Sargent & Lundy LLC

Report C-PAL-96-1063-01, Rev. 2
Project 09906-140

Consumers Power Company
Palisades Nuclear Plant

Operability Assessment for Transient Conditions at Palisades Nuclear Plant In Response to Generic Letter 96-06

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A. Service Water System Containment Air Cooler Piping

1. PURPOSE/SCOPE

1.1. This section documents the operability assessment for transient conditions occurring in the Palisades Nuclear Plant (PNP) Service Water (SW) system containment air cooler piping during a coincidental Loss of Coolant Accident (LOCA) plus Loss of Offsite Power (LOOP).

The scenario being evaluated herein was originally described in Westinghouse Nuclear Safety Advisory Letter NSAL-96-003 and further defined in NRC Generic Letter 96-06. During a postulated LOOP, coincident with a design basis LOCA, power is lost to all three SW pumps and the four containment air cooler (CAC) fans. The SW pumps will coast down much more quickly than the CAC fans. Accounting for diesel start times, the first service water pump(s) will be re-energized approximately 22 seconds after the LOOP, the next SW pump will be re-energized approximately 38 seconds after the LOOP, and the CAC fan(s) will be energized within approximately 13 seconds after the LOOP. This timing of events provides for hot, steam-laden air to be drawn over the cooling coils for approximately 22 seconds before cooling liquid flow is re-established to the coils.

1.2. This report addresses the bounding case where a design basis LOCA and LOOP occur coincidentally. This case is considered bounding, since :

1.2.1. Containment temperatures peak within 18 seconds of the LOCA initiation. A LOOP may occur any time after the LOCA initiation.

1.2.2. Per FSAR Section 14.18, the design basis LOCA bounds both the LOCA and MSLB containment ambient pressure and temperature profiles because the saturation temperature is lower for the MSLB in the time period of interest.

1.3. This operability assessment consists of: (1) thermal hydraulic analyses to investigate the conditions in the SW system during the postulated transient; (2) piping/pipe support/air cooler analyses to evaluate the impact of the potential waterhammer conditions on the SW system.

The body of this section describes the data, assumptions, and methodology used to evaluate the system and results of the operability assessment. Detailed analyses supporting this report are provided in Appendices A, B, and C.

1.4. The general arrangement of the PNP CACs is shown in Figure 1. There are four CACs located at elevation 600 in the containment. Three of these coolers (VHX-1, VHX-2, and VHX-3) are critical and normally in operation. The non-critical cooler VHX-4 is valved closed during the design basis accident (DBA).

1.5. Service water to each CAC is supplied by an 10-inch diameter schedule 40 pipe. Each of the four coil units comprising a critical CAC is supplied from a 6-inch manifold which is branched into four 4-inch pipes . Similarly, the coil unit return lines are 4-inch diameter and the CAC return line is 6-inch diameter.

1.6. A description of the CAC units can be found in PNP Calculation EA-FC-951-02, Rev. 1, and Specification M-60A, Rev. B and FSAR Sections 14.17 and 14.18.

2. DESIGN INPUTS

2.1. Containment heat transfer coefficients for metal surfaces subjected to post LOCA conditions are defined in Reference 7.7.

2.2. Containment post-LOCA temperatures are defined in PNP FSAR Figure 14.18.1.2. The containment pressure subsequent to a MSLB is given in PNP FSAR Figure 14.18.2.1. A comparison of the saturation temperatures corresponding to the MSLB generated containment pressure with the LOCA temperatures showed that the LOCA temperatures are higher in time period before the service water system is recovered after LOCA/LOOP accident.

2.3. Data for the cooling coil tube sizes and thickness, fin spacing, and physical geometry of each cooler are defined in PNP Calculation EA-FC-951-02, Rev. 1 for critical coolers VHX-1, VHX-2, and VHX-3 , and Specification M-60A, Rev. B for the non-critical cooler VHX-4.

Prior to the issuance of GL 96-06, cooler VHX-4 had been isolated upon SIS signal by closing the return side valve. With this configuration, there is a potential for steam bubble growth into the cooler inlet lines and an accompanying condensation induced waterhammer and/or bubble collapse within the cooler upon system repressurization. In order to eliminate this possibility, VHX-4 isolation has been changed to the inlet side valve.

2.4. Piping system geometry is defined in the isometric drawings listed in Reference 7.4 of this report.

2.5. Post LOOP sequencing of electrical loads on the diesels are defined in PNP document, "Potential Post-Accident Common Mode Containment Air Cooler Failures" dated September 19, 1996.

2.6. Steady state friction drops in the SW system are calculated for in-service piping by standard pipe design equations given in Reference 7.6. Minimum flow requirements for the CACs are provided in PNP DBD-1.02, Rev. 2.

2.7. Theoretical and experimental evaluation of potential waterhammer in the SW system are provided in Reference 7.5.

3. ASSUMPTIONS

3.1. The following assumptions have been made in the thermal hydraulic evaluation of the steam generation portion of the transient:

3.1.1. The service water piping contains check valves at the discharge of the service water pump. Therefore, upon the loss of power, the check valves prevent backflow to the lake. The SW pump discharges into piping at elevation 592 ft. The return piping discharges into the cooling tower basin at elevation 581 ft Thus, any column separation occurring in the supply piping will occur at elevation 614 ft. or about 33 ft. manometric effect. All service water piping in the CAC supply branch is below elevation 612 ft. Therefore, column separation is not expected in the supply piping to the CAC's . It is conservatively assumed that a column separation occurs in the return piping

3.1.2 It is assumed that the coils are water filled at the beginning of the transient. Water vaporization after LOCA/LOOP accident contributes to the evacuation of the supply and discharge pipes.

3.2 The following assumptions have been made in the calculation of potential waterhammer forces during the system refill portion of the transient:

3.2.1 For the refill calculations, 60% of the service water pump(s) output is conservatively assumed to go to the critical cooler inlet piping.

3.2.2 To simplify the refill calculations, it is conservatively assumed that the pressure at the coil discharge remains at 0.6 psia during the entire refill transient. This represents the saturation pressure for the temperature of the SW system (85°F).

3.2.3 During a non-LOCA transient, the cooler remains water solid and no waterhammer is postulated. Subsequent to a LOCA and stoppage of flow through the coolers, boiling may occur in the coils. Steam will void the coils of water. The water will flow to both the inlet and the outlet headers as determined by the column inertia and flow resistances on the respective sides of the coolers. Upon restart of the service water pump(s), the system will re-pressurize and the steam bubbles will attempt to collapse. The high temperature in the cooler coils and attached piping will not allow the heat transfer required for a rapid collapse. Rather, the water at the bubble interface will be heated by the hot piping as it pushes the bubble through the coils to the discharge side.

3.2.4 No credit is taken for cushioning of the water slug due to the presence of non-condensable air released from the fluid during vaporization.

3.2.5 The non-critical cooler VHX-4 is used only during the warmest days of summer to supplement the other three critical coolers. Normally, VHX-4 will be isolated on the inlet side. During a LOCA event, the water in VHX-4 is valved out and the unit will be subject to heating similar to that experienced by the other coolers. As the steam laden atmosphere begins to condense on the coils, a vacuum will be formed which will draw more steam laden air to the cooler and sustain the process until the cooler VHX-4 can no longer absorb heat from the atmosphere, because the coils are full of steam at the same temperature as the atmosphere. Since the coil is isolated on the inlet side, the steam bubble will grow into the discharge header on the cooler, and displace water into the discharge header. Once the coil is void of water, the steam bubble will stagnate and remain stagnant in the cooler. Upon restart of the service water pump(s), the bubble cannot be pressurized from the supply side. Therefore, pressurization can only be accomplished from the discharge side. However, as the discharge header is reflooded, and is pressurized, the check valve on the discharge side of VHX-4 will close and isolate the steam bubble. This bubble will slowly collapse as the containment atmosphere is cooled and absorbs the energy in the bubble.

3.3 The following assumption has been made in the evaluation of piping/pipe supports/cooling coils:

3.3.1 Several scenarios are considered where different combinations of the most highly loaded supports are assumed not operable.

4. APPROACH/METHODOLOGY

4.1. The possible waterhammer scenarios are identified. The analysis is performed such that the bounding waterhammer loads are determined for each particular scenario. The approach will differ from the evaluation of one scenario to the other to ensure that bounding evaluations are performed.

4.2. NUREG/CR-5220 provides reference material and diagnostic procedures concerning condensation-induced waterhammer in nuclear power plants. Five event-classes of condensation-induced waterhammer, which have similar phenomena and levels of damage, are defined in NUREG/CR-5220. Additionally, NUREG/CR-5220 provides case studies to illustrate the diagnostic methods and to document past experience. The majority of the examples and case studies presented in NUREG/CR-5220 deal with high temperature and high pressure systems. The fourth case study presented in NUREG/CR-5220 has some similarities to the SW event considered herein, except that the temperature considered in the scoping study in NUREG/CR-5220 is approximately 25% higher and the refill flow rate is much higher than those in the CAC circuits. It should be noted that no pressure boundary damage was reported for this case study.

4.3. Reference 7.5 describes a series of scaled waterhammer experiments performed over a range of conditions typical of the PNP SW system during this transient. The Palisades geometry is similar to the test configuration because there is a loop seal with a horizontal run at the outlet of the cooler. The steam bubble formed in the cooler can potentially collapse in the horizontal run and produce condensation-induced waterhammer. Downstream of the loop seal there is also the potential for column separation to occur. The experiment apparatus was constructed based on Froude number considerations and investigated the influence of void formation and steam condensation during the transient conditions. The results of these experiments demonstrate that no significant waterhammer transients were observed even with significant voiding, and that peak pressures occurred during refilling of the system. Additionally, the peak pressures were substantially less than those that would be calculated using standard waterhammer methodology.

4.4. Based on a review of the system configuration, potential waterhammer is postulated for the CAC outlet piping only.

4.4.1 The CAC inlet lines have no check valves. Therefore, when steam bubbles form, they are assumed to grow toward the supply or discharge piping based on the relative resistance to flow in the respective directions.

4.4.2 As the steam-water interface approaches the cooler, the water will approach saturation temperature and may begin to boil, accelerating the steam bubble into the discharge header. As the flow continues, the supply side piping will cool and the coils will become water solid and begin to remove heat from the containment as the system was designed. During this process, the heat transfer required to collapse the steam bubble in the supply piping, or in the cooler, cannot take place because of the high temperatures in the piping and coils. Therefore, the steam bubble is not expected to collapse and generate a waterhammer transient on the supply side. Also, due to the fact that in each of the four coils of the CAC, the flow is directed through four passes, 108 tubes (0.527 inches inside diameter each) at a velocity of about 6.1 ft/sec, the flow will "flush" the generated steam bubbles from the coil into the discharge lines. The design of the CAC also makes it unlikely to have any steam bubble collapse in the CACs water box on each side of the tubes.

4.4.3 Friction factors for in-service piping, Reference 7.6, were used in the analysis.

4.5. The following waterhammer scenarios were evaluated for their potential to occur during the LOCA/LOOP transient:

4.5.1. A water slug striking another water slug due to condensation in the horizontal sections of the supply and return lines prior to pump start.

4.5.2 A water slug striking another water slug in the sections of the return lines during refilling the system after restart of the pump(s).

4.6 The magnitude of waterhammer loads depends upon the velocity of impact, which is a function of:

- Inertia and friction in supply and return lines.
- Boiling heat transfer coefficient in the coolers.
- Condensation heat transfer coefficient at the fins.
- Steam generation rate in the coolers.
- Steam condensation rate in the return lines.
- Volume of the vapor void.
- Pressure differential across the water slug.
- Time available to accelerate the slug.

4.7. The water slug striking another water slug (condensation induced waterhammer) could occur due to condensation of steam that has been generated in the coolers. The condensation could occur in the horizontal section of the return lines, prior to pump start.

4.7.1 A transient analysis is performed to determine the steam generation rate and the steam velocity in the return line. This is based upon the heat addition rate to the coolers, and the steam condensation rate in the return lines, as well as the inertia and friction in the return lines.

4.7.2 Froude number is determined based upon the water velocity in the horizontal return lines. If the Froude number is greater than 0.1, horizontal legs of the return line will run filled with water and condensation induced waterhammer will not occur based on the results of the testing and theoretical discussions provided in Reference 7.5.

4.7.3 If the criteria described above is not satisfied, condensation induced waterhammer could occur in the horizontal supply and return lines. In such case, the impact velocity would be evaluated based on the methodology provided in NUREG-5220, Sec. 5.1.3, where the slug length and the vapor void length are scaled equally. The guidelines in NUREG-5220, Appendix C would be applied to more accurately determine the waterhammer forces.

4.8 For the calculation of steam velocities before pump start, a simplified algorithm is developed for determining the steam generation rate and the steam velocities in the pipe lines. This is based upon the following:

4.8.1 Containment time-dependent temperature is obtained from the FSAR, and condensation heat transfer values are obtained from Reference 7.7.

4.8.2 Nucleate boiling is considered at the inside surface of the CAC tubes. Nucleate boiling heat transfer coefficient (Thom, 1966) is:

$$h=\exp(2*P/1260)*(Tw-Tsat)/5184*10^6$$

Where P is in psia, and temperatures (T_w and T_{sat}) are in °F.

4.8.3 Thermal resistance of copper tubing is ignored. However, the thermal capacitance of both the tubing and the fins are considered.

4.8.4 The effect of fins on heat transfer is considered.

4.8.5 Inertia and friction in pipe lines, as well as condensation and forced convection heat transfer in the pipe lines are considered.

4.9. Waterhammer due to bubble collapse and/or refilling the pipe, where one water slug strikes another water slug, could occur in the return lines during refilling of the system after pump restart. The following approach is used for this calculation:

4.9.1 A transient analysis is performed to determine the vapor volume. This is based upon the heat addition rate to the coolers, and the steam condensation rate in the return lines, as well as the inertia and friction in the return lines. The possibility of a decreased LOCA heat load was investigated. The results show that, conservatively, if the LOCA temperatures decrease by more than 10% compared to that of double-ended break, the vaporization rate in the CAC will decrease to a point where it becomes insufficient to disperse the water from the CAC's tubes. In this case, the vaporization would cease and the waterhammer in the return piping would be determined by column separation, if any.

4.9.2 Two pumps starting at 0, and the third at 16 seconds (this corresponds to approximately 22.6, and 38.6 seconds after the LOOP). The back pressure is fixed at 6.1 psia.

4.9.3 Inertia and friction in supply lines starting at time 0, as well as in coolers during refilling, are considered in this analysis.

4.9.4 Time dependent velocities and flow rates are determined for each case.

4.10. For the calculation of refill flow rate after pump start, a simplified algorithm is developed for determining the refill flow rate and water velocities after pump start. This is based upon the following:

4.10.1 Inertia and friction in supply lines start at time 0, as well as in coolers during refilling, are considered in the analysis.

4.10.2 Two pumps starting at 0, and the third at 16 seconds (this corresponds to approximately 22.6, and 38.6 seconds after the LOOP). For conservatism, the back pressure is fixed at 6.1 psia.

4.10.3 For conservatism, no credit is taken for drainage through valves during refill or for cushioning by non-condensable gas.

4.11. For the evaluation of the piping/pipe supports/cooling coils, a hydraulic transient evaluation is performed. The analysis uses a simplified conservative force time history for the waterhammer forces.

4.12 The input for the hydraulic transient evaluations is based on the following information:

- Peak fluid flow rate based on the thermal/hydraulic analyses
- Maximum shock overpressure, based on NUREG-5220, Section 5.1.1,:

  $P = (1/2)*\rho*c*V$ [c = sonic velocity]

- Maximum load on pipe segment:

  $F = P * A$, where A = pipe area.

4.13. Results of the static water surge and hydraulic transient analysis are enveloped. These loads do not occur concurrently. The loads generated are be shown to be less critical than the generated waterhammer loads.

4.14. The operability evaluation for the piping is simplified by assuming that highly loaded supports in the system that cannot accommodate the resulting waterhammer loads will fail. Therefore, the piping analysis will be run both with and without highly loaded supports in the model and the pipe stresses are compared to the corresponding interim operability allowable. It is demonstrated that less highly loaded supports will retain support functions.

4.15. The operability acceptance criteria provided in Reference 7.9 is applied for the pipe stresses from the waterhammer loading.

5. CALCULATIONS

5.1 The event scenario as outlined in NSAL-96-003 can be summarized as follows for PNP.

5.1.1 As the SW pumps lose power, flow in the air cooler circuits will begin to slow based on the coast down characteristics for the pumps. Pressure in the CAC discharge piping will decrease.

5.1.2 For the CACs, the back pressure will decrease to 6.1 psia. Water column will be supported by the back pressure in the discharge piping .

5.1.3 As the flow is decreasing, the containment temperature and relative humidity are rising. The containment reaches a peak temperature of 284°F within 15 seconds.

5.1.4 The steam in the containment atmosphere will condense on the coil outside surfaces heating the fluid in the coils. Heat transfer to the fluid is based on forced convection during pump coast down and on nucleate boiling once the inside surface of the tubes rises above the saturation temperature of the fluid. For the CAC's the rate of boiling will be controlled by the pressure in the coils required to move the water column.

5.1.5 The discharge side water column will be accelerated by the pressure of the generated steam.

5.1.6 When the pump flow is re-initiated, at approximately 22.6 seconds, water will flow through the CACs and fill the discharge piping and collapsing the steam bubble.

5.1.7 When the discharge lines have been filled, steady state flow will be re-established and the transient will be over.

5.2 To evaluate the impact of this transient, detailed calculations have been prepared as follows:

5.2.1 The hydraulic analyses for the steam generation portion of the transient are provided in Appendix A.

5.2.2 The thermal/hydraulic analyses for the refill portion of the transient are provided in Appendix B.

5.2.3 The piping, pipe support, and cooling coil evaluations for the refill portion of the transient are provided in Appendix C.

5.3 The time required to return the system to service is evaluated based on the results of the analyses provided in Appendix A and B as follows:

5.3.1 From the analysis in Appendix B it can conservatively estimated that the system inertia will be overcome and flow to the coolers will be re-established within 3 seconds of pump restart. The pressure at the outlet of the CAC will decrease as the steam in the bubble condenses. This will cause the flow to increase due to the lower back pressure (0.6 psia).

5.3.2 From Reference 7.8 Sheet 11, the minimum required flow to ensure adequate heat removal capabilities with three operable CACs is 1500 gpm ($3.34 ft^3/sec$) per CAC.

5.3.3 The average water column flow rate for each CAC was conservatively calculated to be approximately $3.44\ ft^3/sec$ in Appendix B.

5.3.4 Once flow to the CACs is initiated, the service water system will begin to remove heat from the containment. When the column is filled, the pressure at the CAC will return to the steady state value and the transient condition will be over.

5.3.5 As the system begins to reflood following pump restart, the steam on the inlet side of the cooler will begin to flow back to the coils. The following water will be heated by the piping and approach saturation temperature near the cooler. The initial water reaching the cooler will flash to steam and assist in pressurizing the system. In time, the water will reduce the temperature of the cooler and saturated water will begin to emerge from the cooler and push the steam bubble down the hot piping. Therefore, the collapse of steam bubble is not expected in the cooler and adjacent headers.

It has been conservatively assumed that bubble collapse could occur anywhere between the point of downstream bubble growth location to the point of expected column separation (in the return line).

6. RESULTS/CONCLUSIONS

6.1. The isolation scheme for non-critical cooler VHX-4 has been changed in order to eliminate potential problems associated with a "trapped" steam bubble.

6.2. The Froude number for the flow occurring during the steam generation phase was determined to be in the range 0.5 to 0.9. The onset of steam bubble condensation occurs at or below a Froude number of 0.1 (Reference 7.5), therefore, this form of condensation will not occur.

6.3. The thermal/hydraulic analyses demonstrate that the steam generation rates and hence the water column velocities will be sufficiently high such that stratification and separated flows in horizontal runs of piping will not occur. Thus, waterhammer peak overpressures for the steam generation portion of the transient will be bounded by those for the refill transient.

6.4. The calculated maximum flow rate during the refill portion of the transient is less than 3.44 ft^3/s. This flow rate is considerably higher than the normal flow of 1.11 ft^3/s and leads to a conservative estimate of the waterhammer pressure.

6.5. A detailed hydraulic transient model was developed based on the 3.44 ft^3/s refill rate. A refill waterhammer pressure was conservatively calculated to be 244 psig for the 6-inch discharge lines.

The simplified method employed to estimate the waterhammer pressure assumes that two slugs collide. The relative speed calculated for the water slugs is maximized by setting the back pressure on the coil to 0.6 psia and estimating the velocity based on pump flow. Should this velocity be evaluated subsequent to a LOCA, steam bubble formation would raise the back pressure on the coil and reduce the calculated velocity, reducing the estimate for the waterhammer pressure. Therefore, the calculated value, 244 psig, bounds both the LOCA and the non-LOCA cases. This waterhammer pressure value is conservative because a number of factors which have the effect of reducing the pressure (e. g. entrained non-condensable and fouling factors in the piping system flow calculations and cooling coil heat transfer calculations) have been ignored in its determination.

6.6. The resulting piping stresses due to the waterhammer loads are less than the Palisades interim operability criteria (Reference 7.9), thus verifying the integrity of the system. Also, the resulting stresses on CAC nozzles and tubing are well within acceptable limits.

7. REFERENCES

7.1. NSAL-96-003, "Containment Fan Cooler Operation During a Design Basis Accident".

7.2. PNP UFSAR

7.3. NUREG-5220, "Diagnosis of Condensation-Induced Waterhammer", Published October 1988

7.4. PNP Drawings

Isometric Drawing Numbers:
3316, Sheet 2, Rev. 7
3317, Sheet 2, Rev. 8
3382, Sheet 1, Rev. 3
3383, Sheet 1, Rev. 4
3384, Sheet 1, Rev. 3
3385, Sheet 1, Rev. 3
3386, Sheet 1, Rev. 3
3386, Sheet 3, Rev. 5
3386, Sheet 6, Rev. 4
3386, Sheet 7, Rev. 2
3386, Sheet 8, Rev. 2
3387, Sheet 1, Rev. 5
3387, Sheet 2, Rev. 3
3387, Sheet 3, Rev. 5
3387, Sheet 4, Rev. 4
3387, Sheet 6, Rev. 5
3387, Sheet 8, Rev. 4

M200, Rev. 23
M208, Rev. 23
M213, Rev. 62

7.5 FAI/96-75 "Evaluation of Possible Water-Hammer Loads in the Service Water System for DBA Conditions", Dated October 16, 1996. Presented at the NEI GL 96-06 Industry Meeting on October 29, 1996.

7.6 Crane Technical Publication 410, "Flow of Fluids Through Valves, Fittings and Pipe," 1988

7.7 Fax from Gary E. Jarka of Palisades, dated November 11, 1996.

7.8 EA-FC-951-02, Rev. 1 and Specification M-60A, Rev. B.

7.9 Consumers Power Company, Palisades Technical Specification M-195(Q), "Technical Requirements for the Design and Analysis of Safety-Related Piping and Instrument Tubing," Revision 4, 7-18-95.

7.10 PNP Design Basis Document, DBD-1.02, Rev. 2.

B. Overpressurization of Fluid Filled Piping

1. PURPOSE

The purpose of this analysis is to determine whether the piping systems that penetrate the containment are susceptible to thermal expansion of fluid such that overpressurization of piping could occur. The Design Basis Accident (DBA) is taken as the controlling condition for increase in temperature to which piping would be exposed.

2. ANALYSIS

The analysis consists of an evaluation of each piping system that penetrates the containment. The portion inside the containment was considered to be subjected to a temperature increase. Each system P&ID was reviewed to determine if there were sections that could contain trapped fluid capable of causing overpressurization.

The results of the analysis are presented in Table 1 of Appendix D. The principal bases for determining the acceptability of a system are:

A. Steam/Gas Service - Lines containing steam or gas (including air) were considered to have sufficient compressibility so that overpressurization would not be a problem.

B. Expansion Path Available - Lines containing fluid that can expand (typically through check valves) into some volume (such as a tank) were also considered to have sufficient compressibility so that overpressurization would not be a problem.

C. Relief Valves - Lines containing relief valves were considered to have sufficient protection against overpressurization.

For those systems which could not be satisfactorily dispositioned by one of these three approaches, a more detailed assessment was performed to evaluate other means of pressure relief. These included the following approaches:

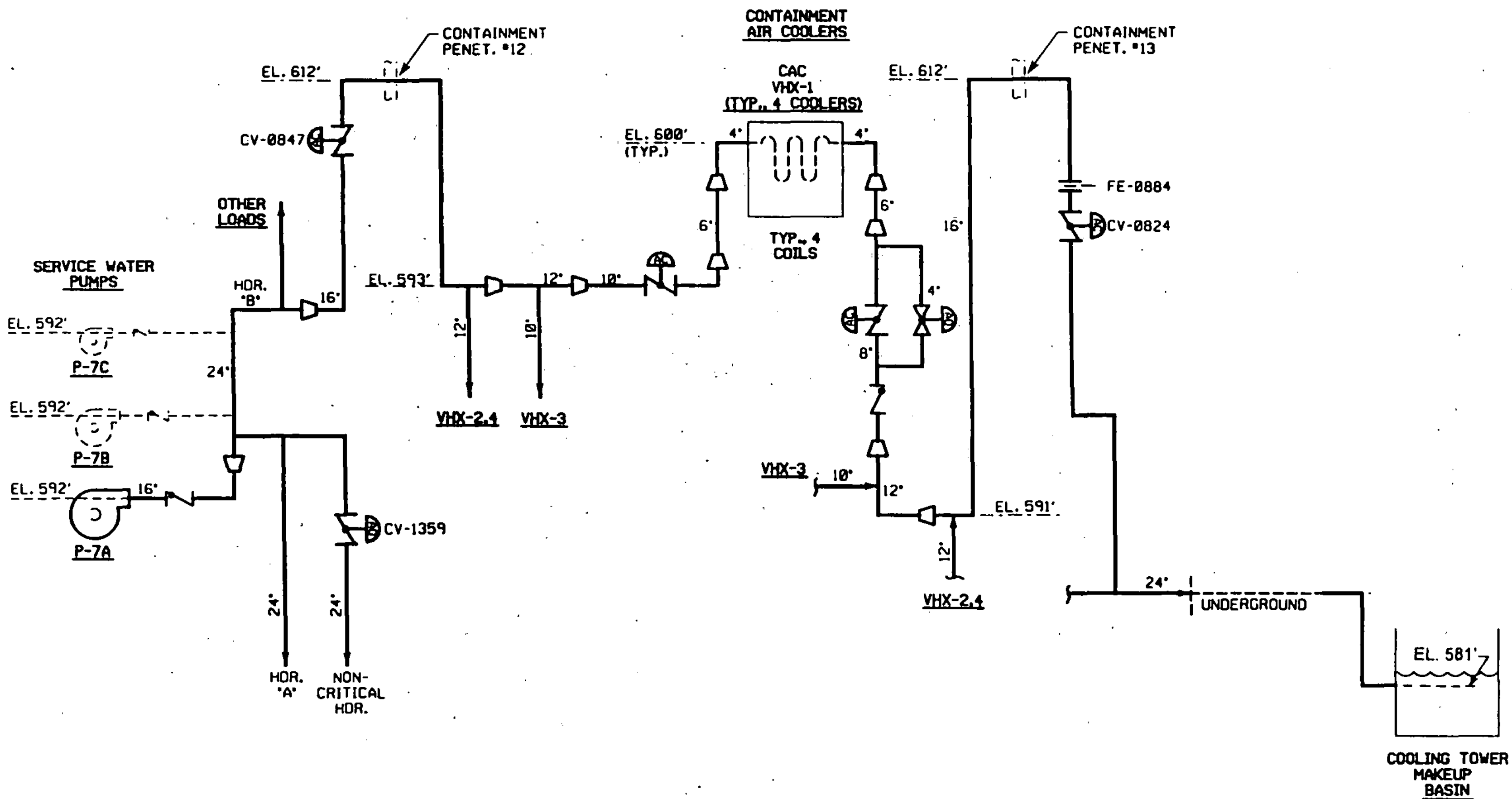
A. Air-Operated Globe Valves - Where this type of valve is confining the fluid undergoing pressurization, if the pressure is against the bottom of the valve seat, the valve stem will momentarily lift and relieve the pressure.

B. Hot Fluid - Lines containing trapped hot fluid (hotter than the DBA temperature) which cool down prior to the DBA will undergo a decrease in specific volume that will offset the increase in specific volume that would occur during the DBA heat up, preventing any overpressure.

C. Operating Procedure - Confirm that the plant operating procedure contains provisions that will prevent the trapping of fluid.

3. CONCLUSION

All the lines penetrating the containment, with the exception of two were determined not be susceptible to overpressurization based on the approaches noted above. Two lines associated with the clean waste receiver tanks were determined to be susceptible to overpressurization. They have been modified to add a pressure relief device.



REV.	DATE	DESCRIPTION	BY	CK	APP
	10-96		LDB		

CONSUMERS POWER COMPANY
PALISADES NUCLEAR PLANT
COVERT, MICHIGAN

SERVICE WATER/ CONTAINMENT AIR COOLER SYSTEM

DRAWING NUMBER: FIGURE 1

SHT. NO. | REV.

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ATTACHMENT 3

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

120-DAY RESPONSE TO GL 96-06, ASSURANCE OF EQUIPMENT OPERABILITY
AND CONTAINMENT INTEGRITY
DURING DESIGN BASIS ACCIDENT CONDITIONS

Operability Evaluation for Two-Phase
Flow/Reduced CAC Heat Removal
Capability Issue Resulting from GL 96-06

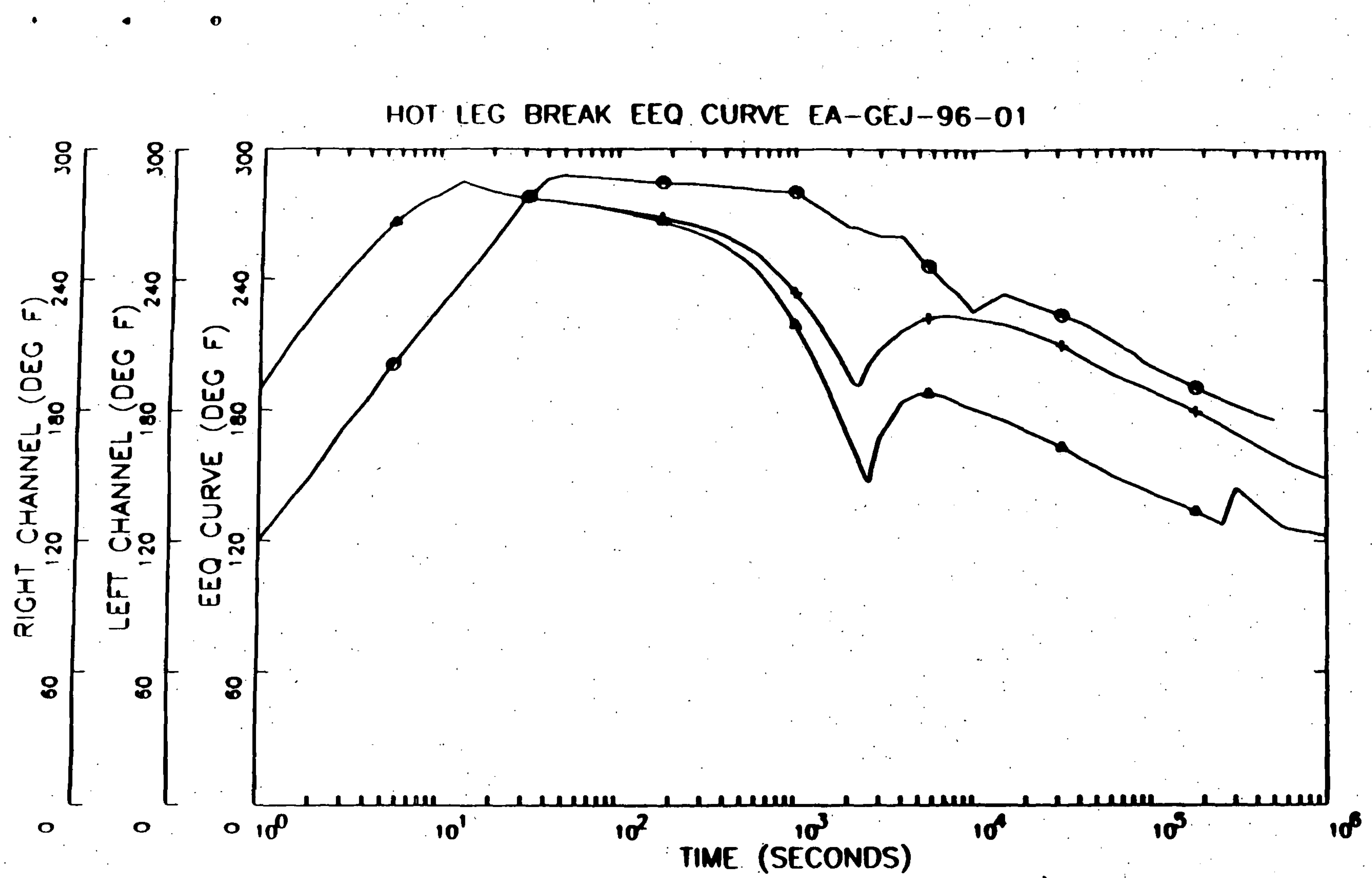
3 Pages

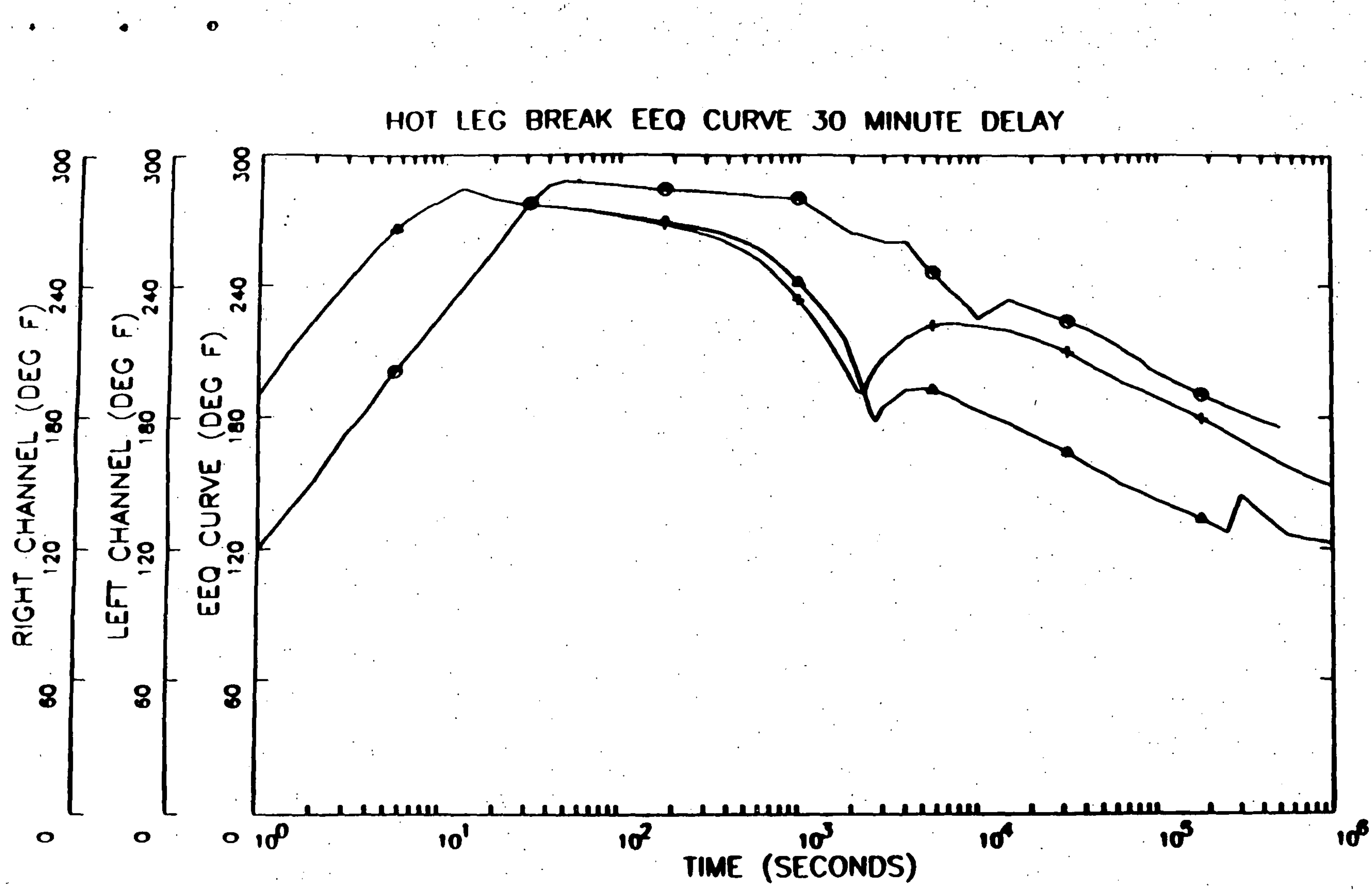
ATTACHMENT 3

Operability Evaluation for Two-phase
Flow/Reduced CAC Heat Removal
Capability Issue Resulting from GL 96-06

Attached are two containment temperature response graphs. The first is the current base FSAR analysis case assuming the air coolers function normally. The second shows the effect of conservatively assuming no air cooler capability at all for the first 30 minutes of the accident (the left channel case has air coolers functional, the right channel case has containment spray functional). The left channel curve shows an increase above the right channel case, but still remains below the EEQ curve. Two-phase flow conditions would only be present in the first minute before service water flow is reestablished. Therefore, this analysis is bounding and shows the safety requirements are maintained.

HOT LEG BREAK EEQ CURVE EA-GEJ-96-01




HOT LEG BREAK EEQ CURVE 30 MINUTE DELAY
RIGHT CHANNEL (DEG F)
LEFT CHANNEL (DEG F)
EEQ CURVE (DEG F)
0
60
120
180
240
300
10^0
10^1
10^2
10^3
10^4
10^5
10^6
TIME (SECONDS)