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Units 2 and 3

LPCI/Containment Cooling System Evaluation

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IMPORTANT NOTICE REGARDING

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ABSTRACT

This report provides the results of an evaluation of the Dresden containment response during a design basis loss-of-coolant accident (DBA-LOCA) considering the current Dresden LPCI/Containment Cooling System parameters. The results of the Dresden containment pressure and temperature response analysis described in this report can be used to update the Dresden SAR and thus clarify the SAR assumption on the number of Containment Cooling Service Water (CCSW) pumps for the limiting containment cooling case in SAR Section 5.2.

This report also contains a review of a NFS Calculation RSA-D-92-01 which was provided to GE by CECO to determine the impact of the suppression pool temperature results documented in NFS Calculation RSA-D-92-01 on the temperature data used in evaluating the containment dynamic loads defined during the Mark I Long Term Program on torus attached piping.

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1.0 Introduction

Section 5.2 of the Dresden SAR documents long-term heatup analyses performed to evaluate the capability of the Dresden LPCI/Containment Cooling System to maintain peak containment pressures and temperatures within limits during the design basis loss-of-coolant accident (DBA-LOCA). The DBA-LOCA for the Dresden Plant is a double-ended guillotine break of a recirculation suction line. Four cases for different LPCI/Containment Cooling configurations are described in Section 5.2 of the SAR. Table 1 summarizes the LPCI/Containment Cooling parameters for these four cases in the SAR. It was recently determined that the measured Containment Cooling Service Water (CCSW) flow rate during two pump operation for a single LPCI/Containment Cooling System Loop is less than the value used in the SAR analysis. This would result in a decrease in the LPCI/Containment Cooling System heat exchanger performance and therefore result in higher peak suppression pool temperatures. To assess the impact of reduced heat exchanger performance, long-term analysis of the containment pressure and temperature after initiation of the LPCI/Containment Cooling System (600 seconds into the event) was performed. Since the SAR reports that 2 CCSW pumps per heat exchanger are assumed in the SAR analysis for all 4 cases, the limiting case for one loop with two CCSW pumps in operation was re-analyzed with the reduced CCSW flow rate. Both Case 1 and Case 3 have this configuration, and the SAR reports the same peak temperature (see SAR Figure 5.2.3:3) for both cases. Case 3, which assumes only 1 Core Spray pump is available, was chosen for the re-analysis. Case 4 of Section 5.2 of the SAR which produced the maximum temperature of the four SAR cases was also described as using 2 CCSW pumps. However, a review of the Dresden SAR and GE files indicated that the analysis used to produce the response for Case 4 in Section 5.2 of the SAR assumed only 1 CCSW pump. Therefore, Case 4 was reanalyzed for this report with the assumption that only 1 CCSW pump is available. The analyses which are documented in this report use the current values of the CCSW and LPCI/Containment Cooling flow rates through the heat exchanger and the current heat exchanger performance, which are described in References 1,2 & 3 (with and without flow rate reductions to account for uncertainties in the flow rates). The containment pressure and temperature response analysis described in this report was performed in accordance with Regulatory Guide 1.49 using current GE codes and models (References 4,5 & 6).

In addition to the evaluation of the Dresden LPCI/Containment Cooling System described above, Appendix A to this report contains a review of NFS Calc. RSA-D-92-01. The purpose of the review was to determine the impact of the results of NFS Calc. RSA-D-92-01 on the temperature data used in evaluating the containment dynamic loads defined for torus attached piping in Dresden during the Mark I Long Term Program (LTP).

Appendix B gives an estimate of the reduction to the containment pressure at the time of the peak suppression pool temperature, for initial conditions which minimize the containment pressure response. A request for this information was made by the Commonwealth Edison Company (CECO) in discussions with General Electric (GE) during the course of the program to evaluate the LPCI/Containment Cooling System.

Appendix C provides the mass and energy release data obtained from the Dresden containment analysis described in Section 2.0.

Results summary

The peak suppression pool temperature for SAR Case 3 (2 LPCI/Containment Cooling System pumps and 2 CCSW pumps) is 3°F higher than the SAR value of 165°F when the uncertainty in the LPCI/Containment Cooling System and CCSW flow rates is not accounted for and 6°F higher than the SAR value when the uncertainty in the flow rates is accounted for. The peak suppression pool temperature for SAR Case 4 (1 LPCI/Containment Cooling System pump and 1 CCSW pump) is equal to the SAR value of 180°F when the uncertainty in the flow rates is not accounted for and 6°F higher than the SAR value when the uncertainty in the flow rates is accounted for.

The review of NFS Calc. RSA-D-92-01 confirmed that the results of the NFS calculation do not impact the temperature data used to evaluate the Mark I containment loads specified for torus attached piping during the Mark I LTP.

2.0 Containment Pressure and Temperature Response

2.1 Model Description

A coupled reactor pressure vessel and containment model, based on the Reference 4 and Reference 5 models, was used to calculate the long-term (> 600 seconds) transient response of the containment during the DBA-LOCA. This model performs fluid mass and energy balances on the reactor primary system and the suppression pool, and calculates the reactor vessel water level, the reactor vessel pressure, the pressure and temperature in the drywell and suppression chamber airspace and the bulk suppression pool temperature. The various modes of operation of all important auxiliary systems, such as SRV's, the MSIV's, ECCS, the RHR system (LPCI/Containment Cooling system in the case of Dresden) and feedwater are modeled. The model can simulate actions based on system setpoints, automatic actions and operator-initiated actions.

2.2 Analysis Assumptions

The initial conditions and key input parameters used in the analysis are provided in Table 2. These are based on the current Dresden containment data which are documented in References 2 & 7. The following key input assumptions were used in performing the Dresden containment LOCA pressure and temperature response analysis:

1. The reactor is operating at 102% of the rated thermal power.

2. Vessel blowdown flowrates are based on the Homogeneous Equilibrium Model (Reference 6).

3. The core decay heat is based on ANSI/ANS-5.1-1979 decay heat (Reference 8).

4. Feedwater flow into the RPV continues until all the feedwater above 180°F is injected into the vessel.

5. Thermodynamic equilibrium exists between the liquids and gases in the drywell. Mechanistic heat and mass transfer between the suppression pool and the suppression chamber airspace is assumed.

6. The vent system flow to the suppression pool consists of a homogeneous mixture of the fluid in the drywell.

7. The initial suppression pool volume is at the minimum Technical Specification (T/S) limit to maximize the calculated suppression pool temperature.

8. The initial suppression pool temperature is at the maximum T/S value to maximize the calculated suppression pool temperature.

9. Consistent with the SAR, containment sprays are used to cool the containment.

10. Passive heat sinks in the drywell, suppression chamber airspace and suppression pool are conservatively neglected.

11. All Core Spray and LPCI/Containment Cooling System pumps have 100% of their horsepower rating converted to a pump heat input which is added either to the RPV liquid or suppression pool water.

12. Heat transfer from the primary containment to the reactor building is conservatively neglected.

2.3 Analysis Description

The long-term containment pressure and temperature response was analyzed for the DBA-LOCA which was identified in the SAR as an instantaneous double-ended guillotine break of a recirculation suction line. Case 3 and Case 4 of Section 5.2 of the SAR (Curves C and D in SAR Figure 5.2.3:2 and Figure 5.2.3:3) were re-analyzed for this report. Case 3 in Section 5.2 of the SAR is used to establish the long-term design basis pool cooling temperature conditions. The LPCI/Containment Cooling System parameters for Case 3 are consistent with the Auxiliary Systems Data Book (Reference 9) and Mode B on the process diagram (Reference 10). For Case 3 it is assumed that one loop, with one heat exchanger, two LPCI/Containment Cooling System pumps and two CCSW pumps are available. Case 4 as described in the SAR assumes the availability of one LPCI/Containment Cooling System pump and two CCSW pumps. For the analysis of this report it was assumed that only 1 CCSW pump is available. This is consistent with the number of CCSW pumps reported for Mode C in the Process Diagram. Additional analyses (identified as Cases 3A and 4A in this report) were performed with a lower heat exchanger heat removal rate to account for the uncertainty in the LPCI and CCSW flow measurements. Table 3 summarizes the LPCI/Containment Cooling System parameters assumed for the long-term heatup analyses of this report (References 2,7). Appendix C provides break flow mass and energy data for the analysis. Note that the integrated break flow mass and energy given in Appendix C is an output from the coupled vessel and containment model used for the analysis.

2.4 Results

Table 4 summarizes the results of the long-term heatup calculations. Figures 1, 1A, 1B, 2, 2A and 2B show long-term pressure and temperature response for Cases 3 and 4, respectively, with the assumption of nominal flow rates. Figures 3, 3A, 3B, 4, 4A and 4B show the containment pressure and temperature responses for Cases 3 and 4 obtained with the reduced heat exchanger K values which account for flow measurement uncertainty. The results in Table 4 show that the peak pool temperature with the nominal flow rates for Case 3 is 3°F higher than the SAR value shown in Figure 5.2.3:3 of the SAR while the peak suppression pool temperature for Case 4 is unchanged. This difference in the results between Case 3 and Case 4 is attributed to the reduction in the CCSW flow rate for 2 pump operation in Case 3 to 5600 gpm versus the SAR value for Case 3 of 7000 gpm. Note that SAR Figure 5.2.3:3 shows the drywell temperature only. However, during the time of the peak suppression pool temperature, the drywell and suppression pool temperature will be nearly the same. The difference in the peak pool temperature between Case 3A and Case 4A of this report is the same as the difference between Cases 3 and 4 in the SAR. This indicates that only 1 CCSW pump was originally used for Case 4 of the SAR. There is a significant effect on the peak suppression pool temperature of using a heat exchanger K value which accounts for uncertainty in the LPCI/Containment Cooling and CCSW flow rates. The increases in the peak suppression pool temperatures due to the use of the reduced K values are 3°F for Case 3,3A and 6°F for Case 4,4A.

3.0 Conclusions

The peak suppression pool temperatures based on the use of nominal values of the current LPCI/Containment Cooling and CCSW flow rates through the LPCI/Containment Cooling System heat exchanger result in peak suppression pool temperatures which are 0 to 3°F higher than the SAR values. The use of decreased heat exchanger coefficient values to account for the uncertainty in the LPCI/Containment Cooling and CCSW flow rates result in peak suppression pool temperatures which are 6°F higher than the results with the nominal pump flow rates and which are also 6°F higher than the values reported in Section 5.2 of the Dresden SAR.

4.0 References

1) Letter, G. G. Chen to S. Mintz,"K Values for Dresden Units 2 & 3 Containment Heat Exchangers," September 14, 1992.

2) Letter, C. R. Parker to S. Eldridge (CECO),"LOCA Long-Term Containment Response Analysis K-values for LPCI/Containment Cooling System Heat Exchangers Dresden Nuclear Power Station, Units 2 & 3," October 6, 1992.

3) Letter, S. L. Eldridge/B. M. Viehl to T. Allen, "Inputs for Heat Exchanger Parameters for CCSW Flow Issue Dresden Units 2 & 3," August 31, 1992.

4) NEDM-10320,"The GE Pressure Suppression Containment System Analytical Model," March 1971.

5) NEDO-20533,"The General Electric Mark III Pressure Suppression Containment System Analytical Model," June 1974.

6) NEDO-21052,"Maximum Discharge of Liquid-Vapor Mixtures from Vessels," General Electric Company, September 1975.

7) Letter, C. R. Parker to S. Eldridge (CECO),"LOCA Long-Term Containment Response Analysis Input Parameters Dresden Nuclear Power Station, Units 2 & 3 (Final Values)," September 21, 1992.

8) "Decay Heat Power in Light Water Reactors," ANSI/ANS 5.1 - 1979, Approved by American National Standards Institute, August 29, 1979.

9) Auxiliary Systems Data Book, Plant Dresden 2, GE Document 257HA654, Issued April 15, 1979.

10) LPCI Containment Cooling System Process Diagram, GE DWG 729E583, Rev. 1, February 24, 1969.

Table 1 - Flow Rates Used in SAR Containment Response Analysis

Case	No. of Loops**	LPCI/ Containment Cooling Pumps Per Loop	Total LPCI/ Containment Cooling Pump Flow (gpm)	CCSW Pumps Per Loop	Total CCSW Pump Flow (gpm)
1	1	2	10,000	2	7000
2	2	2	20,000	2	14000
3	1	2	10,000	2	7000
4	1	1	5,000	2*	7000*

* Section 5.2 of the SAR reports that two CCSW pumps/HX were assumed for Cases 1 to 4. However, it is believed that only one CCSW pump was used for the original analysis for SAR Case 4.

** 1 Heat Exchanger (HX) per LPCI/Containment Cooling Loop.

Table 2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
Core Thermal Power	MWt	2578
Vessel Dome Pressure	psia	1020
Drywell Free (Airspace) Volume (including vent system)	ft^3	158236
Initial Suppression Chamber Free (Airspace) Volume		
Low Water Level (LWL)	ft^3	120097
Initial Suppression Pool Volume		
Min. Water Level	ft^3	112000
Initial Drywell Pressure	psig	1.25
Initial Drywell Temperature	°F	135
Initial Drywell Relative Humidity	%	20
Initial Suppression Chamber Pressure	psig	0.15
Initial Suppression Chamber Airspace Temperature	°F	95
Initial Suppression Chamber Airspace Relative Humidity	%	100
Initial Suppression Pool Temperature	°F	95
No. of Downcomers		96
Total Downcomer Flow Area	ft^2	301.6
Initial Downcomer Submergence (LWL)	ft	3.67

Table 2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
Downcomer I.D.	ft	2.00
Vent System Flow Path Loss Coefficient (includes exit loss)		5.17
Supp. Chamber (Torus) Major Radius	ft	54.50
Supp. Chamber (Torus) Minor Radius	ft	15.00
Suppression Pool Surface Area (in contact with suppression chamber airspace)	ft^2	9971.4
Suppression Chamber-to-Drywell Vacuum Breaker Opening Diff. Press.		
- start	psid	0.15
- full open	psid	0.5
Supp. Chamber-to-Drywell Vacuum Breaker Valve Opening Time	sec	1.0
Supp. Chamber-to-Drywell Vacuum Breaker Flow Area (per valve assembly)	ft^2	3.14
Supp. Chamber-to-Drywell Vacuum Breaker Flow Loss Coefficient (including exit loss)		3.47
No. of Supp. Chamber-to-Drywell Vacuum Breaker Valve Assemblies (2 valves per assembly)		6
LPCI/Containment Cooling Heat Exchanger K in Containment Cooling Mode	Btu/s-°F	See Table 3
LPCI/Containment Cooling Service Water Temperature	°F	95

Table 2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
LPCI/Containment Cooling Pump Heat (per pump)	hp	700
Core Spray Pump Heat (per pump)	hp	800
Time for Operator to turn on LPCI/Containment Cooling System in Containment Cooling mode (after LOCA signal)	sec	600
Feedwater Addition (to RPV after start of event; mass and energy)		

Feedwater Node **	Mass (lbm)	Enthalpy * (Btu/lbm)
1	34658	308.0
2	96419	289.2
3	145651	268.7
4	91600	219.8
5	65072	188.4

* Includes sensible heat in the feedwater system pipe metal.

** Feedwater mass and energy data combined to fit into 5 nodes for use in the analysis.

Table 3 - LPCI/Containment Cooling System Parameters Used in Analysis

Case	No. of Loops*	LPCI/ Containment Cooling Pumps Per Loop	Total LPCI/ Containment Cooling Flow (gpm)	No. of CCSW Pumps	Total CCSW Pump Flow (gpm)	HX K (Btu/s-°F)
3	1	2	10,000	2	5,600	356.1
3A**	1	2	8,916	2	4,795	327.3
4	1	1	5,000	1	3,500	249.6
4A**	1	1	3,881	1	3,071	219.2

* one heat exchanger per loop

** with the uncertainty in the LPCI/Containment Cooling and CCSW flow rates accounted for

Table 4 - Peak Suppression Pool Temperatures

Case No.	Maximum Suppression Pool Temperature (°F)	FSAR Temperature (°F)*
3	168	165
3A	171	N/A
4	180	180
4A	186	N/A

* Note that the FSAR reported drywell temperatures and not suppression pool temperatures. However, during the times of peak suppression pool temperature the drywell and pool temperatures should be similar.

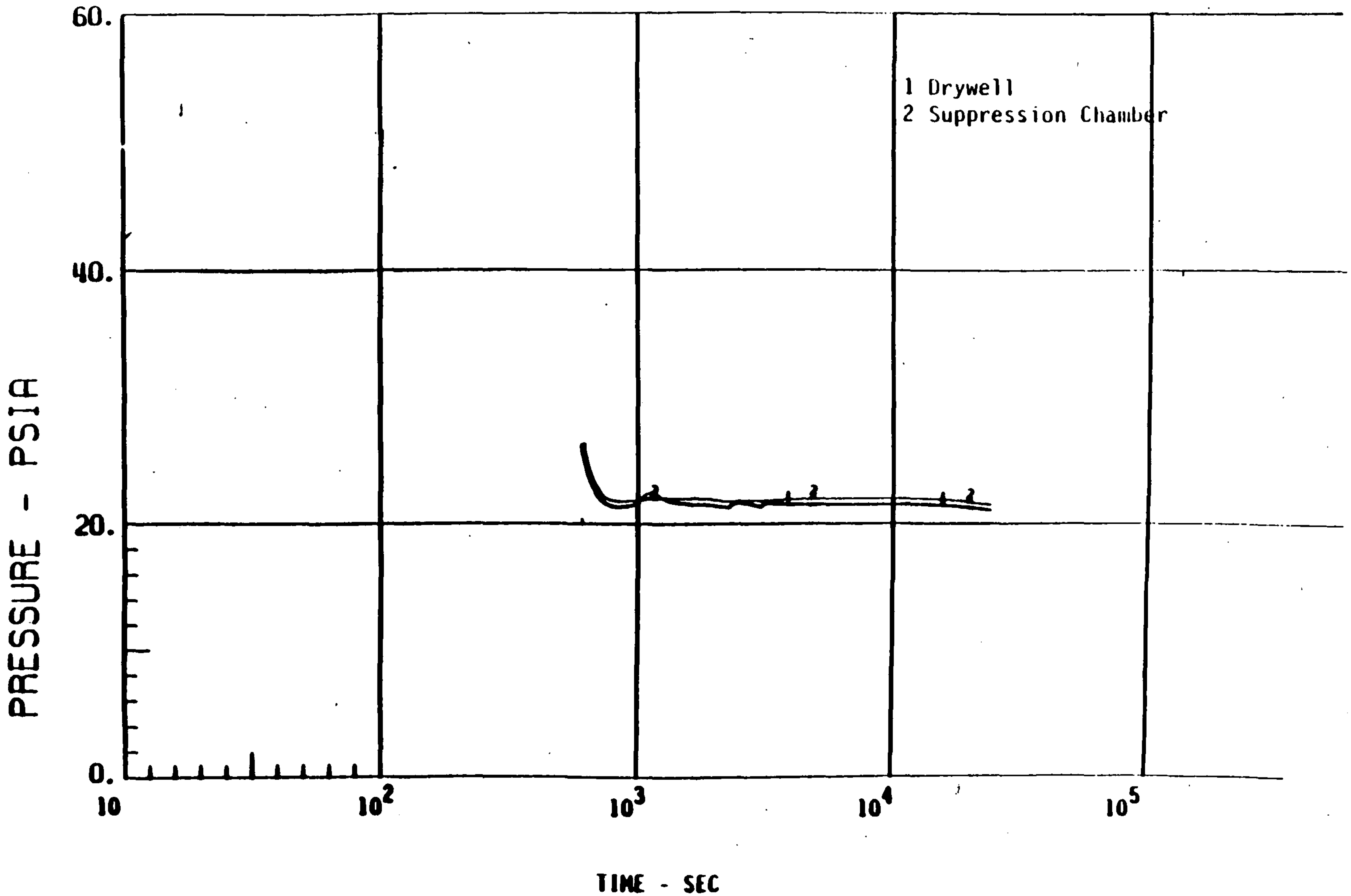

Figure 1 - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 3

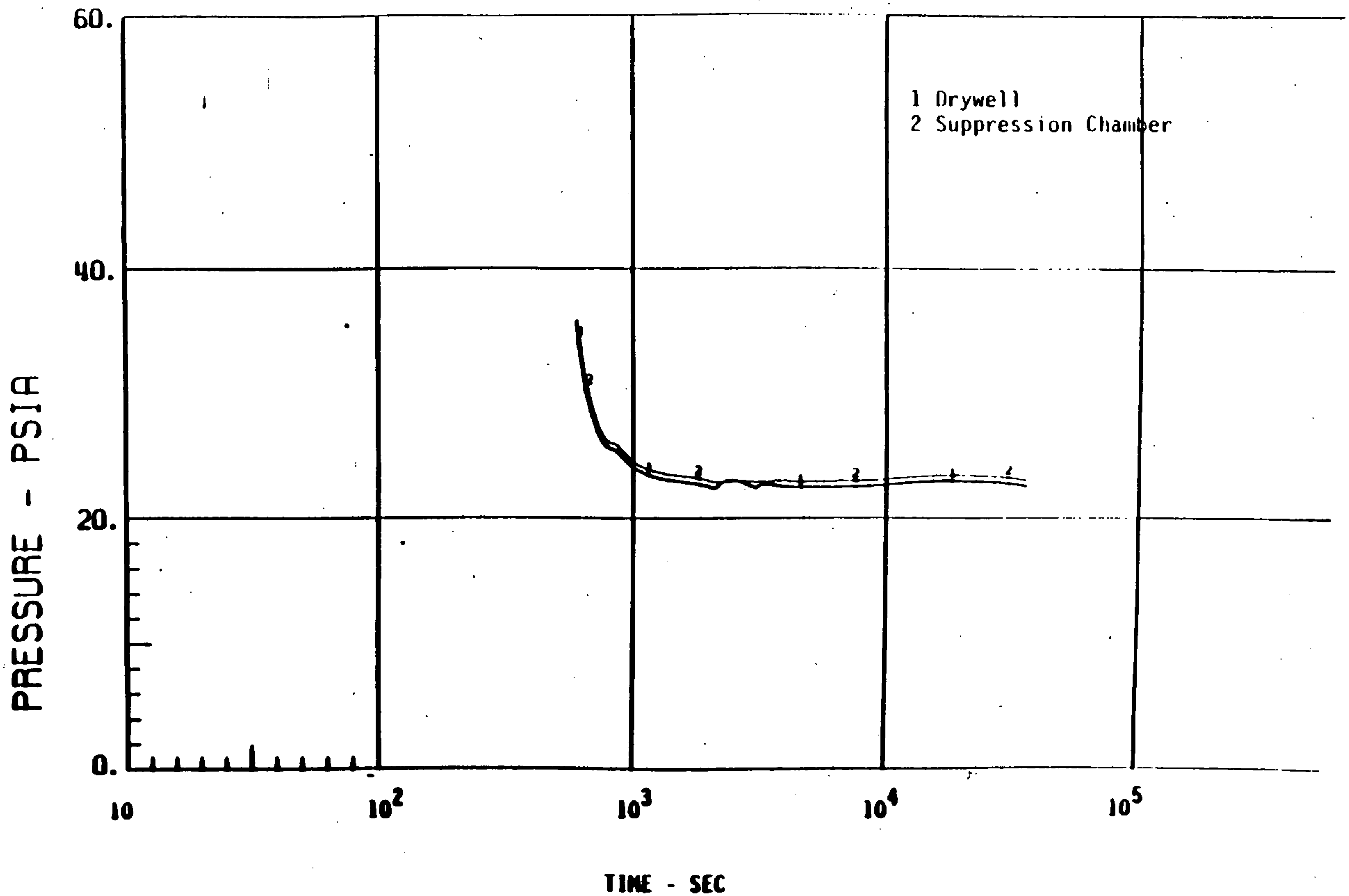

Figure 2 - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 4

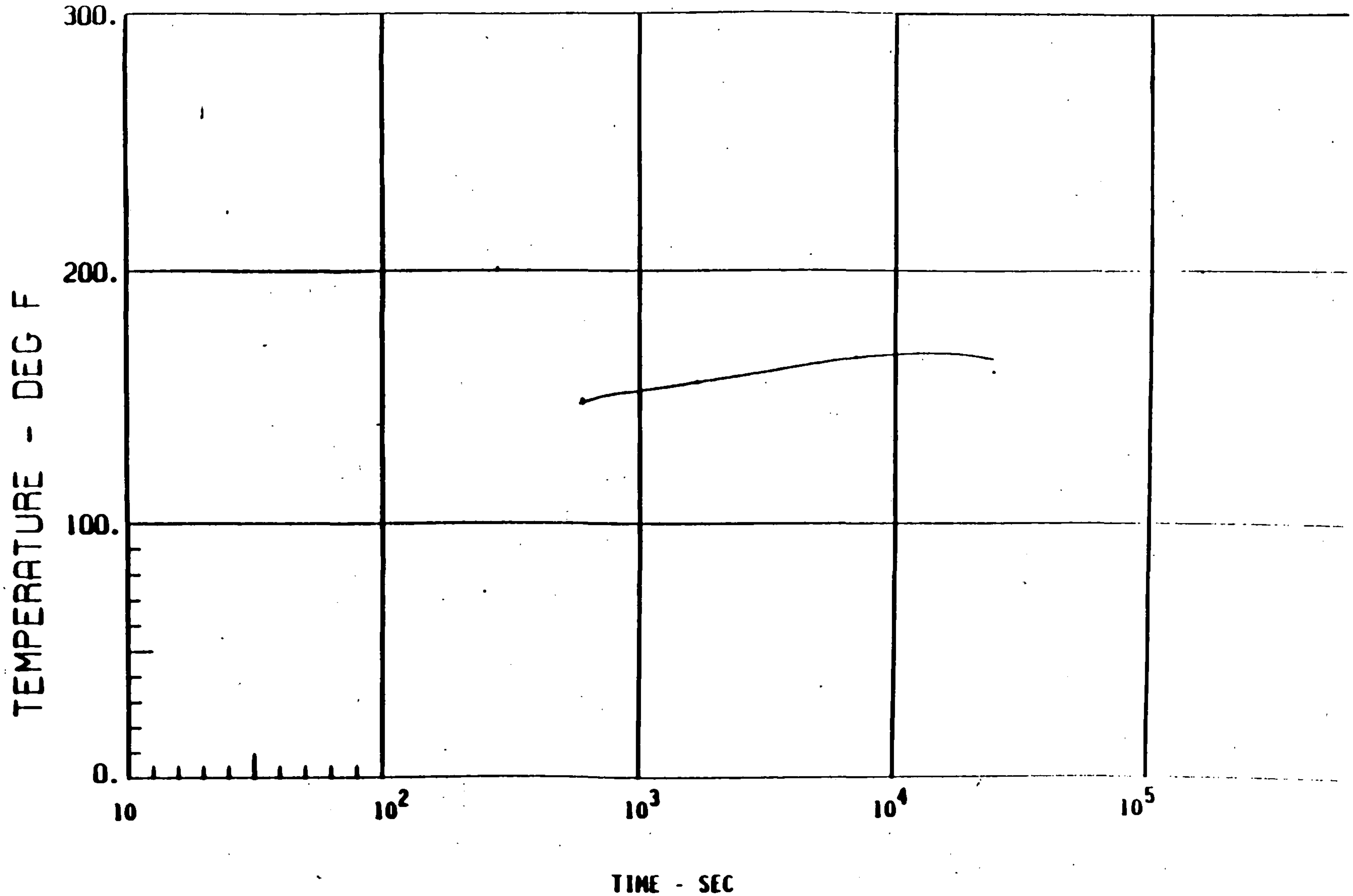

Figure 1B - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case 3

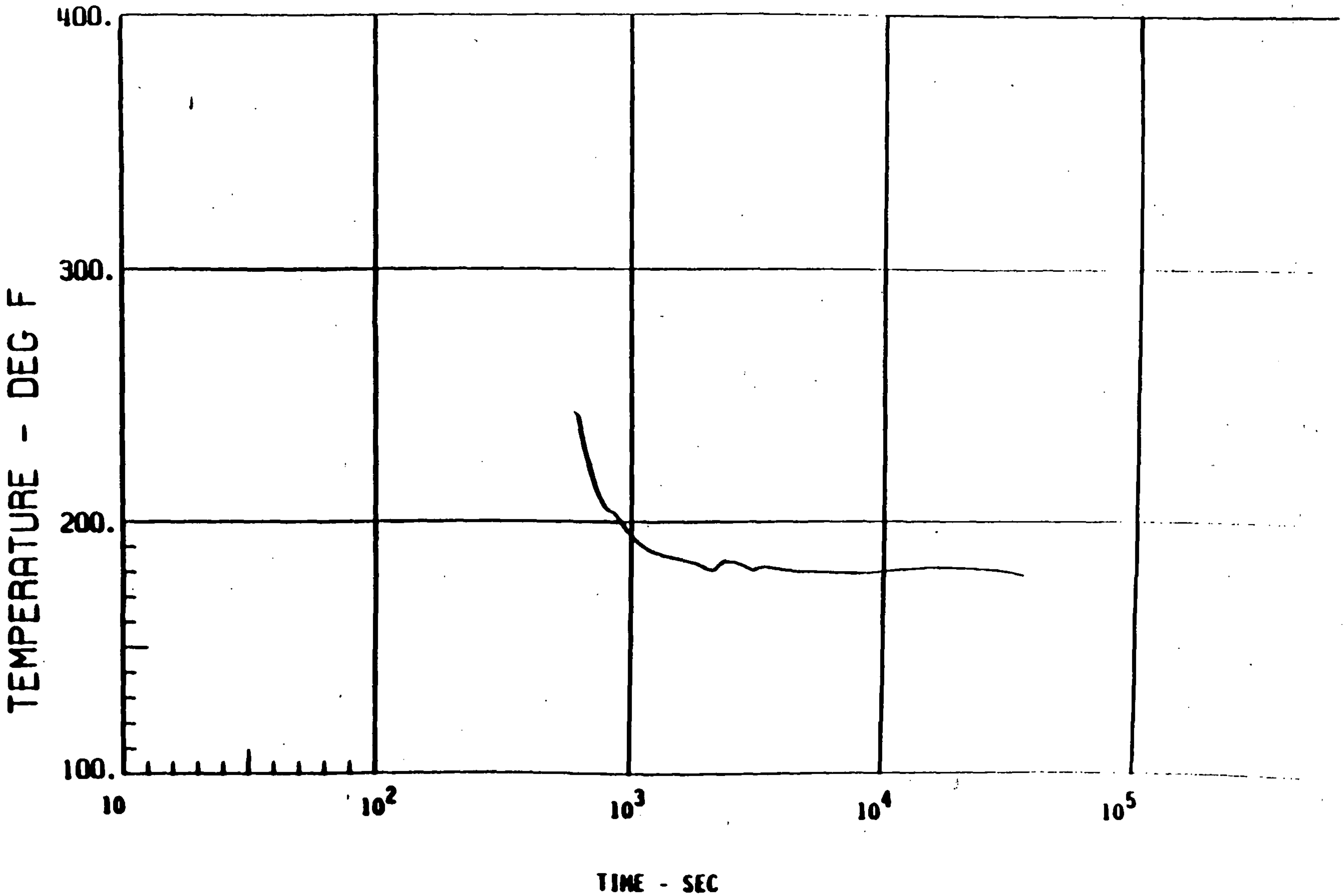

Figure 2A - Long-Term DBA-LOCA Drywell Temperature Response for Case 4

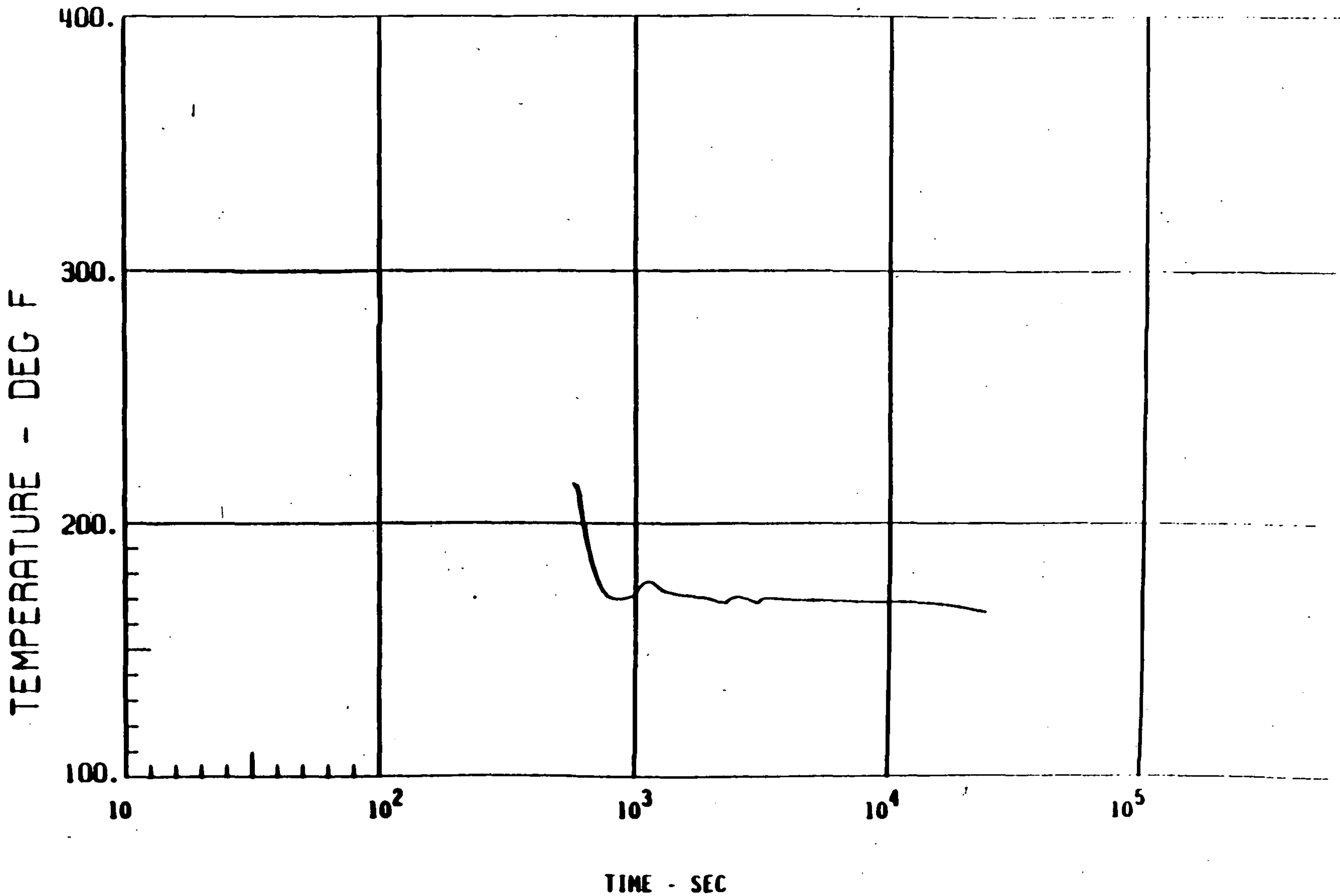

Figure 1A - Long-Term DBA-LOCA Drywell Temperature Response for Case 3

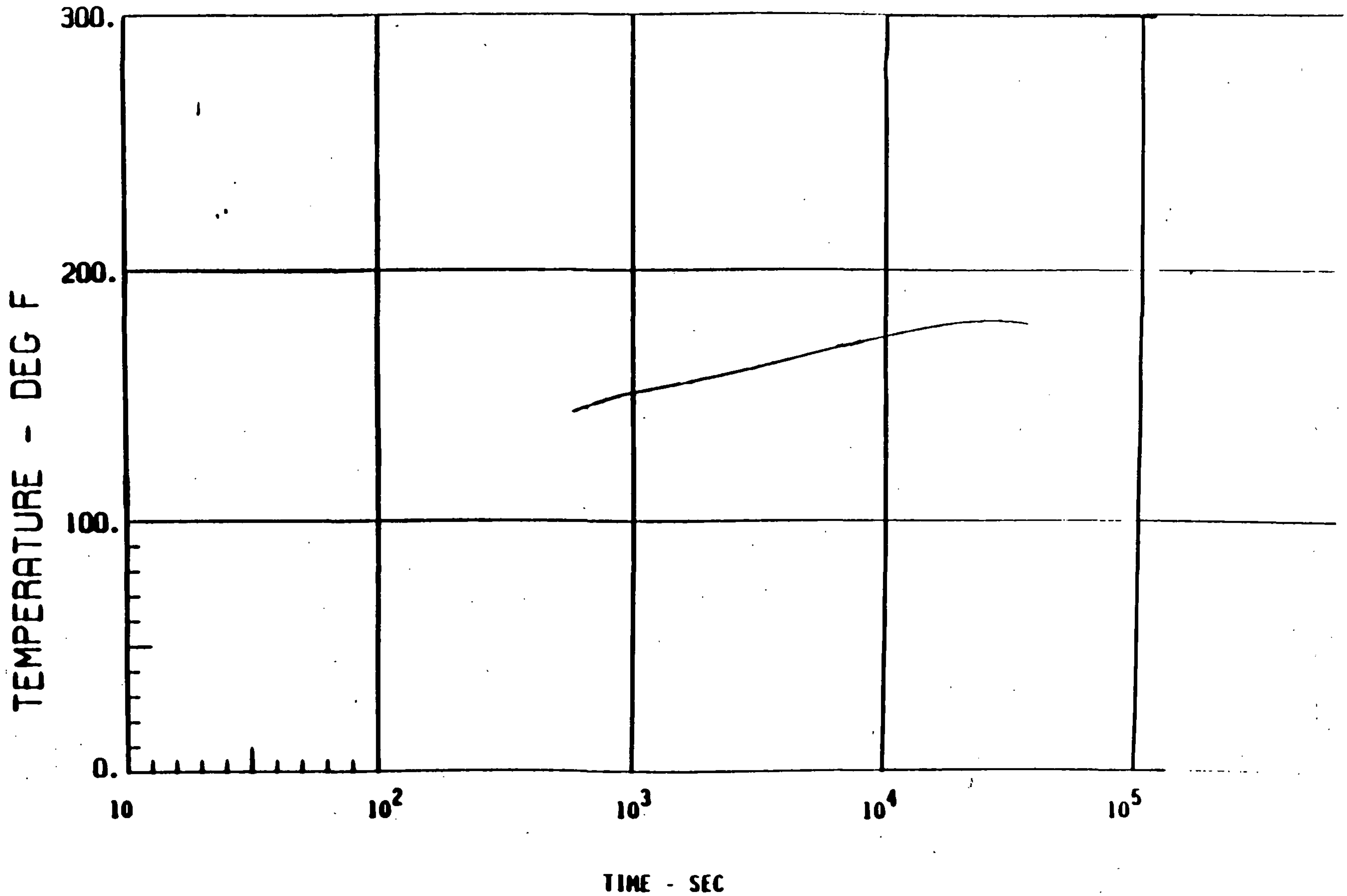

Figure 2B - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case 4

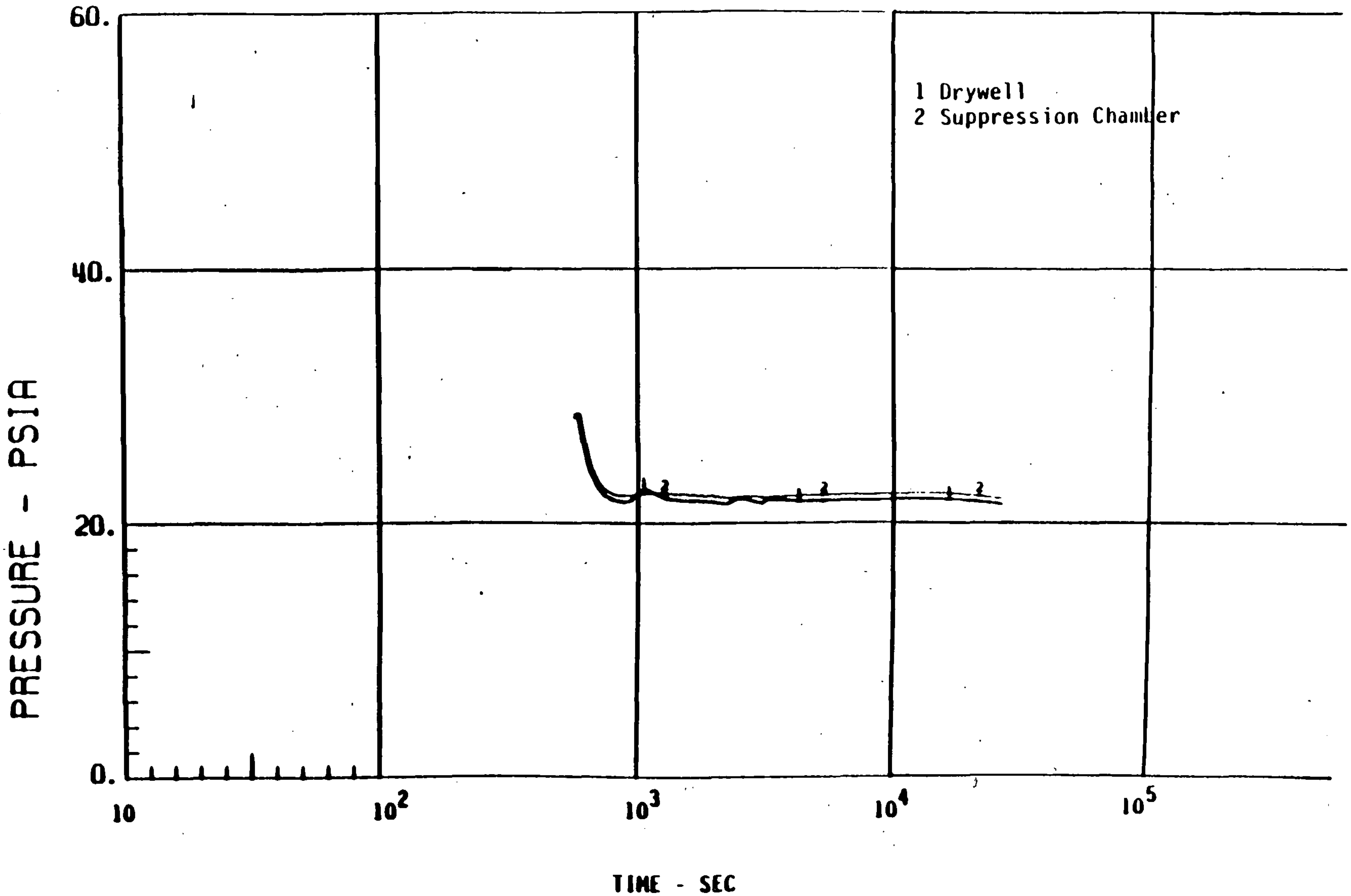

Figure 3 - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 3a

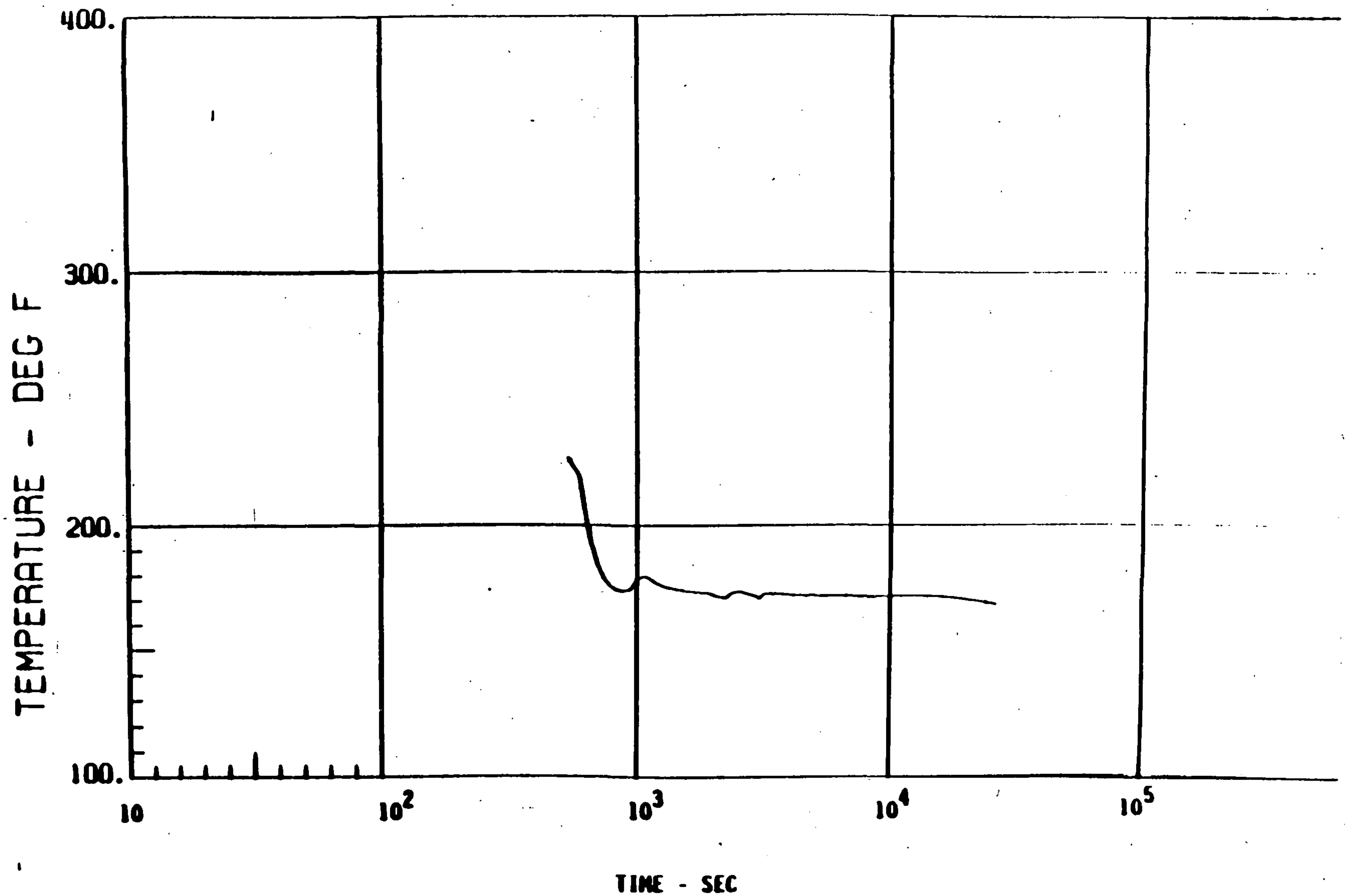

Figure 3A - Long-Term DBA-LOCA Drywell Temperature Response for Case 3a

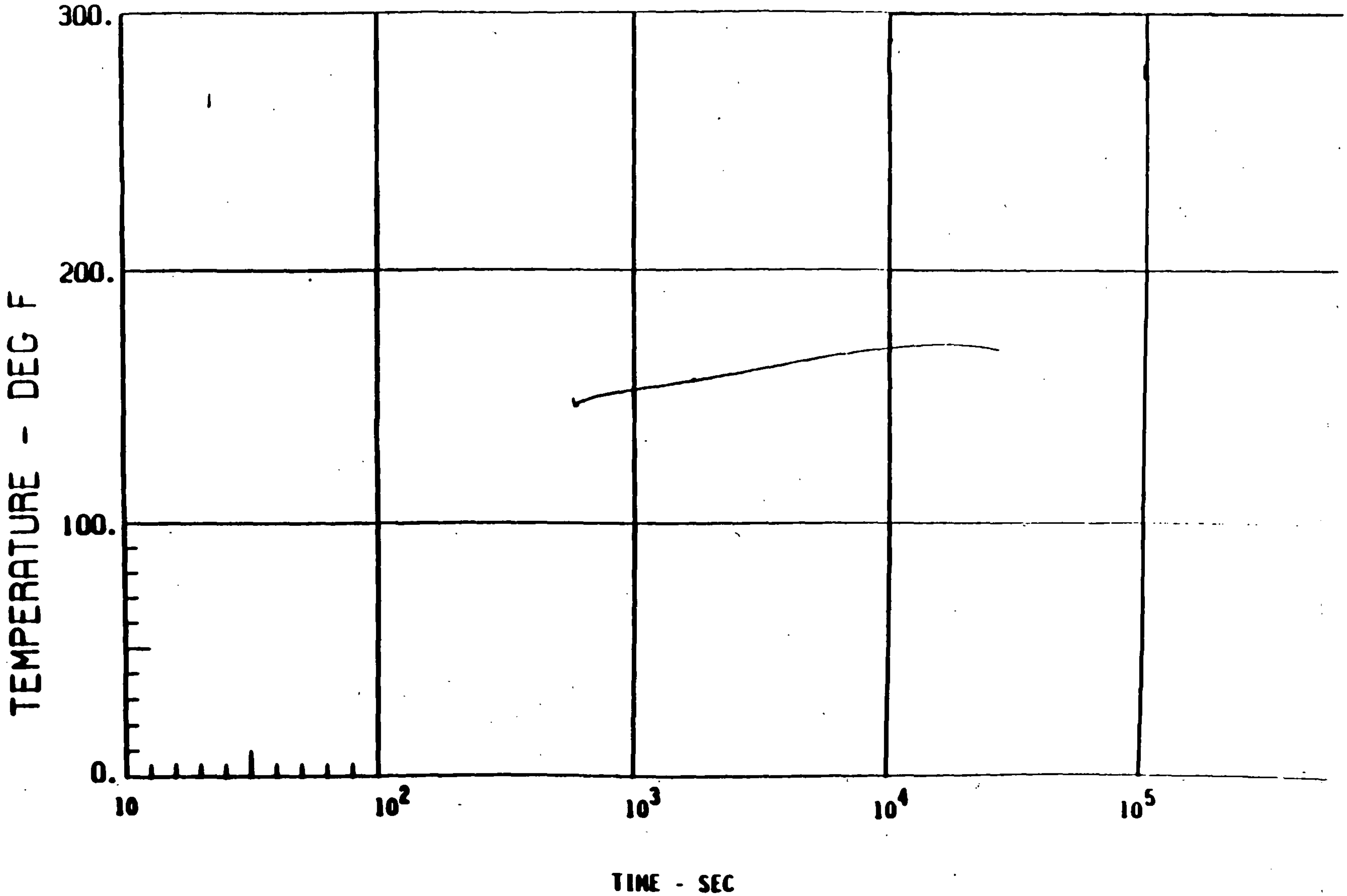

Figure 3B - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case 3a

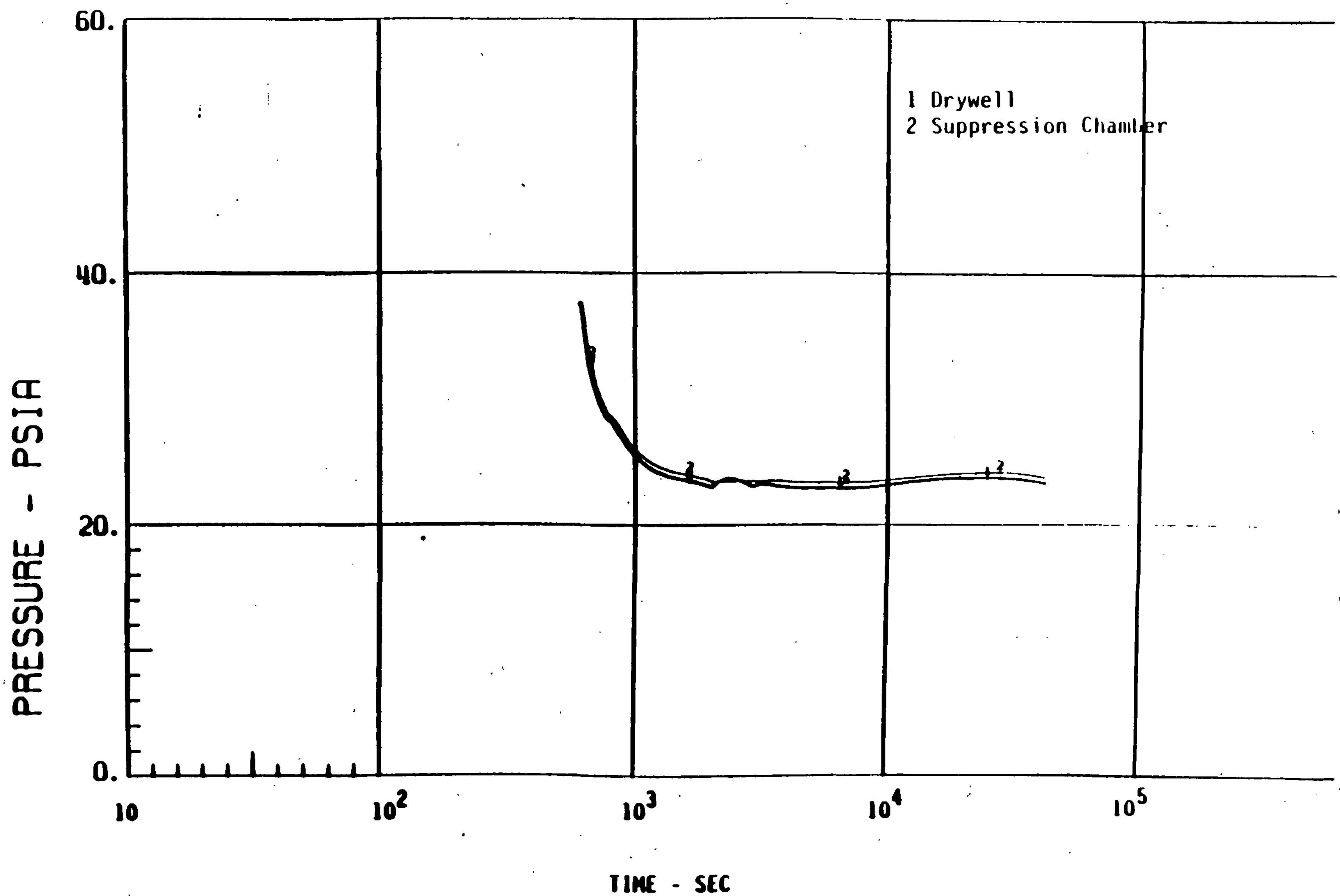

Figure 4 - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 4a

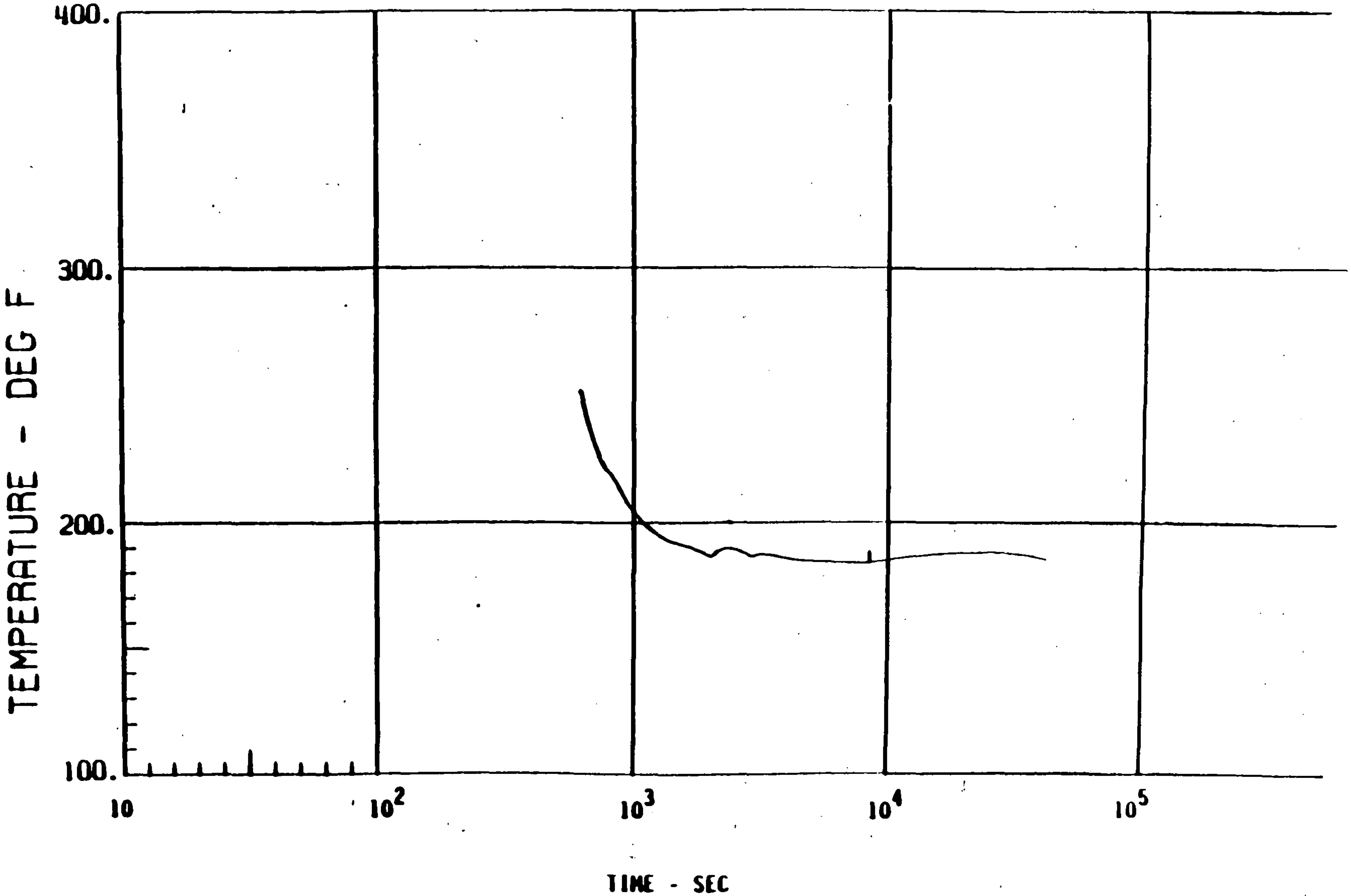

Figure 4A - Long-Term DBA-LOCA Drywell Temperature Response for Case 4a

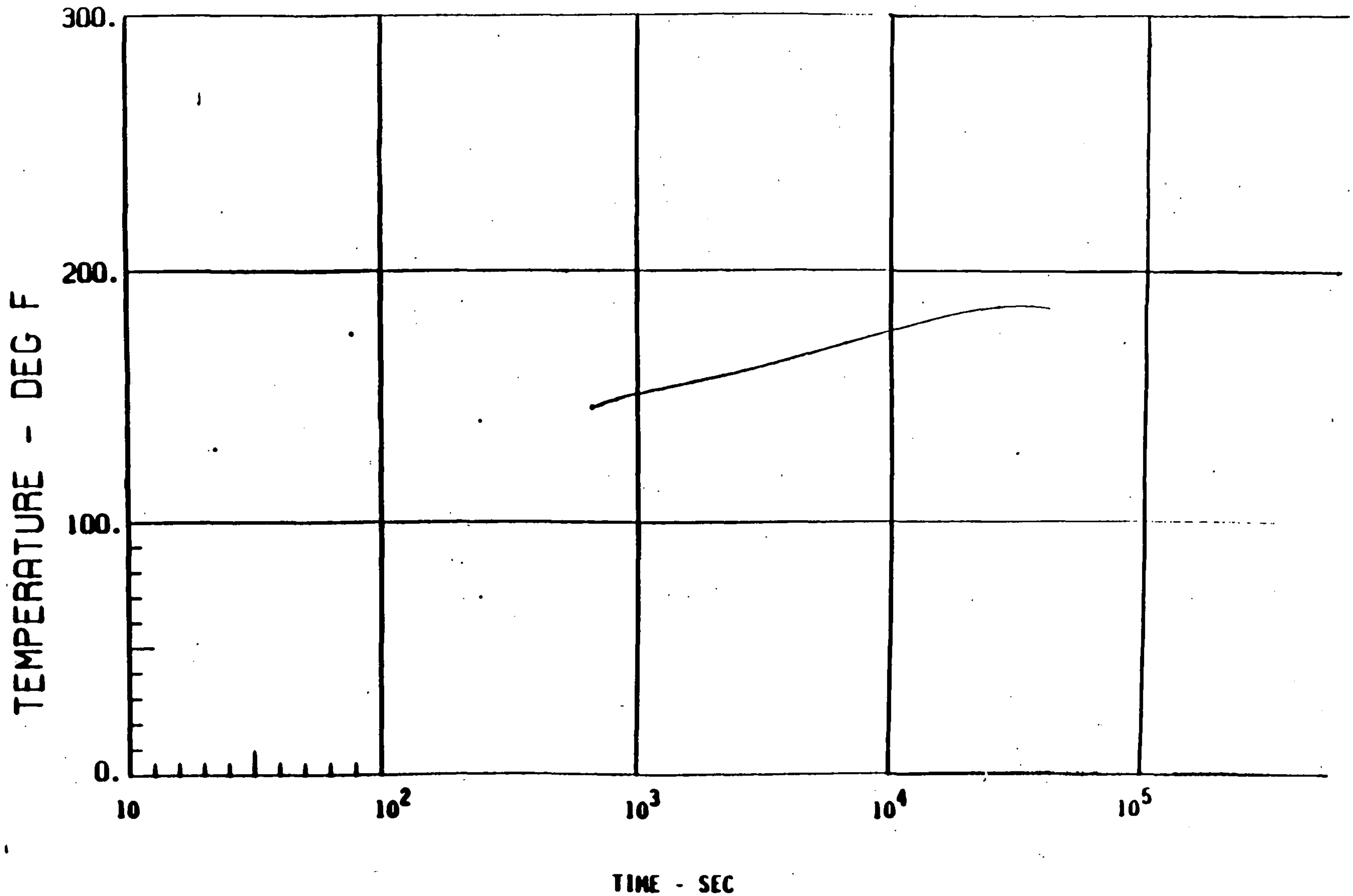

Figure 4B - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case 4a

APPENDIX A

REVIEW OF NFS CALC RSA-D-92-01

NFS-Calc RSA-D-92-01 (Reference 1) was reviewed to determine the impact on the suppression pool temperature data in GE report NEDO-24566 (Reference 2) used in the evaluation of the Mark I containment loads specified during the Mark I Long Term Program (LTP) on Torus attached piping. The results of this review confirm that there is no impact of the results of Reference 1 on the Reference 2 temperature data used to evaluated Mark I LTP loads.

The purpose of the temperature data in Reference 2 was to determine the pool temperatures which should be used to evaluate the Mark I containment LOCA dynamic loads such as pool swell, vent-thrust, CO and chugging. The pool swell, vent-thrust and CO loads occur during the first 30 seconds of a Design Basis Accident (DBA). Because of this, the pool temperatures during the first 30 seconds of a DBA, which are given for Dresden in Reference 2, are the appropriate temperatures used to evaluate these loads. Note that these temperatures are unaffected by heat exchanger performance since the heat exchanger is assumed to be unavailable during this time period. Therefore, the Reference 1 long-term pool temperature calculation for a Small Break Accident (SBA) is not applicable in evaluating the DBA-LOCA containment dynamic loads due to pool swell, vent-thrust and CO and does not impact the Reference 2 temperature data used to evaluate these loads. Chugging loads can occur during a DBA, an Intermediate Break Accident (IBA) and a SBA. Since chugging loads will occur during a SBA, the temperature response during a SBA, should be considered to evaluate the chugging load. However, test data from the Mark I Full Scale Test Facility (FSTF) tests (Reference 3) shows that chugging ceases when suppression pool temperatures exceed 135°F. Therefore a peak pool temperature of 167°F for a SBA given in Reference 1 relative to a value of 165°F (IBA) in Reference 2 does not affect the applicability of the Reference 2 temperature data to evaluate the chugging loads.

Summary:

The results of the Reference 1 calculation do not impact the temperature data of Reference 2 used to evaluate the Mark I LTP containment loads specified for torus attached piping for Dresden.

References for Appendix A:

1) NFS Calculation RSA-D-92-01,"An Evaluation of Reduced CCSW Flows at Dresden Station," April 7, 1992, Nuclear Fuel Services Department, Commonwealth Edison Company.

2) NEDO-24566,"Mark I Containment Program Plant Unique Load Definition, Dresden Nuclear Power Station: Units 2 and 3," March 1979.

3) NEDO-24539,"Mark I Containment Program Full-Scale Test Program Final Report," April 1979.

APPENDIX B

REDUCTION TO THE CONTAINMENT PRESSURE

This appendix provides an estimate of the reduction to the containment pressure calculated at the time of the peak suppression pool temperature if containment initial conditions which minimize the containment pressure are used. This estimate is based on initial conditions which minimize the containment pressure (see Table B.1). This estimate of the pressure reduction to the suppression chamber airspace pressure at the time of the peak suppression pool temperature was determined by calculating the ratio of the total containment (drywell and suppression chamber) air mass for the initial conditions given in Table B.1 to the value used in the analysis of Section 2.0 of this report. This ratio was applied as a reduction factor to the suppression chamber pressure at the time of the peak suppression pool temperature. The effect of the change in the initial conditions shown in Table B.1 on the suppression pool temperature response (and the drywell temperature response) is negligible. Therefore the change to the suppression chamber and drywell vapor pressures at the time of the peak suppression pool temperature is also negligible. Since only the air partial pressure will decrease due to the reduction in the air mass, applying the reduction factor to the total pressure results in a lower suppression chamber airspace pressure and, therefore, is conservative.

Results:

The estimated reduction factor applied to the suppression chamber pressure at the time of the peak pool temperature is the same for Cases 3, 3a, 4 and 4a of Section 2.0, since all assume the same initial containment conditions. Table B.2 shows the suppression chamber pressures at the time of the peak suppression pool temperature obtained from the analysis of Section 2.0 and the corresponding estimated reduced values using the reduction factor derived considering conditions which minimize containment pressure.

TABLE B.1 - Containment Parameters Used to Estimate Suppression Chamber Pressure Reduction

	Value Used to Estimate Pressure Reduction	Value from Table 2
Initial Drywell Pressure (psia)	15.7	15.95
Initial Suppression Chamber Pressure (psia)	14.7	14.85
Initial Drywell Temperature (°F)	150	135
Initial Drywell Relative Humidity (%)	100	20
Initial Suppression Chamber Relative Humidity (%)	100	100
Initial Total Air Mass (lbm) (Drywell and Suppression Chamber)	16499	19284

TABLE B.2 - Estimated Reduced Suppression Chamber Pressure

	Suppression Chamber Pressure at Peak Pool Temperature	
Case	Value from Analysis of Section 2.0 (psia)	Estimated Reduced Value (psia)
3	21.9	18.7
3a	22.3	19.1
4	23.3	19.9
4a	24.1	20.6

APPENDIX C

PRIMARY SYSTEM MASS AND ENERGY RELEASE DATA FOR DRESDEN CONTAINMENT EVALUATION

TABLE C.1 CORE HEAT

Table C.1 provides the core heat (Btu/sec) and integrated core heat (Btu) used in the analysis of Section 2.0. The core heat includes decay heat (ANS 5.1 - 1979), metal-water reaction energy, fission power, and fuel relaxation energy. The core heat in Table C.1 is normalized to the initial core thermal power of 2578 mwt.

TABLE C.2 INTEGRATED BREAK FLOW MASS AND ENERGY (OUTPUT FROM ANALYSIS)

Table C.2 gives the integrated break flow mass (lbm) and integrated energy (Btu) obtained for the analysis of Case 4a. Case 4a is representative of the 4 cases analyzed in Section 2.0. It should be noted that after the end of the vessel blowdown (600 seconds into the event), the break mass and energy consists of suppression pool water which is recirculated between the suppression pool and the vessel (where the core decay heat and vessel sensible heat are removed) by the Core Spray system pumps. Therefore, after 600 seconds no new water mass is added to the containment. Also, most of the increase in the integrated break flow energy shown in Table C.2 after 600 seconds is due to the internal energy of the water being recirculated between the vessel and the suppression pool, with only a small fraction of the integrated energy due to the transfer of core decay heat and vessel sensible energy to the break flow water.

TABLE C.1 - CORE HEAT

Time (sec)	Core Heat*	Integrated Core Heat**
0.0	1.0078	0.
0.1	.9976	.1003
0.2	.9694	.1986
0.6	.7404	.5406
0.8	.6907	.6837
1.0	.5802	.8108
2.0	.5480	1.375
3.0	.5852	1.942
4.0	.5755	2.522
6.0	.5401	3.637
8.0	.4637	4.641
10.	.3771	5.482
20.	.08192	7.777
30.	.06405	8.507
40.	.04697	9.062
60.	.04271	9.959
80.	.04064	10.79
100.	.03925	11.59
120.	.03815	12.37
121.	.03033	12.40
200.	.02752	14.69
600.	.02212	24.61
1000.	.01956	32.95
2000.	.01599	50.72
4000.	.01273	79.44
7800.	.01033	123.2
10200.	.01012	147.8
20400.	.008491	242.7
39600.	.007060	392.0
61200.	.006306	536.4

*Core Heat (normalized to initial core thermal power of 2578 mwt)
= decay heat + fission power + fuel relaxation energy
+ metal-water reaction energy

** Integrated Core Heat in full power-seconds.

TABLE C.2 - INTEGRATED LOCA BREAK FLOW MASS AND ENERGY*

Time (sec)	Integrated Break Flow Mass (lbm)	Integrated Break Flow Energy (Btu)
0.	0.	0.
22.	4.639 E 5	2.661 E 8
42.	5.119 E 5	3.238 E 8
50.	5.208 E 5	3.331 E 8
57.	5.483 E 5	3.414 E 8
65.	5.775 E 5	3.498 E 8
72.	6.011 E 5	3.566 E 8
78.	6.235 E 5	3.629 E 8
85.	6.481 E 5	3.698 E 8
91.	6.702 E 5	3.759 E 8
99.	6.982 E 5	3.836 E 8
107.	7.273 E 5	3.915 E 8
196.	8.585 E 5	4.250 E 8
401.	1.087 E 6	4.782 E 8
611.	1.296 E 6	5.236 E 8
1047.	1.713 E 6	6.141 E 8
2058.	2.327 E 6	7.419 E 8
4007.	3.492 E 6	9.751 E 8
6027.	4.740 E 6	1.212 E 9
8090.	6.024 E 6	1.452 E 9
10022.	7.232 E 6	1.677 E 9
14004.	9.723 E 6	2.144 E 9
15962.	1.094 E 7	2.374 E 9
20094.	1.353 E 7	2.860 E 9
24108.	1.604 E 7	3.330 E 9
30061.	1.976 E 7	4.025 E 9
32551.	2.131 E 7	4.315 E 9
34007.	2.222 E 7	4.484 E 9

Note that after 600 seconds into the event, (after the end of vessel blowdown) the break flow mass and energy consists of suppression pool water which is recirculated between the suppression pool and the vessel (where core decay heat and sensible heat is removed) by the Core Spray system pumps.

* The break flow mass and energy data shown in this table was obtained from the analysis of Case 4a. It is representative of the 4 cases analyzed for this report.

UFSAR UPDATES

AND

10CFR50.59 SAFETY EVALUATION

5.2.3.3 <u>Containment Characteristics After Reactor Blowdown</u>. After the blowdown of the primary coolant into the drywell immediately following the recirculation line break, the temperature of the suppression chamber water approaches 130°F and the primary containment system pressure equalizes out at about 27 psig as discussed in Section 5.2.3.2. Most of the noncondensible gases are transported to the suppression chamber during blowdown. However, soon after initiation of the containment spray they redistribute between the drywell and the suppression chamber via the vacuum-breaker system as the spray reduces drywell pressure.

The core spray system removes decay heat and stored heat from the core, thereby minimizing core heatup and any metal-water reaction. The core heat is removed from the reactor vessel through the broken recirculation line in the form of hot liquid. This hot liquid combines with liquid from the containment spray and flows into the suppression chamber via the drywell-tosuppression-chamber connecting vent pipes. Steam flow is negligible. The energy transported to the suppression chamber water is removed from the primary contaiment system by the containment-spray heat exchangers.

In order to assess the primary containment response after the blowdown and to demonstrate the adequacy and redundancy of the core and containment spray cooling systems, an analysis was made of the recirculation line break under various conditions of core and primary containment cooling. The longterm pressure and temperature response of the primary containment was analyzed for the following cooling conditions.

1. Operation of two core spray cooling system loops and one of the two containment cooling loops.

2. Operation of only one of the two core spray cooling system loops and both of the containment cooling loops.

3. Operation of only one of the two core spray cooling system loops and one-half of one of the two containment cooling loops.

4. Operation of only one of the two core spray cooling sytem loops and one-half of one containment cooling loop. Namely one LPCI pump and 1 ~~2~~ service water pumps. R

The initial pressure response of the system during the period when the reactor vessel is blowing down (the first 30 sec after the break) is as reported in Section 5.2.3.2 for all cases considered here. For each case, the temperature of the suppression pool was calculated as a function of time conservatively considering the pool to be the only heat absorber in the system. The effects on the pool temperature of decay energy, stored energy in the core, and energy from any metal-water reaction, were included. Also, the effect of heat from the various pumps assumed in operation in the LPCI/containment cooling system was included.

The drywell temperature was calculated considering an energy balance on the containment cooling and core spray. The containment cooling enters at the discharge temperature of the heat exchanger and the core spray enters at the suppression pool temperature. The combined flows (containment cooling and core spray) drain back to the suppression pool, having been heated by the decay energy, stored energy in the core, and any metal-water reaction chemical energy. The drywell temperature was then taken to be 5°F hotter than the exiting flow.

The total number of moles of noncondensible gas in the entire system (drywell and suppression chamber) is determined from the amount of gas originally in the system plus gas generation from any metal-water reaction.

With the drywell temperature, suppression pool temperature, and moles of gas in the system, the system pressure is known. It was assumed conservatively that the drywell and suppression chamber gases are saturated. Also, it was assumed that the drywell and suppression chamber are at equal pressure, which is reasonable since the pressure difference cannot exceed 4 ft. of water (1.8 psi), the vent submergence depth, after the initial reactor blowdown.

Two Core Spray and Two Containment Spray Pump Operation. The analysis presented here contains the assumption that both of the two core spray systems are in operation following the recirculation line break. Core spray system operation does not produce full flow until the reactor vessel pressure has decreased to 90 psig. The analysis contains the assumption that the systems commence operation 30 seconds after the recirculation line break. This time is well within the time calculated for the vessel pressure to reach 115 psig as shown in Figure 5.2.3:7.

This analysis also contains the assumption that only two of the four LPCI pumps in the two containment spray cooling sub-systems are in operation. The heat exchanger associated with these two pumps is assumed to be available for removal of energy from the suppression chamber water. These pumps are assumed to commence operation 400 seconds after the recirculation line break. The flow rate for this condition is shown in Table 5.2.3:1.

TABLE 5.2.3:1

FLOW RATE FOR CONTAINMENT RESPONSE

CASE	CONTAINMENT SPRAY*			CORE SPRAY			
	No. of Loops	Pumps Per Loops	Total Flow	No. of Loops	Total Flow	Max. Containment Pressure (psig)	
1	1	2	10,000	2	9,000	6.5	
2	2	~~1~~ 2	20,000	1	4,500	7.6	R
3	1	2	10,000	1	4,500	6.5	
4	1	1	5,000	1	4,500	4.5	

*Two Service Water Pumps/HX used for Cases 1,2 and 3. One Service Water pump/HX used for Case 4. R

Again the core heatup and extent of metal-water reaction are as discussed. The containment pressure and temperature are shown as curve "d" in Figures 5.2.3:2 and 5.2.3:3 respectively. It is shown that following the initiation of the single containment spray cooling pump and its associated heat exchanger, the containment pressure decreases initially, then slowly increases to the maximum shown in Table 5.2.3:1 due to addition of decay-energy to the containment. Thereafter, energy removal by the single containment spray cooling pump and heat exchanger exceeds the addition rate from all sources, resulting in decreasing containment pressure.

Containment spray itself does not significantly affect the peak post accident pressure rise. It does result in a somewhat faster depressurization immediately following the completion of the blowdown, however. The controlling parameter affecting the post accident secondary peak in pressure is the heat removal capability of the containment cooling heat exchanger relative to the core decay heat production.

Insert 1

Insert 2 (Section 5.2.3.3.1)

5.2.3.4 Containment Capability with Respect to Metal-Water Reactions

A. Nature of Requirements

If zircaloy of the reactor core is heated above about 2000°F in the presence of steam due to an accidental loss-of-coolant, a chemical reaction occurs in which zirconium oxide and hydrogen are formed. This is accompanied by an energy release of about 2800 BTU per pound of zirconium reacted. The energy produced is accomodated in the suppression chamber pool. The hydrogen formed, however, will result in an increased pressure due simply to the added moles of gas in the fixed volume depending on the amount produced. Although very small quantities of hydrogen are produced with core spray, the containment has the inherent ability to accommodate much larger amounts as discussed below.

B. Expected Metal Water Reactions

The metal-water reactions during core heatup, and within the first 40 to 60 minutes during which portions of the core are at temperatures of interest in metal-water reactions, are calculated by a core heat-up computer code. The core is sub-divided into nodes consisting of 5 radial zones, five axial nodes, 4 relative rod powers within each assembly, and with 4 radial fuel nodes in each fuel rod. Heat-up is calculated during the blowdown phase employing experimental heat transfer coefficients. Under core spray conditions experimentally determined coefficients from prototypetests are applied. The metal water reaction is calculated as each node temperature is determined by the parabolic law.[1] This is integrated over the entire core until the rods are finally wetted and cooled by the core spray system about an hour after the accident. The extent of the metal-water reaction thus calculated is oxidation of under 0.5% of all the zirconium in the core. This reaction produces an additional energy release of only

---

[1]ANL6548, "Studies of Metal-Water Reaction at High Temperatures III Experimental and Theoretical Studies of Zirconium-Water Reaction."

INSERT 1

*The containment pressure and temperature response after initiation of containment sprays for curves c and d have been recalculated using updated LPCI/Containment Cooling System parameters. The description of this updated analysis is given in Section 5.2.3.3.1.

5.2.3.3.1 Updated Containment Characteristics After Reactor Blowdown

Flow measurements[1] have determined that the measured Containment Cooling Service Water (CCSW) flow rate during two pump operation for a single LPCI/Containment Cooling System Loop is less than the value assumed in the analysis which produced the pressure and temperature curves in Figures 5.2.3:2 and 5.2.3:3. This would result in a decrease in the LPCI/Containment Cooling System heat exchanger performance and, therefore, result in higher peak containment temperatures. Therefore the impact of reduced heat exchanger performance was assessed with long-term analyses of the containment pressure and temperature response after initiation of the LPCI/Containment Cooling System (600 seconds into the event). The limiting case with two CCSW pump operation, Case 3, was re-analyzed with the reduced CCSW flow rate. Case 4, which produced the maximum temperature, was also originally described as using 2 CCSW pumps. However, a review of vendor files[3] indicated that the analysis used to produce the response for Case 4 assumed only 1 CCSW pump. Therefore, Case 4 was reanalyzed with the assumption that only 1 CCSW pump is available. The analysis for Case 3 and Case 4 used values of the CCSW and LPCI/Containment Cooling flow rates through the LPCI/Containment Cooling heat exchanger[1] and values of the heat exchanger performance which accounted for the uncertainty in the LPCI/Containmnent Cooling and CCSW flow rates[2].

A coupled reactor pressure vessel and containment model, based on the General Electric containment models[4,5], was used to calculate the transient response of the containment during the DBA-LOCA. This model performs fluid mass and energy balances on the reactor primary system, the drywell airspace, the suppression chamber airspace and the suppression pool, and calculates the reactor vessel water level, the reactor vessel pressure, the pressure and temperature in the drywell and suppression chamber airspace and the bulk suppression pool temperature. The various modes of operation of all important auxiliary systems, such as SRV's, MSIV's, ECCS, LPCI/Containment Cooling System and feedwater are modeled. The model can simulate actions based on system setpoints, automatic actions and operator-initiated actions.

The initial conditions and key input parameters used in the analysis are provided in Table 5.2.3:2. Table 5.2.3:3 summarizes the LPCI/Containment Cooling System parameters assumed for the long-term heatup analysis. The following key input assumptions were used in performing the analysis:

1. The reactor is operating at 102% of the rated core thermal power.

2. Vessel blowdown flow rates are based on the Homogeneous Equilibrium Model[6].

3. The core decay heat is based on ANSI/ANS-5.1-1979 decay heat[7].

4. Feedwater flow into the RPV continues until all the feedwater above 180°F is injected into the vessel.

5. Thermodynamic equilibrium exists between the liquids and gases in the drywell. Mechanistic heat and mass transfer between the suppression pool and the suppression chamber airspace is assumed.

6. The vent system flow consists of a homogeneous mixture of the fluid in the drywell.

7. The initial suppression pool volume is at the minimum Technical Specification value to maximize the calculated suppression pool temperature.

8. The initial suppression pool temperature is at the maximum Technical Specification value to maximize the calculated suppression pool temperature.

9. Containment sprays are used to cool the containment.

10. Passive heat sinks in the drywell, suppression chamber airspace and suppression pool are conservatively neglected.

11. All Core Spray and LPCI/Containment Cooling System pumps have 100% of their horsepower rating converted to a pump heat input which is added either to the RPV liquid or suppression pool water.

12. Heat transfer from the primary containment to the reactor building is conservatively neglected.

Results

Table 5.2.3:4 summarizes the results of the long-term heatup calculations. Figures 5.2.3:7 to 5.2.3:9 show long-term pressure and temperature response for Case 3 and Figures 5.2.3:10 to 5.2.3:12 show the pressure and temperature response for Case 4. The results in Table 5.2.3:4 show that the peak suppression pool temperatures are higher than the values shown in Figure 5.2.3:3 of the SAR. Note that SAR Figure 5.2.3:3 shows the drywell temperature only. However, during the time of the peak suppression pool temperature, the drywell and suppression pool temperature will be nearly the same. The difference in the peak pool temperature between Case 3 and Case 4 in Table 5.2.3:4 is the same as the difference between Curves c and d in Figure 5.2.3:3. This confirms that only 1 CCSW pump was originally used to determine the containment pressure and temperature response for Case 4 (Curve d).

References:

1) Letter, S. L. Eldridge/B. M. Viehl (CECO) to T. Allen (GE), "Inputs for Heat Exchanger Parameters for CCSW Flow Issue Dresden Units 2 & 3," August 31, 1992.

2) GE Report GENE-770-26-1092,"Dresden Nuclear Power Station - Units 2 and 3, LPCI Containment Cooling System Evaluation," November 1992.

3) Letter, S. Mintz (GE) to J. E. Nash (GE),"Design Basis for LPCI/Containment Cooling System Heat Exchanger Sizing," April 6, 1992.

4) NEDM-10320,"The GE Pressure Suppression Containment System Analytical Model," General Electric Company, March 1971.

5) NEDO-20533,"The General Electric Mark III Pressure Suppression Containment System Analytical Model," General Electric Company, June 1974.

6) NEDO-21052,"Maximum Discharge of Liquid-Vapor Mixtures from Vessels," General Electric Company, September 1975.

7) "Decay Heat Power in Light Water Reactors," ANSI/ANS-5.1 - 1979, Approved by American National Standards Institute, August 29, 1979.

Table 5.2.3:2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
Core Thermal Power	MWt	2578
Vessel Dome Pressure	psia	1020
Drywell Free (Airspace) Volume (including vent system)	ft^3	158236
Initial Suppression Chamber Free (Airspace) Volume		
Low Water Level (LWL)	ft^3	120097
Initial Suppression Pool Volume		
Min. Water Level	ft^3	112000
Initial Drywell Pressure	psig	1.25
Initial Drywell Temperature	°F	135
Initial Drywell Relative Humidity	%	20
Initial Suppression Chamber Pressure	psig	0.15
Initial Suppression Chamber Airspace Temperature	°F	95
Initial Suppression Chamber Airspace Relative Humidity	%	100
Initial Suppression Pool Temperature	°F	95
No. of Downcomers		96
Total Downcomer Flow Area	ft^2	301.6
Initial Downcomer Submergence (LWL)	ft	3.67

Table 5.2.3:2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
Downcomer I.D.	ft	2.00
Vent System Flow Path Loss Coefficient (includes exit loss)		5.17
Supp. Chamber (Torus) Major Radius	ft	54.50
Supp. Chamber (Torus) Minor Radius	ft	15.00
Suppression Pool Surface Area (in contact with suppression chamber airspace)	ft^2	9971.4
Suppression Chamber-to-Drywell Vacuum Breaker Opening Diff. Press.		
- start	psid	0.15
- full open	psid	0.5
Supp. Chamber-to-Drywell Vacuum Breaker Valve Opening Time	sec	1.0
Supp. Chamber-to-Drywell Vacuum Breaker Flow Area (per valve assembly)	ft^2	3.14
Supp. Chamber-to-Drywell Vacuum Breaker Flow Loss Coefficient (including exit loss)		3.47
No. of Supp. Chamber-to-Drywell Vacuum Breaker Valve Assemblies (2 valves per assembly)		6
LPCI/Containment Cooling Heat Exchanger K in Containment Cooling Mode	Btu/s-°F	See Table 5.2.3:3
LPCI/Containment Cooling Service Water Temperature	°F	95

Table 5.2.3:2 - Input Parameters Used for Containment Analysis

Parameter	Units	Value Used in Analysis
LPCI/Containment Cooling Pump Heat (per pump)	hp	700
Core Spray Pump Heat (per pump)	hp	800
Time for Operator to turn on LPCI/Containment Cooling System in Containment Cooling mode (after LOCA signal)	sec	600
Feedwater Addition (to RPV after start of event; mass and energy)		

Feedwater Node **	Mass (lbm)	Enthalpy * (Btu/lbm)
1	34658	308.0
2	96419	289.2
3	145651	268.7
4	91600	219.8
5	65072	188.4

* Includes sensible heat in the feedwater system pipe metal.

** Feedwater mass and energy data combined to fit into 5 nodes for use in the analysis.

Table 5.2.3:3 - LPCI/Containment Cooling System Parameters Used in Analysis of Section 5.2.3.3.1

Case No.	No. of Loops*	LPCI/ Containment Cooling Pumps Per Loop	LPCI/ Containment Cooling Flow** (gpm)	No. of CCSW Pumps	Total CCSW Pump Flow (gpm)	HX K (Btu/s-°F)
3	1	2	8,916	2	4,795	327.3
4	1	1	3,881	1	3,071	219.2

* There is one heat exchanger per loop.

** This is the LPCI/Containment Cooling System flow rate after 600 seconds and it is used in the containment spray mode.

Table 5.2.3:4 - Peak Suppression Pool Temperatures With Updated Containment Cooling Parameters

Case No.	Peak Suppression Pool Temperature (°F)
3	171
4	186

Table 5.2.3:5

Available NPSH for LPCI Pumps Post DBA LOCA

Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus Temp (°F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft^3/lb)	Vapor Pressure (psia)	Suction Piping Losses (ft)	NPSHA (ft)	NPSHR (ft)
3	8,916	4,458	171	19.1	13.32	0.016457	6.1318	3.75	40.3	26.9
4	3,881	3,881	186	20.6	13.32	0.016547	8.568	2.27	39.72	25.7

Reference: Calculation NED-M-MSD-43

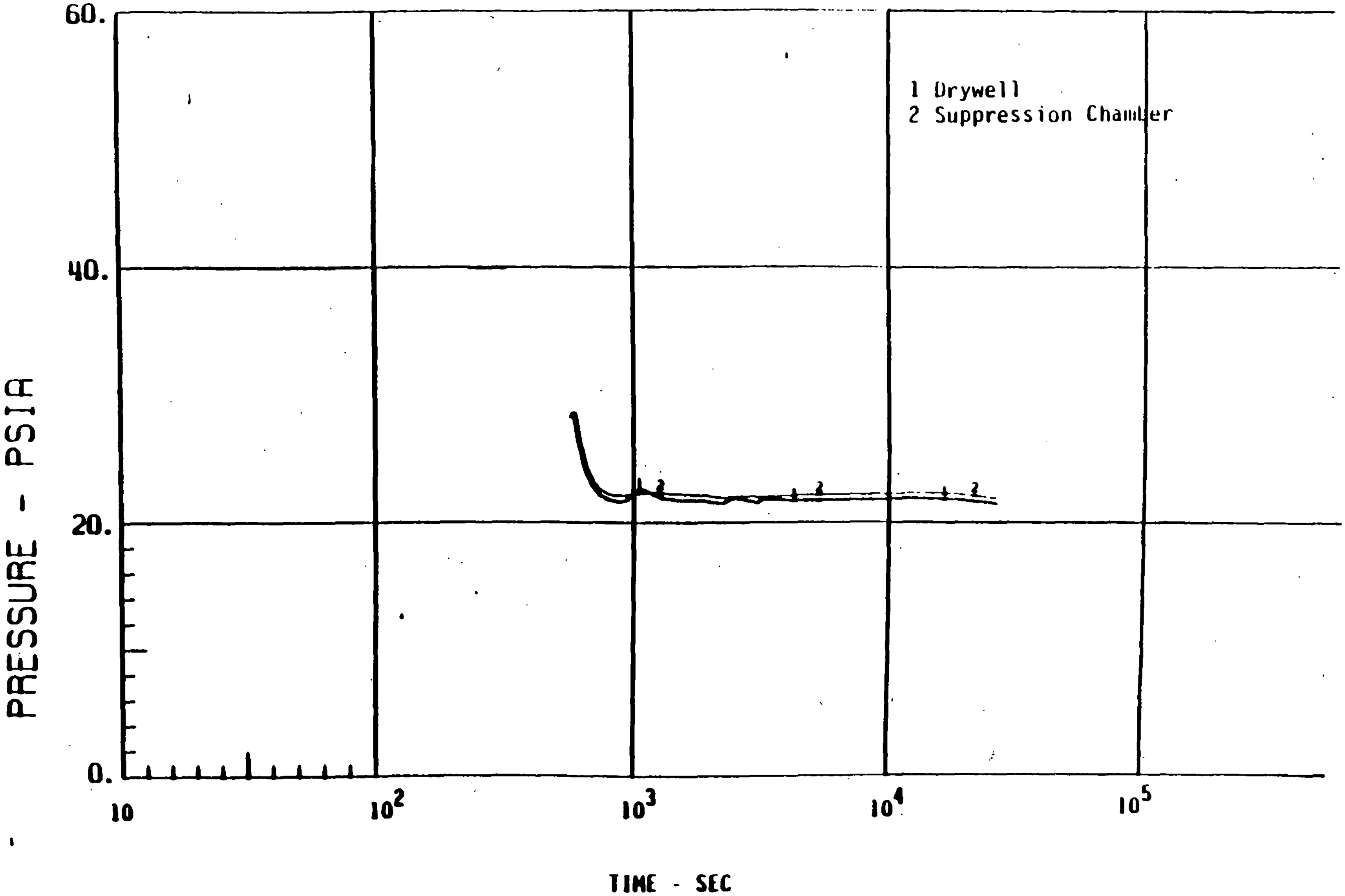

Figure 3 - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 3

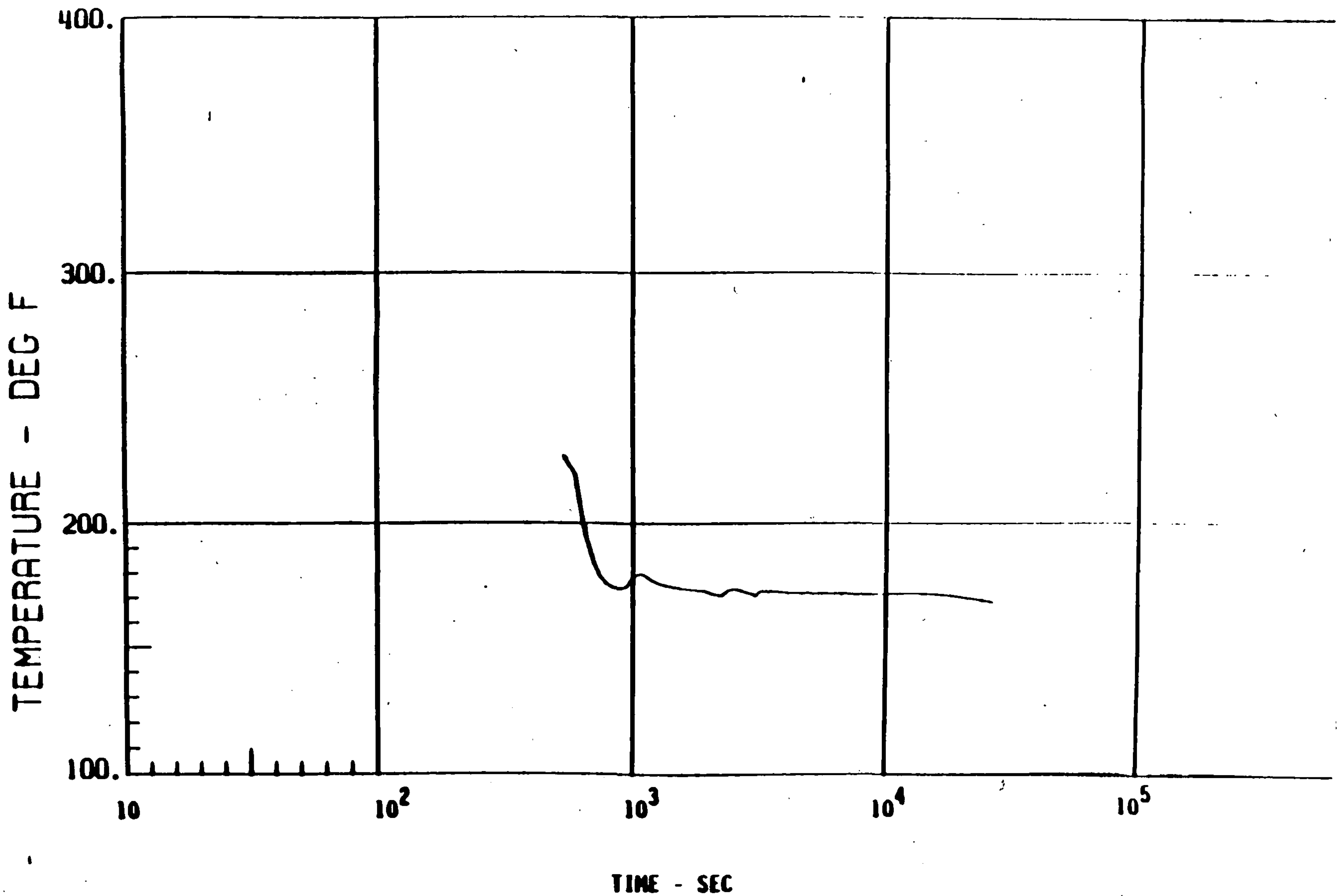

Figure ~~3A~~ - Long-Term DBA-LOCA Drywell Temperature Response for Case ~~3A~~
5.2.3:8

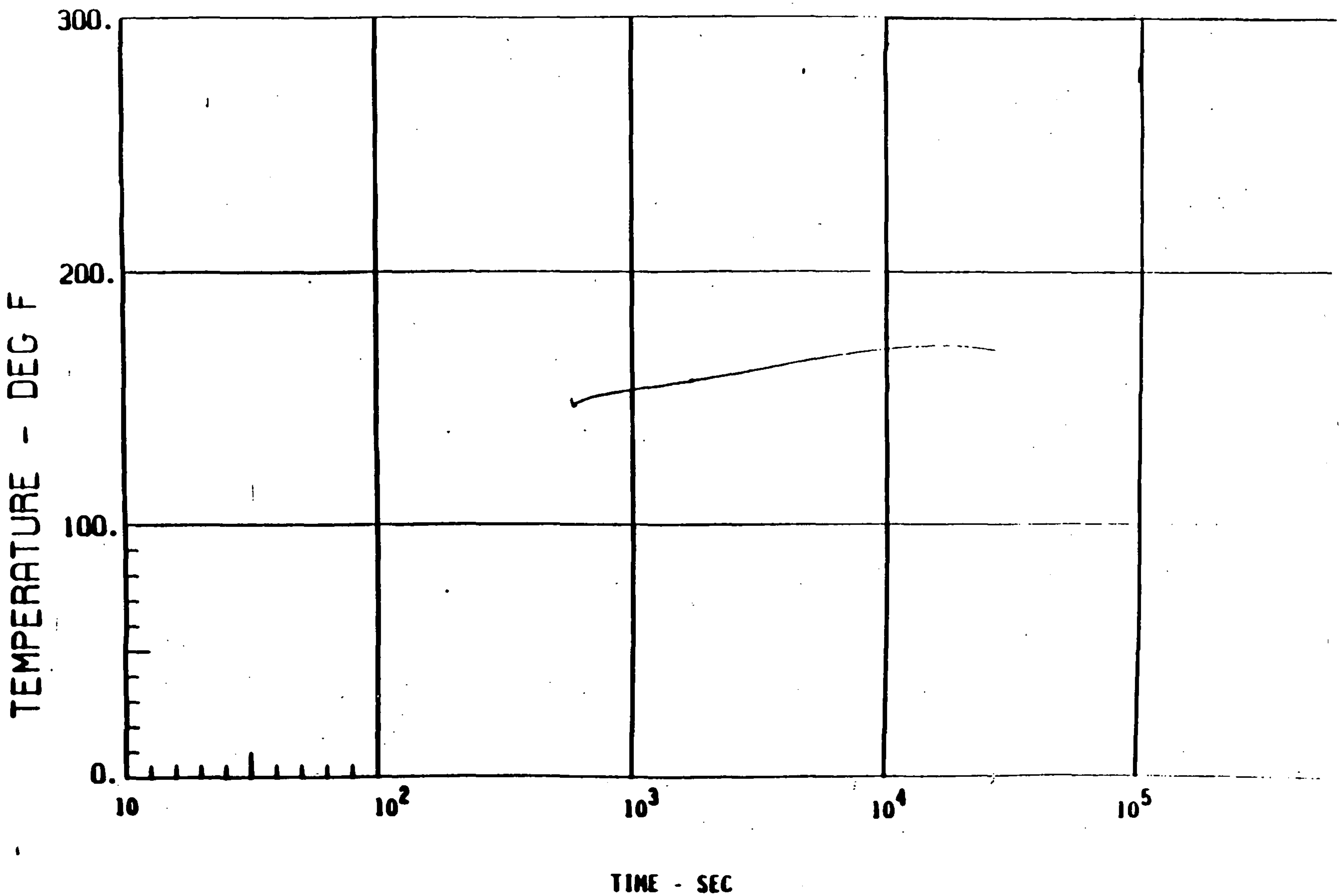

Figure ~~30~~ - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case 3A

5.2.3:9

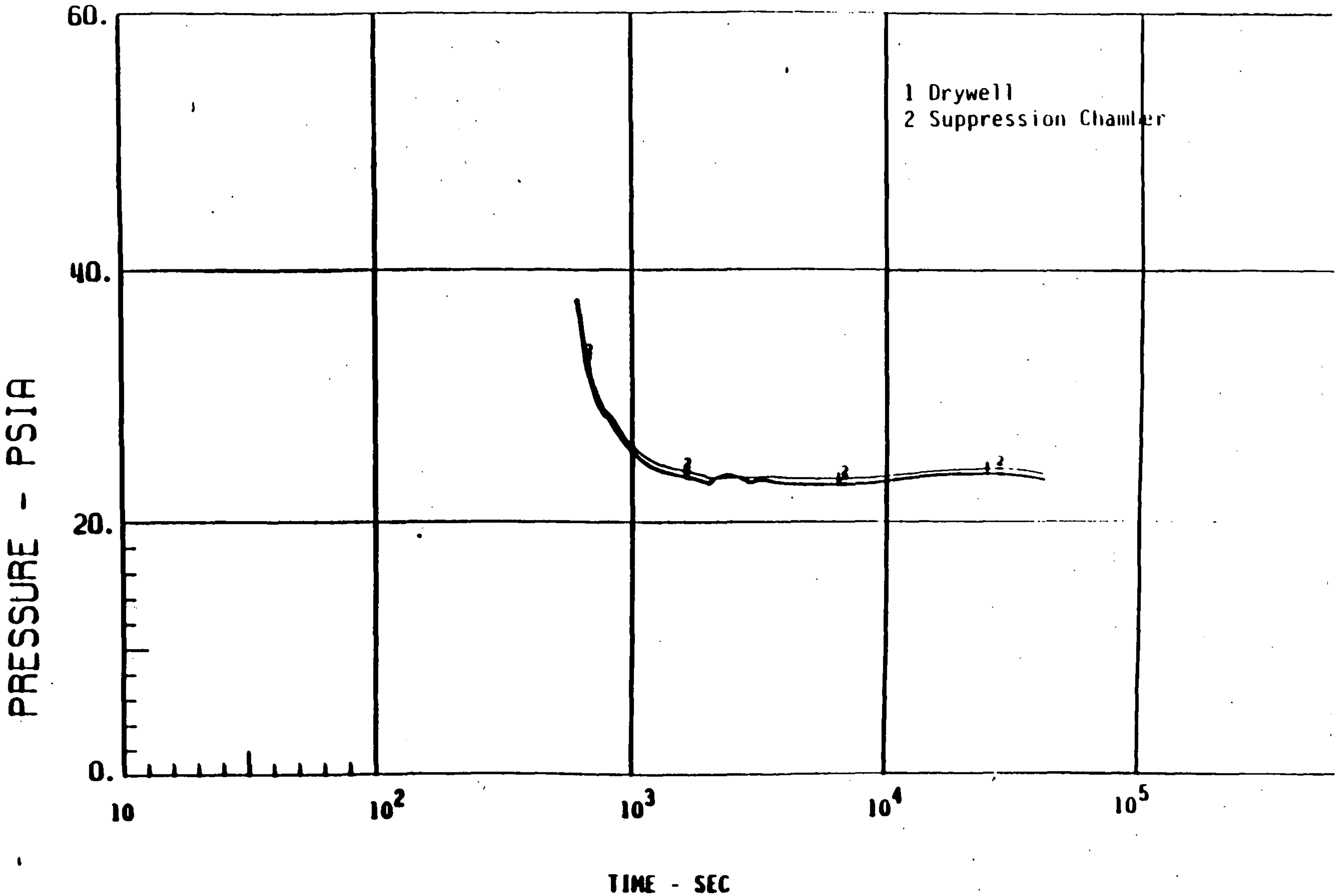

Figure ~~X~~ - Long-Term DBA-LOCA Drywell and Suppression Chamber Pressure Response for Case 4a

5.2.3.10

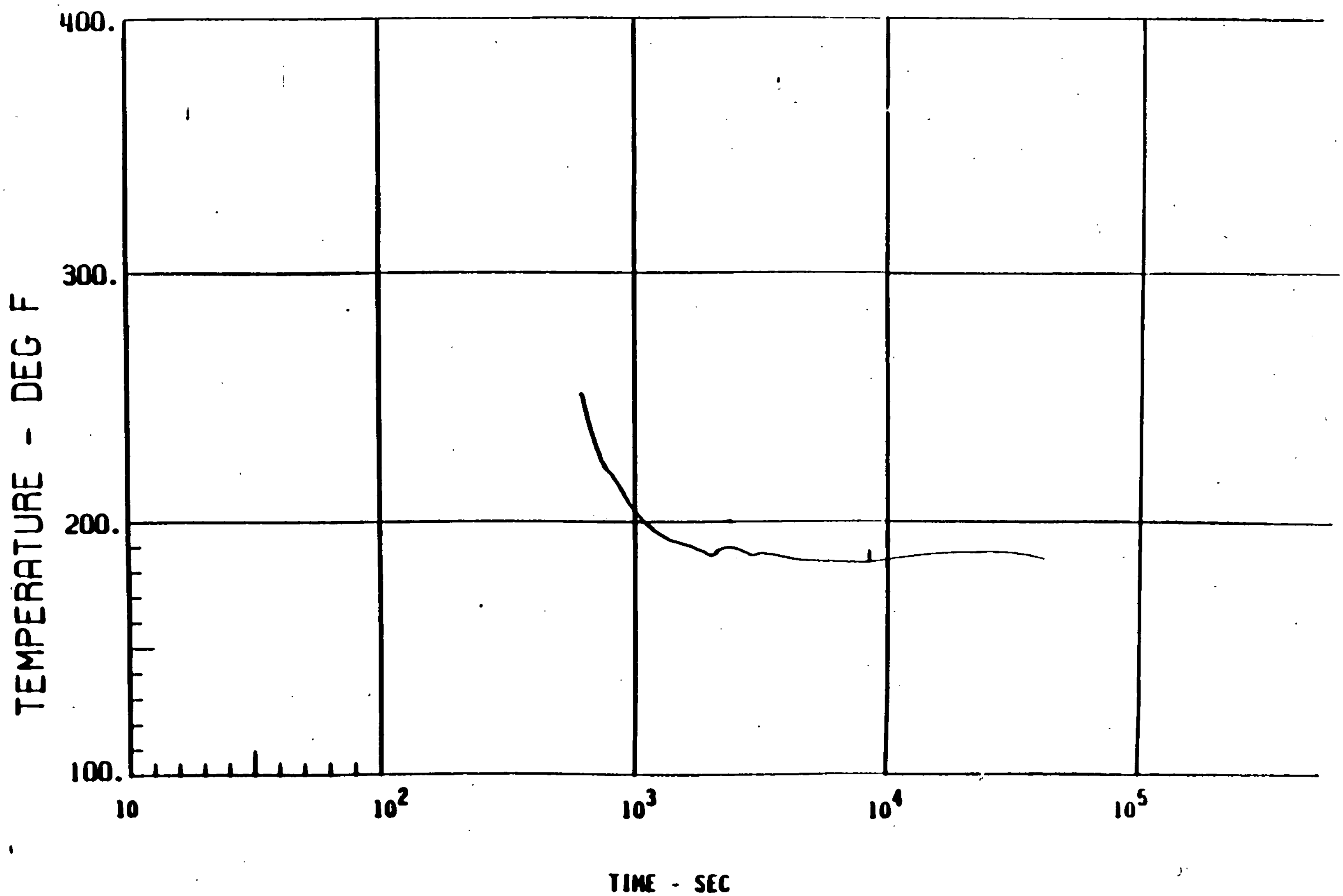

Figure ~~4K~~ - Long-Term DBA-LOCA Drywell Temperature Response for Case 4

5.2.3.11

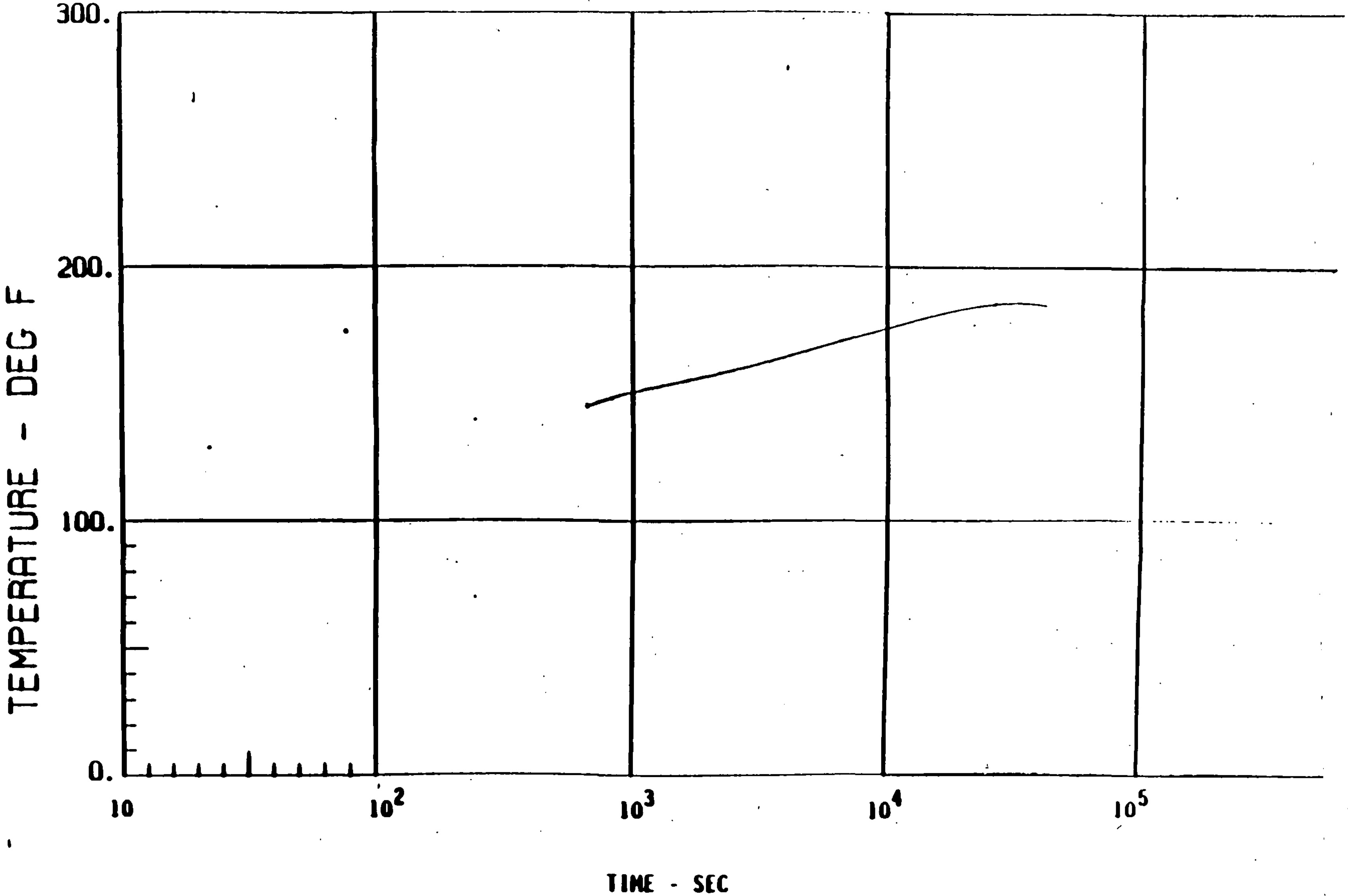

Figure ~~4B~~ - Long-Term DBA-LOCA Suppression Pool Temperature Response for Case ~~4A~~

5.2.3:12

TABLE 6.2.4:1

LPCI/CONTAINMENT COOLING EQUIPMENT SPECIFICATIONS

Main System Pumps

Number	4 (3 required to meet design basis)
Type	Single stage, vertical, centrifugal
Seals	Mechanical
Drive	Electric motor
Power source	Normal auxiliary or emergency diesel
Speed	3600 rpm
Pump casing	Cast steel
Impeller	Bronze
Shaft	Stainless steel
Code	ASME Section III B
Performance Characteristics - 3 pumps running	
At 0 psi reactor pressure	
Flow	5350 gpm each - 16,000 gpm total
Head	263 feet
Power	600 hp each - 1800 hp total
~~NPSH (Available)~~	~~33 ft~~
At 200 psi reactor pressure	
Flow	2675 gpm each - 8,000 gpm total
Head	565 ft
Power	490 hp each - 1500 hp total
~~NPSH (Available)~~	~~42 ft~~
Performance Characteristics - 1 pump running	
Flow	5990 gpm
Head	135 ft
Power	560 hp
~~NPSH (Available)~~	~~40 ft~~

Containment Cooling Service Water Pumps

Number	4 (2 needed to provide required cooling capacity)
Type	Horizontal, centrifugal
Power source	Auxiliary transformer or emergency diesel
Capacity	3500 gpm each - 7000 gpm total
Head (approximately)	435 ft

TABLE 6.2.4:1

LPCI/CONTAINMENT COOLING EQUIPMENT SPECIFICATIONS (Contd.)

Containment Cooling Service Water Pumps

Number	4 (2 needed to provide required cooling capacity)
Type	Horizontal, centrifugal
Power source	Auxiliary transformer or emergency diesel
Capacity	3500 gpm each - 7000 gpm total *see note below
Head (approximately)	435 ft

Heat Exchangers

Number	2
Heat load	~~95~~ 98.6 x 10^6 Btu/hr each (See Section 6.2.4.5)
Primary side flow (containment water)	10,700 gpm *see note below
Secondary side flow (river water)	7,000 gpm *see note below
dP - river water to containment water	20 psi
Design temperatures	
River water	95°F
Containment water	165°F
Primary (shell) design pressure	375 psi
Secondary (tube) design pressure	375 psi

Heat Exchanger Code

The shell side of the LPCI heat exchanger is constructed of carbon steel A212, Grade B. The heat exchangers (2 per unit) were built to ASME Section III (1965), Class C requirements as shown on the manufacturer's specification sheet. Signed Certificate of Shop Inspection Reports indicate that the heat exchangers were constructed in accordance with the applicable code.

Radiography Requirements (see Reference)

GE Specification No. 21A5451 (Rev. 1), Section 4.0 states that the exchanger shall be tested in accordance with ASME III, Class C. The Berlin Chapman Specification Sheet states that the heat exchanger was built to Section III. Also, the manufacturer's Data Sheet gives the shell joint efficiency of 100% and radiography as "Complete".

Containment Spray System

Containment Spray Headers	
Number	2
Size	8 in. sch. 160
No. nozzles (each)	160
Type nozzle	Fog jet
Suppression chamber spray header	
Number	1
Size	4 in. sch. 40
No. nozzles	12
Type	Fog jet

* The 10,700 and 7000 gpm are design parameters used for specification of the LPCI/CCSW heat exchanger. Other flow rates may be utilized for design basis evaluations (refer NFS letter and calculation RSA-D-42-01~~)~~ and also for the analysis described in Section 5.2.3.3.1

CECo's Nuclear Fuel Services (NFS) analyzed the effect of the lower heat rejection rate on the design basis LOCA. Their report documented that the most limiting case is for a situation where a small line break on the Isolation Condenser renders it inoperable coincident with one LPCI heat exchanger to be out of service. The final analysis shows the increase in maximum bulk torus water temperature to be less than 2°F. The resultant local temperature (195°F) is still well below the maximum permissible value of 205°F.

As determined by Perfex, the affect of this modification on flow induced vibration and seismic response will result in a design equal to or slightly more conservative than the original design. Additionally, AL-6XN's thermal expansion is close enough to that of the CuNi material so as to not cause a warpage problem during the combination of both the AL-6XN and CuNi tube material installed in the affected heat exchanger. The Station Technical Staff will be responsible for creating a new Eddy Current Test Standard for the future inspection of the new material.

For schedule and economic reasons, the tubes will be replaced as the old material fails. This will be ongoing task for many outages until all four (4) heat exchangers are completely retubed with the new material. To avoid holding the modification package open that long, the modification will be considered "complete" after the first outage that replaces any of the tubes with the new material.

To ensure that other design basis evaluations are not affected by the replacement of these tubes, the total number of plugged tubes plus tubes replaced with the new material will be limited to ~~6% of the total heat exchanger tubes.~~ a heat removal capability reduction equivalent to plugging of 6% of total tubes The 6% limit is based on the number of excess tubes provided in the LPCI heat exchanger design. This limit will ensure that the design basis of heat exchanger capability will not be reduced.

Based on the above information, the BWRED concludes that AL-6XN can be used to replace the existing CuNi heat exchanger tubing as required on an "as-needed" basis, in accordance with the guidelines above and in Reference 7.

6.2.4.5.5.0 **REFERENCES**

1. "LPCI Heat Exchanger M12-2-86-32 & 33 Dresden Station", SNED memo M. T. Fredrick to H. E. Bliss, 7/28/87.

2. "Suppression Pool Temperature Limits for BWR Containment", USNRC NUREG-0783, Rev. 1.

3. "RETRAN02 Analysis of Suppression Pool Temperature Response at Quad Cities 1/2 and Dresden 2/3", NFSR-0019.

4. "Dresden 2/3 Nuclear Generating Plant Suppression Pool Temperature Response", NEDC-22170, 7/82.

5. "Suppression Pool Temperature Monitoring System Bulk Temperature Accuracy Assessment for the Dresden 2 & 3 and Quad Cities 1 & 2 Stations", Nutech report COM-27-210, Rev. 0.

6. "RETRAN Computer Code Certification", NFSR-0026, 9/84.

7. "Recommendations for Tube Replacement versus Plugging on LPCI Heat Exchangers", NFS Transmittal dated November 24, 1992 T. Rieck to B. Viehl.

10CFR50.59 Safety Evaluation Cover Sheet

Station Dresden

Modification/Minor Plant Change # UFSAR UPDATE

Design Issues Worksheets have been completed prior to Safety Evaluation. The following design issues could impact the Safety Evaluation and should be considered during performance of the Safety Evaluation, particularly during Steps 5 (normal operation) and 6 (failure modes):

M13, M15, M16, M19, OP1, OP5,
R7, S7, ST1

[ ] This evaluation identified an Unreviewed Safety Question. See Item 14 on the 10CFR50.59 Safety Evaluation form.

[ ] A Technical Specification change is required and a Technical Specification Revision Request has been prepared. See Item 14 on the 10CFR50.59 Safety Evaluation form.

[X] This evaluation did not identify an Unreviewed Safety Question and no Technical Specification change is required. The modification or minor plant change may be installed without prior NRC approval.

Cognizant Engineer Date 12/1/92

Design Superintendent or Supervisor Date 12/1/92

Mod # UFSAR UPDATE ______________

Station/Unit Dresden ______________/______

Exhibit E
10CFR50.59 SAFETY EVALUATION

1. List the documents implementing the proposed change.

   N/A

2. Describe the proposed change and the reason for the change.

   The changes are being incorporated to correct inconsistencies between the UFSAR and the actual equipment/components of the LPCI/CCSW system. The changes are as follows:

   1) Provide the Design Basis parameters and results of analysis for Containment Long Term heat up post LOCA. These results include the resultant peak pool temperature post accident.
   2) Provide a revised acceptability for replacement of LPCI heat exchanger tubes with AL-6XN tube material.
   3) Provide a table with required NPSH and actual NPSH for the LPCI pumps under the analyzed conditions and parameters.

3. Is the change:

   [X] Permanent

   [ ] Temporary -
   Expected duration ______________

   AND
   Plant Mode(s) restrictions while installed ______________
   (NONE if no plant mode restrictions apply) ______________

4. List the SAR sections which describe the affected systems, structures, or components (SSCs) or activities. Also list the SAR accident analysis sections which discuss the affected SSCs or their operation. List any other controlling documents such as SERs, previous modifications or Safety Evaluations, etc.

   UFSAR Sections 5.2, 6.2 and 14.2

   SER 104301

   50.59 Safety Evaluation for previous UFSAR change on LPCI Heat Exchanger Tube Replacement dated April 7, 1992

Exhibit E
10CFR50.59 SAFETY EVALUATION

5. Describe how the change will affect plant operation when the changed SSCs function as intended (i.e., focus on system operation/interactions in the absence of equipment failures). Consider all applicable operating modes. Include a discussion of any changed interactions with other SSCs.

   The changes being made to the UFSAR will not affect plant operation. The Tech Spec surveillance limits for the LPCI and CCSW pumps are unchanged by these changes to the UFSAR. The changes consist of the following:
   1) Updates to Section 6.2 which provide clarifications on the LPCI/CCSW Pump flows and the heat exchanger duty.
   2) Updates to Section 5.2.3.3 which provide the Bases and results of the long term containment heat up analysis post LOCA.
   3) Updates to Section 6.2.4.5.1.0 to provide conditions under which tube replacements with AL-6XN tube material may be performed.

6. Describe how the change will affect equipment failures. In particular, describe any new failure modes and their impact during all applicable operating modes.

   The descriptive changes will not affect any equipment failures. The analysis was performed to verify that the existing equipment will satisfy the requirements of the Design Basis Accident (DBA).

7. Identify each accident or anticipated transient (i.e., large/small break LOCA, loss of load, turbine missiles, fire, flooding) described in the SAR where any of the following is true:
   - The change alters the initial conditions used in the SAR analysis
   - The changed SSC is explicitly or implicitly assumed to function during or after the accident
   - Operation or failure of the changed SSC could lead to the accident

ACCIDENT	SAR SECTION
LOCA	14.2

Exhibit E
10CFR50.59 SAFETY EVALUATION

8. List each Technical Specification (Safety Limit, Limiting Safety System Setting or Limiting Condition for Operation) where the requirement, associated action items, associated surveillances, or bases may be affected. To determine the factors affecting the specification, it is necessary to review the FSAR and SER where the bases section of the Technical Specifications does not explicitely state the basis.

   SECTIONS 3.5/4.5, 3.7/4.7

9. Will the change involve a Technical Specification revision?

   [ ] Yes [X] No

   If a Technical Specification revision is involved, the change cannot be implemented until the NRC issues a license amendment. When completing Step 14, indicate that a Technical Specification revision is required.

Exhibit E
10CFR50.59 SAFETY EVALUATION

10. To determine if the probability or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the SAR may be increased, use one copy of this page to answer the following questions for each accident listed in Step 7. Provide the rationale for all NO answers.

Affected accident LOCA

SAR Section: 14.2

May the probability of the accident be increased? [ ] Yes [X] No

The updates to the UFSAR have no affect of the porbability of the accident because no physical changes are being made to any equipment or systems.

May the consequences of the accident (off-site dose) be increased? [ ] Yes [X] No

The analysis has verified that the revised parameters provide the same level of accident mitigation as originally designed.

May the probability of a malfunction of equipment important to safety increase? [ ] Yes [X] No

The changes are being made to the Design Basis and no equipment changes are being made, therfore the probability of equipment failure remains unchanged.

May the consequences of a malfunction of equipment important to safety increase? [ ] Yes [X] No

The accident mitigation capability fo the Containment System is unchanged from the original design analysis. The analysis validates the capability of the exisitng equipment to perform its original design function.

If any answer to Question 10 is YES, then an Unreviewed Safety Question exists.

Exhibit E
10CFR50.59 SAFETY EVALUATION

11. Based on your answers to Questions 5 and 6, does the change adversely impact systems or functions so as to create the possibility of an accident or malfunction of a type different from those evaluated in the SAR?

    [ ] Yes [X] No

    Describe the rationale for your answer.

    The analysis validates the ability of existing LPCI/CCSW system components to perform their original design functions. No physical equipment changes have been made, therefore is no possibility of an unanlyzed accident occurring.

    If the answer to Question 11 is Yes, then an Unreviewed Safety Question exists.

Exhibit E
10CFR50.59 SAFETY EVALUATION

12. Determine if parameters used to establish the Technical Specification limits are changed. Use one copy of this page to answer the following questions for each Technical Specification listed in Step 8. List the Technical Specification, Technical Specification Bases, SAR and SER Sections reviewed for this evaluation.

TECH SPEC 3.5, 3.7 4.5, 4.7
UFSAR SECTIONS 5.2 AND 6.2
SER 104301

Evaluation of Technical Specification
(Enter N/A if none are affected and check last option.)

N/A

(Check appropriate condition):

[ ] All changes to the parameters or conditions used to establish the Technical Specification requirements are in a conservative direction. Therefore, the actual acceptance limit need not be identified to determine that no reduction in margin of safety exists - proceed to Question 13.

[ ] The Technical Specification or SAR provides a margin of safety or acceptance limit for the applicable parameter or condition. List the limit(s)/margin(s) and applicable reference for the margin of safety below - proceed to question 13.

[ ] The applicable parameter or condition change is in a potentially non-conservative direction and neither the Technical Specification, the SAR, or the SER provides a margin of safety or an acceptance limit. Request Nuclear Licensing assistance to identify the acceptance limit/margin for the Margin of Safety determination by consulting the NRC, SAR, SER's or other appropriate references. List the agreed limit(s)/margin(s) below.

[X] The change does not affect any parameters upon which Technical Specifications are based; therefore, there is no reduction in the margin of safety. Proceed to question 14.

List Acceptance Limit(s)/Margin(s) of Safety

Exhibit E
10CFR50.59 SAFETY EVALUATION

13. Use the above limits to determine if the margin of safety is reduced (i.e., the new values exceed the acceptance limits). Describe the rationale for your determination. Include a description of compensating factors used to reach that conclusion.

<u>If a Margin of Safety is reduced an Unreviewed Safety Question exists.</u>

Exhibit E
10CFR50.59 SAFETY EVALUATION

14. Check one of the following:

[ ] An Unreviewed Safety Question was identified in Step 10, Step 11, or Step 13. The proposed change MUST NOT be implemented without NRC approval.

[X] No Unreviewed Safety Question will result (Steps 10, 11, and 13) AND no Technical Specification revision will be involved. The change may be implemented in accordance with applicable procedures.

[ ] A Technical Specification revision is involved; but no Unreviewed Safety Question will result. The proposed change requires a License Amendment. Notify Station Regulatory Assurance and Nuclear Licensing that a Technical Specification revision is required. Mark below as applicable.

[ ] The change is not a plant modification or minor plant change and will not be implemented under 10CFR50.59. Upon receipt of the approved Technical Specification change from the NRC, the change may be implemented.

[ ] The change is a plant modification or minor plant change. Mark below as applicable.

[ ] A revision to an existing Technical Specification is required. The change MUST NOT be installed until receipt of an approved Technical Specification revision.

[ ] The change will not conflict with any existing Technical Specifications and only new Technical Specifications are required. In these cases, Nuclear Licensing may authorize installation, but not operation, prior to receipt of NRC approval of the License Amendment. If such authorization is granted, the block below should be checked.

[ ] Nuclear Licensing has authorized installation, but not operation, prior to receipt of NRC approval of the License Amendment. The 10CFR50.59 Safety Evaluation indicates that no Unreviewed Safety Question will result and provides authority for installation only.

Mod # UFSAR UPDATE

Station/Unit Dresden /

Exhibit E
10CFR50.59 SAFETY EVALUATION

Note: Partial Modifications and/or separate 10CFR50.59 reviews for portions of the work may be used to facilitate installation.

Preparer ____________________ 12/1/92
(Cognizant Engineer) Date

15. The reviewer has determined that the documentation is adequate to support the above conclusion and agrees with the conclusion.

Reviewer Brian Viehl 12/1/92
(Design Superintendent/Supervisor) Date

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
ELECTRICAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
E 1	Is Class 1E equipment involved?	safety related electrical or I&C system, basis described in design input document	NO	THE CHANGE IS TO THE UFSAR ONLY, NO EQUIPMENT CHANGES ARE BEING PERFORMED
E 2	Is there any potential for control and power circuit interaction?	separation of voltage classes, induction effects on control signals	NO	THE CHANGE IS TO THE UFSAR ONLY, NO EQUIPMENT CHANGES ARE BEING PERFORMED
E 3	Has a sneak circuit analysis been completed?	potential shorts, inadvertent connections, unintended operating mode	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 4	Is redundancy of existing systems reduced or compromised?	backup of protection system, fire zone consideration, independent control station, interconnection of redundant system, power supply crossties	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 5	Are safety related circuits isolated and separated from non-safety related circuits?	buffer amplifiers, automatic switchgear, separate cable runs, electrical and physical separation	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 6	Is safety related (Class 1E) bus integrity maintained?	bus capacity, automatic isolation, load shedding	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 7	Has diesel generator or battery loading been checked?	overload potential, load sequencing and shedding, uninterruptible power	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 8	Are there adequate fail safe protection features for both components and systems?	automatic transfer, redundant systems, failure mode status	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
ELECTRICAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
E 9	Does the design provide fault trip coordination on the system and interfacing systems?	minimize extent of outage, interaction with load shedding, operations sequencing, timing	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 10	Is actuation time of protection devices and circuitry compatible with all requirements?	response time, reactor trip time, containment isolation, interaction with other systems	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 11	Are in-service periodic testing and inspection of system performance addressed?	availability for testing, frequency of testing, potential for undesirable side effects	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 12	Does the modification of control panels incorporate human factors objectives? (human factors requires a separate evaluation)	control panel layout, control function, separate evaluation, control room panels and remote panels	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 13	Has bypass and inoperable status indication of Class 1E protection equipment been included in the design?	verification of status, technical specification compliance, operational requirement	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 14	Does the design adequately address Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI)?	new off-site sources, new electrical or electronic equipment, new on-site communication devices, hand-held radio signals	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 15	Do system logic configuration changes alter system design?	logic diagram, instrument loop diagram	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS ELECTRICAL ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
E 16	Are there any grounding changes or requirements?	equipment ground, ground grid, disconnecting a ground	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 17	Have Control Room Panel additions and deletions been revised for seismic qualification impact?	equipment changes, impact on seismic qualification of panel, panel requalification	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
E 18	Are there any other Electrical or I&C Issues that should be addressed? If so, list and discuss them here.		NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS
FIRE PROTECTION ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
F 1	Have all ignition sources been adequately controlled?	hydrogen in containment arcing contacts, static electric charges, open flames, off-gas control	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 2	Do any additional sources of energy cause the capacity to a fire zone to be exceeded?	combustibles, materials that could react to produce combustible gas, Zn or Al in containment	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 3	Are all materials of construction appropriate for fire protection purposes?	excessive propagation rate, controlled materials, radiation effects, potential for failure in a fire	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 4	Is there additional storage of combustible material or have combustible materials been added as part of modification?	electrical insulation coatings, gas supplies, additional cable trays constitute added fire loading	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 5	Are there any new potential paths for fire propagation or crossing of fire zone boundaries?	holes through fire walls or stops, ducts, damper failure mode	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 6	Have changes compromised testing or inspection of the fire protection system?	thermal insulation or shielding which could block access	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
F 7	Have any changes been made that degrade required fire detection, control or protection?	new failure modes, move or penetrate fire walls, reduce capacity of water supply system, tie-in to fire detection system	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS
FIRE PROTECTION ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
F 8	Are there any other Fire Protection Issues that should be addressed? If so, list and discuss here.		NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
FLOODING ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
FL 1	Is there any increase in the potential for internal flooding?	circulating water, condenser, D-6 pipe lines, Suppression pool, Fan coolers, Service Water heat exchangers, Drywell chillers, Sprinklers, failed check valves, augumented fire protection systems	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
FL 2	Are any areas or equipment susceptible to flood damage?	Lower levels, Watertight rooms, Electrical equipment close to floor, Pumps, Motors, Air Compressors, Electrical Buses, Breakers, direct or indirect failure	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
FL 3	Are any potential paths for flood propagation created?	Holes through walls, floors, & doors designed to be watertight, Floor Drains, Ventilation Ducts, backflow, siphoning, site topography	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
FL 4	Is the capability to isolate or cope with flooding reduced?	extended removal or disengagement of valves, pumps alarms, indicators, sampling systems, opening or isolating pipeline, blocking or closing drains, sumps.	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
FL 5	Are there adequate design considerations to mitigate flooding?	leak protection or isolation devices drainage systems, barriers, separation of equipment	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS
FLOODING ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
FL 6	Are there any other Flood Protection Issues that should be addressed? If so, list and discuss here.		NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
MECHANICAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
M 1	Are any high energy lines added or affected?	jet impingement, pipe whip, special supports	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 2	Is the vulnerability to internally generated missiles increased?	new missile source(s), pump rotor breakup, valve stem ejection, pressure vessel appendages, change in missile protection requirement	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 3	Is the vulnerability to externally generated missiles increased?	tornado driven object, airplane, protection for new facilities, change in missile protection requirement	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 4	Is there a potential for loose particles within piping systems or components? If so, how is it addressed?	cleanliness requirements, heat exchanger plugging, effect on in-line devices	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 5	Could deformation or catastrophic failure impair the safety function of the system, components or structures being modified, or other surrounding safety related systems?	equipment support failure results in degradation of safety system directly or indirectly, over pressurization failure, excessive flow forces on valve stem causing misoperation	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 6	Is the safety classification of modified systems consistent with and appropriate for the safety classification of existing systems?	modification of interconnecting systems, change from non-safety related to safety related at containment penetration, support attachment point, compatibility of appendages	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS MECHANICAL ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
M 7	Is double valve isolation used if changes from class 1 to any other class or non-class portions of a system, or when a system is in direct contact with containment atmosphere? Is a single valve isolation used in changes from class 2 to class 3, class 2 to non-class, or class three to non-class portions of a system?	containment isolation valves, safety classification change within a piping system	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 8	Does the system have the required fail safe protection? Is the safety function of the interfacing safety systems preserved upon failure?	fail open, fail close, or fail as is at both the components	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 9	Is the redundancy of existing systems reduced by inadequate reliability?	backup system for redundancy, adequate reliability designed in for proper redundancy	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 10	Is there an environmental qualification requirement? (environmental qualification requires a separate evaluation)	certified to operate in a specified temperature, humidity, and radiation environment; by test, by verification analysis, or a combination	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 11	Are there any changes to the environmental profile of an environmental qualification zone?	high energy line routing, changes in process parameters	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS
MECHANICAL ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
M 12	Is seismic qualification required?	maintain structural integrity; operate during and after seismic event; category II over category I	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 13	Have all appropriate design loads (new and existing) in addition to seismic loads been identified?	hydrodynamic loads, pipe break loads, thermal loads	YES	THE REANALYSIS WAS PERFORMED TO VERIFY THE ADEQUACY OF THE LPCI SYSTEM WITH REVISED CAPABILITIES OF THE HEAT EXCHANGERS. ALL LOADS USED WERE VERIFIED AS APPROPRIATE BEFORE COMPLETION OF THE ANALYSIS.
M 14	Has the compatibility of materials been evaluated?	material considerations, prohibited materials, sealants, coatings, insulation, effect of radiation, erosion/corrosion resistance, containment restrictions on some materials, stainless/non-stainless interfaces misoperation	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 15	Have changes been made that could affect the NPSH for any pump?	excessive pressure loss in suction piping, cavitation, fluid temperature change	YES	THE ANALYSIS PRODUCED POTENTIAL INCREASED TEMPERATURES FOR THE TORUS WATER WHICH IS THE SUCTION SOURCE FOR THE LPCI PUMPS. THE REQUIRED AND ACTUAL NPSHs FOR THE PUMPS HAS BEEN CALCULATED TO VERIFY ACCEPTABILITY.
M 16	Are there any changes in process parameters?	balance of flows, temperature, pressure limitation of existing system capability, impact on design function	YES	THE ANALYSIS USED CHANGED PARAMETERS FOR THE HEAT REMOVAL CAPABILITIES OF THE LPCI HEAT EXCHANGERS BASED ON REDUCED FLOWS THROUGH THE HX FROM BOTH LPCI AND CCSW. THESE PARAMETERS WERE INDEPENDENTLY VERIFIED PRIOR TO USE IN THE ANALYSIS.

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
MECHANICAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
M 17	Valve Performance as it relates to system function: - can the valve be placed and maintained in the appropriate position for normal system operation, abnormal system operation, and testing mode? - If the valve is a primary containment isolation valve, can it be closed (if necessary) during the long term phase of a Design Basis Event (DBE)?	valve, containment isolation valves, valve orientation/configuration, Design Basis Event, valve closure time, isolation logic changes	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 18	Have short-term and long-term containment isolation requirements been satisfied?	containment isolation	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
M 19	Have the rules for single failure criteria been applied correctly?	single failure criteria	YES	THE ANALYSIS USES THE LIMITING CASE OF PUMP AVAILABILITY BASED ON A LOCA/LOOP SCENARIO.
M 20	Are there any other Mechanical Issues that should be addressed? If so, list and discuss here.		NO	NONE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
OPERATIONAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
OP 1	Will the operating conditions of this or any other system be changed?	temperature, pressure, flow, cooling water supply, electrical power interruptions	YES	THE OPERATING PARAMETERS AND TECHNICAL SPECIFICATION VALUES FOR THE LPCI AND CCSW PUMP SURVEILLANCES HAVE BEEN VALIDATED BY THIS ANALYSIS.
OP 2	Will the operation of any other system have any effect on the system being modified?	shared source of power system fluid, interlocks, emergency power priorities	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
OP 3	Will the change have any impact on adjacent systems?	failure modes, reduction in availability or reliability	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
OP 4	Can the change affect the operation of another system indirectly?	shared systems, cascading effect, ripple effect	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
OP 5	Has the impact on operability tests been considered?	surveillance, operability test, channel check, calibration	YES	THE TECH SPEC SURVEILLANCE VALUES FOR LPCI AND CCSW PUMP PERFORMANCE HAVE BEEN VALIDATED BY THIS ANALYSIS.
OP 6	Are there any other Operational Interaction Issues that should be addressed? If so, list and discuss them here.		NO	NONE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
RADIOLOGICAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
R 1	Are there any changes that affect the engineered safety feature ventilation system?	wet HEPA filters, cross-connection, bypass or leakage	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 2	Are there any changes to the controlled leakage systems (BWR), such as a change in back pressure?	high filter pressure drop, backup through air intakes, structural integrity	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 3	Are stores of personnel protective equipment preserved?	emergency air supplies for control room personnel, emergency breathing air supplies, impaired access	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 4	Are there any effects on radiation detection and monitoring or alarm systems?	false readings due to placement, unintended shielding, side effects of enclosures	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 5	Are there any effects on containment isolation systems, ventilation systems or containment cleanup system?	reliability, operability, access, containment spray system, iodine removal	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 6	Has separation or primary/secondary coolant systems (PWR) or containment drywell (BWR) been maintained?	secondary side detection system, equipment leakage, boundary changes	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 7	Are there any effects on fission product control for incidents/accident or post accident cleanup and monitor points?	containment spray - cleanup system	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS RADIOLOGICAL ISSUES

Mod #UFSAR UPDATE

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
R 8	Have adequate provisions been made to control effluent containment levels?	monitoring required, human error protection, potential releases, sump contamination	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 9	Is there any potential for additional radiation exposure?	decontamination, ALARA, reduction in shielding	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
R 10	Are there any other Radiological Issues that should be addressed? If so, list and discuss here.		NO	NONE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS   Mod #UFSAR UPDATE
SITE RELATED ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
S 1	Is there any change in the exclusion area or site boundary conditions which would increase the on-site or off-site dose rates?	Change the fence line, construct a new building containing radioactive materials, relocate activated materials.	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 2	Is the site radioactive material inventory control affected?	quantity or composition of radioactive materials on site - increased or changed	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 3	Are release and dispersion of effluents affected?	stack height change, concentration of radwaste, or other factors affecting effluent pathways, containment isolation valve leak rates or closure times	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 4	Are there any changes affecting protection of safety class structures from natural phenomena and meteorological conditions (tornados, rain loads, snow loads)?	failure effects of non-safety related structure or system, change to surface water control structures, secondary effects	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 5	Are there any potential effects on security barriers or controlled access?	placing equipment in close proximity to guardhouse or security equipment	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 6	Are any potential hazards added to the site or exclusion area?	fire source, explosive material, toxic material, radwaste material, on-site or off-site, permanent or temporary.	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 7	Are there any changes to cooling water supply capacity or characteristics?	quantity, temperature, sediment content, aquatic growth potential, flowrates, pump curve changes, etc.	YES	THE REVISED PARAMETERS USED IN THE ANALYSIS ACCOMMODATE THE REDUCED CAPABILITY OF THE LPCI HEAT EXCHANGERS FOR HEAT REMOVAL AT REDUCED CCSW FLOWS.

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
SITE RELATED ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
S 8	Is the stability of subsurface materials or foundations for Class 1 structures affected directly or indirectly?	ground water level, soil ph, soil response to excitation, excavating near existing structures, subsidence	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 9	Is plant access altered or affected?	roadway or railroad changes, GSEP, access gate change, underground tunnel	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 10	Will site topography changes increase the potential for external flooding?	excavation, topography	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
S 11	Are there any other Site Related Issues that should be addressed? If so, list and discuss here.		NO	NONE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

DESIGN ISSUES WORKSHEETS Mod #UFSAR UPDATE
STRUCTURAL ISSUES

No.*	DESIGN ISSUE	KEY WORDS	IS ISSUE RELEVANT?	PROVIDE BASIS FOR CONCLUSION
ST 1	What is the seismic classification of the structure?	Category I or non-seismic	YES	THE CONTAINMENT STRUCTURE IS SEISMIC CATEGORY I. THE LOCA ANALYSIS ON LONG TERM SUPPRESSION POOL HEAT UP IS NOT DEPENDENT ON THE SEISMIC QUALIFICATION OF THE STRUCTURE.
ST 2	Is the response characteristic of the existing structure changed by the modification?	subsystem analysis, fundamental frequency, stiffness, coupling, adding or redistributing mass	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
ST 3	Does the modification degrade the structure integrity of the existing structure?	enlarge openings, create numerous discontinuities, additional loads, penetrations, cumulative effects	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
ST 4	Does the modification create the possibility of failure due to failure of non-seismic equipment affecting nearby seismic category I equipment?	Seismic II over I, non-seismic/non-safety structures or equipment	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
ST 5	Are there any changes that would affect testing and/or in-service inspection of the structure?	obstruct surface, reduce availability for testing, restrict access	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
ST 6	Has qualification by testing, as opposed to analysis, been considered for seismic structures or components?	purchase of seismically qualified structures or components, size limit, weight limit	NO	CHANGES ARE TO THE UFSAR ONLY. NO EQUIPMENT/PLANT PHYSICAL CHANGES ARE BEING MADE
ST 7	Are there any other structural issues that should be addressed? If so, list and discuss here.		NO	NONE

* List this item on the 10CFR50.59 Safety Evaluation Cover Sheet if the issue changes the normal operation or the failure modes/effects resulting from the modification.

November 30, 1992
CHRON # 194770

To: C. Schroeder

Subject: Post DBA-LOCA LPCI NPSHA Evaluation

References:
1. Nuclear Engineering Department calculation NED-M-MSD-43, "Dresden LPCI Pumps NPSHA Evaluation Post DBA-LOCA". dated November 30, 1992.
2. General Electric Report No. GENE-770-26-1092 "Dresden Nuclear Power Station Units 2 & 3 LPCI/Containment Cooling System Evaluation", November, 1992.

Post DBA-LOCA torus conditions were determined by GE in Reference 2 and were used to calculate the available NPSH for the LPCI pumps at Dresden Station (Reference 1). The results (Table 1) indicate that the available NPSH is greater than the NPSH required (with margin) for all four cases analyzed in Reference 2, and therefore adequate to protect the pump under these conditions.

If there are any questions or comment, please contact Harry Palas at x7494.

prepared by: Harry Palas

Harry Palas
M/S Design

approved by: Paul E Dietz

Paul Dietz
Equipment Specialists
Supervisor

cc: S. Eldridge
R. Kolflat

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

QE-51.D
EXHIBIT B
REV. 3

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):

$$\text{NPSHA (ft)} = \text{Torus Pressure} + \text{Static Head} - \text{Vapor Pressure} - \text{Suction Losses} \quad (1)$$

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)

	SINGLE PUMP				2 PUMP		
Q	NPSHR*	h_L	NPSHR + h_L - 0.87	P_{OUT}	h_L	NPSHR + h_L - .87	P_{OUT}
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	4.55	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

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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 3-64?
☐	☐	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	Harry Palas	2/11/93	[illegible]	2/11/93	Paul E Dietz	2/11/93

QE-51.D
EXHIBIT B
REV. 3

COMMONWEALTH EDISON COMPANY

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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

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	5000	180	19.9
4A	1	3881	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:

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

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" ID= 23.25"	Entrance loss 90 deg elbow (LR)[b] 45 deg elbow gate valve reducing tee (thru) 16' straight pipe[d]	- 1 1 1 1 -	---- 0.19 0.19 0.10 0.24 	 8.26	0.6
	Total		0.72	8.26	0.6
2-1502A-14" ID= 13.25"	reducer, 24x14 90 deg elbow 45 deg elbow gate valve strainer 4' straight pipe[d]	1 2 1 1 1 -	0.07[c] 0.78 0.21 0.10 ---- 	 3.62	 0.8
	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:

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

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

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

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

Calc. No. NED-M-MSD-43 Rev 1

Dresden LPCI/Core Spray Pumps NPSHA Evaluation - Post DBA LOCA

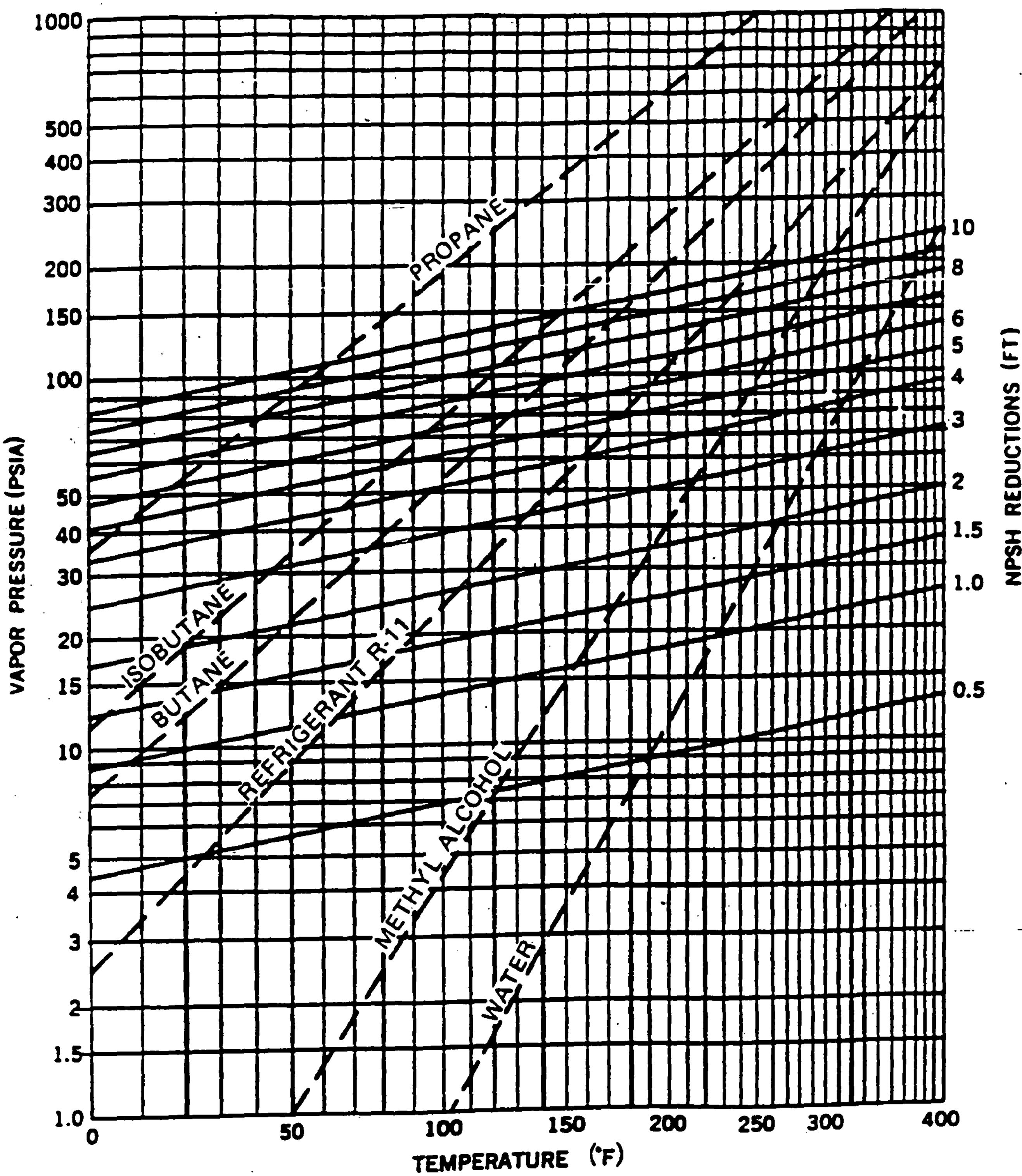


Figure 1.29 NPSH reductions for pumps handling hydrocarbon liquids and high-temperature water (Courtesy Hydraulic Institute Standards of 1975.)

FIGURE 1 (Ref. 11, p.56)

REVIEW CHECKLIST

CALCULATION NO: NED-M-MSD-43	REV. 1	PAGE 13 OF 13
REVIEWED BY: Dan K. Lu		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	
☐	☐	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?

Appendix A

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

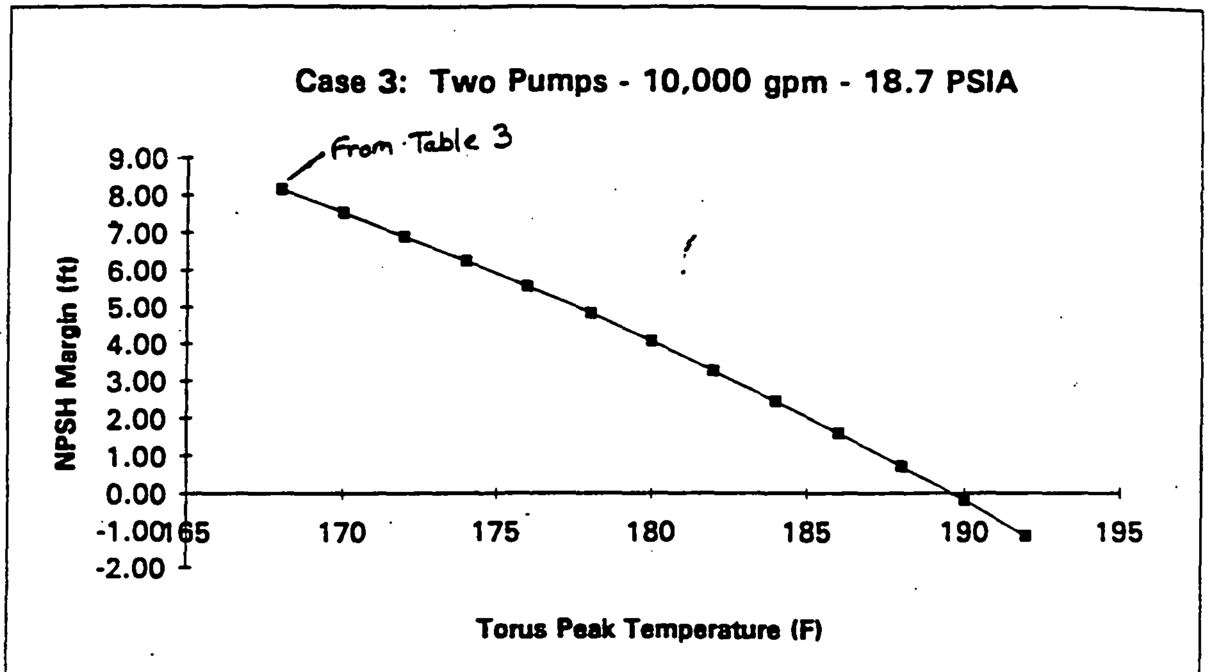
Case	Total Flow (gpm)	Single Pump Flow (gpm)	Torus* Temp (F)	Torus Pressure (psia)	Static Head (ft)	Specific Volume (ft3/lb)	Vapor Pressure (psia)	Suction Losses (ft)	NPSHA (ft)	NPSHR (ft)	1800 s Margin (ft)	600 s Margin (ft)
3'	10000	5000	172	18.7	13.29	0.016463	6.274	5.87	36.88	30.00	6.88	8.14
3A'	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



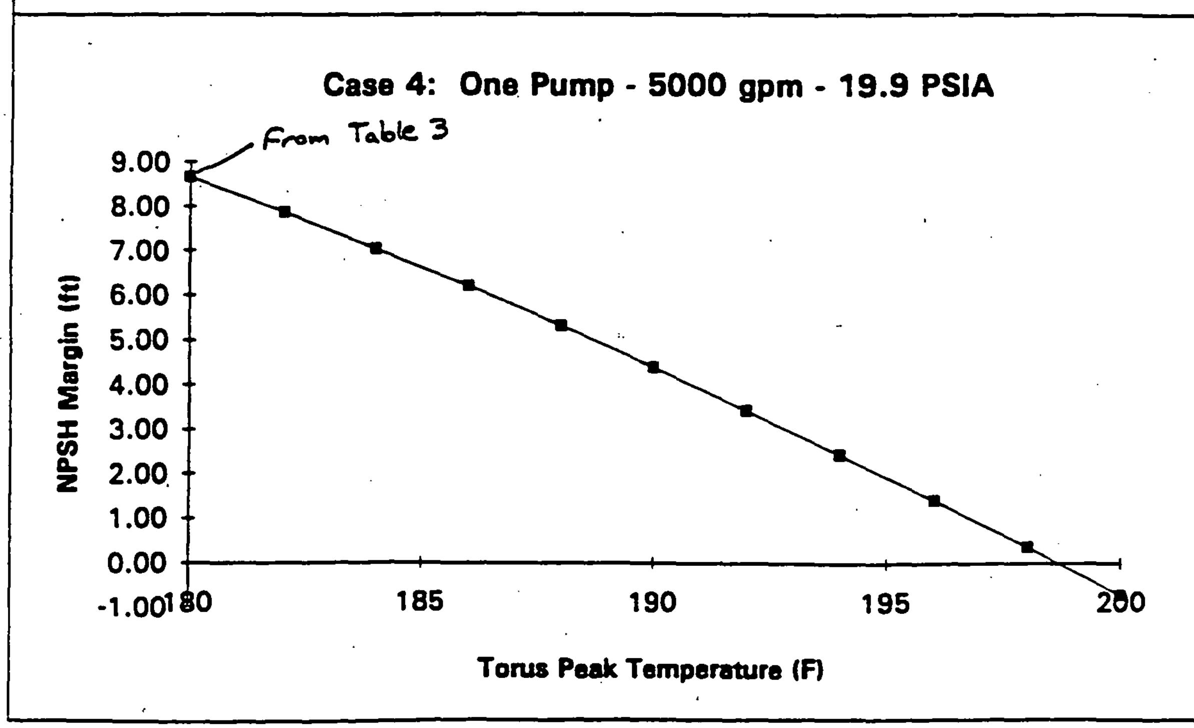
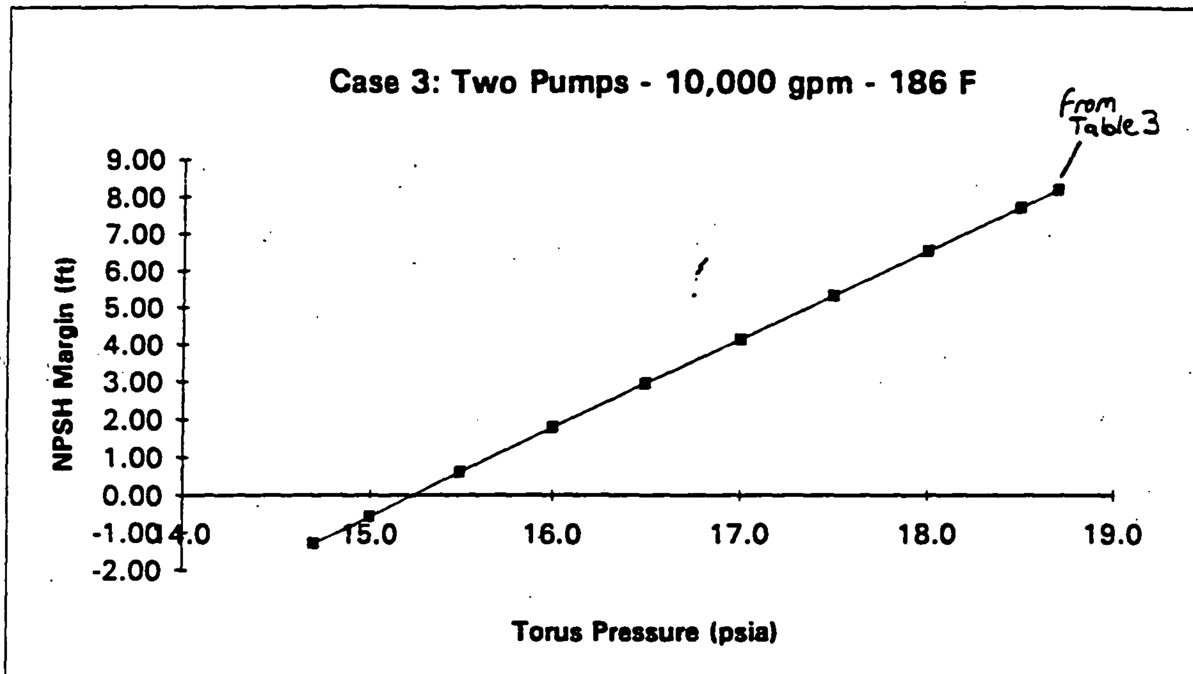


Figure A-1

Appendix A

NPSH Margin Pressure Sensitivity



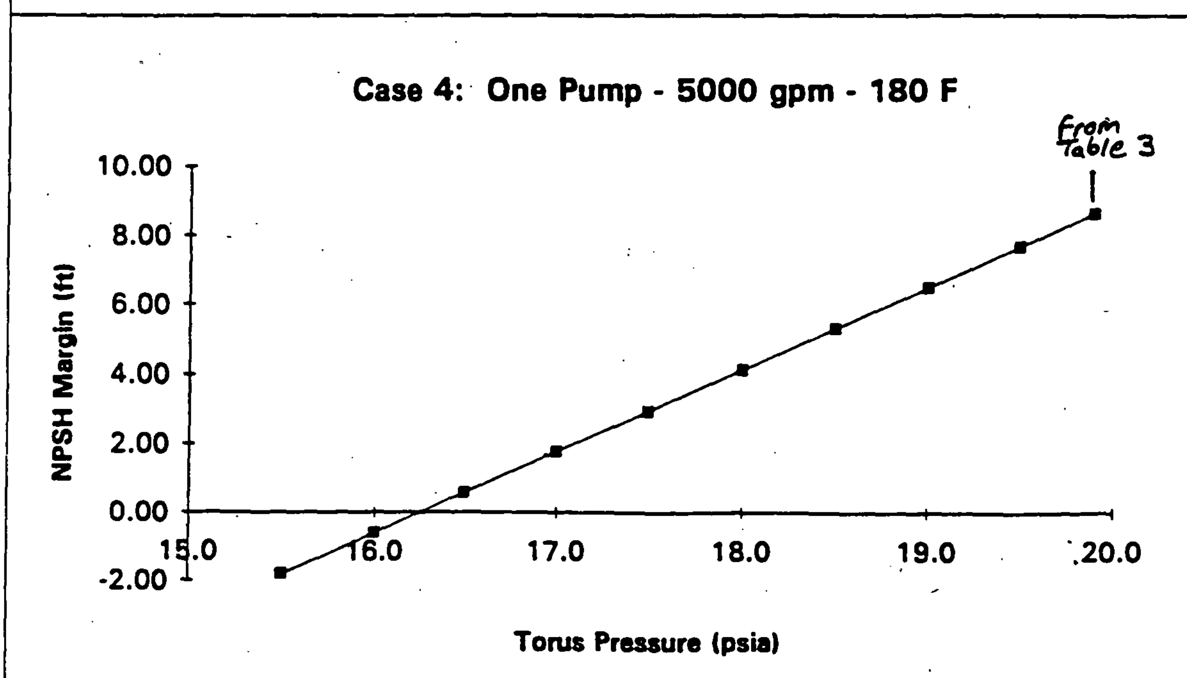


Figure A-2

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

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

$b = d1/d2$

$d1$ = 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 L = assume $d1 + d2$

$d2 = 23.25$ in $= 36.5$ in

Therefore,

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

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

$$K = 0.07$$