Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus Temp (F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft3/lb)	Vapor Pressure (psia)	Suction Piping Losses (ft)	NPSHA (ft)	NPSHR (ft)	Margin (ft)
3	10000	5000	168	18.7	13.32	0.01644	5.7223	4.72	39.32	30.00	9.32
3A	8916	4458	171	19.1	13.32	0.016457	6.1318	3.75	40.30	26.90	13.40
4	5000	5000	180	19.9	13.32	0.01651	7.511	3.77	39.00	30.00	9.00
4A	3881	3881	186	20.6	13.32	0.016547	8.568	2.27	39.72	25.70	14.02

TABLE 1

COMMONWEALTH EDISON COMPANY

TITLE PAGE

CALCULATION NO. NED-M-MSD-43	PAGE 1 OF 7
☒ SAFETY RELATED	☐ NON-SAFETY RELATED

CALCULATION TITLE

Dresden LPCI Pumps NPSHA Evaluation

Post DBA-LOCA

EQUIP NUMBER(S)	STATION/UNIT	SYSTEM
2(3)-1502 A/B/C/D	Dresden 2 & 3	LPCI

REV.	CHRON #	PREPARER	DATE	REVIEWER	DATE	APPROVER	DATE
0		[signature]	11/30/92	[signature]	11/30/92	[signature]	11/30/92

GE-6.1.D
EXHIBIT B
REV. 2

Calculation No. NED-M-MSD-43
Dresden LPCI Pumps NPSHA Evaluation - Post DBA-LOCA

Purpose/Objective:

Calculate the Net Positive Suction Head Available (NPSHA) for the LPCI pumps at Dresden Station under post-accident conditions as outlined in Reference 2, and compare with NPSH required (NPSHR) to ensure pump protection.

Assumptions/Inputs:

The NPSHA is calculated for each of the four cases analyzed by General Electric in Reference 2. Inputs to this calculation were taken from Tables 3, 4 and B.2 of Reference 2 and are summarized in Table 1 below:

Case	LPCI Pumps /Loop	Total Flow (gpm)	Maximum Suppression Pool Temp(F)	Reduced Suppression Chamber Pressure(psia)
3	2	10000	168	18.7
3A	2	8916	171	19.1
4	1	5000	180	19.9
4A	1	3881	186	20.6

Table 1

These calculations include the following assumptions:

1) An even split of flow is assumed between two pumps operating in parallel.

2) Suction piping losses based on calculations in References 1 and 5.

3) NPSHR values taken from Reference 1 (Table 2 - no temperature correction). For cases 3A and 4A, NPSHR values were obtained through linear interpolation.

References:

1) R. Kolflat letter report titled "Alternate Shutdown Cooling Core Spray and LPCI pumps", Chron #841425 dated April 23, 1984

2) General Electric Report No. GENE-770-26-1092 "Dresden Nuclear Power Station Units 2 & 3 LPCI/Containment Cooling System Evaluation," November, 1992

3) S. Eldridge letter to C. Schroeder titled "Submergence of LPCI Discharge Line Post LOCA Dresden Units 2 and 3" dated September 29, 1992, chron# 0115532

4) ASME Steam Tables, 1967

5) Alternate Shutdown Cooling Core Spray and LPCI pump notes and back-up calculations for Reference 1, R. Kolflat, circa 4/89

Equations:

Net Positive Suction Head Available (NPSHA) is determined using the following equation (Reference 1):

NPSHA (ft)	=	Torus Pressure	+	Static Head	-	Vapor Pressure	-	Suction Losses	(1)

where: **Torus Pressure** = given in Table 1 (psia); converted to feet using specific volume

Static Head = the minimum water elevation expected above the LPCI pump suction as calculated below:

Minimum Torus water level elevation (including maximum post-LOCA draw down as discussed in Reference 3)	491.5'
LPCI pump suction elevation	- 478.13'
Static Head	13.32'

Vapor Pressure = from Reference 4, in psia; converted to feet using specific volume

Suction Losses = piping losses in feet
= $K * Q^2$, K calculated at Q = 5000 gpm using suction losses from References 1 and 5. (Tables 2 and 3)

LPCI NPSHA Calculations:

Using Equation 1 and the inputs provided above, the NPSHA is calculated for each of the four cases (Table 4). The required NPSH is also provided and the difference between the two is calculated.

Summary/Conclusions:

Post DBA-LOCA torus conditions were determined in Reference 2 and were used to calculate the available NPSH for the LPCI pumps at Dresden Station. The results in Table 4 indicate that the available NPSH is greater than the NPSH required (with margin) for all four cases, and therefore adequate to protect the pump under these conditions.

FLOW DEPENDENT TERM - f(Q)

SCALE Q

Q	NPSHR*	h_L	NPSHR - h_L - 0.87
3500	25	1.89	26.02
3800	25.5	2.21	26.84
4000	26.	2.44	27.57
4300	26.5	2.81	28.44
4500	27.0	3.07	29.2
4600	27.6	3.21	29.94
4700	28.2	3.35	30.68
4800	28.8	3.49	31.42
4900	29.4	3.63	32.16
5000	30.0	3.77	32.9
5100	31.0	3.92	34.05
5200	32	4.07	35.2
5300	33	4.23	36.36
5400	34	4.39	37.52
5500	35	4.55	38.68
5600	36.1	4.71	39.94
5700	37.2	4.87	41.2
5800	38.4	5.04	42.57
5900	39.5	5.21	43.84
6000	40.6	5.39	45.12

* AT 95° - NO TEMPERATURE CORRECTION

TABLE 2

(REFERENCE 1)

Q	NPSHR*	h_L	NPSHR − h_L − 0.87	DIFF	h_L (2 PUMP)	NPSHR − h_L − .87 (2 PUMP)	[illegible] (2 PUMP)
3500	25	1.89	26.02	0	2.36	26.49	
3800	25.5	2.21	26.84	0.82	2.77	27.4	.91
4000	26.	2.44	27.57	1.55	3.06	28.19	1.7
4300	26.5	2.81	28.44	2.42	3.52	29.15	2.66
4500	27.0	3.07	29.2	3.18	3.85	29.98	3.49
4600	27.6	3.21	29.94	3.92	4.02	30.75	4.26
4700	28.2	3.35	30.68	4.66	4.19	31.52	5.03
4800	28.8	3.49	31.42	5.4	4.36	32.29	5.8
4900	29.4	3.63	32.16	6.14	4.54	33.07	6.58
5000	30.0	3.77	32.9	6.88	4.72	33.85	7.36
5100	31.0	3.92	34.05	8.03	4.91	35.04	8.55
5200	32	4.07	35.2	9.18	5.10	36.23	9.74
5300	33	4.23	36.36	10.34	5.29	37.42	10.93
5400	34	4.39	37.52	11.5	5.49	38.62	12.13
5500	35	4.56	38.68	12.66	5.69	39.82	13.33
5600	36.1	4.71	39.94	13.92	5.89	41.12	14.63
5700	37.2	4.87	41.2	15.18	6.10	42.43	15.94
5800	38.4	5.04	42.57	16.55	6.31	43.84	17.35
5900	39.5	5.21	43.84	17.82	6.52	45.15	18.66
6000	40.6	5.39	45.12	19.1	6.74	46.47	19.96

* AT 85°F - NO CORRECTION FOR TEMPERATURE

TABLE 3
(REFERENCE 5)

Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus Temp (F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft3/lb)	Vapor Pressure (psia)	Suction Piping Losses (ft)	NPSHA (ft)	NPSHR (ft)	Margin (ft)
3	10000	5000	168	18.7	13.32	0.01644	5.7223	4.72	39.32	30.00	9.32
3A	8916	4458	171	19.1	13.32	0.016457	6.1318	3.75	40.30	26.90	13.40
4	5000	5000	180	19.9	13.32	0.01651	7.511	3.77	39.00	30.00	9.00
4A	3881	3881	186	20.6	13.32	0.016547	8.568	2.27	39.72	25.70	14.02

Table 4

COMMONWEALTH EDISON COMPANY

REVIEW CHECKLIST

CALCULATION NO: NED-M-MSD-43	REV. 0	PAGE 7 OF 7
REVIEWED BY: Rolf S. Kolflat		DATE: 11/30/92

YES	NO		REMARKS
☒	☐	1. IS THE OBJECTIVE OF THE ANALYSIS CLEARLY STATED?	
☒	☐	2. ARE ASSUMPTIONS AND ENGINEERING JUDGEMENTS VALID AND DOCUMENTED?	
☐	☒	3. ARE THERE ASSUMPTIONS THAT NEED VERIFICATION?	
☒	☐	4. ARE THE REFERENCES (I.E. DRAWINGS, CODES, STANDARDS) LISTED BY REVISION EDITION, DATE, ETC.?	
☒	☐	5. IS THE DESIGN METHOD CORRECT AND APPROPRIATE FOR THIS ANALYSIS?	
☒	☐	6. IS THE CALCULATION IN COMPLIANCE WITH DESIGN CRITERIA, CODES, STANDARDS, AND REG. GUIDES?	
☒	☐	7. ARE THE UNITS CLEARLY IDENTIFIED, AND EQUATIONS PROPERLY DERIVED AND APPLIED?	
☒	☐	8. ARE THE DESIGN INPUTS AND THEIR SOURCES IDENTIFIED AND IN COMPLIANCE WITH UFSAR & TECH SPECS?	
☒	☐	9. ARE THE RESULTS COMPATIBLE WITH THE INPUTS AND RECOMMENDATIONS MADE?	

Computer software (spreadsheet) used for simple operations (addition, multiplication, etc). checked/verified by hand calcs

10. INDICATE TYPE OF CALCULATION (HAND-PREPARED AND/OR COMPUTER-AIDED) AND METHOD OF REVIEW:

☒ HAND PREPARED DESIGN CALCULATION

THE REVIEW OF THE HAND-PREPARED DESIGN CALCULATION WAS ACCOMPLISHED BY ONE OR A COMBINATION OF THE FOLLOWING (AS CHECKED):

- ☒ A DETAILED REVIEW OF THE ORIGINAL CALCULATION
- ☐ A REVIEW BY AN ALTERNATE, SIMPLIFIED OR APPROXIMATE METHOD OF CALCULATION
- ☐ A REVIEW OF A REPRESENTATIVE SAMPLE OF REPETITIVE CALCULATIONS
- ☒ A REVIEW OF THE CALCULATION AGAINST A SIMILAR CALCULATION PREVIOUSLY PERFORMED

☐ COMPUTER AIDED DESIGN CALCULATION

YES	NO	
☐	☐	11. IS THE PROGRAM APPLICABLE TO THIS PROBLEM?
☐	☐	12. IS THE COMPUTER PROGRAM VALIDATED PER QP 3-54?
☐	☐	13. IS THE COMPUTER PROGRAM VALIDATED BY OTHER AE'S / ORGANIZATIONS AND HAS IT BEEN PREVIOUSLY APPLIED TO NUCLEAR PROJECTS?
☐	☐	14. IS THE INPUT DATA IN CONFORMANCE WITH THE DESIGN INPUTS?
☐	☐	15. ARE THE RESULTS CONSISTENT WITH THE ASSUMPTIONS AND THE INPUT DATA?
☐	☐	16. IS A LIST OF THE PROGRAMS USED AND DATE OF EACH COMPUTER RUN REFERENCED IN THE CALCULATION?
☐	☐	17. IS THE PROGRAM VERSION AND IT'S REVISION IDENTIFIED ON THE COMPUTER RUN?

COMMONWEALTH EDISON COMPANY

TITLE PAGE

CALCULATION NO. NED-M-MSD-43	PAGE 1 OF 13
X SAFETY RELATED	___ NON-SAFETY RELATED

CALCULATION TITLE

Dresden LPCI/Core Spray Pumps NPSHA Evaluation

Post DBA-LOCA

EQUIP NUMBER(S)	STATION/UNIT	SYSTEM
2(3) - 1502A/B/C/D 2(3) - 1401A/B	Dresden 2 & 3	LPCI/Core Spray

REV.	CHRON #	PREPARER	DATE	REVIEWER	DATE	APPROVER	DATE
0	194745	H. Palas	11/30/92	R. Kolflat	11/30/92	P. Dietz	11/30/92
1	198391	[signature]	2/11/93	[signature]	2/11/93	Paul E Dietz	2/11/93

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1	TITLE PAGE	1
2	TABLE OF CONTENTS	2
3	REVISION SUMMARY	3
4	CALCULATION SHEET(S)	4-12
5	REVIEW CHECKLIST	13
	<u>Attachments</u>	
	APPENDIX A	A.1-A.3
	APPENDIX B	B.1

COMMONWEALTH EDISON COMPANY

REVISION SUMMARY

CALCULATION NO: **NED-M-MSD-43**	REV 1	PAGE 3 OF 13

DESCRIPTION OF REVISIONS/REASON FOR CHANGE

Calculation revised to eliminate non-QA references and inputs and to incorporate the calculation of these inputs into this document. In addition, Core Spray added to scope and a sensitivity analysis on NPSH is included.

AFFECTED PAGES

PAGES	REV.	DESCRIPTION
1	1	Changed Title and Equipment Nos./System to include Core Spray
2	1	Added Table of Contents
4	1	Changed Purpose/Objective to include Core Spray
4,5	1	Added assumptions regarding hydraulic loss calculations and addition of Core Spray pps to scope
5	1	Removed two R. Kolflat references; added references for hydraulic loss calculations and Core Spray
6	1	Added equation for hydraulic loss calculations
7-9	1	Added calculations for hydraulic losses
9	1	Included discussion of NPSHR reduction due to increased temperature
10	1	Added sensitivity analysis to NPSHA calculations
10	1	Added Core Spray to Summary/Conclusions
11	1	Added Table 2 - NPSHR values Updated Table 3 for new suction loss values
12	1	Added Figure 1 - NPSHR reduction vs. temperature
A.1-A.3	1	New NPSH sensitivity analysis
B.1	1	New calculation of resistance coefficient for a 24 x 14 reducer

Calculation No. NED-M-MSD-43 Rev 1
Dresden LPCI/Core Spray Pumps NPSHA Evaluation - Post DBA-LOCA

Purpose/Objective:

Calculate the Net Positive Suction Head Available (NPSHA) for the LPCI and Core Spray pumps at Dresden Station under post-accident conditions as outlined in Reference 2, and compare with NPSH required (NPSHR) to ensure pump protection.

Assumptions/Inputs:

The NPSHA is calculated for each of the four cases analyzed by General Electric in Reference 2. Inputs to this calculation for the LPCI pumps were taken from Tables 3, 4 and B.2 of Reference 2 and are summarized in Table 1 below:

Case	LPCI Pumps /Loop	Total Flow (gpm)	Maximum Suppression Pool Temp(F)	Reduced Torus Pressure(psia)
3	2	10000	168	18.7
3A	2	8916	171	19.1
4	1	[illegible]000	180	19.9
4A	1	[illegible]881	186	20.6

Table 1

In addition to the assumptions made in Reference 2, the following assumptions are also made in this calculation:

1) An even split of flow is assumed between two pumps operating in parallel; frictional losses to each pump assumed similar.

2) Suction piping losses determined at 90 deg F, 5000 gpm (one pump) and 10000 gpm (two pumps). Assumed lower temperature than Table 1 for higher kinematic viscosity and conservatively higher suction losses.

3) Strainer losses assumed to be 0.8 ft @ 5000 gpm and entrance losses assumed 0.6 ft @ 5000 gpm, 1.8 ft @ 10000 gpm (Used Reference 11 as basis; extrapolated values provided for 5750 and 11620 gpm to 5000 and 10000 gpm respectively using quadratic relationship between flow and friction losses).

4) NPSHR values (Table 2) are developed based on the NPSHR curves for the LPCI and Core Spray pumps (References 5 and 6). NPSHR not reduced for higher temperatures.

5) Minimum torus level (including maximum drawdown) assumed as provided in Reference 3.

6) Assumed roughness factor, e, for clean commercial steel pipe (e = 0.00015).

7) Assumed turbulent flow through fittings.

8) Core Spray and LPCI pump suction losses similar. Also, Unit 3 LPCI/Core Spray suction losses assumed similar.

9) Core Spray case bounded by LPCI case due to similar suction losses, similar NPSHR curves, and identical pump centerline elevations; also, Core Spray runs at a lower flow than LPCI, therefore operating at a lower NPSHR condition than LPCI.

10) Assumed all gate valves to be fully open.

References:

1) "Flow of Fluids Through Valves, Fittings, and Pipe", Crane Technical Paper No. 410, 24th Printing, 1988

2) General Electric Report No. GENE-770-26-1092 "Dresden Nuclear Power Station Units 2 & 3 LPCI/Containment Cooling System Evaluation," November, 1992

3) S. Eldridge letter to C. Schroeder titled "Submergence of LPCI Discharge Line Post LOCA Dresden Units 2 and 3" dated September 29, 1992, chron# 0115532

4) ASME Steam Tables, 1967

5) Bingham Pump Curve No. 25355 for 12x14x14.5 CVDS, Dresden Station LPCI Pump

6) Bingham Pump Curve No. 25231 for 12x16x14.5 CVDS, Dresden Station Core Spray Pump

7) Sargent & Lundy drawing M-547, LPCI pump suction

8) Sargent & Lundy drawing M-549, Core Spray pump suction

9) "Cameron Hydraulic Data," Ingersoll-Rand Co., 16th Edition, 2nd Printing, 1984

10) "Dresden LPCI/Containment Cooling System," GE Nuclear Energy letter from S. Mintz to T. L. Chapman dated January 27, 1993

11) "Dresden Station Units 2 and 3, Quad-Cities Station Units 1 and 2, NRC Docket Nos. 50-237, 50-249, 50-254, and 50-265," letter from G. J. Pliml to D. L. Ziemann dated September 27, 1976

12) "Centrifugal Pump Clinic," Karassik, Igor J., second edition, Marcel Dekker, Inc., New York, 1989

Equations:

Suction Losses

Straight piping and fitting losses are determined using the following equation (Reference 1, page 3-4):

$$hL = \frac{0.00259 * K * Q^2}{d^4} \qquad (1)$$

where: hL = frictional losses (ft)

K = resistance coefficient

Q = flow (gpm)

d = inner diameter of pipe (in)

The resistance coefficient, K, is the sum of the resistance coefficient for the fittings, Kf, and the resistance coefficient for the straight pipe, Kp. Kf can be obtained directly from applicable tables (Reference 9). For straight pipe, Kp is defined as:

$$Kp = f \frac{L}{D} \qquad (2)$$

where: f = friction factor

L = length of pipe (ft)

D = inner diameter of pipe (ft)

The friction factor, f, is dependent upon the pipe diameter, Reynold's number, and pipe roughness, and can be determined using the Moody diagram (Reference 1). Reynold's number, Re, is determined using the following equation (Reference 1, page 3-2):

$$Re = \frac{50.6 * Q * \rho}{d * \mu} \qquad (3)$$

where: ρ = density, lb/ft^3

μ = dynamic viscosity (centipoise)

Net Positive Suction Head

Net Positive Suction Head Available (NPSHA) is determined using the following equation:

$$NPSHA = 144 * \frac{(Pt - Pv)}{\rho} + Z - hL \quad (4)$$

where: Pt = Torus Pressure given in Table 1 (psia)

Pv = Vapor Pressure from Reference 4 (psia)

Z = Static Head, the minimum water elevation expected above the LPCI/Core Spray pump suction as calculated below:

Minimum Torus water level elevation (including maximum post-LOCA draw down as discussed in Reference 3)	491.42'
LPCI/CS pump suction elevation	- 478.13'
Static Head	13.29'

hL = suction losses in feet

Calculations:

Suction Losses - One Pump

The suction piping for LPCI pump 2A is shown in Reference 7 and is made up of the following components:

Line	Component	No.	Kf[a]	L/D	Loss(ft)
2-1502-24"	Entrance loss	-	----		0.6
	90 deg elbow (LR)[b]	1	0.19		
ID= 23.25"	45 deg elbow	1	0.19		
	gate valve	1	0.10		
	reducing tee (thru)	1	0.24		
	16' straight pipe[d]	-		8.26	
	Total		0.72	8.26	0.6
2-1502A-14"	reducer, 24x14	1	0.07[c]		
	90 deg elbow	2	0.78		
ID= 13.25"	45 deg elbow	1	0.21		
	gate valve	1	0.10		
	strainer	1	----		0.8
	4' straight pipe[d]	-		3.62	
	Total		1.16	3.62	0.8

[a] from Reference 9
[b] from Reference 11
[c] see Appendix B
[d] Total straight pipe length determined as the sum of all straight pipe lengths minus the length of all fittings

The Reynold's number for each piping run is determined using Equation 3 (@ 90 deg F):

$$Re_{24} = \frac{50.6 * (5000) * (62.116)}{(23.25) * (0.75)} = 9.0 \times 10^5$$

$$Re_{14} = \frac{50.6 * (5000) * (62.116)}{(13.25) * (0.75)} = 1.6 \times 10^6$$

The friction factor for each piping run can then be determined using the Moody diagram for clean commercial steel pipe (Reference 1: A-25):

$$f_{24} = 0.0132$$

$$f_{14} = 0.0134$$

The resistance coefficient, K, is now be determined for each piping run utilizing Equation 2 for the straight pipe portion:

$$\begin{aligned} K_{24} &= Kf + Kp \\ &= 0.72 + (0.0132)*(8.26) \\ &= 0.83 \end{aligned}$$

$$\begin{aligned} K_{14} &= 1.16 + (0.0134)*(3.62) \\ &= 1.21 \end{aligned}$$

Using Equation 1, the friction loss for each piping run and total suction friction losses can be determined as follows:

$$\begin{aligned} hL_{24} &= 0.6' + \frac{0.00259 \times 0.83 \times (5000)^2}{(23.25)^4} \\ &= 0.78 \text{ feet} \end{aligned}$$

$$\begin{aligned} hL_{14} &= 0.8' + \frac{0.00259 \times 1.21 \times (5000)^2}{(13.25)^4} \\ &= 3.34 \text{ feet} \end{aligned}$$

$$\begin{aligned} hL_{tot} &= 0.78 + 3.34 \\ &= \mathbf{4.12 \text{ feet}} \text{ @ 5000 gpm} \end{aligned}$$

To determine frictional losses at any flow, the quadratic relationship between hL and Q establishes the following:

$$hL2 = hL1 \times (Q2/Q1)^2 \qquad (5)$$

Suction Losses - Two Pumps

For two pump operation, most of the 24" line (assume all) sees full flow (10000 gpm), while each of the 14" lines that branch off of it see one-half full flow (5000 gpm). Since the 14" line was previously analyzed at 5000 gpm, only the 24" line at 10000 gpm needs to be analyzed.

The Reynold's number and friction factor for the 24" line at 10000 gpm are:

$$Re_{24} = \frac{50.6 \times 10000 \times 62.116}{23.25 \times 0.75} = 1.8 \times 10^6$$

$$f_{24} = 0.0125$$

The resistance coefficient and frictional losses for the 24" pipe at 10000 gpm are then calculated as:

$$\begin{aligned} K_{24} &= Kf + Kp \\ &= 0.72 + (0.0125)*(8.26) \\ &= 0.82 \end{aligned}$$

$$\begin{aligned} hL_{24} &= 1.8' + \frac{0.00259 \times 0.82 \times (10000)^2}{(23.25)^4} \\ &= 2.53 \text{ feet} \end{aligned}$$

The suction friction losses for each pump with two pumps running is:

$$\begin{aligned} hL_{tot} &= 2.53 + 3.34 \\ &= \mathbf{5.87\ feet} \text{ @ 10000 gpm total flow} \end{aligned}$$

NPSHA Calculations:

Using Equation 4 and the inputs provided in Table 1 and Equation 5, the NPSHA is calculated for each of the four cases (Table 3). The required NPSH is also provided and the difference between the two is calculated. The NPSHR provided is for cold water and is not adjusted for the increased temperatures expected in the torus. This adjustment would have taken the form of a NPSHR reduction and resulted in a greater margin for NPSHA over NPSHR. From Figure 1 (Ref. 12), the reduction at 170 deg F (Cases 3 and 3A) would be about 0.3 feet, and at 180 deg F (Cases 4 and 4A) would be about 0.4 feet.

The margin between available and required NPSH in Table 3 is given in feet. In order to better understand the significance of this margin, a sensitivity analysis was performed (Appendix A) based on each of the following:

A1) torus temperature increase (Cases 3 and 4)
A2) torus pressure decrease (Cases 3 and 4)
A3) CCSW initiation time increase (All cases)

In preparing this sensitivity analysis, the following conservative assumptions were made:

A1) As torus temperature increases, torus pressure remains constant.
A2) Torus temperature remains unchanged for lower torus pressures.
A3) Higher temperatures produced by delaying the initiation of CCSW will not be accompanied by higher pressures.

Summary/Conclusions:

Post DBA-LOCA torus conditions were determined in Reference 2 and were used to calculate the available NPSH for the LPCI and Core Spray pumps at Dresden Station. The results in Table 3 indicate that the available NPSH is greater than the required NPSH (with margin) for all four cases, and therefore adequate to protect the pumps under these conditions. While the calculations performed were for the LPCI 2A pump, the results bound the remaining LPCI pumps as well as the Core Spray pumps for both Units based on similar suction losses, required NPSH and pump elevations.

Flow (gpm)	NPSHR (ft)	Flow (gpm)	NPSHR (ft)
3500	25.0	5500	35.0
3800	25.5	5600	36.1
4000	26.0	5700	37.2
4500	27.0	5800	38.4
5000	30.0	5900	39.5
5300	33.0	6000	40.6

Table 2

Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus Temp (F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft3/lb)	Vapor Pressure (psia)	Suction Losses (ft)	NPSHA (ft)	NPSHR (ft)	Margin (ft)
3	10000	5000	168	18.7	13.29	0.01644	5.722	5.87	38.14	30.00	8.14
3A	8916	4458	171	19.1	13.29	0.016457	6.132	4.67	39.35	26.90	12.45
4	5000	5000	180	19.9	13.29	0.01651	7.511	4.12	38.62	30.00	8.62
4A	3881	3881	186	20.6	13.29	0.016547	8.568	2.48	39.48	25.70	13.78

Table 3

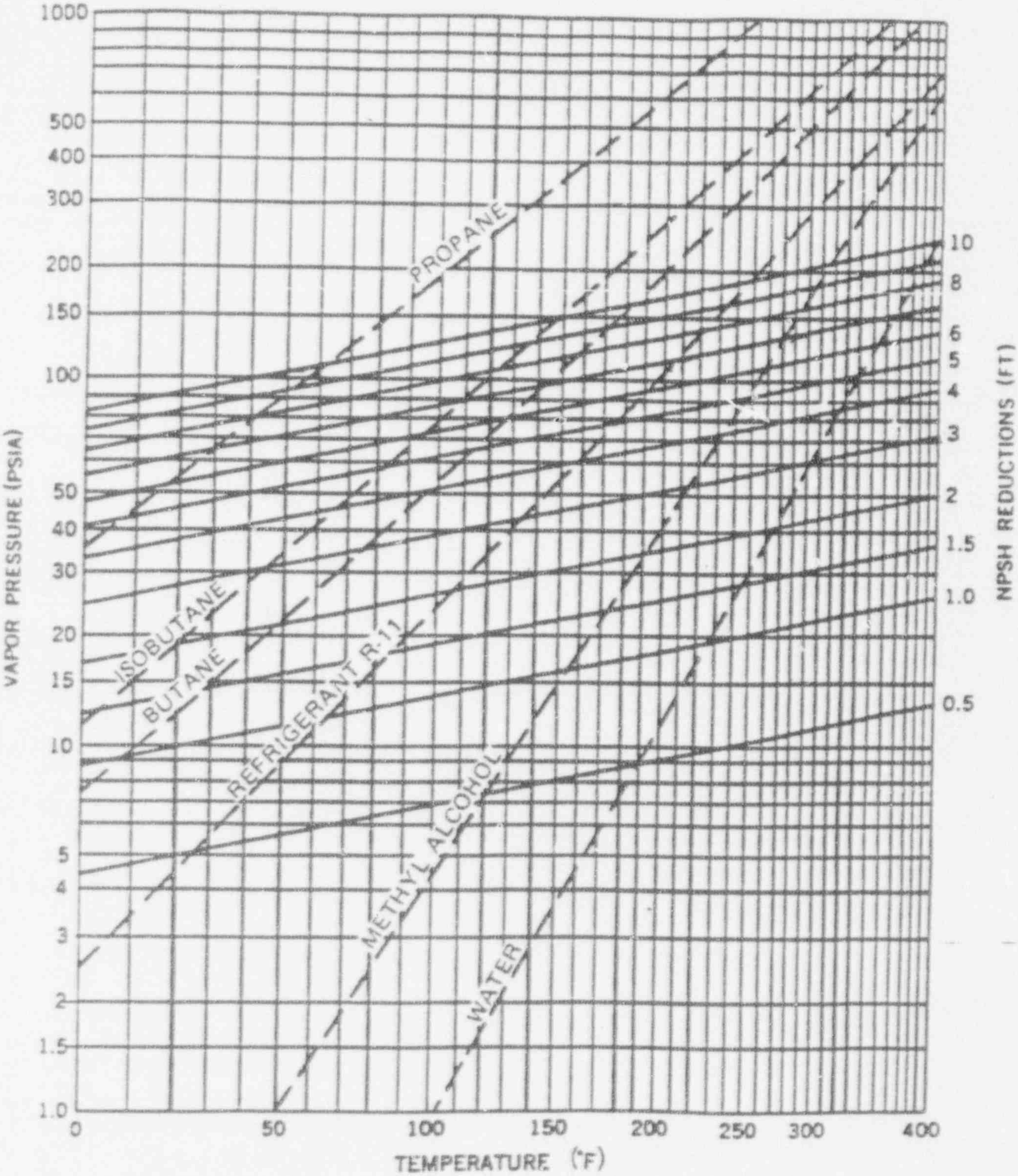

Figure 1.29 NPSH reductions for pumps handling hydrocarbon liquids and high-temperature water (Courtesy Hydraulic Institute Standards of 1975.)

FIGURE 1 (Ref. 11, p. 56)

COMMONWEALTH EDISON COMPANY

REVIEW CHECKLIST

CALCULATION NO: NED-M-MSD-43	REV. 1	PAGE 13 OF 13
REVIEWED BY: Dan K. Lee		DATE: 2/11/93

YES	NO		REMARKS
☑	☐	1. IS THE OBJECTIVE OF THE ANALYSIS CLEARLY STATED?	
☑	☐	2. ARE ASSUMPTIONS AND ENGINEERING JUDGEMENTS VALID AND DOCUMENTED?	
☐	☑	3. ARE THERE ASSUMPTIONS THAT NEED VERIFICATION?	
☑	☐	4. ARE THE REFERENCES (I.E. DRAWINGS, CODES, STANDARDS) LISTED BY REVISION EDITION, DATE, ETC.?	
☑	☐	5. IS THE DESIGN METHOD CORRECT AND APPROPRIATE FOR THIS ANALYSIS?	
☑	☐	6. IS THE CALCULATION IN COMPLIANCE WITH DESIGN CRITERIA, CODES, STANDARDS, AND REG. GUIDES?	
☑	☐	7. ARE THE UNITS CLEARLY IDENTIFIED, AND EQUATIONS PROPERLY DERIVED AND APPLIED?	
☑	☐	8. ARE THE DESIGN INPUTS AND THEIR SOURCES IDENTIFIED AND IN COMPLIANCE WITH UFSAR & TECH SPECS?	
☑	☐	9. ARE THE RESULTS COMPATIBLE WITH THE INPUTS AND RECOMMENDATIONS MADE?	

10. INDICATE TYPE OF CALCULATION (HAND-PREPARED AND/OR COMPUTER-AIDED) AND METHOD OF REVIEW:

☑ HAND PREPARED DESIGN CALCULATION

THE REVIEW OF THE HAND-PREPARED DESIGN CALCULATION WAS ACCOMPLISHED BY ONE OR A COMBINATION OF THE FOLLOWING (AS CHECKED):

- ☑ A DETAILED REVIEW OF THE ORIGINAL CALCULATION
- ☐ A REVIEW BY AN ALTERNATE, SIMPLIFIED OR APPROXIMATE METHOD OF CALCULATION
- ☐ A REVIEW OF A REPRESENTATIVE SAMPLE OF REPETITIVE CALCULATIONS
- ☑ A REVIEW OF THE CALCULATION AGAINST A SIMILAR CALCULATION PREVIOUSLY PERFORMED

☐ COMPUTER AIDED DESIGN CALCULATION

YES	NO		YES	NO	
☐	☐	11. IS THE PROGRAM APPLICABLE TO THIS PROBLEM?	☐	☐	15. ARE THE RESULTS CONSISTENT WITH THE ASSUMPTIONS AND THE INPUT DATA?
☐	☐	12. IS THE COMPUTER PROGRAM VALIDATED PER QP 3-54?	☐	☐	16. IS A LIST OF THE PROGRAMS USED AND DATE OF EACH COMPUTER RUN REFERENCED IN THE CALCULATION?
☐	☐	13. IS THE COMPUTER PROGRAM VALIDATED BY OTHER AE'S / ORGANIZATIONS AND HAS IT BEEN PREVIOUSLY APPLIED TO NUCLEAR PROJECTS?	☐	☐	17. IS THE PROGRAM VERSION AND IT'S REVISION IDENTIFIED ON THE COMPUTER RUN?
☐	☐	14. IS THE INPUT DATA IN CONFORMANCE WITH THE DESIGN INPUTS?			

Appendix A

NPSH Margin CCSW Initiation Time Sensitivity
Increase from 600 to 1800 Seconds

Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus* Temp (F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft3/lb)	Vapor Pressure (psia)	Suction Losses (ft)	NPSHA (ft)	NPSHR (ft)	1800 s Margin (ft)	600 s Margin (ft)
3'	10000	5000	172	18.7	13.29	0.016463	6.274	5.87	36.88	30.00	6.88	8.14
3A'	8916	4458	174	19.1	13.29	0.016474	6.566	4.67	38.35	26.90	11.45	12.45
4'	5000	5000	182	19.9	13.29	0.016522	7.851	4.12	37.84	30.00	7.84	8.62
4A'	3881	3881	188	20.6	13.29	0.016559	8.947	2.48	38.60	25.70	12.90	13.78

Table A-1

* Increased Values of Torus Temperature from Reference 10

Appendix A

NPSH Margin Temperature Sensitivity

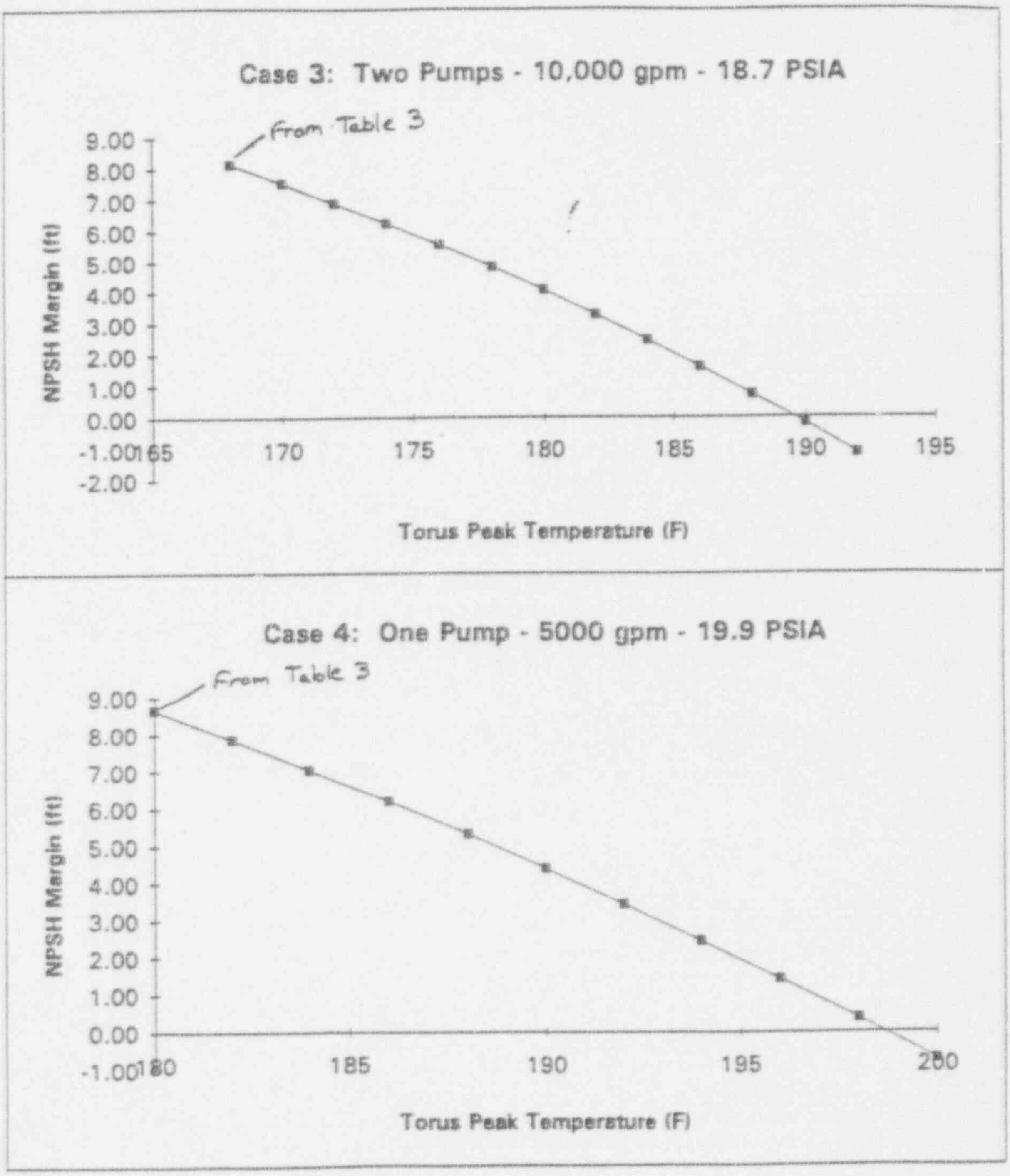

Figure A-1

Appendix A

NPSH Margin Pressure Sensitivity

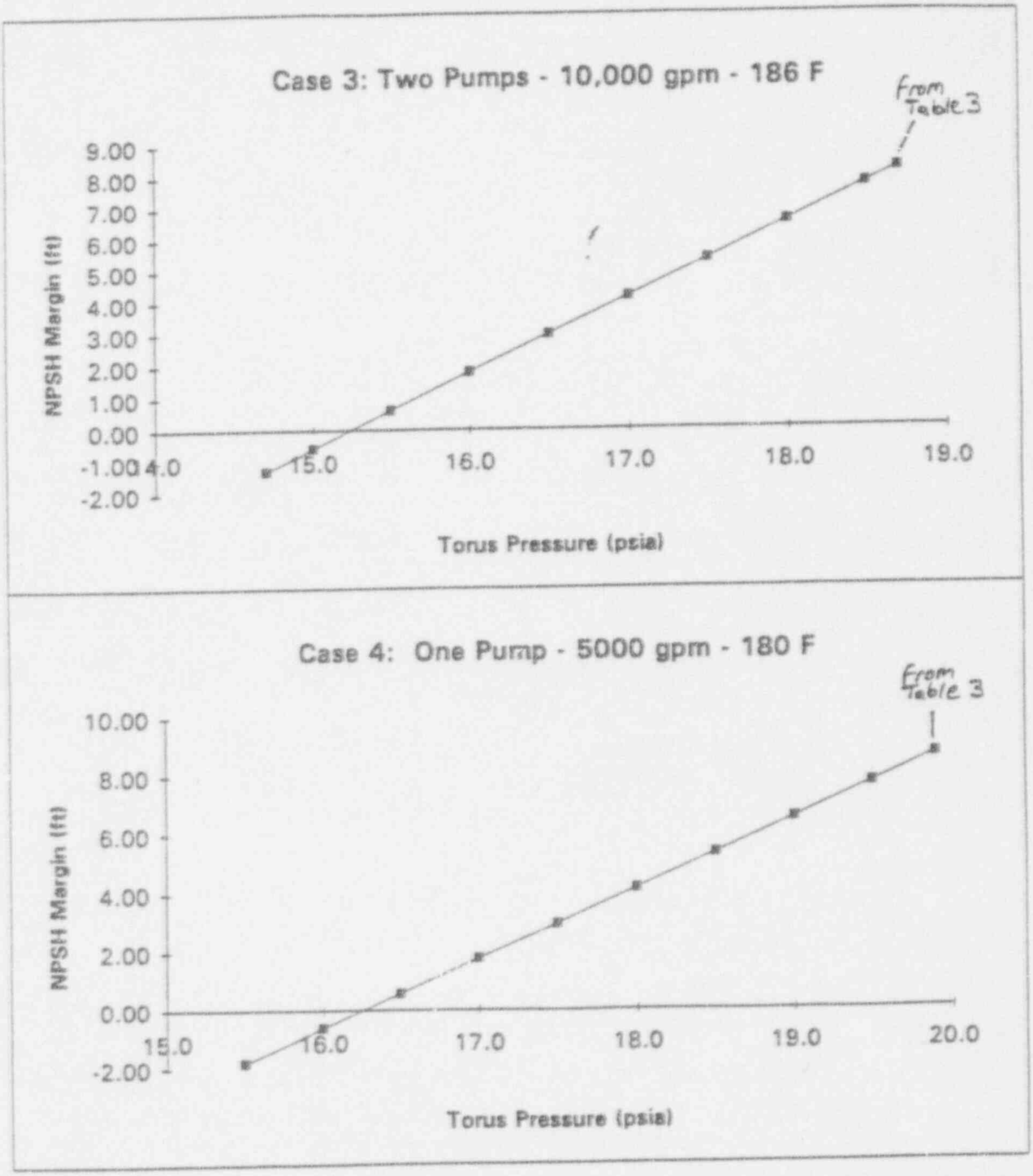

Figure A-2

APPENDIX B

Calculation of Resistance Coefficient of 24 x 14 Reducer

From Reference 1 (A-26), the equation for the resistance coefficient of a reducer is given by:

$$K = 0.8 \sin(a/2)\,(1 - b^2) \qquad \text{(B-1)}$$

where $a = 2 \tan^{-1}\left[\frac{(d2 - d1)}{2L}\right]$

$b = d1/d2$

$d1$ = small diameter of reducer (in)

$d2$ = large diameter of reducer (in)

L = length of reducer (in)

For a 24 x 14 reducer, the above parameters are defined as:

$d1 = 13.25$ in $\qquad L$ = assume $d1 + d2$

$d2 = 23.25$ in $\qquad = 36.5$ in

Therefore,

$b = 0.57$ and $a = 15.6$ deg

Substituting into Equation A-1, the resistance coefficient for the reducer is:

$$K = 0.07$$