ATTACHMENT B

SVP-98-335

ComEd Calculation No. QDC-1000-M-0535, Rev. 1, "Long-Term RHR/Core Spray Pump NPSH Analysis – Design Basis LOCA"

PREPARATION, REVIEW AND APPROVAL OF CALCULATIONS

CALCULATION TITLE PAGE

ComEd

STATION Quad Cities Units 1 and 2

Calculation No: QDC-1000-M-0535

DESCRIPTION CODE: M10
DISCIPLINE CODE: M
SYSTEM CODE: RH

TITLE: Long Term RHR/Core Spray Pump NPSH Analysis - Design Basis LOCA

X **Safety Related** ____ **Augmented Quality** ____ **Non-Safety Related**

REFERENCE NUMBERS

Type	Number	Type	Number
~~CALC~~	~~QDC-1000-M-0292~~ DEC 9/28/98		
CALC	QDC-1000-M-0419		

A complete list of References can be found in Section 5 of this calculation.

COMPONENT EPN:

EPN	Compt Type
1(2)-1002A/B	Pumps
1(2)-1002C/D	Pumps
1(2)-1401A/B	Pumps

DOCUMENT NUMBERS:

Doc Type/SubType	Document Number

REMARKS: This calculation supersedes Calc. No. QDC-1000-M-0292 in its entirety.

REV. NO.	REVISING ORGANIZATION	APPROVED PRINT/SIGN	DATE
0	COMED	STEVE BOLINE / [signature] 12/23/97	12/8/97
1	COMED	STEVE BOLINE / [signature]	9/29/98

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CALCULATION REVISION PAGE

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REVISION SUMMARIES

REV: 1

REVISION SUMMARY:
Initial Issue

Electronic Calculation Data Files:
(Program Name, Version, File name ext/size/date/hour/: min)
SEE REV. 0.

Prepared by: Douglas F. Collins / SIGNATURE ON FILE 12/23/97
Print/Sign Date

Reviewed by: Roger H. Heyn / SIGNATURE ON FILE 12/23/97
Print/Sign Date

Type of Review
[X] Detailed [ ] Alternate [ ] Test

Supplemental Review Required [ ] Yes (NEP-12-05 documentation attached) [X] No
Supervisor N/A /

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION [ ] YES [X] NO
Tracked by:

REV: 1

REVISION SUMMARY:
This revision incorporates the results of the 1998 containment analysis, and provides time-dependent curves of the required containment pressure. Rev. 1 supersedes Rev. 0 in its entirety.

Electronic Calculation Data Files:
(Program Name, Version, File name ext/size/date/hour/: min)
PIPE-FLO, Ver. 4.11, CASE-1.PLU / 36 KB / 09-25-98 / 01:26PM CASE-2.PLU / 36 KB / 09-25-98 / 01:26PM
CASE-3.PLU / 36 KB / 09-25-98 / 01:27PM CASE-4.PLU / 36 KB / 09-25-98 / 01:33PM
CASE-5.PLU / 36 KB / 09-25-98 / 01:33PM CASE-6.PLU / 36 KB / 09-25-98 / 01:34PM
CASE-7.PLU / 36 KB / 09-25-98 / 01:41PM LONG-NEW.PLL / 135 KB / 09-25-98 / 10:25AM
LONG-NEW.PLU / 36 KB / 09-25-98 / 01:45PM

Prepared by: Douglas F. Collins Douglas F Collins 09/28/98
Print/Sign Date

Reviewed by: Roger H. Heyn Roger H Heyn 9/28/98
Print/Sign Date

Type of Review
[X] Detailed [ ] Alternate [ ] Test

Supplemental Review Required [ ] Yes (NEP-12-05 documentation attached) [X] No
Supervisor S [illegible] / 9/28/98

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION [ ] YES [X] NO
Tracked by:

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1. PURPOSE/OBJECTIVE

The purpose of this calculation is to determine if sufficient net positive suction head (NPSH) is available for the Residual Heat Removal (RHR) and Core Spray (CS) pumps following a Design Basis 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 Quad Cities License Amendment request. Upon approval of this request, this calculation will represent a Design Basis Document.

2. METHODOLOGY AND ACCEPTANCE CRITERIA

This calculation will utilize a FLO-Series model of the RHR and CS piping generated by Calculation No. QDC-1000-M-0419, Rev. 1 (Ref. 5.1). This calculation will determine the minimum suppression chamber pressure required to ensure that the NPSH available (NPSHA) at the suction intakes of the RHR and CS pumps are greater than the NPSH required (NPSHR) for the pumps. NPSHR curves for the LPCI/CS pumps are provided on the original vendor pump curves (attached to Ref. 5.1).

Per Refs. 5.2 and 5.3, the most limiting flow case with respect to long term suppression pool temperature is the operation of one RHR pump at 5000 gpm and one CS pump at 4500 gpm. This pump combination is the long term design basis flow case and is based on a single failure of one diesel generator (or battery failure).

This calculation will explore additional flow cases, but additional RHR pumps running would increase the heat removal rate and decrease the maximum pool temperature. Operations personnel have also been trained in recognizing cavitation conditions (Ref. 5.16). If additional pumps were running, existing operating procedures would allow the operators to throttle or turn off pumps in order to maintain sufficient NPSHA. Quad Cities Procedure QCAP 0200-10 "Emergency Operating Procedure (QGA) Execution Standards" (Ref 5.9) provides NPSH limit curves which will be used by the operators to control pump flow rates following an accident. These curves are based on the same flow model as this calculation.

Per Equation 5.2 on page 66 of Ref 5.8, the equation for NPSHA is as follows:

$$NPSHA = h_{psa} + Z - h_f - h_{vpa} \qquad \text{(Eq. 1)}$$

Where:

h_{psa} = Suppression chamber pressure, feet absolute.
Z = Static head above pump, feet.
h_f = Suction friction losses, feet.
h_{vpa} = Vapor pressure, feet absolute.

This equation can be rewritten in terms of the suppression chamber pressure, and the minimum suppression chamber pressure required is that which will yield a value of NPSHA which is equal to the NPSHR. Thus:

$$h_{psa} = NPSHR - Z + h_f + h_{vpa} \qquad \text{(Eq. 2)}$$

Or this equation can be written to solve for the suppression chamber pressure in units of psia:

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P_{min} = (NPSHR - Z + h_f + h_{vpa})/(144V) (Eq. 3)

Where:

P_{min} = Minimum Required Suppression Chamber Pressure, psia.
V = Specific volume, ft^3/lb.

The value of P_{min} for each flow case will be plotted as a function of time and compared to the Available and Credited Pressure in the Suppression Chamber (See Assumption 3.3).

Acceptance Criteria:

2.1 Available Pressure ≥ Required Pressure at all times for each flow case (Adequate NPSH).
2.2 Total RHR flow ≥ 5000 gpm for each flow case (Adequate Containment Cooling).
2.3 Total CS flow ≥ 4500 gpm for each flow case (Adequate Core Cooling).

3. ASSUMPTIONS/ENGINEERING JUDGEMENTS

3.1 It is assumed that at 10 minutes into the accident, operator action will be taken to throttle the RHR/CS pumps as necessary. Therefore, the RHR/CS pumps will be at their rated flows (5000 and 4500 gpm, respectively) for the design basis flow case (Refs. 5.2 and 5.3).

3.2 To account for strainer plugging, one of the four suction strainers inside the torus is assumed 100 percent blocked, while the remaining three strainers are assumed clean (Ref. 5.4). For each flow case, the strainer nearest the pump with the lowest differential between NPSHA and NPSHR will be chosen.

3.3 The long term suppression chamber pressure response from the containment analysis (Ref 5.2) is contained in Attachment A along with the assumed pressure response which is modeled as a time-dependent step function, consistent with the NRC-approved methodology from Dresden station. The assumed (credited) pressure response was determined in Design Input 4.1 such that it is conservatively bounded by the available pressure response from Ref. 5.2. The containment analysis incorporates assumptions to minimize containment overpressure that are consistent with NRC Information Notice 96-55. This data will predict the minimum available overpressure and will, therefore, be conservative.

3.4 This calculation assumes the maximum temperature response of the suppression pool from the bounding containment analysis. This assumption is conservative because it minimizes the NPSHA at the pumps.

3.5 The value of the long term suppression pool drawdown comes from GE letters regarding Dresden station (Refs. 5.5 and 5.6). Based on a review of the letters, this information is applicable to Quad Cities station as well.

3.6 The initial suppression pool temperature of 95°F (Ref. 5.10) is used to determine the physical properties of water in the hydraulic model. Following a DBA-LOCA, the suppression pool temperature will increase from this initial condition. The use of the minimum temperature will conservatively maximize the friction losses through the suction piping. Other conservative assumptions from the hydraulic model are listed in Ref. 5.1.

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4. DESIGN INPUT

4.1 Per the results of the containment analyses contained in Refs. 5.2, the available pressure response in the long term conservatively bounds the following values (See Attachment A):

Time (sec)	Credited Pressure (psig)
600 - 10000	3.0
10000 – End	3.5

4.2 This calculation uses an approved FLO-Series model of the ECCS piping generated by Calculation No. QDC-1000-M-0419, Rev. 0 (Ref. 5.1).

4.3 The long-term suppression pool temperature and pressure response was generated in Ref. 5.2 based on a containment model developed by GE. The intent of this model was to determine the maximum pool temperature expected post-LOCA and the minimum corresponding containment pressure response. A tabular representation of the suppression pool temperature/pressure response is provided in Ref 5.2 and is summarized in Attachment A.

4.4 The maximum drawdown of the suppression chamber water level at the time of peak suppression pool temperature is 1 foot (Ref 5.5 and 5.6). Applying this drawdown to the minimum water level allowed by Technical Specifications used in Ref. 5.1 yields a water elevation of 569.6 ft.

4.5 The values for the vapor pressures and specific volumes of water at various temperatures are taken from Ref. 5.11 and are included in Attachment A.

4.6 NPSHR values at various RHR/CS pump flow rates are taken from the NPSHR curves provided on the manufacturer's pump curves attached to Ref. 5.1. These values are summarized in the following table:

Pump Flow (gpm)	NPSHR (feet)
3000	25.0
4500	27.0
5000	30.0

5. REFERENCES

5.1 Calculation No. QDC-1000-M-0419, Rev. 1, "Flow Model of Emergency Core Cooling System (ECCS) Suction Piping with Core Spray and Residual Heat Removal (RHR) Discharge Piping."

5.2 GE Report GE-NE-T2300750-00-02-R1, "Quad Cities Nuclear Power Station Units 1 and 2 Containment Analysis for Long-Term NPSH Evaluation with ANS 5.1 – 1979 + 2 Sigma Decay Heat, September 1998."

5.3 Quad Cities UFSAR, Rev. 4, Section 6.2.1.3.3, "Containment Long Term Response to a Design Basis Accident."

5.4 Quad Cities UFSAR, Rev. 4, Section 6.3, "Emergency Core Cooling System."

5.5 GE Letter - S. Mintz to S. Eldridge, dated September 24, 1992 (Attachment E).

5.6 GE Letter - S. Mintz to T. Chapman, dated January 25, 1993 (Attachment E).

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5.7 Crane Technical Paper 410, "Flow of Fluids Through Valves, Fittings and Pipe" - 1991.
5.8 Durco Pump Engineering Manual - 4th Edition.
5.9 Quad Cities Procedure QCAP 0200-10, Rev. 17 "Emergency Operating Procedure (QGA) Execution Standards"
5.10 Quad Cities Technical Specifications DPR-29/DPR-30, Amendments 180 and 178, Section 3.7.K.
5.11 Keenan and Keyes. *Steam Tables (English Units)*. Wiley and Sons, New York: 1969.
5.12 NDIT No. 9800039, "ECCS Flow to Meet 10CFR50.46 Core Cooling Requirements of a DBA LOCA for Short Term and Long Term."
5.13 "LOCA Break Spectrum for Quad Cities Unit 1 and 2," Siemens document EMF-96-184(P), dated December 1996.
5.14 "Quad Cities Nuclear Power Station Units 1 & 2, SAFER/GESTR – LOCA, Loss-Of-Coolant Accident Analysis," General Electric document NEDC-31345P, Revision 2, dated July 1989.
5.15 "Long Term Cooling of the Reactor Cores of the Dresden and Quad Cities Nuclear Plants Following Postulated Design Basis Accidents (DBA)," GE letter DRF:T23-685, to K. Ramsden (ComEd) from R. Muralidharan (GE), dated February 12, 1993.
5.16 Licensee Event Report No. 96-025.
5.17 Duke Engineering and Services Report No. TR-VQ1500-02, Rev. 0.
5.18 Calculation No. QDC-0010-M-0396, Rev. 0, "Quad Cities Unit 2 - ECCS Strainer Head Loss Estimate."
5.19 Calculation No. QDC-1600-M-0545, Rev. 0, "Quad Cities Unit 1 - ECCS Strainer Head Loss Estimate."

6. CALCULATIONS

This calculation will analyze ten flow cases considering different possible pump combinations for the long term operation of RHR and CS pumps following the DBA-LOCA. The flow cases analyzed in the calculation are as follows:

Flow Case	Pump Combination	
1	1/1 Nominal Case	1 RHR at 5000 gpm and 1 CS at 4500 gpm
2	2/2 Nominal Case	2 RHR at 5000 gpm and 2 CS at 4500 gpm
3	2/2 Throttled Case	2 RHR at 3000 gpm and 2 CS at 4000 gpm
4	3/2 Nominal Case	3 RHR at 5000 gpm and 2 CS at 4500 gpm
5	3/2 Throttled Case	3 RHR at 3000 gpm and 2 CS at 4000 gpm
6	4/2 Nominal Case	4 RHR at 5000 gpm and 2 CS at 4500 gpm
7	4/2 Throttled Case	4 RHR at 3000 gpm and 2 CS at 4000 gpm

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These flow cases utilized a FLO-Series hydraulic model of the RHR and CS piping from Ref. 5.1 (Attachments B and C). The results of these cases are summarized in Attachment A. These results demonstrate that there is sufficient containment pressure available at all times following a DBA-LOCA. Note also that in every flow case, there is a minimum of 4500 gpm of CS flow and 5000 gpm of RHR flow. Per Ref. 5.12, the minimum flow rate to maintain the core flooded is 2200 gpm.

6.1 Example Calculation of Required Containment Pressure

The required containment pressure for each flow case is determined in the tables of Attachment A. This example demonstrates how the numbers in the table were determined, specifically for the RHR pump in Flow Case 1 at Time = 24372 sec.

Per Table A.1, at this time, the suppression pool temperature is 182.0°F, and thus per Ref. 5.11:

$V = 0.016521$ ft³/lb.
$h_{vpa} = 18.68$ feet.

The RHR pump is operating at 5000 gpm and, thus, per Design Input 4.6:

NPSHR = 30.0 feet

The value of $Z - h_f$ is determined in the FLO-Series model:

$Z - h_f = 3.715$ psia (for 95°F water, $V_{95} = 0.016114$ ft³/lb)

$Z - h_f = (144\ \text{in}^2/\text{ft}^2)(0.016114\ \text{ft}^3/\text{lb})(3.715\ \text{lb/in}^2) = 8.62$ feet.

This number is adjusted by 1 foot to account for the 1 foot drawdown assumed in the long term (Assumption 3.4 and Design Input 4.4) and thus:

$Z - h_f = 7.62$ feet

Per Eq. 3:

$$P_{min} = (NPSHR - Z + h_f + h_{vpa})/(144V)$$
$$= (30.00 - 7.62 + 18.68)/(144(0.016521))$$
$$= 17.3 \text{ psia} = 2.6 \text{ psig}$$

This example represents one time for one flow case. The results of the analysis for all seven flow cases over time can be found in both tabular and graphical form in Attachment A.

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New Strainer Design Basis

The current Quad Cities design basis for strainer blockage is one strainer blocked and 3 strainers clean (Assumption 3.2, Ref. 5.4). In response to NRC Bulletin 96-03, Quad Cities plans to revise this design basis to four partially clogged strainers, with the head loss associated with the new strainers (Ref. 5.17) and the debris loading as modeled in Ref. 5.18 – 5.19. (This model is attached as file LONG_NEW.PLL) This possible, future design basis would slightly decrease the NPSH margin in the long term, as demonstrated in Attachment D. However, there would still be adequate containment pressure available to satisfy the pump NPSH requirements. Currently, one strainer completely blocked and three strainers clean is the Quad Cities strainer debris loading design basis.

7. SUMMARY AND CONCLUSIONS

This NPSH analysis was performed for the CS and RHR pumps under long term post-accident conditions as outlined in Ref. 5.2. Selecting inputs to minimize NPSH margin, it was determined that adequate NPSH exists to meet RHR and CS pump requirements for all pump combinations. However, the potential exists for the pumps to cavitate in several of the scenarios. For these cases, throttling of the pumps may be required to ensure NPSH requirements are met. Operating procedures provide NPSH limit curves to the operators and direct the operators to throttle the pumps to maintain adequate NPSH to the pumps. Under all post-LOCA pump combinations, positive NPSH margin could be obtained by throttling the available pumps.

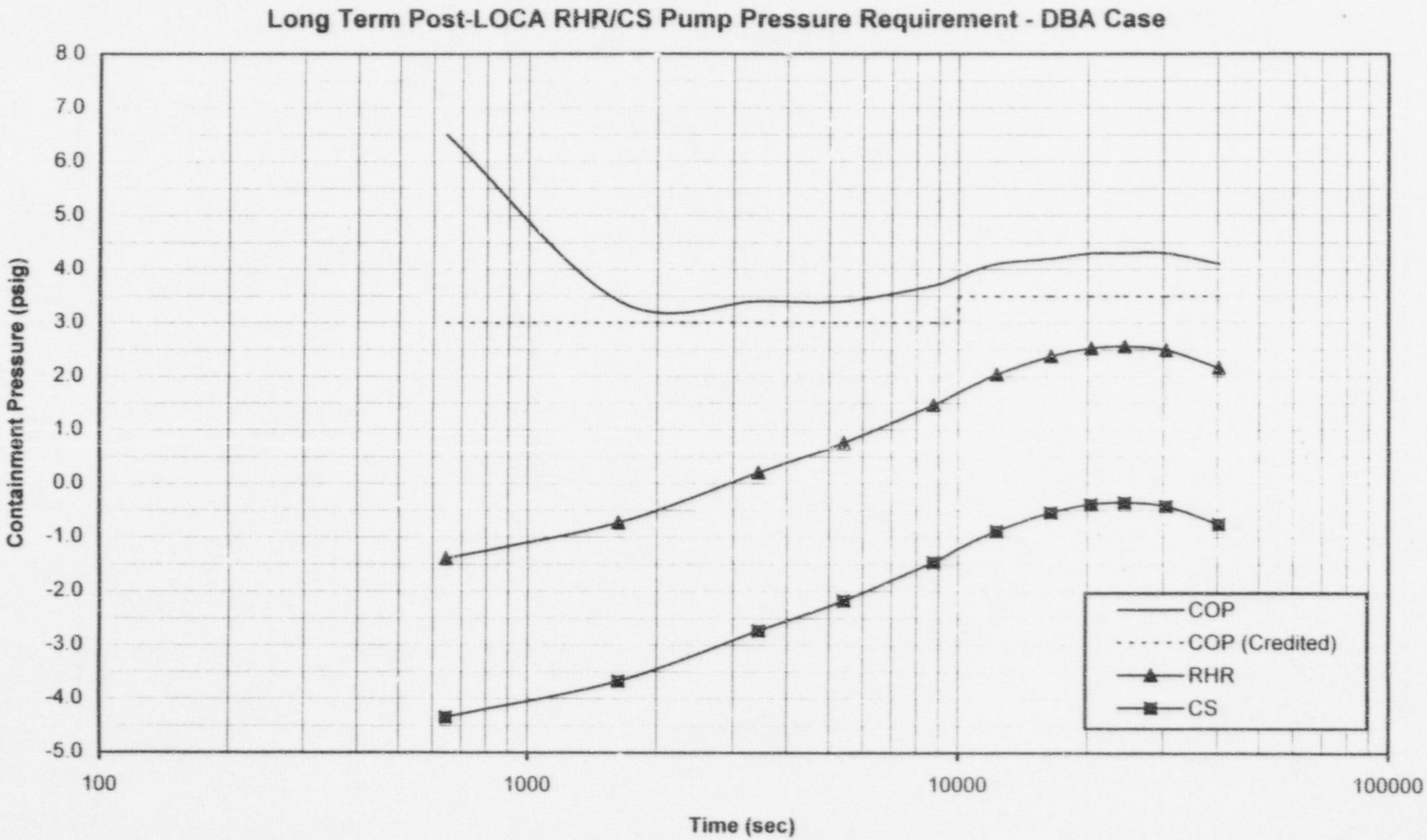
RHR/CS Pump Pressure Requirements - Design Basis Case											
						RHR			CS		
Sec	P (psig)	T (deg. F)	P_v (psia)	V (ft^3/lb)	h_{vpa} (feet)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)
643	6.5	150.8	3.796	0.016347	8.94	7.62	30.0	-1.40	11.56	27.0	-4.34
1627	3.4	157.6	4.480	0.016382	10.57	7.62	30.0	-0.73	11.56	27.0	-3.67
3434	3.4	164.8	5.439	0.016421	12.86	7.62	30.0	0.20	11.56	27.0	-2.73
5412	3.4	170.1	6.010	0.016451	14.24	7.62	30.0	0.76	11.56	27.0	-2.17
8756	3.7	175.1	6.735	0.016480	15.98	7.62	30.0	1.47	11.56	27.0	-1.46
12290	4.1	178.8	7.318	0.016502	17.39	7.62	30.0	2.04	11.56	27.0	-0.88
16434	4.2	180.9	7.666	0.016514	18.23	7.62	30.0	2.38	11.56	27.0	-0.54
20372	4.3	181.8	7.820	0.016520	18.60	7.62	30.0	2.53	11.56	27.0	-0.39
24372	4.3	182.0	7.854	0.016521	18.68	7.62	30.0	2.56	11.56	27.0	-0.36
30424	4.3	181.6	7.786	0.016519	18.52	7.62	30.0	2.49	11.56	27.0	-0.42
40266	4.1	179.6	7.449	0.016507	17.71	7.62	30.0	2.16	11.56	27.0	-0.76

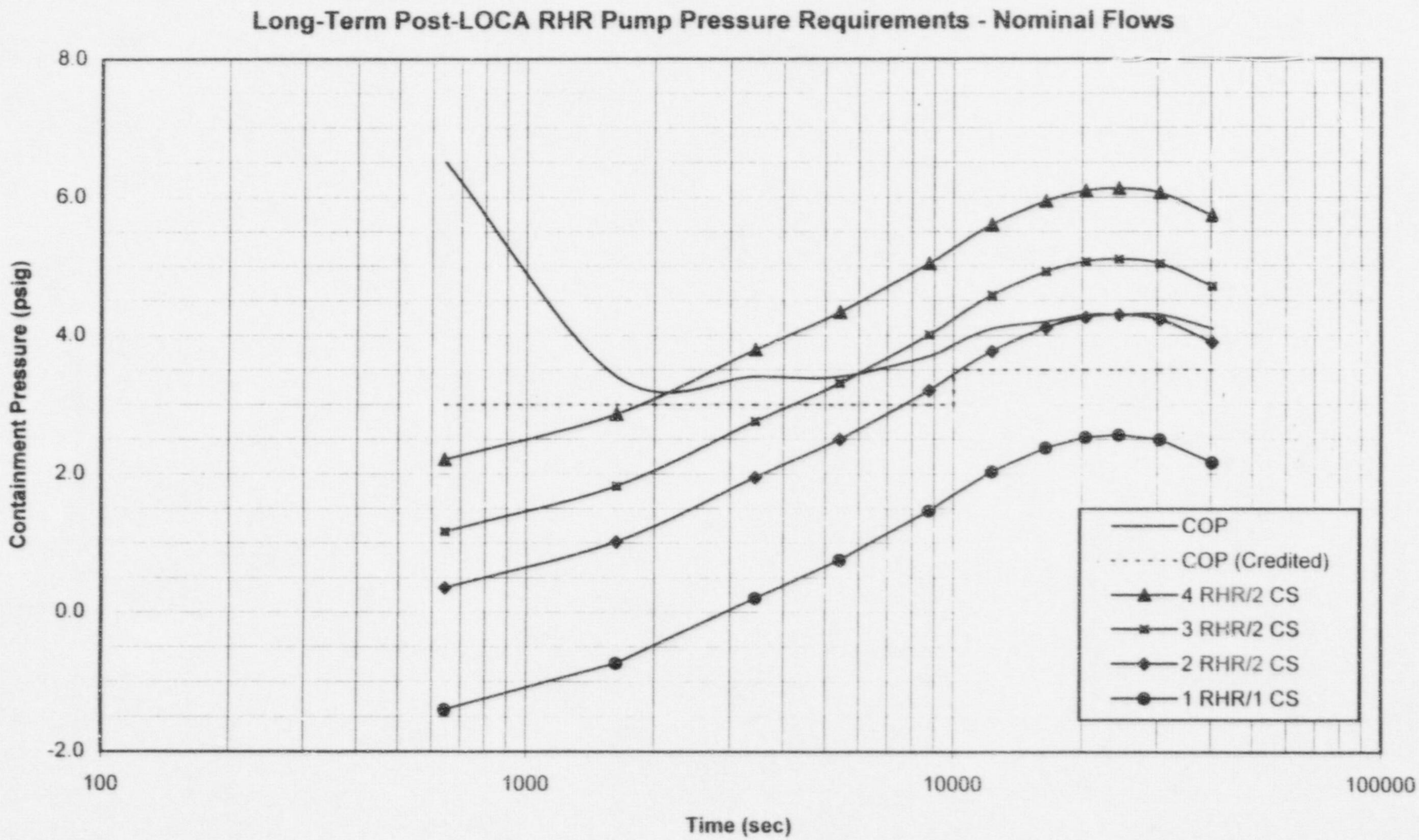
RHR Pump Pressure Requirements - Nominal Flows												
	4 RHR / 2 CS			3 RHR / 2 CS			2 RHR / 2 CS			1 RHR / 1 CS		
Sec	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)
643	-0.86	30.0	2.21	1.58	30.0	1.17	3.49	30.0	0.36	7.62	30.0	-1.40
1627	-0.86	30.0	2.86	1.58	30.0	1.83	3.49	30.0	1.02	7.62	30.0	-0.73
3434	-0.86	30.0	3.79	1.58	30.0	2.76	3.49	30.0	1.95	7.62	30.0	0.20
5412	-0.86	30.0	4.34	1.58	30.0	3.31	3.49	30.0	2.50	7.62	30.0	0.76
8756	-0.86	30.0	5.04	1.58	30.0	4.01	3.49	30.0	3.21	7.62	30.0	1.47
12290	-0.86	30.0	5.60	1.58	30.0	4.58	3.49	30.0	3.77	7.62	30.0	2.04
16434	-0.86	30.0	5.94	1.58	30.0	4.92	3.49	30.0	4.11	7.62	30.0	2.38
20372	-0.86	30.0	6.09	1.58	30.0	5.07	3.49	30.0	4.26	7.62	30.0	2.53
24372	-0.86	30.0	6.13	1.58	30.0	5.10	3.49	30.0	4.30	7.62	30.0	2.56
30424	-0.86	30.0	6.06	1.58	30.0	5.03	3.49	30.0	4.23	7.62	30.0	2.49
40266	-0.86	30.0	5.73	1.58	30.0	4.71	3.49	30.0	3.90	7.62	30.0	2.16

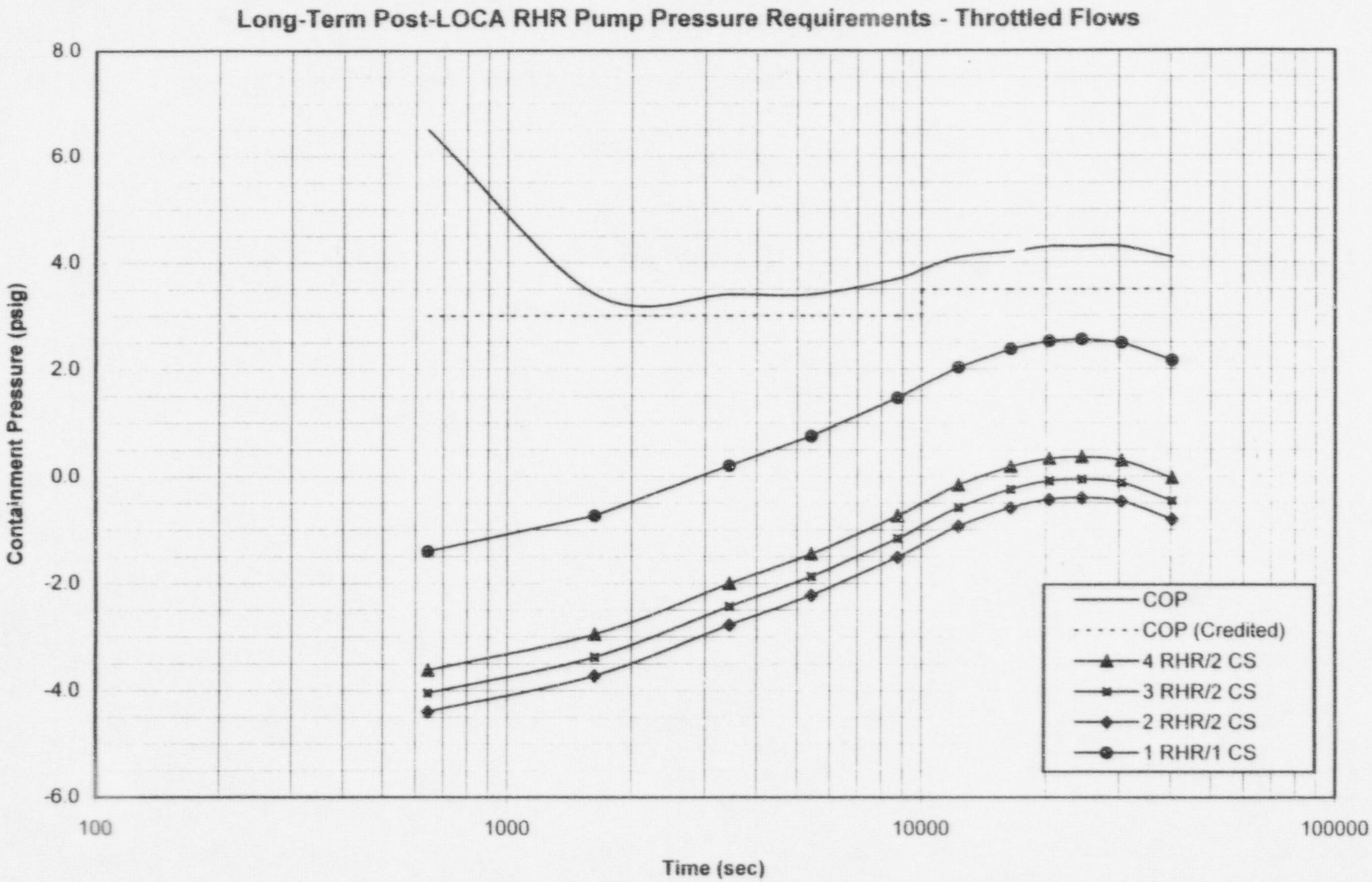
RHR Pump Pressure Requirements - Throttled Flows												
	4 RHR / 2 CS			3 RHR / 2 CS			2 RHR / 2 CS			1 RHR / 1 CS		
Sec	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)
643	7.85	25.0	-3.62	8.85	25.0	-4.04	9.67	25.0	-4.39	7.62	30.0	-1.40
1627	7.85	25.0	-2.95	8.85	25.0	-3.37	9.67	25.0	-3.72	7.62	30.0	-0.73
3434	7.85	25.0	-2.01	8.85	25.0	-2.43	9.67	25.0	-2.78	7.62	30.0	0.20
5412	7.85	25.0	-1.45	8.85	25.0	-1.87	9.67	25.0	-2.22	7.62	30.0	0.76
8756	7.85	25.0	-0.74	8.85	25.0	-1.16	9.67	25.0	-1.51	7.62	30.0	1.47
12290	7.85	25.0	-0.16	8.85	25.0	-0.59	9.67	25.0	-0.93	7.62	30.0	2.04
16434	7.85	25.0	0.18	8.85	25.0	-0.24	9.67	25.0	-0.59	7.62	30.0	2.38
20372	7.85	25.0	0.33	8.85	25.0	-0.09	9.67	25.0	-0.44	7.62	30.0	2.53
24372	7.85	25.0	0.36	8.85	25.0	-0.06	9.67	25.0	-0.40	7.62	30.0	2.56
30424	7.85	25.0	0.30	8.85	25.0	-0.12	9.67	25.0	-0.47	7.62	30.0	2.49
40266	7.85	25.0	-0.04	8.85	25.0	-0.46	9.67	25.0	-0.80	7.62	30.0	2.16

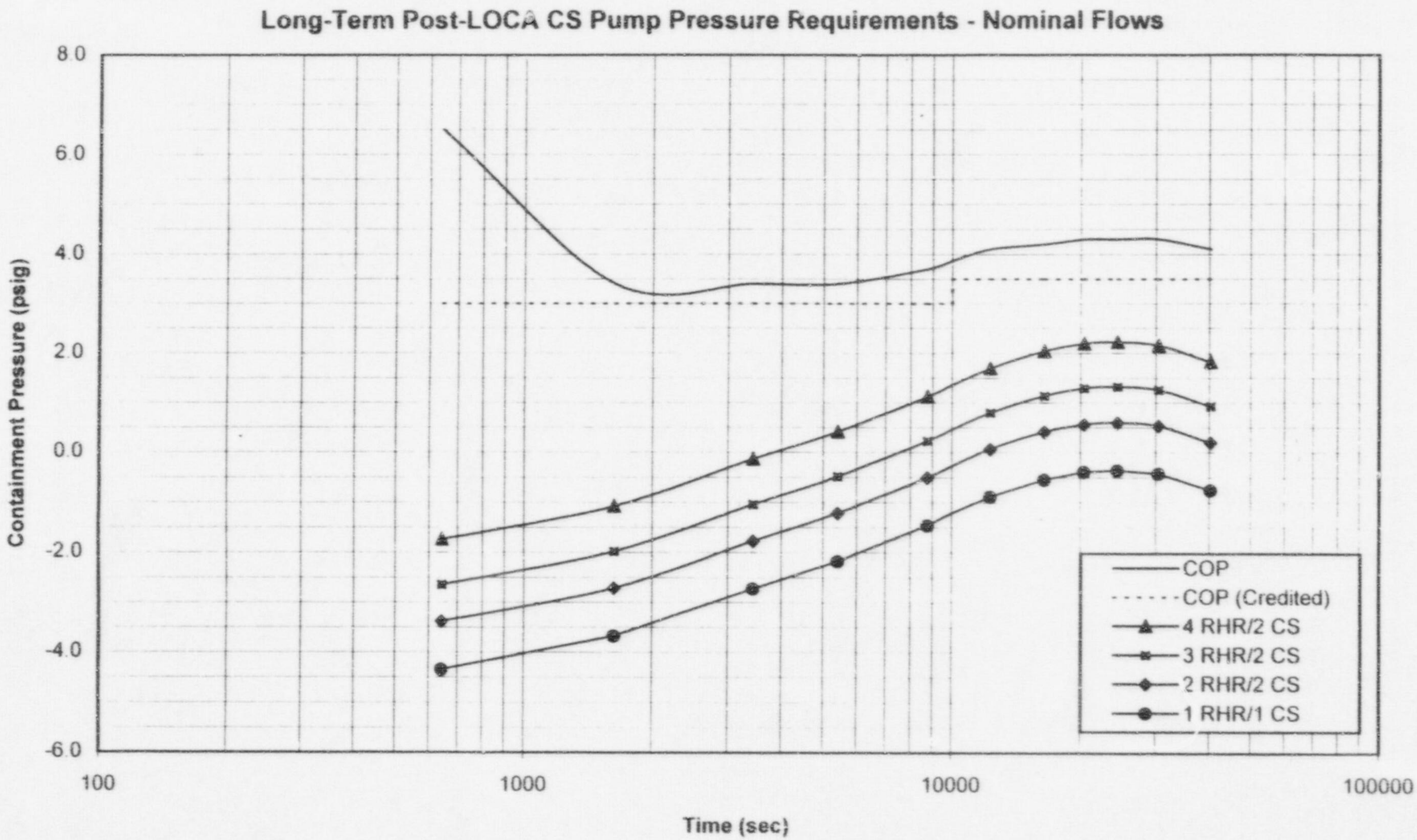
CS Pump Pressure Requirements - Nominal Flows												
	4 RHR / 2 CS			3 RHR / 2 CS			2 RHR / 2 CS			1 RHR / 1 CS		
Sec	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)	Z - h_f (feet)	NPSHR (feet)	P_{min} (psig)
643	5.43	27.0	-1.74	7.56	27.0	-2.65	9.29	27.0	-3.38	11.56	27.0	-4.34
1627	5.43	27.0	-1.08	7.56	27.0	-1.98	9.29	27.0	-2.71	11.56	27.0	-3.67
3434	5.43	27.0	-0.14	7.56	27.0	-1.04	9.29	27.0	-1.77	11.56	27.0	-2.73
5412	5.43	27.0	0.42	7.56	27.0	-0.48	9.29	27.0	-1.21	11.56	27.0	-2.17
8756	5.43	27.0	1.12	7.56	27.0	0.23	9.29	27.0	-0.50	11.56	27.0	-1.46
12290	5.43	27.0	1.70	7.56	27.0	0.80	9.29	27.0	0.07	11.56	27.0	-0.88
16434	5.43	27.0	2.04	7.56	27.0	1.14	9.29	27.0	0.41	11.56	27.0	-0.54
20372	5.43	27.0	2.19	7.56	27.0	1.29	9.29	27.0	0.56	11.56	27.0	-0.39
24372	5.43	27.0	2.22	7.56	27.0	1.33	9.29	27.0	0.60	11.56	27.0	-0.36
30424	5.43	27.0	2.15	7.56	27.0	1.26	9.29	27.0	0.53	11.56	27.0	-0.42
40266	5.43	27.0	1.82	7.56	27.0	0.93	9.29	27.0	0.20	11.56	27.0	-0.76

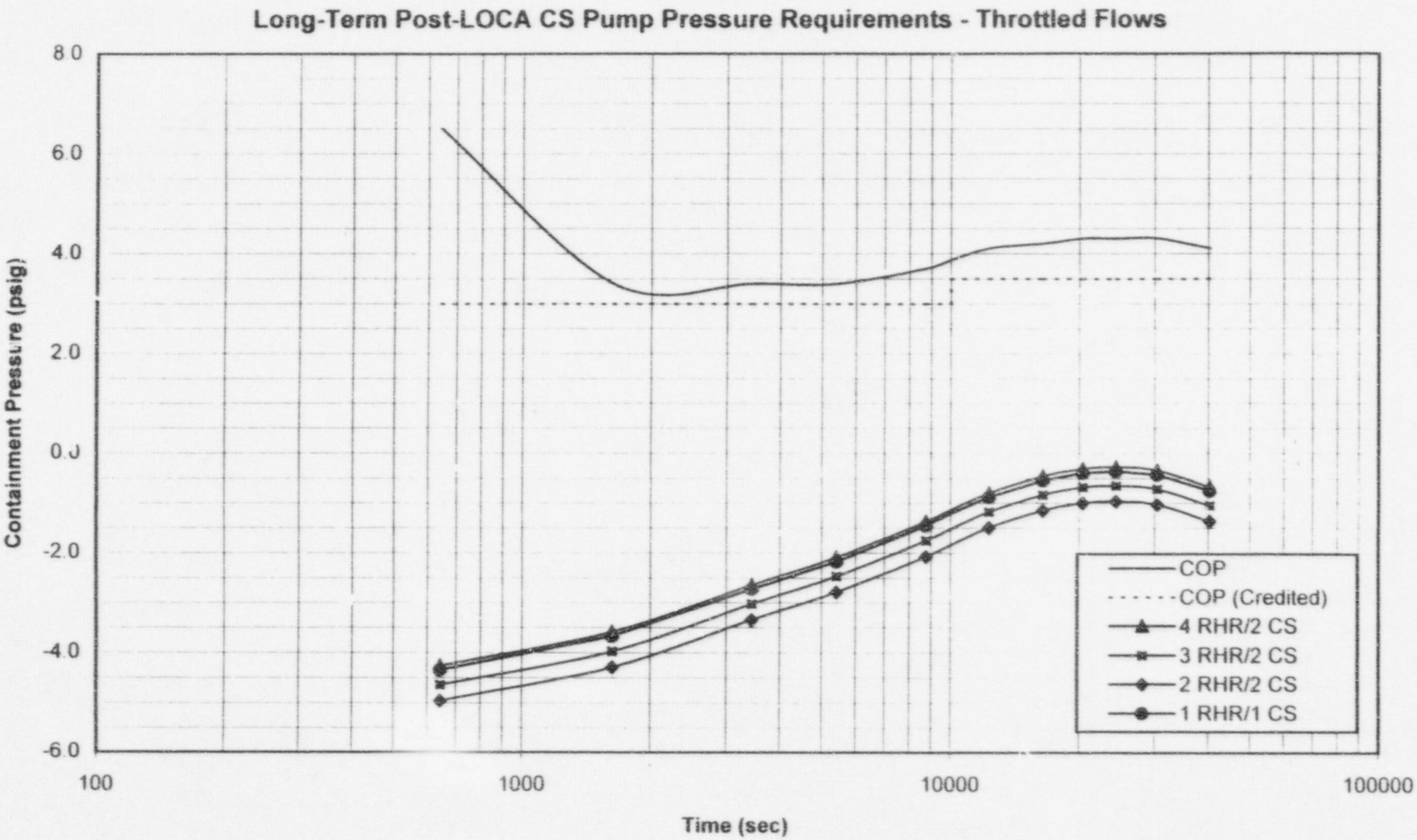
CS Pump Pressure Requirements - Throttled Flows												
	4 RHR / 2 CS			3 RHR / 2 CS			2 RHR / 2 CS			1 RHR / 1 CS		
Sec	$Z - h_f$ (feet)	NPSHR (feet)	P_{min} (psig)	$Z - h_f$ (feet)	NPSHR (feet)	P_{min} (psig)	$Z - h_f$ (feet)	NPSHR (feet)	P_{min} (psig)	$Z - h_f$ (feet)	NPSHR (feet)	P_{min} (psig)
643	9.36	25.0	-4.26	10.26	25.0	-4.64	11.01	25.0	-4.96	11.56	27.0	-4.34
1627	9.36	25.0	-3.59	10.26	25.0	-3.97	11.01	25.0	-4.29	11.56	27.0	-3.67
3434	9.36	25.0	-2.65	10.26	25.0	-3.03	11.01	25.0	-3.34	11.56	27.0	-2.73
5412	9.36	25.0	-2.09	10.26	25.0	-2.47	11.01	25.0	-2.78	11.56	27.0	-2.17
8756	9.36	25.0	-1.37	10.26	25.0	-1.75	11.01	25.0	-2.07	11.56	27.0	-1.46
12290	9.36	25.0	-0.80	10.26	25.0	-1.18	11.01	25.0	-1.49	11.56	27.0	-0.88
16434	9.36	25.0	-0.46	10.26	25.0	-0.84	11.01	25.0	-1.15	11.56	27.0	-0.54
20372	9.36	25.0	-0.31	10.26	25.0	-0.68	11.01	25.0	-1.00	11.56	27.0	-0.39
24372	9.36	25.0	-0.27	10.26	25.0	-0.65	11.01	25.0	-0.97	11.56	27.0	-0.36
30424	9.36	25.0	-0.34	10.26	25.0	-0.72	11.01	25.0	-1.03	11.56	27.0	-0.42
40266	9.36	25.0	-0.67	10.26	25.0	-1.05	11.01	25.0	-1.37	11.56	27.0	-0.76


Long Term Post-LOCA RHR/CS Pump Pressure Requirement - DBA Case
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
Containment Pressure (psig)
100
1000
10000
100000
Time (sec)
COP
COP (Credited)
RHR
CS


Long-Term Post-LOCA RHR Pump Pressure Requirements - Nominal Flows
Containment Pressure (psig)
8.0
6.0
4.0
2.0
0.0
-2.0
100
1000
10000
100000
Time (sec)
COP
COP (Credited)
4 RHR/2 CS
3 RHR/2 CS
2 RHR/2 CS
1 RHR/1 CS


Long-Term Post-LOCA RHR Pump Pressure Requirements - Throttled Flows
Containment Pressure (psig)
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
100
1000
10000
100000
Time (sec)
COP
COP (Credited)
4 RHR/2 CS
3 RHR/2 CS
2 RHR/2 CS
1 RHR/1 CS


Long-Term Post-LOCA CS Pump Pressure Requirements - Nominal Flows
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
Containment Pressure (psig)
100
1000
10000
100000
Time (sec)
COP
COP (Credited)
4 RHR/2 CS
3 RHR/2 CS
2 RHR/2 CS
1 RHR/1 CS


Long-Term Post-LOCA CS Pump Pressure Requirements - Throttled Flows
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
Containment Pressure (psig)
100
1000
10000
100000
Time (sec)
COP
COP (Credited)
4 RHR/2 CS
3 RHR/2 CS
2 RHR/2 CS
1 RHR/1 CS

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 0.000198 %
after: 7 iterations

Design Basis Flow Case: 1 RHR pump @ 5000 gpm and 1 CS pump @ 4500 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10C	>>>	5000	Suc14B	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 9500 gpm
NET FLOWS OUT: 9500 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	3106	<<<	X-204A	0
LB-1	<<<	3111	<<<	X-204B	0
LD-1	<<<	3283	<<<	X-204D	0

FLOWS IN: 9500 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 9500 gpm

LINEUP NODES

CASE-1
09/25/98

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi a	H GRADE ft
A	559.5		* 4.475	569.9
B	559.5		* 4.475	569.9
C	559.5		* 4.474	569.9
D	559.5		* 4.474	569.9
E	559.5		* 4.473	569.9
F	559.5		* 4.456	569.8
G	559.5		* 4.449	569.8
H	559.5		* 4.438	569.8
I	559.5		* 4.42	569.8
J	559.5		* 4.423	569.8
K	559.5		* 4.423	569.8
L	559.5		* 4.425	569.8
M	559.5		* 4.433	569.8
N	559.5		* 4.436	569.8
O	559.5		* 4.439	569.8
P	559.5		* 4.439	569.8
Q	559.5		* 4.439	569.8
R	559.5		* 4.434	569.8
Red10A	562.25		* 3.271	569.8
Red10B	562.25		* 2.858	568.9
Red14A	555.63		6.132	569.9
Red14B	555.63		5.415	568.2
S	559.5		* 4.446	569.8
Suc10A	555.58		6.144	569.8
Suc10B	555.58		6.144	569.8
Suc10C	555.58	> 5000	3.715	564.2
Suc10D	555.58		5.868	569.2
Suc14A	555.63		6.132	569.9
Suc14B	555.63	> 4500	5.411	568.2
T	559.5		* 4.457	569.8
Tee10A-1	562.25		* 3.271	569.8
Tee10A-2	557.08		5.498	569.8
Tee10B-1	562.25		* 2.994	569.2
Tee10B-2	556.75		5.64	569.8
Tee10C-2	556.79		4.084	566.3
Tee10D-2	556.92		5.291	569.2
Tee14A	555.63		6.132	569.9
Tee14B	555.63		5.441	568.3
U	559.5		* 4.465	569.9

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	4.474	569.9
X-204A	570.6		p	0	570.6
X-204B	570.6		p	0	570.6
X-204C	570.6		*	-0.359	569.8
X-204D	570.6		p	0	570.6
X-223A	559.5		*	4.456	569.8
X-223B	559.5		*	4.42	569.8
X-224A	559.5			4.465	569.9
X-224B	559.5			4.434	569.8
X-225	559.5			4.443	569.8
X-226	559.5			4.433	569.8
ZA	560.5		*	4.109	570
ZB	560.5		*	4.108	570
ZC	560.5		*	3.992	569.8
ZD	560.5		*	4.081	570

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	0	0	0	0
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	5000	3.781	1.425	0.558
2-1015B-2	Tee10B-1		Red10B	5000	3.781	0.137	0.318
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	0	0	0	0
2-1016B-2	Tee10B-2		Suc10B	0	0	0	0
2-1016C-1	Red10B		Tee10C-2	5000	11.64	(1.226)	2.614
2-1016C-2	Tee10C-2		Suc10C	5000	11.64	0.368	2.065
2-1016D-1	Tee10B-1		Tee10D-2	0	0	0	0
2-1016D-2	Tee10D-2		Suc10D	0	0	0	0
2-1025-1	A		B	399.9	0.319	0	0
2-1025-10	I	<->	X-223B	1489	1.189	0	0
2-1025-11	J	<->	I	1489	1.126	0.003	0.008
2-1025-12	K	<->	J	1489	1.189	0	0
2-1025-13	L	<->	K	1489	1.189	0.002	0.005
2-1025-14	M	<->	L	1489	1.126	0.008	0.018
2-1025-15	X-226	<->	M	1489	1.189	0	0
2-1025-16	N	<->	X-226	1489	1.189	0.002	0.005
2-1025-17	O	<->	N	1489	1.126	0.003	0.007
2-1025-18	P	<->	O	1489	1.189	0	0
2-1025-19	P		Q	1794	1.433	0	0
2-1025-2	B		C	399.9	0.302	0	0.002
2-1025-20	Q		R	1794	1.357	0.004	0.010
2-1025-21	R		X-224B	1794	1.433	0	0
2-1025-22	X-225	<->	X-224B	2706	2.161	0.009	0.021
2-1025-23	S	<->	X-225	2706	2.161	0.003	0.007
2-1025-24	T	<->	S	2706	2.046	0.011	0.025
2-1025-25	X-224A	<->	T	2706	2.161	0.008	0.018
2-1025-26	U	<->	X-224A	2706	2.161	0	0
2-1025-27	V	<->	U	2706	2.046	0.009	0.021
2-1025-28	A	<->	V	2706	2.161	0	0.001
2-1025-3	C		D	399.9	0.319	0	0
2-1025-4	D		E	3511	2.805	0	0.002
2-1025-5	E		F	3511	2.656	0.017	0.039
2-1025-6	F		X-223A	3511	2.805	0	0.002
2-1025-7	X-223A		G	3511	2.805	0.006	0.014
2-1025-8	G		H	3511	2.656	0.011	0.027
2-1025-9	H		X-223B	3511	2.805	0.018	0.042

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	0	0	0	0
2-1401-2	Tee14A	Red14A	0	0	0	0
2-1401-3	Red14A	Suc14A	0	0	0	0
2-1402-1	X-224B	Tee14B	4500	6.183	(1.007)	1.533
2-1402-2	Tee14B	Red14B	4500	6.183	0.026	0.061
2-1402-3	Red14B	Suc14B	4500	7.911	0.004	0.009
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	3106	3.76	(4.109)	0.562
--- strainer --- dP: 0.241 --- Hl: 0.559						
LA-2	ZA	A	3106	3.426	(0.366)	0.151
LB-1	X-204B	ZB	3111	3.767	(4.108)	0.564
--- strainer --- dP: 0.242 --- Hl: 0.562						
LB-2	ZB	D	3111	3.433	(0.366)	0.151
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	3283	3.975	(4.081)	0.628
--- strainer --- dP: 0.269 --- Hl: 0.625						
LD-2	ZD	P	3283	3.622	(0.358)	0.168
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 9.27e-005 %
after: 7 iterations

2/2 Unthrottled Case: 2 RHR pump @ 5000 gpm and 2 CS pump @ 4500 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10C	>>>	5000	Suc10D	>>>	5000
Suc14A	>>>	4500	Suc14B	>>>	4500

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

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	6288	<<<	X-204A	0
LB-1	<<<	6288	<<<	X-204B	0
LD-1	<<<	6424	<<<	X-204D	0

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

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	3.524	567.7
B	559.5		*	3.524	567.7
C	559.5		*	3.524	567.7
D	559.5		*	3.524	567.7
E	559.5		*	3.521	567.7
F	559.5		*	3.47	567.6
G	559.5		*	3.449	567.5
H	559.5		*	3.414	567.4
I	559.5		*	3.357	567.3
J	559.5		*	3.375	567.3
K	559.5		*	3.376	567.3
L	559.5		*	3.391	567.4
M	559.5		*	3.436	567.5
N	559.5		*	3.451	567.5
O	559.5		*	3.468	567.5
P	559.5		*	3.469	567.6
Q	559.5		*	3.468	567.6
R	559.5		*	3.459	567.5
Red10A	562.25		*	2.283	567.5
Red10B	562.25		*	1.079	564.8
Red14A	555.63			4.448	566
Red14B	555.63			4.439	565.9
S	559.5		*	3.464	567.5
Suc10A	555.58			5.157	567.5
Suc10B	555.58			5.157	567.5
Suc10C	555.58	> 5000		1.937	560.1
Suc10D	555.58	> 5000		2.876	562.3
Suc14A	555.63	> 4500		4.446	565.9
Suc14B	555.63	> 4500		4.435	565.9
T	559.5		*	3.469	567.6
Tee10A-1	562.25		*	2.283	567.5
Tee10A-2	557.08			4.511	567.5
Tee10B-1	562.25		*	1.216	565.1
Tee10B-2	556.75			4.653	567.5
Tee10C-2	556.79			2.305	562.1
Tee10D-2	556.92			3.194	564.3
Tee14A	555.63			4.475	566
Tee14B	555.63			4.465	566
U	559.5		*	3.474	567.6

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	3.521	567.7
X-204A	570.6		p	0	570.6
X-204B	570.6		p	0	570.6
X-204C	570.6		*	-1.406	567.3
X-204D	570.6		p	0	570.6
X-223A	559.5		*	3.468	567.5
X-223B	559.5		*	3.356	567.3
X-224A	559.5			3.472	567.6
X-224B	559.5			3.459	567.5
X-225	559.5			3.463	567.5
X-226	559.5			3.436	567.5
ZA	560.5		*	3.359	568.3
ZB	560.5		*	3.359	568.3
ZC	560.5		*	2.946	567.3
ZD	560.5		*	3.315	568.2

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi	Hl ft
2-1015A-1	X-223A		Tee10A-1	0	0	0	0
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	10000	7.563	2.14	2.217
2-1015B-2	Tee10B-1		Red10B	5000	3.781	0.137	0.318
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	0	0	0	0
2-1016B-2	Tee10B-2		Suc10B	0	0	0	0
2-1016C-1	Red10B		Tee10C-2	5000	11.64	(1.226)	2.614
2-1016C-2	Tee10C-2		Suc10C	5000	11.64	0.368	2.065
2-1016D-1	Tee10B-1		Tee10D-2	5000	11.64	(1.978)	0.738
2-1016D-2	Tee10D-2		Suc10D	5000	11.64	0.318	2.077
2-1025-1	B	<->	A	13.01	0.010	0	0
2-1025-10	I	<->	X-223B	3725	2.975	0	0.002
2-1025-11	J	<->	I	3725	2.817	0.019	0.044
2-1025-12	K	<->	J	3725	2.975	0	0.002
2-1025-13	L	<->	K	3725	2.975	0.014	0.034
2-1025-14	M	<->	L	3725	2.817	0.045	0.104
2-1025-15	X-226	<->	M	3725	2.975	0	0.002
2-1025-16	N	<->	X-226	3725	2.975	0.014	0.033
2-1025-17	O	<->	N	3725	2.817	0.017	0.039
2-1025-18	P	<->	O	3725	2.975	0	0.002
2-1025-19	P		Q	2699	2.156	0	0.001
2-1025-2	C	<->	B	13.01	0.010	0	0
2-1025-20	Q		R	2699	2.041	0.009	0.021
2-1025-21	R		X-224B	2699	2.156	0	0
2-1025-22	X-225	<->	X-224B	1801	1.438	0.004	0.009
2-1025-23	S	<->	X-225	1801	1.438	0.001	0.003
2-1025-24	T	<->	S	1801	1.362	0.005	0.012
2-1025-25	X-224A	<->	T	1801	1.438	0.003	0.008
2-1025-26	U	<->	X-224A	6301	5.033	0.002	0.005
2-1025-27	V	<->	U	6301	4.765	0.047	0.109
2-1025-28	A	<->	V	6301	5.033	0.002	0.005
2-1025-3	D	<->	C	13.01	0.010	0	0
2-1025-4	D		E	6275	5.012	0.002	0.005
2-1025-5	E		F	6275	4.746	0.051	0.119
2-1025-6	F		X-223A	6275	5.012	0.002	0.005
2-1025-7	X-223A		G	6275	5.012	0.019	0.045
2-1025-8	G		H	6275	4.746	0.035	0.080
2-1025-9	H		X-223B	6275	5.012	0.058	0.135

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	4500	6.183	(1.003)	1.542
2-1401-2	Tee14A	Red14A	4500	6.183	0.027	0.063
2-1401-3	Red14A	Suc14A	4500	7.911	0.003	0.006
2-1402-1	X-224B	Tee14B	4500	6.183	(1.007)	1.533
2-1402-2	Tee14B	Red14B	4500	6.183	0.026	0.061
2-1402-3	Red14B	Suc14B	4500	7.911	0.004	0.009
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	6288	7.613	(3.359)	2.303
--- strainer --- dP: 0.988 --- Hl: 2.293						
LA-2	ZA	A	6288	6.937	(0.165)	0.617
LB-1	X-204B	ZB	6288	7.613	(3.359)	2.303
--- strainer --- dP: 0.988 --- Hl: 2.293						
LB-2	ZB	D	6288	6.937	(0.165)	0.617
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	6424	7.778	(3.315)	2.404
--- strainer --- dP: 1.031 --- Hl: 2.394						
LD-2	ZD	P	6424	7.087	(0.153)	0.644
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 0.000255 %
after: 7 iterations

2/2 Throttled Case: 2 RHR pump @ 3000 gpm and 2 CS pump @ 4000 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10C	>>>	3000	Suc10D	>>>	3000
Suc14A	>>>	4000	Suc14B	>>>	4000

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

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	4633	<<<	X-204A	0
LB-1	<<<	4624	<<<	X-204B	0
LD-1	<<<	4743	<<<	X-204D	0

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

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	4.099	569
B	559.5		*	4.099	569
C	559.5		*	4.101	569
D	559.5		*	4.101	569
E	559.5		*	4.1	569
F	559.5		*	4.079	569
G	559.5		*	4.07	568.9
H	559.5		*	4.055	568.9
I	559.5		*	4.032	568.9
J	559.5		*	4.038	568.9
K	559.5		*	4.038	568.9
L	559.5		*	4.042	568.9
M	559.5		*	4.056	568.9
N	559.5		*	4.06	568.9
O	559.5		*	4.066	568.9
P	559.5		*	4.066	568.9
Q	559.5		*	4.065	568.9
R	559.5		*	4.056	568.9
Red10A	562.25		*	2.893	569
Red10B	562.25		*	2.452	567.9
Red14A	555.63			5.183	567.7
Red14B	555.63			5.18	567.7
S	559.5		*	4.058	568.9
Suc10A	555.58			5.767	569
Suc10B	555.58			5.767	569
Suc10C	555.58	> 3000		4.598	566.3
Suc10D	555.58	> 3000		4.936	567
Suc14A	555.63	> 4000		5.181	567.7
Suc14B	555.63	> 4000		5.176	567.6
T	559.5		*	4.061	568.9
Tee10A-1	562.25		*	2.893	569
Tee10A-2	557.08			5.121	569
Tee10B-1	562.25		*	2.502	568.1
Tee10B-2	556.75			5.263	569
Tee10C-2	556.79			4.399	567
Tee10D-2	556.92			4.683	567.8
Tee14A	555.63			5.204	567.7
Tee14B	555.63			5.2	567.7
U	559.5		*	4.064	568.9

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi a	H GRADE ft
V	559.5		* 4.097	569
X-204A	570.6		p 0	570.6
X-204B	570.6		p 0	570.6
X-204C	570.6		* -0.744	568.9
X-204D	570.6		p 0	570.6
X-223A	559.5		* 4.078	569
X-223B	559.5		* 4.032	568.9
X-224A	559.5		4.063	568.9
X-224B	559.5		4.056	568.9
X-225	559.5		4.058	568.9
X-226	559.5		4.056	568.9
ZA	560.5		* 3.812	569.3
ZB	560.5		* 3.814	569.4
ZC	560.5		* 3.607	568.9
ZD	560.5		* 3.787	569.3

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	0	0	0	0
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	6000	4.538	1.53	0.802
2-1015B-2	Tee10B-1		Red10B	3000	2.269	0.049	0.115
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	0	0	0	0
2-1016B-2	Tee10B-2		Suc10B	0	0	0	0
2-1016C-1	Red10B		Tee10C-2	3000	6.986	(1.946)	0.942
2-1016C-2	Tee10C-2		Suc10C	3000	6.986	(0.199)	0.747
2-1016D-1	Tee10B-1		Tee10D-2	3000	6.986	(2.181)	0.268
2-1016D-2	Tee10D-2		Suc10D	3000	6.986	(0.253)	0.752
2-1025-1	B	<->	A	629.6	0.503	0	0
2-1025-10	I	<->	X-223B	2006	1.602	0	0
2-1025-11	J	<->	I	2006	1.517	0.006	0.013
2-1025-12	K	<->	J	2006	1.602	0	0
2-1025-13	L	<->	K	2006	1.602	0.004	0.010
2-1025-14	M	<->	L	2006	1.517	0.014	0.032
2-1025-15	X-226	<->	M	2006	1.602	0	0
2-1025-16	N	<->	X-226	2006	1.602	0.004	0.010
2-1025-17	O	<->	N	2006	1.517	0.005	0.012
2-1025-18	P	<->	O	2006	1.602	0	0
2-1025-19	P		Q	2737	2.186	0	0.001
2-1025-2	C	<->	B	629.6	0.476	0.002	0.005
2-1025-20	Q		R	2737	2.07	0.009	0.022
2-1025-21	R		X-224B	2737	2.186	0	0
2-1025-22	X-225	<->	X-224B	1263	1.008	0.002	0.005
2-1025-23	S	<->	X-225	1263	1.008	0	0.002
2-1025-24	T	<->	S	1263	0.955	0.003	0.006
2-1025-25	X-224A	<->	T	1263	1.008	0.002	0.004
2-1025-26	U	<->	X-224A	5263	4.203	0.001	0.003
2-1025-27	V	<->	U	5263	3.98	0.033	0.077
2-1025-28	A	<->	V	5263	4.203	0.002	0.004
2-1025-3	D	<->	C	629.6	0.503	0	0
2-1025-4	D		E	3994	3.191	0	0.002
2-1025-5	E		F	3994	3.021	0.021	0.050
2-1025-6	F		X-223A	3994	3.191	0	0.002
2-1025-7	X-223A		G	3994	3.191	0.008	0.019
2-1025-8	G		H	3994	3.021	0.015	0.034
2-1025-9	H		X-223B	3994	3.191	0.024	0.055

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	4000	5.496	(1.142)	1.219
2-1401-2	Tee14A	Red14A	4000	5.496	0.021	0.050
2-1401-3	Red14A	Suc14A	4000	7.032	0.002	0.005
2-1402-1	X-224B	Tee14B	4000	5.496	(1.145)	1.213
2-1402-2	Tee14B	Red14B	4000	5.496	0.021	0.048
2-1402-3	Red14B	Suc14B	4000	7.032	0.003	0.007
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	4633	5.609	(3.812)	1.251
--- strainer --- dP: 0.536 --- Hl: 1.245						
LA-2	ZA	A	4633	5.111	(0.286)	0.335
LB-1	X-204B	ZB	4624	5.598	(3.814)	1.246
--- strainer --- dP: 0.534 --- Hl: 1.24						
LB-2	ZB	D	4624	5.102	(0.287)	0.334
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	4743	5.742	(3.787)	1.311
--- strainer --- dP: 0.562 --- Hl: 1.305						
LD-2	ZD	P	4743	5.233	(0.279)	0.351
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 0.000169 %
after: 6 iterations

3/2 Unthrottled Case: 3 RHR pump @ 5000 gpm and 2 CS pump @ 4500 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10B	>>>	5000	Suc10C	>>>	5000
Suc10D	>>>	5000	Suc14A	>>>	4500
Suc14B	>>>	4500			

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

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	7957	<<<	X-204A	0
LB-1	<<<	8005	<<<	X-204B	0
LD-1	<<<	8038	<<<	X-204D	0

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

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi a	H GRADE ft
A	559.5		* 2.767	565.9
B	559.5		* 2.767	565.9
C	559.5		* 2.747	565.9
D	559.5		* 2.743	565.9
E	559.5		* 2.737	565.9
F	559.5		* 2.609	565.6
G	559.5		* 2.591	565.5
H	559.5		* 2.568	565.5
I	559.5		* 2.532	565.4
J	559.5		* 2.564	565.5
K	559.5		* 2.566	565.5
L	559.5		* 2.591	565.5
M	559.5		* 2.669	565.7
N	559.5		* 2.695	565.8
O	559.5		* 2.725	565.8
P	559.5		* 2.726	565.8
Q	559.5		* 2.726	565.8
R	559.5		* 2.714	565.8
Red10A	562.25		* 1.18	565
Red10B	562.25		* 0.254	562.8
Red14A	555.63		3.698	564.2
Red14B	555.63		3.694	564.2
S	559.5		* 2.717	565.8
Suc10A	555.58		4.054	565
Suc10B	555.58	> 5000	2.001	560.2
Suc10C	555.58	> 5000	1.111	558.2
Suc10D	555.58	> 5000	2.051	560.3
Suc14A	555.63	> 4500	3.695	564.2
Suc14B	555.63	> 4500	3.69	564.2
T	559.5		* 2.72	565.8
Tee10A-1	562.25		* 1.18	565
Tee10A-2	557.08		3.407	565
Tee10B-1	562.25		* 0.390	563.2
Tee10B-2	556.75		2.421	562.4
Tee10C-2	556.79		1.48	560.2
Tee10D-2	556.92		2.369	562.4
Tee14A	555.63		3.725	564.3
Tee14B	555.63		3.72	564.3
U	559.5		* 2.724	565.8

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	2.765	565.9
X-204A	570.6		p	0	570.6
X-204B	570.6		p	0	570.6
X-204C	570.6		*	-2.216	565.5
X-204D	570.6		p	0	570.6
X-223A	559.5		*	2.604	565.5
X-223B	559.5		*	2.53	565.4
X-224A	559.5			2.722	565.8
X-224B	559.5			2.713	565.8
X-225	559.5			2.716	565.8
X-226	559.5			2.67	565.7
ZA	560.5		*	2.762	566.9
ZB	560.5		*	2.743	566.9
ZC	560.5		*	2.135	565.5
ZD	560.5		*	2.73	566.8

LINEUP PIPELINES

CASE-4
09/25/98

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	5000	3.781	1.424	0.554
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	10000	7.563	2.14	2.217
2-1015B-2	Tee10B-1		Red10B	5000	3.781	0.137	0.318
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	5000	11.64	(1.24)	2.621
2-1016B-2	Tee10B-2		Suc10B	5000	11.64	0.419	2.143
2-1016C-1	Red10B		Tee10C-2	5000	11.64	(1.226)	2.614
2-1016C-2	Tee10C-2		Suc10C	5000	11.64	0.368	2.065
2-1016D-1	Tee10B-1		Tee10D-2	5000	11.64	(1.978)	0.738
2-1016D-2	Tee10D-2		Suc10D	5000	11.64	0.318	2.077
2-1025-1	A		B	2045	1.633	0	0
2-1025-10	I	<->	X-223B	4950	3.954	0.001	0.003
2-1025-11	J	<->	I	4950	3.744	0.032	0.075
2-1025-12	K	<->	J	4950	3.954	0.001	0.003
2-1025-13	L	<->	K	4950	3.954	0.025	0.059
2-1025-14	M	<->	L	4950	3.744	0.078	0.180
2-1025-15	X-226	<->	M	4950	3.954	0.001	0.003
2-1025-16	N	<->	X-226	4950	3.954	0.025	0.059
2-1025-17	O	<->	N	4950	3.744	0.029	0.068
2-1025-18	P	<->	O	4950	3.954	0.001	0.003
2-1025-19	P		Q	3087	2.466	0	0.001
2-1025-2	B		C	2045	1.546	0.020	0.046
2-1025-20	Q		R	3087	2.335	0.012	0.028
2-1025-21	R		X-224B	3087	2.466	0	0.001
2-1025-22	X-225	<->	X-224B	1413	1.128	0.002	0.006
2-1025-23	S	<->	X-225	1413	1.128	0	0.002
2-1025-24	T	<->	S	1413	1.068	0.003	0.007
2-1025-25	X-224A	<->	T	1413	1.128	0.002	0.005
2-1025-26	U	<->	X-224A	5913	4.723	0.002	0.004
2-1025-27	V	<->	U	5913	4.472	0.041	0.096
2-1025-28	A	<->	V	5913	4.723	0.002	0.005
2-1025-3	C		D	2045	1.633	0.004	0.010
2-1025-4	D		E	10050	8.027	0.006	0.013
2-1025-5	E		F	10050	7.601	0.128	0.298
2-1025-6	F		X-223A	10050	8.027	0.005	0.012
2-1025-7	X-223A		G	5050	4.033	0.013	0.029
2-1025-8	G		H	5050	3.819	0.023	0.053
2-1025-9	H		X-223B	5050	4.033	0.038	0.087

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	4500	6.183	(1.003)	1.542
2-1401-2	Tee14A	Red14A	4500	6.183	0.027	0.063
2-1401-3	Red14A	Suc14A	4500	7.911	0.003	0.006
2-1402-1	X-224B	Tee14B	4500	6.183	(1.007)	1.533
2-1402-2	Tee14B	Red14B	4500	6.183	0.026	0.061
2-1402-3	Red14B	Suc14B	4500	7.911	0.004	0.009
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	7957	9.634	(2.762)	3.688
--- strainer --- dP: 1.582 --- Hl: 3.672						
LA-2	ZA	A	7957	8.779	(0.005)	0.988
LB-1	X-204B	ZB	8005	9.692	(2.743)	3.733
--- strainer --- dP: 1.601 --- Hl: 3.717						
LB-2	ZB	D	8005	8.832	0	1
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	8038	9.731	(2.73)	3.763
--- strainer --- dP: 1.614 --- Hl: 3.747						
LD-2	ZD	P	8038	8.868	0.004	1.009
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 5.55e-005 %
after: 7 iterations

3/2 Throttled Case: 3 RHR pump @ 3000 gpm and 2 CS pump @ 4000 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10B	>>>	3000	Suc10C	>>>	3000
Suc10D	>>>	3000	Suc14A	>>>	4000
Suc14B	>>>	4000			

FLOWS IN: 0 gpm
FLOWS OUT: 17000 gpm
NET FLOWS OUT: 17000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	5640	<<<	X-204A	0
LB-1	<<<	5647	<<<	X-204B	0
LD-1	<<<	5712	<<<	X-204D	0

FLOWS IN: 16999 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 16999 gpm

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	3.769	568.2
B	559.5		*	3.769	568.2
C	559.5		*	3.767	568.2
D	559.5		*	3.767	568.2
E	559.5		*	3.765	568.2
F	559.5		*	3.714	568.1
G	559.5		*	3.706	568.1
H	559.5		*	3.697	568.1
I	559.5		*	3.681	568
J	559.5		*	3.692	568.1
K	559.5		*	3.692	568.1
L	559.5		*	3.7	568.1
M	559.5		*	3.725	568.1
N	559.5		*	3.733	568.2
O	559.5		*	3.743	568.2
P	559.5		*	3.743	568.2
Q	559.5		*	3.743	568.2
R	559.5		*	3.732	568.2
Red10A	562.25		*	2.44	567.9
Red10B	562.25		*	2.101	567.1
Red14A	555.63			4.857	566.9
Red14B	555.63			4.855	566.9
S	559.5		*	3.733	568.2
Suc10A	555.58			5.314	567.9
Suc10B	555.58	> 3000		4.573	566.2
Suc10C	555.58	> 3000		4.247	565.4
Suc10D	555.58	> 3000		4.585	566.2
Suc14A	555.63	> 4000		4.854	566.9
Suc14B	555.63	> 4000		4.852	566.9
T	559.5		*	3.735	568.2
Tee10A-1	562.25		*	2.44	567.9
Tee10A-2	557.08			4.668	567.9
Tee10B-1	562.25		*	2.151	567.2
Tee10B-2	556.75			4.403	567
Tee10C-2	556.79			4.048	566.2
Tee10D-2	556.92			4.332	567
Tee14A	555.63			4.878	567
Tee14B	555.63			4.876	566.9
U	559.5		*	3.738	568.2

NODE	ELEVATION ft	DEMAND gpm	PRESSURE psi a	H GRADE ft
V	559.5		* 3.768	568.2
X-204A	570.6		p 0	570.6
X-204B	570.6		p 0	570.6
X-204C	570.6		* -1.09	568.1
X-204D	570.6		p 0	570.6
X-223A	559.5		* 3.712	568.1
X-223B	559.5		* 3.681	568
X-224A	559.5		3.736	568.2
X-224B	559.5		3.731	568.2
X-225	559.5		3.733	568.2
X-226	559.5		3.726	568.1
ZA	560.5		* 3.553	568.7
ZB	560.5		* 3.551	568.7
ZC	560.5		* 3.261	568.1
ZD	560.5		* 3.532	568.7

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	3000	2.269	1.271	0.201
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	6000	4.538	1.53	0.802
2-1015B-2	Tee10B-1		Red10B	3000	2.269	0.049	0.115
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	3000	6.986	(1.963)	0.944
2-1016B-2	Tee10B-2		Suc10B	3000	6.986	(0.170)	0.777
2-1016C-1	Red10B		Tee10C-2	3000	6.986	(1.946)	0.942
2-1016C-2	Tee10C-2		Suc10C	3000	6.986	(0.199)	0.747
2-1016D-1	Tee10B-1		Tee10D-2	3000	6.986	(2.181)	0.268
2-1016D-2	Tee10D-2		Suc10D	3000	6.986	(0.253)	0.752
2-1025-1	A		B	603.3	0.482	0	0
2-1025-10	I	<->	X-223B	2749	2.196	0	0.001
2-1025-11	J	<->	I	2749	2.079	0.011	0.024
2-1025-12	K	<->	J	2749	2.196	0	0.001
2-1025-13	L	<->	K	2749	2.196	0.008	0.018
2-1025-14	M	<->	L	2749	2.079	0.025	0.058
2-1025-15	X-226	<->	M	2749	2.196	0	0.001
2-1025-16	N	<->	X-226	2749	2.196	0.008	0.018
2-1025-17	O	<->	N	2749	2.079	0.010	0.022
2-1025-18	P	<->	O	2749	2.196	0	0.001
2-1025-19	P		Q	2963	2.367	0	0.001
2-1025-2	B		C	603.3	0.456	0.002	0.005
2-1025-20	Q		R	2963	2.241	0.011	0.025
2-1025-21	R		X-224B	2963	2.367	0	0.001
2-1025-22	X-225	<->	X-224B	1037	0.828	0.001	0.003
2-1025-23	S	<->	X-225	1037	0.828	0	0.001
2-1025-24	T	<->	S	1037	0.784	0.002	0.004
2-1025-25	X-224A	<->	T	1037	0.828	0.001	0.003
2-1025-26	U	<->	X-224A	5037	4.023	0.001	0.003
2-1025-27	V	<->	U	5037	3.81	0.030	0.071
2-1025-28	A	<->	V	5037	4.023	0.002	0.004
2-1025-3	C		D	603.3	0.482	0	0
2-1025-4	D		E	6251	4.992	0.002	0.005
2-1025-5	E		F	6251	4.727	0.051	0.118
2-1025-6	F		X-223A	6251	4.992	0.002	0.005
2-1025-7	X-223A		G	3251	2.596	0.005	0.012
2-1025-8	G		H	3251	2.458	0.010	0.023
2-1025-9	H		X-223B	3251	2.596	0.016	0.036

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	[illegible]	0	0	0
2-1401-1	X-224A	Tee14A	4000	5.496	(1.142)	1.219
2-1401-2	Tee14A	Red14A	4000	5.496	0.021	0.050
2-1401-3	Red14A	Suc14A	4000	7.032	0.002	0.005
2-1402-1	X-224B	Tee14B	4000	5.496	(1.145)	1.213
2-1402-2	Tee14B	Red14B	4000	5.496	0.021	0.048
2-1402-3	Red14B	Suc14B	4000	7.032	0.003	0.007
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	5640	6.829	(3.553)	1.853
--- strainer --- dP: 0.795 --- Hl: 1.845						
LA-2	ZA	A	5640	6.223	(0.217)	0.497
LB-1	X-204B	ZB	5647	6.837	(3.551)	1.858
--- strainer --- dP: 0.797 --- Hl: 1.85						
LB-2	ZB	D	5647	6.23	(0.216)	0.498
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	5712	6.916	(3.532)	1.901
--- strainer --- dP: 0.815 --- Hl: 1.893						
LD-2	ZD	P	5712	6.302	(0.211)	0.510
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 0.000114 %
after: 6 iterations

4/2 Nominal Case: 4 RHR pump @ 5000 gpm and 2 CS pump @ 4500 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10A	>>>	5000	Suc10B	>>>	5000
Suc10C	>>>	5000	Suc10D	>>>	5000
Suc14A	>>>	4500	Suc14B	>>>	4500

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

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	9603	<<<	X-204A	0
LB-1	<<<	9734	<<<	X-204B	0
LD-1	<<<	9663	<<<	X-204D	0

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

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	1.848	563.8
B	559.5		*	1.847	563.8
C	559.5		*	1.782	563.6
D	559.5		*	1.767	563.6
E	559.5		*	1.757	563.6
F	559.5		*	1.527	563
G	559.5		*	1.512	563
H	559.5		*	1.5	563
I	559.5		*	1.484	562.9
J	559.5		*	1.538	563.1
K	559.5		*	1.541	563.1
L	559.5		*	1.584	563.2
M	559.5		*	1.714	563.5
N	559.5		*	1.759	563.6
O	559.5		*	1.808	563.7
P	559.5		*	1.811	563.7
Q	559.5		*	1.81	563.7
R	559.5		*	1.798	563.7
Red10A	562.25		*	-0.751	560.5
Red10B	562.25		*	-0.795	560.4
Red14A	555.63			2.78	562.1
Red14B	555.63			2.777	562.1
S	559.5		*	1.8	563.7
Suc10A	555.58	> 5000		0.773	557.4
Suc10B	555.58	> 5000		0.205	556.1
Suc10C	555.58	> 5000		0.062	555.7
Suc10D	555.58	> 5000		1.002	557.9
Suc14A	555.63	> 4500		2.778	562.1
Suc14B	555.63	> 4500		2.773	562.1
T	559.5		*	1.802	563.7
Tee10A-1	562.25		*	-0.616	560.8
Tee10A-2	557.08			1.088	559.6
Tee10B-1	562.25		*	-0.658	560.7
Tee10B-2	556.75			0.624	558.2
Tee10C-2	556.79			0.431	557.8
Tee10D-2	556.92			1.32	560
Tee14A	555.63			2.807	562.1
Tee14B	555.63			2.804	562.1
U	559.5		*	1.806	563.7

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	1.846	563.8
X-204A	570.6		p	0	570.6
X-204B	570.6		p	0	570.6
X-204C	570.6		*	-3.241	563.1
X-204D	570.6		p	0	570.6
X-223A	559.5		*	1.518	563
X-223B	559.5		*	1.482	562.9
X-224A	559.5			1.804	563.7
X-224B	559.5			1.797	563.7
X-225	559.5			1.799	563.7
X-226	559.5			1.716	563.5
ZA	560.5		*	2.037	565.2
ZB	560.5		*	1.973	565.1
ZC	560.5		*	1.11	563.1
ZD	560.5		*	2.008	565.2

LINEUP PIPELINES

CASE-6
09/25/98

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A	Tee10A-1	10000	7.563	2.134	2.204
2-1015A-2	Tee10A-1	Red10A	5000	3.781	0.135	0.313
2-1015B-1	X-223B	Tee10B-1	10000	7.563	2.14	2.217
2-1015B-2	Tee10B-1	Red10B	5000	3.781	0.137	0.318
2-1016A-1	Red10A	Tee10A-2	5000	11.64	(1.839)	0.901
2-1016A-2	Tee10A-2	Suc10A	5000	11.64	0.315	2.232
2-1016B-1	Tee10A-1	Tee10B-2	5000	11.64	(1.24)	2.621
2-1016B-2	Tee10B-2	Suc10B	5000	11.64	0.419	2.143
2-1016C-1	Red10B	Tee10C-2	5000	11.64	(1.226)	2.614
2-1016C-2	Tee10C-2	Suc10C	5000	11.64	0.368	2.065
2-1016D-1	Tee10B-1	Tee10D-2	5000	11.64	(1.978)	0.738
2-1016D-2	Tee10D-2	Suc10D	5000	11.64	0.318	2.077
2-1025-1	A	B	3804	3.038	0	0.002
2-1025-10	I	<-> X-223B	6462	5.162	0.002	0.005
2-1025-11	J	<-> I	6462	4.887	0.054	0.126
2-1025-12	K	<-> J	6462	5.162	0.002	0.006
2-1025-13	L	<-> K	6462	5.162	0.043	0.101
2-1025-14	M	<-> L	6462	4.887	0.130	0.302
2-1025-15	X-226	<-> M	6462	5.162	0.002	0.005
2-1025-16	N	<-> X-226	6462	5.162	0.043	0.100
2-1025-17	O	<-> N	6462	4.887	0.049	0.114
2-1025-18	P	<-> O	6462	5.162	0.002	0.006
2-1025-19	P	Q	3201	2.557	0	0.001
2-1025-2	B	C	3804	2.877	0.065	0.151
2-1025-20	Q	R	3201	2.421	0.013	0.029
2-1025-21	R	X-224B	3201	2.557	0	0.001
2-1025-22	X-225	<-> X-224B	1299	1.038	0.002	0.005
2-1025-23	S	<-> X-225	1299	1.038	0	0.002
2-1025-24	T	<-> S	1299	0.983	0.003	0.006
2-1025-25	X-224A	<-> T	1299	1.038	0.002	0.004
2-1025-26	U	<-> X-224A	5799	4.632	0.002	0.004
2-1025-27	V	<-> U	5799	4.386	0.040	0.093
2-1025-28	A	<-> V	5799	4.632	0.002	0.005
2-1025-3	C	D	3804	3.038	0.015	0.035
2-1025-4	D	E	13538	10.81	0.010	0.024
2-1025-5	E	F	13538	10.24	0.230	0.533
2-1025-6	F	X-223A	13538	10.81	0.009	0.021
2-1025-7	X-223A	G	3538	2.826	0.006	0.015
2-1025-8	G	H	3538	2.676	0.012	0.027
2-1025-9	H	X-223B	3538	2.826	0.019	0.043

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	4500	6.183	(1.003)	1.542
2-1401-2	Tee14A	Red14A	4500	6.183	0.027	0.063
2-1401-3	Red14A	Suc14A	4500	7.911	0.003	0.006
2-1402-1	X-224B	Tee14B	4500	6.183	(1.007)	1.533
2-1402-2	Tee14B	Red14B	4500	6.183	0.026	0.061
2-1402-3	Red14B	Suc14B	4500	7.911	0.004	0.009
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	9603	11.63	(2.037)	5.371
--- strainer --- dP: 2.304 --- Hl: 5.349						
LA-2	ZA	A	9603	10.59	0.189	1.439
LB-1	X-204B	ZB	9734	11.79	(1.973)	5.519
--- strainer --- dP: 2.368 --- Hl: 5.496						
LB-2	ZB	D	9734	10.74	0.206	1.479
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	9663	11.7	(2.008)	5.439
--- strainer --- dP: 2.333 --- Hl: 5.416						
LD-2	ZD	P	9663	10.66	0.197	1.457
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

Company: ComEd
Project:
by: Doug Collins

CASE-7
09/25/98

LINEUP REPORT rev: 09/25/98

LINELIST: ECCS
dated: 09/24/98

DEVIATION: 2.01e-005 %
after: 7 iterations

4/2 Throttled Case: 4 RHR pump @ 3000 gpm and 2 CS pump @ 4000 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10A	>>>	3000	Suc10B	>>>	3000
Suc10C	>>>	3000	Suc10D	>>>	3000
Suc14A	>>>	4000	Suc14B	>>>	4000

FLOWS IN: 0 gpm
FLOWS OUT: 20000 gpm
NET FLOWS OUT: 20000 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	6635	<<<	X-204A	0
LB-1	<<<	6675	<<<	X-204B	0
LD-1	<<<	6690	<<<	X-204D	0

FLOWS IN: 20000 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 20000 gpm

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	3.381	567.3
B	559.5		*	3.381	567.3
C	559.5		*	3.367	567.3
D	559.5		*	3.364	567.3
E	559.5		*	3.36	567.3
F	559.5		*	3.27	567.1
G	559.5		*	3.264	567.1
H	559.5		*	3.258	567.1
I	559.5		*	3.251	567
J	559.5		*	3.269	567.1
K	559.5		*	3.27	567.1
L	559.5		*	3.283	567.1
M	559.5		*	3.326	567.2
N	559.5		*	3.341	567.3
O	559.5		*	3.357	567.3
P	559.5		*	3.358	567.3
Q	559.5		*	3.357	567.3
R	559.5		*	3.345	567.3
Red10A	562.25		*	1.69	566.2
Red10B	562.25		*	1.671	566.1
Red14A	555.63			4.469	566
Red14B	555.63			4.469	566
S	559.5		*	3.346	567.3
Suc10A	555.58	> 3000		4.074	565
Suc10B	555.58	> 3000		3.871	564.6
Suc10C	555.58	> 3000		3.816	564.4
Suc10D	555.58	> 3000		4.154	565.2
Suc14A	555.63	> 4000		4.467	566
Suc14B	555.63	> 4000		4.466	566
T	559.5		*	3.348	567.3
Tee10A-1	562.25		*	1.739	566.3
Tee10A-2	557.08			3.776	565.8
Tee10B-1	562.25		*	1.72	566.2
Tee10B-2	556.75			3.701	565.3
Tee10C-2	556.79			3.617	565.2
Tee10D-2	556.92			3.901	566
Tee14A	555.63			4.491	566.1
Tee14B	555.63			4.49	566.1
U	559.5		*	3.35	567.3

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	3.38	567.3
X-204A	570.6		p	0	570.6
X-204B	570.6		p	0	570.6
X-204C	570.6		*	-1.512	567.1
X-204D	570.6		p	0	570.6
X-223A	559.5		*	3.267	567.1
X-223B	559.5		*	3.25	567
X-224A	559.5			3.349	567.3
X-224B	559.5			3.345	567.3
X-225	559.5			3.346	567.3
X-226	559.5			3.327	567.2
ZA	560.5		*	3.246	568
ZB	560.5		*	3.233	568
ZC	560.5		*	2.839	567.1
ZD	560.5		*	3.228	568

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	6000	4.538	1.528	0.797
2-1015A-2	Tee10A-1		Red10A	3000	2.269	0.049	0.113
2-1015B-1	X-223B		Tee10B-1	6000	4.538	1.53	0.802
2-1015B-2	Tee10B-1		Red10B	3000	2.269	0.049	0.115
2-1016A-1	Red10A		Tee10A-2	3000	6.986	(2.086)	0.328
2-1016A-2	Tee10A-2		Suc10A	3000	6.986	(0.298)	0.808
2-1016B-1	Tee10A-1		Tee10B-2	3000	6.986	(1.963)	0.944
2-1016B-2	Tee10B-2		Suc10B	3000	6.986	(0.170)	0.777
2-1016C-1	Red10B		Tee10C-2	3000	6.986	(1.946)	0.942
2-1016C-2	Tee10C-2		Suc10C	3000	6.986	(0.199)	0.747
2-1016D-1	Tee10B-1		Tee10D-2	3000	6.986	(2.181)	0.268
2-1016D-2	Tee10D-2		Suc10D	3000	6.986	(0.253)	0.752
2-1025-1	A		B	1689	1.349	0	0
2-1025-10	I	<->	X-223B	3636	2.904	0	0.002
2-1025-11	J	<->	I	3636	2.75	0.018	0.042
2-1025-12	K	<->	J	3636	2.904	0	0.002
2-1025-13	L	<->	K	3636	2.904	0.014	0.032
2-1025-14	M	<->	L	3636	2.75	0.043	0.099
2-1025-15	X-226	<->	M	3636	2.904	0	0.002
2-1025-16	N	<->	X-226	3636	2.904	0.014	0.032
2-1025-17	O	<->	N	3636	2.75	0.016	0.038
2-1025-18	P	<->	O	3636	2.904	0	0.002
2-1025-19	P		Q	3054	2.439	0	0.001
2-1025-2	B		C	1689	1.277	0.014	0.032
2-1025-20	Q		R	3054	2.31	0.012	0.027
2-1025-21	R		X-224B	3054	2.439	0	0.001
2-1025-22	X-225	<->	X-224B	946.1	0.756	0.001	0.003
2-1025-23	S	<->	X-225	946.1	0.756	0	0
2-1025-24	T	<->	S	946.1	0.716	0.002	0.003
2-1025-25	X-224A	<->	T	946.1	0.756	0	0.002
2-1025-26	U	<->	X-224A	4946	3.951	0.001	0.003
2-1025-27	V	<->	U	4946	3.741	0.029	0.068
2-1025-28	A	<->	V	4946	3.951	0.001	0.003
2-1025-3	C		D	1689	1.349	0.003	0.007
2-1025-4	D		E	8364	6.68	0.004	0.009
2-1025-5	E		F	8364	6.326	0.090	0.208
2-1025-6	F		X-223A	8364	6.68	0.004	0.008
2-1025-7	X-223A		G	2364	1.888	0.003	0.007
2-1025-8	G		H	2364	1.788	0.005	0.013
2-1025-9	H		X-223B	2364	1.888	0.008	0.019

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	4000	5.496	(1.142)	1.219
2-1401-2	Tee14A	Red14A	4000	5.496	0.021	0.050
2-1401-3	Red14A	Suc14A	4000	7.032	0.002	0.005
2-1402-1	X-224B	Tee14B	4000	5.496	(1.145)	1.213
2-1402-2	Tee14B	Red14B	4000	5.496	0.021	0.048
2-1402-3	Red14B	Suc14B	4000	7.032	0.003	0.007
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	6635	8.033	(3.246)	2.564
--- strainer --- dP: 1.1 --- Hl: 2.553						
LA-2	ZA	A	6635	7.32	(0.135)	0.687
LB-1	X-204B	ZB	6675	8.081	(3.233)	2.596
--- strainer --- dP: 1.113 --- Hl: 2.584						
LB-2	ZB	D	6675	7.364	(0.131)	0.696
LC-1	X-204C	ZC	0	0	0	0
--- strainer --- dP: --- Hl:						
LC-2	ZC	K	0	0	0	0
LD-1	X-204D	ZD	6690	8.1	(3.228)	2.607
--- strainer --- dP: 1.118 --- Hl: 2.596						
LD-2	ZD	P	6690	7.381	(0.130)	0.699
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

LINEUP REPORT rev: 09/25/98

LINELIST: LONG-NEW
dated: 09/25/98

DEVIATION: 6.32e-005 %
after: 9 iterations

Design Basis Flow Case: 1 RHR pump @ 5000 gpm and 1 CS pump @ 4500 gpm

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

NODE		DEMAND gpm	NODE		DEMAND gpm
Suc10C	>>>	5000	Suc14B	>>>	4500

FLOWS IN: 0 gpm
FLOWS OUT: 9500 gpm
NET FLOWS OUT: 9500 gpm

PIPELINE		FLOW gpm		PRESSURE SOURCE	SET psia
LA-1	<<<	2274	<<<	X-204A	0
LB-1	<<<	2277	<<<	X-204B	0
LC-1	<<<	2475	<<<	X-204C	0
LD-1	<<<	2474	<<<	X-204D	0

FLOWS IN: 9500 gpm
FLOWS OUT: 0 gpm
NET FLOWS IN: 9500 gpm

LINEUP NODES

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
A	559.5		*	3.813	568.4
B	559.5		*	3.813	568.4
C	559.5		*	3.813	568.4
D	559.5		*	3.813	568.4
E	559.5		*	3.813	568.3
F	559.5		*	3.804	568.3
G	559.5		*	3.801	568.3
H	559.5		*	3.795	568.3
I	559.5		*	3.786	568.3
J	559.5		*	3.796	568.3
K	559.5		*	3.796	568.3
L	559.5		*	3.796	568.3
M	559.5		*	3.796	568.3
N	559.5		*	3.796	568.3
O	559.5		*	3.796	568.3
P	559.5		*	3.796	568.3
Q	559.5		*	3.796	568.3
R	559.5		*	3.788	568.3
Red10A	562.25		*	2.619	568.3
Red10B	562.25		*	2.224	567.4
Red14A	555.63			5.474	568.3
Red14B	555.63			4.769	566.7
S	559.5		*	3.795	568.3
Suc10A	555.58			5.493	568.3
Suc10B	555.58			5.493	568.3
Suc10C	555.58	> 5000		3.082	562.7
Suc10D	555.58			5.234	567.7
Suc14A	555.63			5.474	568.3
Suc14B	555.63	> 4500		4.765	566.7
T	559.5		*	3.802	568.3
Tee10A-1	562.25		*	2.619	568.3
Tee10A-2	557.08			4.846	568.3
Tee10B-1	562.25		*	2.361	567.7
Tee10B-2	556.75			4.989	568.3
Tee10C-2	556.79			3.45	564.8
Tee10D-2	556.92			4.657	567.7
Tee14A	555.63			5.474	568.3
Tee14B	555.63			4.795	566.8
U	559.5		*	3.807	568.3

NODE	ELEVATION ft	DEMAND gpm		PRESSURE psi a	H GRADE ft
V	559.5		*	3.813	568.4
X-204A	568.6		p	0	568.6
X-204B	568.6		p	0	568.6
X-204C	568.6		p	0	568.6
X-204D	568.6		p	0	568.6
X-223A	559.5		*	3.804	568.3
X-223B	559.5		*	3.786	568.3
X-224A	559.5			3.807	568.3
X-224B	559.5			3.788	568.3
X-225	559.5			3.794	568.3
X-226	559.5			3.796	568.3
ZA	560.5		*	3.417	568.4
ZB	560.5		*	3.417	568.4
ZC	560.5		*	3.406	568.4
ZD	560.5		*	3.407	568.4

PIPELINE	FROM		TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1015A-1	X-223A		Tee10A-1	0	0	0	0
2-1015A-2	Tee10A-1		Red10A	0	0	0	0
2-1015B-1	X-223B		Tee10B-1	5000	3.781	1.425	0.558
2-1015B-2	Tee10B-1		Red10B	5000	3.781	0.137	0.318
2-1016A-1	Red10A		Tee10A-2	0	0	0	0
2-1016A-2	Tee10A-2		Suc10A	0	0	0	0
2-1016B-1	Tee10A-1		Tee10B-2	0	0	0	0
2-1016B-2	Tee10B-2		Suc10B	0	0	0	0
2-1016C-1	Red10B		Tee10C-2	5000	11.64	(1.226)	2.614
2-1016C-2	Tee10C-2		Suc10C	5000	11.64	0.368	2.065
2-1016D-1	Tee10B-1		Tee10D-2	0	0	0	0
2-1016D-2	Tee10D-2		Suc10D	0	0	0	0
2-1025-1	A		B	166.1	0.133	0	0
2-1025-10	I	<->	X-223B	2557	2.042	0	0
2-1025-11	J	<->	I	2557	1.934	0.009	0.021
2-1025-12	K	<->	J	2557	2.042	0	0
2-1025-13	L	<->	K	82.17	0.066	0	0
2-1025-14	M	<->	L	82.17	0.062	0	0
2-1025-15	X-226	<->	M	82.17	0.066	0	0
2-1025-16	N	<->	X-226	82.17	0.066	0	0
2-1025-17	O	<->	N	82.17	0.062	0	0
2-1025-18	P	<->	O	82.17	0.066	0	0
2-1025-19	P		Q	2392	1.91	0	0
2-1025-2	B		C	166.1	0.126	0	0
2-1025-20	Q		R	2392	1.809	0.007	0.017
2-1025-21	R		X-224B	2392	1.91	0	0
2-1025-22	X-225	<->	X-224B	2108	1.684	0.005	0.013
2-1025-23	S	<->	X-225	2108	1.684	0.002	0.005
2-1025-24	T	<->	S	2108	1.594	0.007	0.016
2-1025-25	X-224A	<->	T	2108	1.684	0.005	0.011
2-1025-26	U	<->	X-224A	2108	1.684	0	0
2-1025-27	V	<->	U	2108	1.594	0.006	0.013
2-1025-28	A	<->	V	2108	1.684	0	0
2-1025-3	C		D	166.1	0.133	0	0
2-1025-4	D		E	2443	1.951	0	0
2-1025-5	E		F	2443	1.848	0.008	0.019
2-1025-6	F		X-223A	2443	1.951	0	0
2-1025-7	X-223A		G	2443	1.951	0.003	0.007
2-1025-8	G		H	2443	1.848	0.006	0.013
2-1025-9	H		X-223B	2443	1.951	0.009	0.021

PIPELINE	FROM	TO	FLOW gpm	VEL ft/sec	dP psi a	Hl ft
2-1318-1	X-226	Red13	closed	0	0	0
2-1401-1	X-224A	Tee14A	0	0	0	0
2-1401-2	Tee14A	Red14A	0	0	0	0
2-1401-3	Red14A	Suc14A	0	0	0	0
2-1402-1	X-224B	Tee14B	4500	6.183	(1.?07)	1.533
2-1402-2	Tee14B	Red14B	4500	6.183	0.026	0.061
2-1402-3	Red14B	Suc14B	4500	7.911	0.004	0.009
2-2302-1	X-225	Red23-1	closed	0	0	0
LA-1	X-204A	ZA	2274	2.753	(3.417)	0.168
--- strainer --- dP: 0.072 --- Hl: 0.166						
LA-2	ZA	A	2274	2.509	(0.396)	0.081
LB-1	X-204B	ZB	2277	2.757	(3.417)	0.168
--- strainer --- dP: 0.072 --- Hl: 0.167						
LB-2	ZB	D	2277	2.512	(0.396)	0.081
LC-1	X-204C	ZC	2475	2.996	(3.406)	0.193
--- strainer --- dP: 0.082 --- Hl: 0.191						
LC-2	ZC	K	2475	2.73	(0.390)	0.096
LD-1	X-204D	ZD	2474	2.995	(3.407)	0.193
--- strainer --- dP: 0.082 --- Hl: 0.191						
LD-2	ZD	P	2474	2.729	(0.390)	0.096
Pmp10A	Suc10A	Dis10A	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10B	Suc10B	Dis10B	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10C	Suc10C	Dis10C	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp10D	Suc10D	Dis10D	closed	0	0	0
--- RHR Pump --- dP: --- Hl:						
Pmp14A	Suc14A	Dis14A	closed	0	0	0
--- CS Pump --- dP: --- Hl:						
Pmp14B	Suc14B	Dis14B	closed	0	0	0
--- CS Pump --- dP: --- Hl:						

September 24, 1992

Ms. Sharon Eldridge
Commonwealth Edison Company
Rural Route # 1
Dresden Nuclear Power Station
Morris, IL 60450

Subject: Dresden Units 2 & 3 - Post LOCA Pool Drawdown

References: 1) Telecopy, J.C. Elliott to S. Mintz, "Small Job Authorization," September 21, 1992. (Small Job Task Number DR127)

Dear Ms. Eldridge:

In response to your request and per Reference 1, this letter provides an estimate of the maximum reduction in the Dresden suppression pool level following a loss-of-coolant accident (LOCA). The maximum suppression pool level decrease during a LOCA for Dresden is estimated to be 2.1 feet. This pool level decrease is the same as the value estimated for Quad Cities previously. A comparison of the key parameters between Quad Cities and Dresden confirmed that these plants are essentially identical and therefore allows application of the Quad Cities pool level decrease estimate to Dresden. This pool level decrease can be used together with the lower Technical Specification limit on pool level to determine the minimum post-LOCA pool level.

This estimate of 2.1 feet pool level reduction post-LOCA is based on a conservative analysis of another BWR with a 251 inch ID reactor pressure vessel and a Mark I containment. This analysis considered the water which may be transferred to the reactor pressure vessel, drywell and drywell-to-wetwell vent system from the suppression pool during a LOCA. A more detailed calculation could be performed with the Dresden specific geometry, but it is not expected that the results would change significantly.

Documentation and evidence of verification of this letter is included in the GE design record file, DRF-T23-00692.

Sincerely,

S. Mintz

cc: GE
J. E. Torbeck
C. T. Young
J. E. Nash

GE NUCLEAR ENERGY
San Jose, CA

PLANT PERFORMANCE ANALYSIS PROJECTS

January 25, 1993

To: T. L. Chapman

From: S. Mintz

Subject: Dresden LPCI/Containment Cooling System

Attachment 1 provides the responses to CECO questions requested by Sharon Eldridge (CECO) in connection to the Dresden LPCI/Containment Cooling System evaluation. Please provide these responses to Sharon Eldridge of CECO.

Documentation and evidence of verification is contained in DRF-T23-685.

S. Mintz

S. Mintz

cc J. S. Torbeck
J. E. Nash
C. T. Young
DRF-T23-685

Calc. No. QDC-1000-M-0535 Rev. 1 ATTACHMENT 1 Attachment C

RESPONSE TO CECO QUESTIONS

DRESDEN LPCI/CONTAINMENT COOLING SYSTEM EVALUATION

Question 1:

What is the impact on the peak suppression pool temperature calculated for Case 4a of GENE-770-26-1092 of assuming Containment Cooling Service Water (CCSW) initiation at 1800 seconds for containment cooling instead of the time of 600 seconds used for the GENE-770-26-1092 analysis?

Response to Question 1:

It is estimated that the peak suppression pool temperature for Case 4a of GENE -770-26-1092 will increase by no more than 2°F to no more than 188°F. This temperature increase was estimated by determining the energy removed by the LPCI/Containment Cooling System heat exchanger between 600 and 1800 seconds for Case 4a. This energy was then added to the suppression pool at the time of the peak suppression pool temperature to determine the increase in the peak suppression pool temperature.

It should be noted that this temperature increase is conservative since it is more representative of the increase in the pool temperature at 1800 seconds (i.e., at the new initiation time for CCSW) than the increase in the peak pool temperature. Once CCSW is initiated this increase in the suppression pool temperature will be reduced due to the increased effectiveness of the heat exchanger with a higher suppression pool temperature.

Question 2:

What is the impact of initiation of CCSW at 1800 second (with estimated increase in the suppression pool temperature to 188°F) on the containment pressure at the time of the peak suppression pool temperature relative to the value given in Appendix B of Reference 1 for Case 4a?

Response to Question 2:

At the time of the peak suppression pool temperature the suppression chamber airspace temperature is very close to the water temperature of the containment sprays. A change in the peak suppression pool temperature of 2°F will produce a change in temperature of the spray water temperature of approximately 1°F. Therefore the suppression chamber airspace temperature will also increase by this amount. The change in the suppression chamber vapor pressure for this change in airspace temperature is approximately 0.1 psi. This is therefore the estimated increase in the suppression chamber airspace pressure due to an increase in the suppression pool temperature of 2°F to 188°F.

It should be noted that this estimate conservatively neglects (with respect to minimizing the containment pressure) the effects of the increase in the drywell temperature and drywell vapor pressure with an increase in the suppression pool temperature. An increase in the drywell pressure would result in an additional increase in the suppression chamber airspace pressure due to the flow through the suppression chamber-to-drywell vacuum breakers.

Question 3:

What is the maximum drawdown expected for a LOCA for Dresden?

Response to Question 3:

Reference 2 reported a maximum drawdown of 2.1 feet for Dresden. This was based on a conservative application of pool drawdown analyses conducted for a range of break sizes for another plant with a 251 inch ID reactor pressure vessel and a Mark I containment. However this maximum drawdown (which occurs only for breaks smaller than the DBA-LOCA) would only occur early in the LOCA (< 1000 seconds) when suppression pool temperatures are significantly cooler than the maximum pool temperature. During the times of peak suppression pool temperatures when NPSH is of greatest concern a maximum drawdown of 1 foot is expected.

Question 4:

What is the impact of using May-Witt or ANS 5.1 + 2σ on the peak suppression pool temperature determined for Case 4a of GENE-770-26-1020?

Response to Question 4:

The impact of using May-Witt on the peak suppression pool temperature is estimated based on a comparison of the decay heat near the time of the peak suppression pool temperature. The basis for using this comparison is that at the time of the peak suppression pool temperature the heat rejection rate to the suppression pool from the reactor pressure vessel (RPV) is equal to the rate of containment cooling which is itself established by the suppression pool temperature. The peak suppression pool temperature for Case 4a occurs at approximately 30000 seconds. The value of the May-Witt decay heat is approximately 15% higher than the ANS 5.1 value at this time. This would produce an increase of approximately 14°F in the peak suppression pool temperature. The decay heat for ANS 5.1 + 2σ is less than the May-Witt decay heat therefore the increase with ANS 5.1 + 2σ will be bounded by the 14°F increase estimated for the May-Witt decay heat.

References:

1) GE Report GENE-770-26-1092, "Dresden Nuclear Power Station, Units 2 and 3, LPCI/Containment Cooling System Evaluation," November 1982.

2) Letter, S. Mintz to S. Eldridge, "Dresden Units 2 & 3, - Post LOCA Drawdown," September 24, 1992.

RHR/CS Pump Pressure Requirements - Design Basis Case											
						Old Design Basis			New Design Basis		
Sec	P	T	Pv	V	Hvap	Hsuc	NPSHR	Req. OP	Hsuc	NPSHR	Req. OP
643	6.5	150.8	3.796	0.016347	8.94	7.62	30.0	-1.40	7.15	30.0	-1.20
1627	3.4	157.6	4.480	0.016382	10.57	7.62	30.0	-0.73	7.15	30.0	-0.53
3434	3.4	164.8	5.439	0.016421	12.86	7.62	30.0	0.20	7.15	30.0	0.40
5412	3.4	170.1	6.010	0.016451	14.24	7.62	30.0	0.76	7.15	30.0	0.96
8756	3.7	175.1	6.735	0.016480	15.98	7.62	30.0	1.47	7.15	30.0	1.66
12290	4.1	178.8	7.318	0.016502	17.39	7.62	30.0	2.04	7.15	30.0	2.23
16434	4.2	180.9	7.666	0.016514	18.23	7.62	30.0	2.38	7.15	30.0	2.57
20372	4.3	181.8	7.820	0.016520	18.60	7.62	30.0	2.53	7.15	30.0	2.73
24372	4.3	182.0	7.854	0.016521	18.68	7.62	30.0	2.56	7.15	30.0	2.76
30424	4.3	181.6	7.786	0.016519	18.52	7.62	30.0	2.49	7.15	30.0	2.69
40266	4.1	179.6	7.449	0.016507	17.71	7.62	30.0	2.16	7.15	30.0	2.36

Old Strainer Design Basis vs. New Design Basis (NRC Bulletin 96-03)