINELIST: RING
dated: 12/18/96

DEVIATION: 0.00898 %
after: 5 iterations

4 LPCI @5150 and 2 CS @5800 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	>>>	5800	O	>>>	0.0001
P	>>>	10300	R	>>>	5150
S	>>>	5150	U	>>>	5800

FLOWS IN: 0 gpm
FLOWS OUT: 32200 gpm

NET FLOWS OUT: 32200 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	10501	<<<	A	0
Torus-2	<<<	10632	<<<	B	0
Torus-3	<<<	11068	<<<	C	0

FLOWS IN: 32201 gpm
FLOWS OUT: 0 gpm

NET FLOWS IN: 32201 gpm

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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		* -1.739	-4.037
F	0		* -1.783	-4.138
G	0		* -1.932	-4.484
H	0		* -2.052	-4.763
I	0		* -1.792	-4.16
J	0		* -1.948	-4.521
K	0		* -1.942	-4.507
L	0		* -2.06	-4.782
M	0		* -2.049	-4.755
N	0	> 5800	* -2.209	-5.127
O	0	> 0.0001	* -1.942	-4.507
P	0	> 10300	* -2.341	-5.433
Q	0		* -2.596	-6.026
R	0	> 5150	* -3.172	-7.362
S	0	> 5150	* -4.493	-10.43
T	0		* -2.473	-5.74
U	0	> 5800	* -4.203	-9.756

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LINEUP PIPELINES

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I	N	5800	8.086	0.417	0.967
CS3B-16	T	U	5800	10.2	1.73	4.016
CS3B-18	M	T	5800	8.086	0.424	0.984
HPCI	K	O	0	0	0	0
LPCI3A	Q	R	5150	11.99	0.576	1.336
LPCI3A/B	J	Q	10300	7.79	0.649	1.506
LPCI3B	Q	S	5150	11.99	1.897	4.404
LPCI3C/D	L	P	10300	7.79	0.281	0.651
Ring-1	E	I	3020	2.284	0.053	0.124
Ring-2	F	I	2780	2.103	0.010	0.022
Ring-3	F	J	7852	5.938	0.165	0.383
Ring-4	K	J	2448	1.852	0.006	0.013
Ring-5	G	K	2448	1.852	0.010	0.023
Ring-6	G	L	8619	6.519	0.128	0.298
Ring-7	H	L	1681	1.271	0.008	0.019
Ring-8	M	<-> H	1681	1.271	0.004	0.008
Ring-9	E	M	7481	5.658	0.310	0.719
Torus-1	A	E	10501	12.71	1.739	4.037
Torus-2	B	F	10632	12.87	1.783	4.138
Torus-3	C	G	11068	13.4	1.932	4.484
Torus-4	D	H	closed	0	0	0

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Company: comed
Project: Dresden GE SIL 151 Case
by: palas

4L512C55
01/03/97

LINEUP REPORT rev: 01/03/97

LINELIST: RING
dated: 12/18/96

DEVIATION: 0.01 %
after: 5 iterations

4 LPCI @5150 and 2 CS @5500 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	>>>	5500	O	>>>	0.0001
P	>>>	10300	R	>>>	5150
S	>>>	5150	U	>>>	5500

FLOWS IN: 0 gpm
FLOWS OUT: 31600 gpm

NET FLOWS OUT: 31600 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	10299	<<<	A	0
Torus-2	<<<	10428	<<<	B	0
Torus-3	<<<	10873	<<<	C	0

FLOWS IN: 31600 gpm
FLOWS OUT: 0 gpm

NET FLOWS IN: 31600 gpm

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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		*	-1.673	-3.883
F	0		*	-1.715	-3.981
G	0		*	-1.865	-4.328
H	0		*	-1.978	-4.591
I	0		*	-1.723	-4
J	0		*	-1.88	-4.364
K	0		*	-1.875	-4.351
L	0		*	-1.988	-4.614
M	0		*	-1.973	-4.58
N	0	> 5500	*	-2.098	-4.87
O	0	> 0.0001	*	-1.875	-4.351
P	0	> 10300	*	-2.268	-5.265
Q	0		*	-2.529	-5.87
R	0	> 5150	*	-3.104	-7.206
S	0	> 5150	*	-4.426	-10.27
T	0		*	-2.355	-5.466
U	0	> 5500	*	-3.911	-9.079

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PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I	N	5500	7.668	0.375	0.870
CS3B-16	T	U	5500	9.669	1.557	3.613
CS3B-18	M	T	5500	7.668	0.381	0.885
HPCI	K	O	0	0	0	0
LPCI3A	Q	R	5150	11.99	0.576	1.336
LPCI3A/B	J	Q	10300	7.79	0.649	1.506
LPCI3B	Q	S	5150	11.99	1.897	4.404
LPCI3C/D	L	P	10300	7.79	0.281	0.651
Ring-1	E	I	2932	2.217	0.050	0.117
Ring-2	F	I	2568	1.942	0.008	0.019
Ring-3	F	J	7860	5.945	0.165	0.383
Ring-4	K	J	2440	1.845	0.006	0.013
Ring-5	G	K	2440	1.845	0.010	0.023
Ring-6	G	L	8433	6.378	0.123	0.286
Ring-7	H	L	1867	1.412	0.010	0.023
Ring-8	M	<-> H	1867	1.412	0.004	0.010
Ring-9	E	M	7367	5.572	0.300	0.697
Torus-1	A	E	10299	12.47	1.673	3.883
Torus-2	B	F	10428	12.63	1.715	3.981
Torus-3	C	G	10873	13.16	1.865	4.328
Torus-4	D	H	closed	0	0	0

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Company: comed
Project: Dresden GE SIL 151 Case
by: palas

4L512C50
01/03/97

LINEUP REPORT rev: 01/03/97

LINELIST: RING
dated: 12/18/96

DEVIATION: 0.0121 %
after: 5 iterations

4 LPCI @5150 and 2 CS @5000 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	>>>	5000	O	>>>	0.0001
P	>>>	10300	R	>>>	5150
S	>>>	5150	U	>>>	5000

FLOWS IN: 0 gpm
FLOWS OUT: 30600 gpm

NET FLOWS OUT: 30600 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psig
Torus-1	<<<	9962	<<<	A	0
Torus-2	<<<	10088	<<<	B	0
Torus-3	<<<	10550	<<<	C	0

FLOWS IN: 30600 gpm
FLOWS OUT: 0 gpm

NET FLOWS IN: 30600 gpm

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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		* -1.565	-3.633
F	0		* -1.605	-3.725
G	0		* -1.755	-4.075
H	0		* -1.856	-4.309
I	0		* -1.611	-3.74
J	0		* -1.771	-4.111
K	0		* -1.765	-4.097
L	0		* -1.87	-4.34
M	0		* -1.851	-4.296
N	0	> 5000	* -1.921	-4.458
O	0	> 0.0001	* -1.765	-4.097
P	0	> 10300	* -2.15	-4.991
Q	0		* -2.42	-5.616
R	0	> 5150	* -2.995	-6.952
S	0	> 5150	* -4.317	-10.02
T	0		* -2.166	-5.027
U	0	> 5000	* -3.453	-8.016

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PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi g	Hl ft
CS-3A	I	N	5000	6.971	0.310	0.719
CS3B-16	T	U	5000	8.79	1.287	2.988
CS3B-18	M	T	5000	6.971	0.315	0.732
HPCI	K	O	0	0	0	0
LPCI3A	Q	R	5150	11.99	0.576	1.336
LPCI3A/B	J	Q	10300	7.79	0.649	1.506
LPCI3B	Q	S	5150	11.99	1.897	4.404
LPCI3C/D	L	P	10300	7.79	0.281	0.651
Ring-1	E	I	2789	2.109	0.046	0.106
Ring-2	F	I	2211	1.672	0.006	0.014
Ring-3	F	J	7877	5.957	0.166	0.385
Ring-4	K	J	2423	1.833	0.006	0.013
Ring-5	G	K	2423	1.833	0.010	0.023
Ring-6	G	L	8127	6.146	0.114	0.265
Ring-7	H	L	2173	1.644	0.013	0.031
Ring-8	M	<-> H	2173	1.644	0.006	0.014
Ring-9	E	M	7173	5.425	0.285	0.662
Torus-1	A	E	9962	12.06	1.565	3.633
Torus-2	B	F	10088	12.21	1.605	3.725
Torus-3	C	G	10550	12.77	1.755	4.075
Torus-4	D	H	closed	0	0	0

CALCULATION NO. DRE97-ØØØ2 REV. Ø
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