Attachment 3

SALEM UNITS 1 AND 2

CONTAINMENT RESPONSE ANALYSIS
WCAP-16193

CFCU/SW ENHANCEMENT PROJECT

April 2004

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Salem Unit 1 and Unit 2 Containment Response to LOCA and MSLB for Containment Fan Cooler Unit/Service Water System Enhancement Project

Westinghouse

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-16193-NP

Salem Unit 1 and Unit 2 Containment Response to LOCA and MSLB for Containment Fan Cooler Unit/ Service Water System Enhancement Project

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EXECUTIVE SUMMARY

Containment Integrity Analyses have been performed for design basis LOCA and MSLB transients consistent with a proposed change to the Salem Nuclear Generating Station containment fan cooler and service water system. The proposed change will affect the post-accident operation of the containment heat removal systems. These analyses can be used to update the licensing basis safety analyses to support the service water system enhancement program. The analyses conducted are consistent with current licensed methodology for LOCA and MSLB (References 1 and 6).

The containment integrity analyses consider the containment response to both long-term MSLB and LOCA mass and energy releases. The results of the analyses demonstrate the acceptability of the containment safeguards systems to mitigate the containment consequences of a hypothetical design basis pipe break. The analyses ensure that the containment heat removal capability is sufficient to remove the maximum possible discharge of mass and energy release to containment from the Nuclear Steam Supply System without exceeding the containment design pressure and temperature limits. Contrary to prior containment analyses, these calculations credit recirculation spray.

The peak calculated pressure for the DEPS minimum safeguards LOCA case for Salem Unit 1 with Model F steam generators was 40.1 psig. The peak calculated pressure for the DEPS minimum safeguards LOCA case for Salem Unit 2 with Model 51 steam generators was 41.6 psig. The long term LOCA temperatures are within the Equipment Qualification (EQ) temperature profile, however the EQ limits are slightly exceeded for a short duration (about two hours).

For MSLB, the limiting containment pressure case is a 1.4 ft^2 DER initiated at 30% power with a containment safeguards failure. The limiting containment temperature case is 0.88 ft^2 split rupture initiated at 30% power with a MSIV failure. For Unit 1, the peak pressure is 40.2 psig and the peak temperature is 345.7°F. For Unit 2, the peak pressure is 42.2 psig and the peak temperature is 345.4°F. While this is less than 351.3°F and the long term temperature is less than the current profile, there is a period from approximately 140 seconds to 320 seconds where the new composite exceeds the envelop from about 6°F to as much as 18°F.

In general, these results show that the service water system enhancement program is a viable option for the Salem units with respect to containment integrity concerns. The noted EQ temperature limit issues are being addressed by PSEG Nuclear outside of this report.

Included in Appendix A is a copy of PSEG letter EA-CFCU-03-004 and Appendix B contains letter EA-CFCU-03-005. These letters are provided in this format for future convenience of identifying the program input assumptions. Some of the information is proprietary to Westinghouse, so this information does not appear in this non-proprietary document.

1 INTRODUCTION

The long-term containment integrity analyses demonstrate the acceptability of the containment safeguards systems to mitigate the consequences of a hypothetical loss of coolant accident or main steamline break. The calculations conservatively predict the containment pressure and temperature response subsequent to a postulated pipe break. These analyses demonstrate that the changes that PSEG has proposed for the service water (SW) system and the containment fan cooler units (CFCUs) provide adequate cooling to maintain the post-accident containment pressure and temperature within the allowable limits.

This evaluation identifies the most limiting loss of coolant accident (LOCA) and the most limiting main steamline break (MSLB) configuration(s) for the containment for Salem Unit 1 and Salem Unit 2 with the revised containment heat removal systems. The impact of the most limiting single failure is applied to each scenario. This evaluation determined the limiting transients based on the containment analysis methodology described in the following sections.

Note that this analysis is performed specifically in terms of containment response to design basis mass and energy release events; any specific requirements for the service water system, the containment ventilation, and the spray coverage for dose related analyses are outside the scope of this report.

2 BACKGROUND

PSEG is proposing to modify the configuration of the SW System alignment to the CFCUs for both Salem Unit 1 and Salem Unit 2. Under the new alignment for normal operation, the CFCUs will transfer heat to a new closed loop chilled water system in order to maintain the containment temperature below a specified limit (currently 120°F). Under accident conditions, the system alignment will change such that heat will be transferred to the SW System. Overall, the intent of the service water system enhancement program is to result in requiring fewer CFCUs to be operable for normal and accident modes. This should improve the overall system performance, reduce maintenance and avoid Technical Specification limiting conditions for operations (LCO) issues. This plant modification will be referred to as the CFCU/SW enhancement project.

The overall purpose of this analytical effort is for Westinghouse to execute a sufficient number of containment mass and energy (M&E) release scenarios so that PSEG can be assured that the proposed CFCU/SW enhancement project will result in sufficient cooling under postulated M&E release accidents. The design basis containment pressure and temperature limits are to be maintained and the current acceptable equipment qualification (EQ) temperature profile preferably remains unchanged. Containment work that was recently performed by Westinghouse for PSEG included an increased CFCU delay time and Generic Letter 96-06 (1996-1997), the Salem Unit 1 replacement steam generator assessment (1997), and the phase 1 and phase 2 containment capability studies (2001/2002). These were all documented in References 1 through 4.

The purpose of the 2001/2002 capability study was to determine whether the CFCUs did not need to be credited for the containment integrity events. Based on the LOCA results showing high second pressure rise exceeding the containment design limit after about 2.5 hours and peaking around 95 psig twelve hours later, it was clear that relying solely on containment sprays was not adequate for the LOCA event. The project then considered the change to limited CFCU heat removal via a manual operator action to occur at about 1 hour. While this was shown under the phase 2 analyses to sufficiently reduce the peak containment pressure for the LOCA event, it effectively removes any CFCU heat removal for the steamline break events. Thus, to ensure that pressure and temperature limits would not be exceeded for the MSLB events, several iterations occurred to regain margin through some modeling changes and taking less restrictive input assumptions.

The limiting phase 2 cases for the main steamline breaks were close to the limits, so an appropriate spectrum of cases (break size, limiting single failure scenario, and power level) was considered. With respect to the EQ temperature profile, under the proposed manual CFCU initiation scenario, the LOCA event in the phase 2 study resulted in exceeding the current established EQ basis for a considerable amount of time. Since the critical equipment needs to be qualified out through $1x10^7$ seconds (approximately 120 days), the new LOCA runs will need to cover through this time period.

The present proposed CFCU/SW configuration includes an automatic swap to service water cooling (accident mode), even for those events where the limiting single failure is not the result of a loss of offsite power, such that accident heat removal (from the CFCUs) will start by 100 seconds following the actuation trip signal. To ensure the appropriate CFCU initiation time is implemented, the set of containment response cases performed with COCO (Reference 5) will provide the necessary information for both the LOCA and MSLB scenarios.

The planned configuration is to have three CFCUs available to swap from the closed loop chiller mode to the service water mode. The service water flow rate will be reduced from the current configuration, such that the CFCU heat removal capability will also be reduced. However, due to the intended CFCU normal closed loop cooling configuration, the fouling factor will be significantly lower than currently achievable. As such, the exact CFCU heat removal rate as a function of containment temperature was determined by PSEG as part of the input specification. For those cases where the single failure is the loss of a safeguards train, two CFCUs and one containment spray pump are available for containment cooling (three CFCUs and two spray pumps for other single failure scenarios).

As part of the analysis performed in 1996 and 1997 (see Reference 1), the plant design change required to meet Generic Letter 96-06 (head tanks connected to the service water lines used a nitrogen gas cover to ensure the system remained pressurized) resulted in 10% degraded heat removal (due to gas entrainment) for the first two minutes that the CFCUs were running in accident mode. The new CFCU/SW configuration will not have this short term degraded heat removal since in the new chilled-water configuration, the CFCU piping is a closed loop with no potential for column separation during the period when the service water pumps are being restarted on the diesel-generators. The head tanks back-up the closed loop by pressurizing the piping and accommodating any potential piping leakage. Any water injected from these tanks will be minimal, if any. Since the injected water will be little or none, there are no reasons to continue to include a full heat capacity time-delay in the containment analysis.

3 ANALYSES DESCRIPTION

3.1 OBJECTIVE

The objective of this program is to demonstrate through analyses and evaluations that the containment pressure and temperature for Salem Unit 1 and Unit 2 resulting from a design basis large break LOCA or main steamline break will remain within the acceptable design limits for the proposed changes to the CFCUs and the SW system.

3.2 ANALYSES APPROACH

Consistent with the methodology reported in References 1 through 4, the LOCA and MSLB cases for Salem Unit 1 and Unit 2 will be analyzed with the current licensing basis methods and analysis tools that have been reviewed and approved for the Salem units many times over the duration of plant operation.

3.3 ACCEPTANCE CRITERIA

This analysis is considered acceptable if the current design limits are maintained. The containment design limits are defined in Section 5.2.2 of the Salem Technical Specifications: maximum internal pressure of 47 psig; air temperature up to 351.3°F (providing the containment pressure is in accordance with that described in the UFSAR).

It is also desirable for the containment temperature transients to remain below the EQ temperature profile in Table 3.3-1. However, it is recognized that the temperature transient may shift slightly due to the delayed start of the fan coolers from 60 seconds to 100 seconds, the reduced number of fan coolers (i.e., a maximum of five to a possible maximum of three), and the reduced fan cooler heat removal rate compared to the performance employed in the current licensing basis containment integrity analyses.

Table 3.3-1 Equipment Qualification Temperature Profile	
Time (seconds)	**Temperature (°F)**
0	120
1	165
3	217
6	240
20	265
60	351
80	351
150	325
240	270
1,000	265
4,000	237
4,800	224
18,000	224
180,000	172
518,400	160
1,000,000	140
4,406,400	132
8,640,000	119
10,368,000	113.2

4 STEAMLINE BREAK MASS/ENERGY RELEASE ANALYSIS

Steamline ruptures occurring inside a reactor containment structure may result in significant releases of high-energy fluid to the containment environment and elevated containment temperatures and pressures. The magnitude of the releases following a steamline rupture is dependent upon the plant initial operating conditions and the size of the rupture as well as the configuration of the plant steam system and the containment design. These variations make it difficult to determine the absolute worst cases for either containment pressure or temperature evaluation following a steamline break. The analysis considers a variety of postulated pipe breaks encompassing wide variations in plant operation, safety system performance, and break size in determining the main steamline break (MSLB) mass and energy releases for use in containment analysis.

This section discusses the analysis that is done to generate the mass and energy releases from the steamline break. The containment pressure and temperature response analysis is documented in Section 6.2.

4.1 ANALYSIS METHOD

The steamline break mass and energy releases are generated using the NRC-approved LOFTRAN code (Reference 6). LOFTRAN is used for studies of the transient response of a PWR system to specified perturbations in process parameters. The code simulates a multi-loop system including the reactor vessel, hot and cold leg piping, steam generator (shell and tube sides), and the pressurizer. A neutron point kinetics model is used and the reactivity effects of the moderator, fuel, boron, and rods are included. The secondary side of the steam generator is modeled as a homogeneous saturated mixture. Protection and control systems are simulated, as well as the Emergency Core Cooling System. The calculation of secondary side break flow is based on the Moody critical flow correlation (Reference 7) with fL/D = 0.

The Westinghouse steamline break mass and energy release methodology was approved by the NRC (Reference 8) and is documented in WCAP-8822, "Mass and Energy Releases Following a Steam Line Rupture" (Reference 9). WCAP-8822 forms the basis for the assumptions and models used in the calculation of the mass and energy releases resulting from a steamline rupture.

4.2 CASE DEFINITIONS AND SINGLE FAILURES

There are many factors that influence the quantity and rate of the mass and energy release from the steamline. To encompass these factors, a spectrum of cases are analyzed that vary the initial power level, the break type, the break area and the single failure. This section summarizes the basis of the cases that have been defined for the Salem plant.

The power level at which the plant is operating when the steamline break is postulated can cause different competing effects that make it difficult to pre-determine a single limiting case. For example, at higher power levels there is less initial water/steam in the steam generator, which is a benefit. However, at a higher power level there is a higher initial feedwater flowrate, higher feedwater temperature, higher decay heat, and there is a higher rate of heat transfer from the primary side, which are all penalties. Therefore, cases consider initial power levels varying from full power to zero power.

There are two types of pipe ruptures that are considered. First is a double-ended guillotine rupture in which the steam pipe is completely severed and the ends of the break displace from each other. Guillotine ruptures are characterized by two distinct break locations, each of equal area but being fed by different steam generators. The other postulated break type is a split rupture in which a hole opens at some point on the side of the steam pipe but does not result in a complete severance of the pipe. A single, distinct break area is fed uniformly by all steam generators until steamline isolation occurs. Following MSIV closure, the split break is unisolable from one faulted steam generator.

The break area is also important when evaluating steamline breaks. It controls the rate of releases to the containment as well as influencing the amount of entrained water in the blowdown and the steamline depressurization. There are a total of 5 break types/areas that are analyzed.

1. A 4.6 ft^2 double-ended rupture (DER) upstream of the in-line flow restrictor. This break size/location only applies to Unit 2 with model 51 steam generators, since the model F steam generators in Unit 1 have an integral flow restrictor. The reverse flow area for these cases is limited to 1.4 ft^2, the cross-sectional area of the in-line flow restrictor.

2. A 1.4 ft^2 DER downstream of the flow restrictor. The reverse flow area for theses cases is limited to 3.2 ft^2, the cross-sectional area of the MSIV.

3. Small DERs having the smallest area that gets water entrainment.

4. Small DERs having the largest area that does not get water entrainment.

5. Split ruptures that are the largest break area that will neither generate a steamline isolation signal from the primary protection equipment nor result in moisture entrainment. The safety injection signal is also generated by a high containment pressure signal for these cases.

Several single failures can be postulated that would impair the performance of various steamline break protection systems. The single failures either reduce the heat removal capacity of the containment safeguards, or increase the energy release from steamline break. The single failures that have been postulated for Salem are summarized below.

Containment Safeguards Failure (CSF)

The worst containment safeguards failure is the failure of "C" vital bus that results in the failure of 1 out of 2 containment spray pumps and 1 out of 3 containment fan coolers. The effect of this failure is a reduction of approximately 70,000 Btu/sec heat removal.

AFW Runout Protection Failure

This failure increases the auxiliary feedwater flowrate to the faulted SG. Figure 4-1 shows an example of the increase in AFW flowrate as a function of SG pressure, with either the intact SGs fully pressurized or the faulted SG fully depressurized. The penalty of this failure depends on the SG pressure, but in the long-term will usually be between about 150 to 350 gpm extra AFW to the faulted SG.

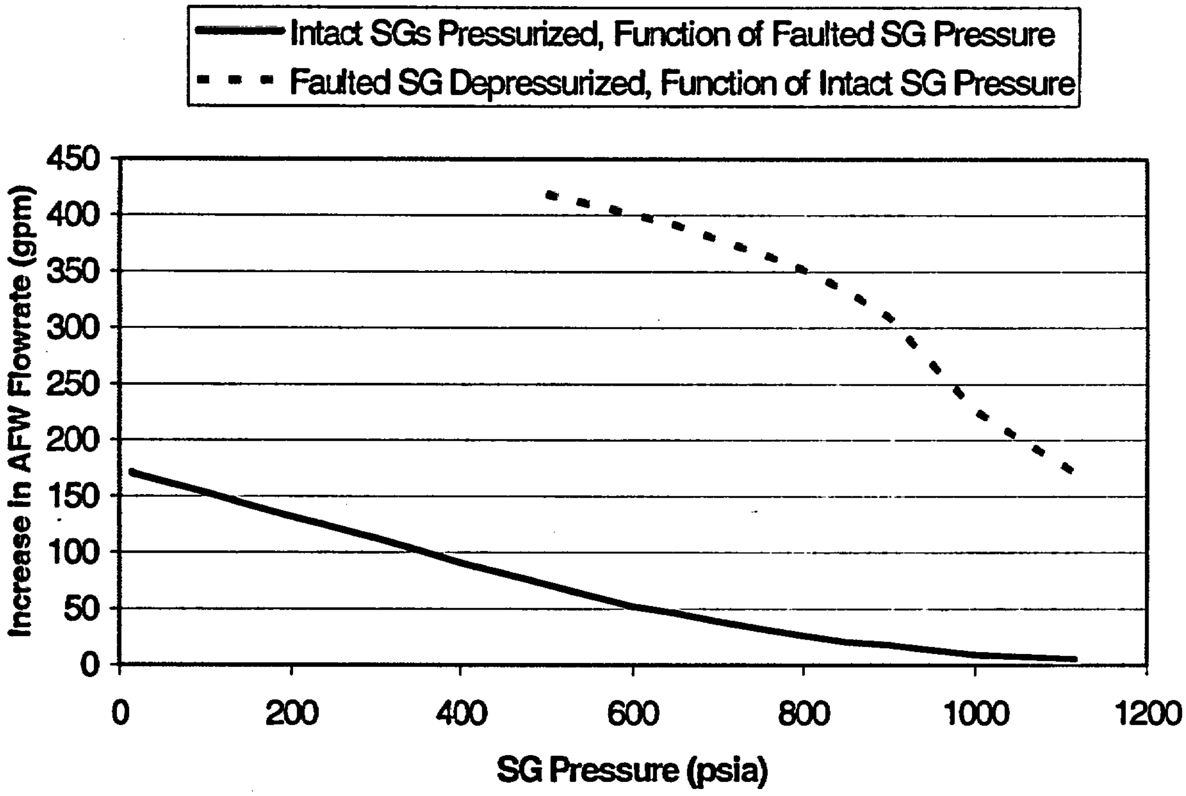


Figure 4-1 Increase in AFW to the Faulted SG Due to AFW Runout Protection Failure

Feedwater Reg Valve Failure

When the feedwater regulator valve (FRV) on the faulted loop fails open, the feedwater isolation valve (FIV) is credited to close. Additional feedwater enters the faulted SG because the closure time of the FIV is slower (an additional 22 seconds) and because of a slight increase in the unisolable feedline volume.

This failure is the most severe for the largest breaks which depressurize the SG the fastest and thus allow a higher pumped feedwater flowrate to continue for the extra 22 seconds. The extra pumped feedwater can be on the order of 20,000 lbm to 30,000 lbm, and the extra unisolable feedline volume adds another 2000 to 3000 lbm of water.

MSIV Failure

When the MSIVs close, the intact loop SGs are isolated from the break. Even if the faulted loop MSIV fails open, the isolation of the intact SGs is accomplished by the closure of the MSIVs on each of those loops. However, the unisolable steamline volume increases from 542 ft^3 to 10,083 ft^3 if the MSIV on the faulted loop fails open. This causes approximately an extra 20,000 lbm of steam to be released out the break.

The full spectrum of steamline break cases that has been analyzed for Salem is summarized in Table 4-1. However, a subset of cases was selected for this analysis to evaluate the acceptability of the CFCU modifications. The selected cases are indicated in Table 4-1, and represent some of the most limiting containment pressure scenarios, the most limiting containment temperature scenarios, and cases that might experience the largest impact from the CFCU modifications. Cases are separately analyzed for Unit 1 and Unit 2. Note that the 4.6 ft^2 DER cases only apply to Unit 2 with model 51 SGs.

Table 4-1 Spectrum of Salem SLB/Containment Cases

Break	Power	Single Failure			
		CSF	AFW	FRV	MSIV
4.6 ft^2 DER	100	Case 1	Case 5	**CASE 9**	Case 13
	70	Case 2	Case 6	Case 10	Case 14
	30	Case 3	Case 7	**CASE 11**	Case 15
	0	Case 4	Case 8	Case 12	Case 16
1.4 ft^2 DER	100	Case 17	Case 21	**CASE 25**	Case 29
	70	Case 18	Case 22	Case 26	Case 30
	30	**CASE 19**	**CASE 23**	Case 27	Case 31
	0	Case 20	Case 24	Case 28	Case 32
Small DER With Entrainment	100	Case 33	Case 37	Case 41	Case 45
	70	Case 34	Case 38	Case 42	Case 46
	30	Case 35	Case 39	Case 43	Case 47
	0	Case 36	Case 40	Case 44	Case 48
Small DER Without Entrainment	100	Case 49	Case 53	Case 57	**CASE 61**
	70	Case 50	Case 54	Case 58	Case 62
	30	Case 51	Case 55	Case 59	Case 63
	0	Case 52	Case 56	Case 60	Case 64
Split Break	100	Case 65	Case 69	Case 73	Case 77
	70	Case 66	Case 70	Case 74	Case 78
	30	**CASE 67**	Case 71	Case 75	**CASE 79**
	0	Case 68	Case 72	Case 76	Case 80

Note that cases in **BOLD** were selected for this service water enhancement program analysis.

4.3 ANALYSIS ASSUMPTIONS

4.3.1 Protection Logic and Setpoints

Salem Unit 1 and Unit 2 steamline break protection, in terms of the pertinent signals and setpoints that are actuated in these analyses is summarized below.

The first SI signal comes from either:

- Low steamline pressure (514.7 psia) in at least 2 loops coincident with high steam flow in at least 2 loops, or
- High steamline differential pressure (200 psid), or
- High-1 containment pressure (5.5 psig).

An SI signal starts the SI pumps and will also result in:

- Reactor trip (2 sec delay)
- Start of auxiliary feedwater (no delay)
- Closure of feedwater reg valve (10 sec delay) and feedwater isolation valve (32 sec delay, only credited if FRV fails open)
- Trip of MFW pumps (10 second coastdown, only credited if FRV fails open)
- Start of containment fan coolers (100 sec delay)

Steamline isolation (closure of main steam isolation valves, MSIVs) will also occur on the low steamline pressure coincident with high steam flow signal, after a 12.0 second delay. However, if this signal is not generated, MSIVs will close on a high-2 containment pressure (17.0 psig) signal. The high-2 containment pressure signal also causes the start of containment spray pumps, after an 85 second delay.

4.3.2 Secondary Side Assumptions

This section summarizes the input assumptions associated with the steam generator and the piping attached to it.

Initial Steam Generator Inventory

A high initial steam generator mass is assumed. The initial level corresponds to 44% NRS + 5% uncertainty for at power cases. At zero power, the nominal initial water level decreases to 33%.

Main Feedwater System

Key assumptions and methods regarding the main feedwater system are summarized below.

1. The initial flow to each SG is based on the initial power.

2. The FRV on each of the intact SGs is assumed to close at the time of the SI signal. This terminates the main feedwater addition to the intact SGs. Since they are isolated from the break long before their inventory is depleted, the overall results are insensitive to the details of this modeling.

3. The FRV on the faulted loop is assumed to quickly open in response to the steamline break. Starting at 0.2 seconds, the main feedwater flowrate modelling is based on the faulted loop FRV fully open (and the intact FRVs fully closed).

4. Main feedwater is added to the faulted SG until the FRV closes, 10 seconds after the SI signal.

5. If the FRV on the faulted loop fails open, the main feedwater pump trip is credited. However, the condensate pumps are not tripped from an SI signal, and pumped flow continues until the feedwater isolation valve is fully closed 32 seconds after the SI signal.

6. All cases model the flashing of the feedwater in the unisolable section of the feedline between the faulted steam generator and the FRV or FIV, whichever is credited to close. Only the cases initiated from hot zero power do not experience feedwater flashing due to the low temperature of the feedwater.

Auxiliary Feedwater

Generally within the first minute following a steamline break, the auxiliary feedwater system will be initiated due to an SI signal. Addition of auxiliary feedwater to the steam generators will increase the secondary mass available for release to containment. Maximum auxiliary feedwater flowrates are assumed, and are input as a function of the pressure in the faulted steam. In addition, the full auxiliary feedwater flowrate is assumed at the time the SI setpoint is reached, with no electronic delay or pump start-up time. Operator action is credited to terminate the auxiliary feedwater flow to the faulted steam generator after 10 minutes.

Quality of the Break Effluent

The quality of the break effluent is generally assumed to be 1.0, corresponding to saturated steam that is all vapor with no liquid. However, when a large double-ended break first occurs, it is expected that there will be a significant quantity of liquid in the break effluent. Modeling entrainment is a benefit to the analysis, since it allows a portion of the initial steam generator inventory to be released at the lower enthalpy of saturated liquid rather than saturated vapor. The break quality for the DERs is from WCAP-8822 (Reference 9) for model 51 steam generators, and similar information was generated with the same methodology for model F steam generators.

Heat Transfer to Faulted Steam Generator

The ability of the steam generator feeding the broken steamline to transfer heat from the primary coolant to the secondary water inventory can have an important influence on the mass and energy that is released through the break. As discussed in Reference 8, the film coefficient on the outside of the tubes and the forced convection from the reactor coolant pumps will typically maintain a large secondary side heat transfer coefficient. The only mechanism for reducing the heat transfer capability to the steam generator is to lower the effective heat transfer area. Such a reduction occurs when sufficient mass is lost from the steam generator to lower the water level below the top of the tube bundle. To conservatively force a high heat transfer rate to the faulted steam generator, the SG tubes are assumed to be fully covered until the water volume on the secondary side decreases below 100 ft^3.

4.3.3 Reactor Coolant System Assumptions

While the mass and energy released from the break is determined from assumptions that have been discussed in the previous section, the long-term rate at which the release occurs is largely controlled by the conditions in the reactor coolant system. The major features of the primary side analysis model are summarized below.

- Continued operation of the reactor coolant pumps maintains a high heat transfer rate to the steam generators.
- The model includes consideration of the heat that is stored in the RCS metal.
- Reverse heat transfer from the intact steam generator to the RCS coolant is modeled as the temperature in the RCS falls below the steam generator fluid temperature.
- Minimum flowrates are modeled from ECCS injection, to conservatively minimize the amount of boron that provides negative reactivity feedback.
- The core power is 3459 MWt, with a maximum pump heat of 20 MWt, resulting in NSSS power of 3479 MWt. This bounds the current NSSS power of 3471 MWt.
- Maximum reactor power calorimetric uncertainty of +0.6% is used for full power cases.
- RCS average temperature is the full-power nominal (high-end) value of 577.9°F plus an uncertainty of +5.0°F.
- Core residual heat generation is assumed based on the 1979 ANS decay heat plus 2σ model (Reference 10).
- Conservative core reactivity coefficients corresponding to end-of-cycle conditions were chosen to maximize the reactivity feedback effects as the RCS cools down as a result of the steamline break.
- All cases have credited a shutdown margin of 1.3% $\Delta k/k$.

4.4 STEAMLINE BREAK MASS/ENERGY RELEASES

Steamline break mass and energy release rates are provided in Table 4-2 to Table 4-7 for Unit 1 and Table 4-8 to Table 4-15 for Unit 2.

Table 4-2 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 19-1 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	8942.9	1192.1
1.4	8238.0	1194.7
1.6	8372.8	1171.0
1.8	8895.2	1113.4
2.0	9751.0	1037.1
2.2	10428.3	984.2
3.0	10702.7	943.0
3.2	10953.7	935.4
3.4	11080.1	924.2
6.0	9653.6	953.6
7.2	9107.3	966.8
9.0	8517.4	975.7
11.4	7598.9	1006.0
13.2	7076.7	1025.4
13.4	7076.7	1028.9
13.6	4769.1	950.1
13.8	2971.6	805.7
16.0	2616.1	844.7
17.4	2341.4	885.2
19.2	2029.5	939.5
20.8	1794.2	988.4
22.4	1594.6	1038.1
24.2	1407.9	1094.9
25.8	1269.6	1146.1
27.6	1138.8	1204.3

Table 4-2 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 19-1 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
32.2	1046.1	1204.0
36.8	988.3	1203.8
40.0	961.3	1203.6
46.2	927.7	1203.4
58.8	895.6	1203.2
102.4	860.4	1202.9
163.0	845.9	1202.7
164.2	838.2	1202.6
166.6	800.4	1202.2
169.0	742.1	1201.5
171.4	659.6	1200.1
176.8	430.5	1193.8
178.6	367.0	1191.0
180.4	318.3	1188.5
192.2	297.7	1187.4
222.2	294.6	1187.2
255.2	289.6	1186.9
312.4	275.9	1186.0
342.8	264.8	1185.2
373.4	248.0	1184.0
434.4	204.0	1180.1
449.6	196.3	1179.4
464.8	191.0	1178.8
480.2	187.6	1178.5
510.8	184.3	1178.1
600.2	182.5	1178.0
604.0	138.0	1172.4
604.6	132.2	1171.6
612.2	84.4	1162.5
616.6	51.9	1154.0

Table 4-2 (cont.)	**Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 19-1 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure**	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
617.8	41.6	1152.1
618.6	33.6	1151.2
618.8	33.0	1150.9
619.0	28.2	1150.8
619.2	28.4	1150.5
619.4	22.4	1150.5
619.6	22.7	1150.4
619.8	0.0	0.0
700.0	0.0	0.0

Table 4-3 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 23-1 – 1.4 ft^2 DER, 30% Power, AFW Runout Protection Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	8942.9	1192.1
1.4	8238.0	1194.7
1.6	8372.8	1171.0
1.8	8895.1	1113.4
2.0	9750.8	1037.1
2.2	10428.0	984.2
3.0	10701.7	943.0
3.4	11078.9	924.2
7.2	9104.5	966.7
11.4	7595.0	1005.9
13.4	7072.4	1028.8
13.6	4766.0	950.1
13.8	2969.6	805.6
16.0	2614.0	844.6
19.2	2027.3	939.4
20.8	1792.0	988.4
22.4	1592.6	1038.1
24.2	1406.0	1094.9
27.6	1137.0	1204.3
32.2	1044.2	1204.0
36.8	986.3	1203.8
45.8	927.2	1203.4
63.8	886.1	1203.1
100.2	859.0	1202.8
168.4	836.1	1202.6
171.4	788.3	1202.1
174.2	715.4	1201.1
176.2	645.0	1199.9
182.0	415.1	1193.2

Table 4-3 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 23-1 – 1.4 ft^2 DER, 30% Power, AFW Runout Protection Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
183.8	360.8	1190.7
185.2	328.1	1189.0
200.8	297.6	1187.4
299.2	290.2	1186.9
370.0	282.4	1186.4
371.6	279.1	1186.2
373.2	282.0	1186.4
374.8	278.7	1186.2
376.4	281.5	1186.4
378.0	278.3	1186.2
379.6	281.1	1186.4
381.2	277.9	1186.2
382.8	280.7	1186.3
600.8	240.0	1183.2
603.2	202.2	1179.8
604.2	194.9	1179.2
608.2	184.6	1178.1
610.2	175.2	1177.1
619.0	121.0	1169.5
628.4	55.3	1154.7
629.4	47.1	1153.0
630.8	33.8	1151.2
631.4	28.4	1150.6
631.8	23.0	1150.4
632.0	0.0	0.0
700.0	0.0	0.0

Table 4-4 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 25-1 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
0.0	0.0	0.0
0.2	7953.3	1194.9
0.4	7828.9	1195.3
0.8	7660.8	1195.9
1.4	7435.1	1196.7
1.6	7515.0	1179.8
1.8	7620.8	1161.3
2.0	7745.6	1141.2
2.2	7899.1	1119.2
2.4	8087.2	1095.0
2.6	8318.2	1068.2
2.8	8604.4	1038.5
3.0	8963.3	1005.3
3.2	9542.8	993.1
4.0	9670.5	977.3
4.2	9632.7	978.0
5.0	9222.9	999.5
5.6	8945.0	1014.8
6.2	8689.4	1029.4
7.4	8232.1	1056.6
8.0	8023.3	1069.3
8.6	7905.6	1073.4
9.8	7685.8	1077.9
10.4	7546.0	1081.7
13.4	6765.3	1108.9
13.6	4353.6	1061.4
13.8	2461.8	960.2
15.0	2295.6	981.8
16.4	2087.4	1015.7
17.6	1923.3	1045.8

Table 4-4 (cont.) **Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 25-1 – 1.4 ft² DER, 100% Power, Feedwater Reg Valve Failure**

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
18.4	1822.3	1066.1
19.0	1751.1	1081.4
19.6	1683.6	1096.8
20.4	1599.1	1117.5
21.0	1539.7	1133.1
21.6	1483.6	1148.8
22.2	1430.6	1164.6
23.6	1317.9	1201.8
23.8	1306.9	1204.5
24.6	1279.8	1204.5
26.4	1225.9	1204.5
28.0	1184.7	1204.4
29.6	1148.7	1204.3
31.4	1113.1	1204.3
33.0	1085.1	1204.2
34.8	1057.0	1204.1
36.4	1034.8	1204.0
38.2	1012.8	1203.9
40.0	993.8	1203.8
41.6	979.4	1203.7
45.0	955.0	1203.6
48.4	936.6	1203.5
52.0	921.8	1203.4
55.4	910.9	1203.3
58.8	902.1	1203.2
65.8	888.3	1203.1
72.6	878.1	1203.0
79.4	870.2	1202.9
93.2	858.9	1202.8
107.0	851.4	1202.8

Table 4-4 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 25-1 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
149.0	839.3	1202.7
192.6	834.9	1202.6
193.0	832.6	1202.6
194.0	823.1	1202.5
196.0	800.6	1202.2
197.8	777.8	1202.0
199.8	750.1	1201.6
203.6	693.5	1200.8
207.6	630.9	1199.6
211.4	567.7	1198.2
215.4	498.6	1196.3
219.2	434.7	1194.1
221.0	406.6	1192.9
222.0	391.7	1192.3
223.0	377.7	1191.6
224.8	354.2	1190.5
226.8	330.7	1189.2
228.6	312.2	1188.2
230.6	294.0	1187.1
231.4	287.4	1186.7
232.4	280.0	1186.2
234.4	267.1	1185.4
235.4	261.5	1185.0
236.4	256.3	1184.6
237.4	251.7	1184.2
238.4	247.7	1183.9
240.4	240.7	1183.4
242.4	235.0	1182.9
244.4	230.6	1182.5
246.2	227.1	1182.2

Table 4-4 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 25-1 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
248.0	222.9	1181.9
250.0	218.8	1181.5
252.0	215.4	1181.2
254.0	212.7	1180.9
257.8	208.7	1180.6
261.6	205.9	1180.3
265.4	203.9	1180.1
269.4	202.2	1179.9
277.2	199.8	1179.7
284.8	198.0	1179.5
315.8	191.8	1178.9
331.4	189.5	1178.7
377.6	184.6	1178.1
408.4	182.1	1177.9
423.8	181.2	1177.8
452.2	180.5	1177.7
600.2	180.5	1177.8
602.2	158.9	1174.9
605.0	102.9	1166.2
605.2	100.0	1165.6
605.6	94.3	1164.5
606.0	89.3	1163.6
606.8	80.2	1161.5
607.2	76.0	1160.3
607.4	73.6	1159.7
608.4	63.1	1156.7
608.8	58.7	1155.5
609.0	56.5	1154.9
609.4	51.7	1153.8
610.0	44.2	1152.4

Table 4-4 (cont.)	Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 25-1 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
610.2	41.4	1152.0
610.4	38.6	1151.6
610.8	32.6	1151.0
611.0	29.1	1150.7
611.2	25.1	1150.5
611.4	20.0	1150.4
611.6	0.0	0.0
700.0	0.0	0.0

Table 4-5 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 61-1 – 0.33 ft² Small DER, 100% Power, MSIV Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	1244.1	1194.7
0.4	1237.6	1194.8
1.4	1218.1	1195.2
2.8	1198.6	1195.7
5.2	1172.4	1196.3
7.8	1149.3	1196.8
10.4	1130.1	1197.2
12.8	1115.4	1197.5
15.4	1102.6	1197.8
19.2	1088.4	1198.1
20.6	1081.5	1198.3
20.8	1105.0	1198.1
21.0	1115.1	1197.9
22.8	1170.6	1196.7
24.0	1204.2	1195.9
25.2	1234.8	1195.1
26.2	1256.4	1194.6
27.4	1274.8	1194.1
28.6	1283.1	1193.9
30.2	1286.0	1193.8
31.4	1281.5	1193.9
48.4	1179.6	1196.1
57.8	1127.5	1197.2
74.2	1046.7	1198.8
75.2	1043.1	1199.6
86.0	888.8	1200.2
95.2	761.2	1200.7
104.6	635.0	1201.4
114.0	511.9	1202.2

Table 4-5 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 61-1 – 0.33 ft^2 Small DER, 100% Power, MSIV Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
124.6	375.7	1203.9
124.8	374.1	1203.9
132.6	368.6	1204.0
142.0	363.2	1204.1
151.4	358.8	1204.1
160.6	355.3	1204.2
186.4	349.1	1204.3
219.0	346.2	1204.3
409.8	345.6	1204.3
568.8	347.3	1204.3
572.0	345.5	1204.3
575.2	342.7	1204.3
578.4	339.0	1204.3
581.8	334.3	1204.4
585.0	329.0	1204.4
588.4	322.3	1204.4
591.8	314.8	1204.5
597.4	300.3	1204.5
600.6	292.5	1204.5
609.0	232.8	1203.8
619.6	230.1	1203.7
622.4	227.3	1203.6
625.8	226.7	1203.6
639.2	218.9	1203.4
649.0	211.8	1203.2
654.0	207.5	1203.0
659.0	202.7	1202.8
664.0	197.1	1202.6
668.8	191.2	1202.4
673.8	184.3	1202.0

Table 4-5 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 61-1 – 0.33 ft^2 Small DER, 100% Power, MSIV Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
678.8	176.5	1201.6
683.8	168.0	1201.1
688.8	158.5	1200.4
693.8	148.2	1199.6
698.8	137.1	1198.6
703.8	125.3	1197.3
716.2	95.4	1192.9
721.2	84.0	1190.6
726.0	73.7	1188.2
728.4	68.7	1187.0
730.8	64.0	1185.7
733.4	59.1	1184.1
735.8	54.9	1182.7
738.2	50.8	1181.2
739.8	48.1	1180.1
740.8	46.7	1179.5
744.8	40.9	1176.9
749.4	34.8	1173.8
752.4	31.1	1171.6
761.4	22.4	1164.9
770.0	16.3	1158.7
779.0	9.9	1152.1
782.0	6.4	1150.7
783.0	5.2	1150.4
783.2	0.0	0.0
1000.0	0.0	0.0

Table 4-6 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 67-1 – 0.88 ft^2 Split Break, 30% Power, Cont. Safeguards Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	1813.9	1191.7
3.8	1722.9	1193.5
7.4	1654.0	1194.8
14.8	1549.6	1196.7
20.4	1562.1	1196.6
24.2	1547.4	1196.9
60.0	1258.7	1201.3
63.2	1140.7	1202.7
65.2	1078.6	1203.3
68.8	989.1	1204.0
72.4	920.1	1204.3
76.4	860.0	1204.4
80.6	813.6	1204.5
85.6	775.1	1204.5
88.6	758.4	1204.4
97.6	725.6	1204.4
113.0	700.3	1204.3
141.0	683.2	1204.2
201.4	670.2	1204.1
314.8	666.2	1204.1
316.8	657.9	1204.0
319.0	640.7	1203.9
322.2	602.0	1203.6
324.2	568.7	1203.2
327.2	506.8	1202.3
333.4	366.4	1198.5
335.6	325.4	1196.8
337.8	292.7	1195.2
338.8	280.4	1194.5

Table 4-6 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 67-1 – 0.88 ft^2 Split Break, 30% Power, Cont. Safeguards Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
340.8	260.1	1193.2
344.0	237.3	1191.6
347.2	223.0	1190.5
350.2	214.6	1189.8
356.4	205.5	1189.1
360.6	202.7	1188.8
373.2	199.8	1188.6
386.6	199.0	1188.5
395.8	191.6	1187.8
406.6	187.5	1187.4
496.6	187.0	1187.4
542.0	186.9	1187.4
604.2	184.9	1187.2
618.0	179.4	1186.6
642.4	175.1	1186.2
656.2	170.6	1185.7
670.0	164.0	1185.0
683.8	153.6	1183.7
690.8	145.9	1182.7
697.6	136.0	1181.3
704.4	123.0	1179.3
707.8	115.2	1178.0
712.6	102.3	1175.7
717.8	86.0	1172.3
720.0	79.8	1170.6
727.0	56.8	1163.9
732.8	39.2	1156.7
735.4	30.3	1153.3
736.0	28.6	1152.6
736.6	25.0	1152.1

Table 4-6 (cont.) Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 67-1 – 0.88 ft^2 Split Break, 30% Power, Cont. Safeguards Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
736.8	25.2	1151.7
737.0	23.1	1151.7
737.2	23.3	1151.4
737.4	21.1	1151.3
738.0	19.2	1150.7
738.2	16.8	1150.7
738.4	17.0	1150.5
738.8	12.9	1150.4
739.0	0.0	0.0
1000.0	0.0	0.0

Table 4-7 Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 79-1 – 0.88 ft^2 Split Break, 30% Power, MSIV Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	1813.9	1191.7
3.8	1724.7	1193.5
7.4	1656.9	1194.8
14.8	1553.3	1196.6
20.2	1564.7	1196.6
24.2	1550.0	1196.9
60.4	1255.1	1201.4
63.6	1142.2	1202.7
65.6	1085.1	1203.2
69.0	1005.1	1203.9
73.0	931.1	1204.3
76.6	877.9	1204.4
80.6	831.9	1204.5
87.4	779.1	1204.5
94.0	747.2	1204.4
100.8	726.3	1204.4
117.2	700.0	1204.3
146.0	682.6	1204.2
211.6	669.5	1204.1
356.4	666.5	1204.1
359.4	652.2	1204.0
361.8	630.0	1203.8
363.8	604.3	1203.6
366.8	552.2	1203.0
369.0	505.3	1202.3
374.2	385.9	1199.2
377.2	327.6	1196.9
379.2	297.1	1195.5
381.4	270.8	1193.9

Table 4-7 (cont.)	Salem Unit 1 (Model F SG) Steamline Break Mass/Energy Release, Case 79-1 – 0.88 ft^2 Split Break, 30% Power, MSIV Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
384.4	245.4	1192.2
387.8	227.3	1190.9
391.8	214.9	1189.9
394.0	210.6	1189.5
400.2	203.9	1188.9
406.6	201.1	1188.7
431.8	198.9	1188.5
440.6	191.6	1187.8
510.0	187.1	1187.4
601.0	186.0	1187.2
620.2	181.1	1186.8
622.6	179.0	1186.6
659.8	170.1	1185.7
673.4	163.4	1184.9
687.0	152.7	1183.6
693.8	145.0	1182.5
700.4	135.2	1181.1
707.2	121.9	1179.1
712.2	109.8	1177.0
724.0	74.5	1169.1
733.2	44.6	1159.2
739.8	21.7	1151.1
740.2	19.7	1150.8
740.6	17.4	1150.5
741.0	14.5	1150.4
741.2	0.0	0.0
1000.0	0.0	0.0

Table 4-8 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 9-2 – 4.6 ft^2 DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
0.0	0.0	0.0
0.2	10588.9	1197.2
0.4	11053.4	1116.9
0.6	13236.7	964.6
0.8	14765.0	881.4
1.0	15083.4	854.7
1.2	15479.0	827.2
1.4	15976.6	799.1
1.6	16596.7	770.2
2.2	14858.3	790.8
2.4	14314.2	798.5
2.8	13303.0	814.0
3.2	12381.6	829.7
3.4	11953.5	837.6
3.6	11764.2	852.1
4.0	11061.7	869.8
4.4	10424.8	887.2
4.8	9856.1	904.6
5.0	9594.6	913.2
5.4	9122.9	930.2
5.8	8706.9	946.9
6.0	8515.4	955.1
6.4	8160.8	971.3
7.0	7692.3	995.0
7.6	7288.5	1017.8
8.2	6938.1	1039.8
8.4	6831.2	1046.9
8.6	6681.6	1059.3
8.8	6496.2	1076.8
9.2	6162.0	1110.1

Table 4-8 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 9-2 – 4.6 ft^2 DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
9.4	6011.4	1126.1
9.8	5737.6	1156.5
10.2	5486.2	1186.6
10.4	5374.6	1200.2
13.6	4919.3	1199.7
13.8	4919.3	1199.6
14.6	2486.3	1201.3
14.8	2403.3	1201.3
15.8	2307.8	1200.9
16.8	2220.7	1200.5
17.8	2142.4	1200.0
18.6	2085.6	1199.7
19.4	2033.8	1199.4
20.4	1975.6	1199.0
21.4	1923.8	1198.6
22.4	1877.6	1198.3
24.2	1806.3	1197.8
26.2	1738.2	1197.2
28.2	1676.4	1196.7
30.2	1620.4	1196.2
32.0	1573.8	1195.7
34.0	1526.6	1195.2
35.8	1491.0	1194.9
37.8	1460.8	1194.5
39.8	1436.5	1194.2
41.6	1418.9	1194.0
43.4	1405.2	1193.9
45.4	1393.2	1193.7
49.2	1376.1	1193.5
53.0	1363.9	1193.4

Table 4-8 (cont.)	Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 9-2 – 4.6 ft^2 DER, 100% Power, Feedwater Reg Valve Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
60.8	1346.7	1193.1
76.0	1325.5	1192.9
91.2	1311.5	1192.7
114.4	1299.0	1192.5
114.6	1296.5	1192.4
115.0	1279.6	1192.1
115.4	1256.1	1191.8
116.0	1213.8	1191.2
117.0	1133.5	1189.9
118.0	1044.4	1188.4
118.4	1006.5	1187.7
119.0	947.0	1186.6
120.0	843.2	1184.4
121.0	737.6	1181.7
121.8	655.5	1179.4
122.2	617.8	1178.2
122.6	582.7	1177.1
123.0	549.7	1176.0
123.6	503.1	1174.3
124.0	474.2	1173.2
124.2	460.7	1172.6
124.6	435.3	1171.5
124.8	426.8	1170.9
125.6	386.4	1168.8
126.0	367.2	1167.8
126.4	349.3	1166.8
126.8	333.0	1165.9
127.0	325.6	1165.5
127.4	311.9	1164.7
127.8	299.8	1164.0

Table 4-8 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 9-2 – 4.6 ft^2 DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
128.0	294.3	1163.7
128.4	284.2	1163.1
128.8	275.2	1162.4
129.4	263.5	1161.6
129.8	257.1	1161.1
130.2	251.9	1160.6
130.4	248.6	1160.4
130.8	243.2	1160.0
131.4	236.8	1159.5
131.8	233.2	1159.2
132.4	228.8	1158.8
133.2	224.4	1158.5
134.0	221.3	1158.2
135.0	218.9	1158.0
136.0	217.7	1157.9
137.4	217.3	1157.9
144.2	218.6	1158.0
182.4	217.1	1157.8
188.4	215.8	1157.7
268.8	205.3	1156.8
349.4	190.7	1155.6
394.4	185.6	1155.2
448.2	180.8	1154.9
478.8	179.7	1154.8
600.2	179.8	1154.9
600.4	181.4	1154.8
600.6	179.6	1154.6
600.8	176.2	1154.3
601.0	171.2	1154.0
601.2	164.5	1153.5

Table 4-8 (cont.)	Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 9-2 – 4.6 ft^2 DER, 100% Power, Feedwater Reg Valve Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
601.4	156.1	1153.0
601.6	143.1	1151.0
601.8	0.0	0.0
700.0	0.0	0.0

Table 4-9 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 11-2 – 4.6 ft^2 DER, 30% Power, Feedwater Reg Valve Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	12164.1	1193.6
0.4	13449.9	1070.6
0.6	18717.6	843.7
0.8	19216.4	817.1
1.0	19795.2	789.8
1.2	20512.5	761.8
1.4	21394.1	733.0
2.0	19057.3	752.3
2.2	18323.7	759.1
2.6	16918.8	773.2
2.8	16255.9	780.5
3.2	15056.8	795.2
3.4	14497.6	802.7
4.0	13017.6	827.0
4.4	12125.3	843.1
4.8	11276.8	861.6
5.0	10880.1	871.2
5.2	10505.6	880.9
5.4	10154.4	890.5
5.6	9828.5	900.0
6.0	9239.2	918.8
6.4	8712.7	937.4
6.8	8242.1	955.6
7.2	7821.5	973.4
7.6	7445.3	990.8
7.8	7192.2	1007.3
8.0	6953.7	1023.8
8.2	6732.9	1039.8
8.4	6528.1	1055.4

Table 4-9 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 11-2 – 4.6 ft^2 DER, 30% Power, Feedwater Reg Valve Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
8.6	6337.9	1070.6
8.8	6160.9	1085.4
9.2	5831.5	1115.1
9.4	5667.3	1131.7
9.8	5373.0	1163.2
10.2	5118.2	1192.6
10.4	5040.1	1199.6
11.4	4862.1	1199.4
12.6	4675.6	1199.2
14.8	4380.7	1199.0
15.0	4380.7	1198.9
15.8	2058.1	1199.1
16.0	1983.4	1199.0
17.4	1878.7	1198.3
18.2	1824.7	1197.9
19.2	1762.8	1197.4
20.0	1717.5	1197.0
20.8	1676.2	1196.7
21.6	1638.9	1196.3
23.2	1574.6	1195.7
24.0	1547.7	1195.5
24.8	1523.9	1195.2
25.6	1503.5	1195.0
27.2	1471.5	1194.6
28.8	1448.6	1194.4
30.4	1432.4	1194.2
32.0	1420.9	1194.1
35.2	1406.9	1193.9
41.8	1388.6	1193.7
54.8	1364.9	1193.4

Table 4-9 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 11-2 – 4.6 ft^2 DER, 30% Power, Feedwater Reg Valve Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
67.8	1346.9	1193.1
80.8	1333.1	1193.0
93.8	1323.1	1192.8
112.4	1313.4	1192.7
114.4	1207.4	1191.1
116.4	1010.1	1187.8
118.4	823.2	1184.1
120.2	795.9	1183.5
122.4	804.2	1183.7
124.0	804.3	1183.7
125.2	801.3	1183.6
127.4	792.6	1183.4
129.6	781.0	1183.1
138.6	721.0	1181.5
140.8	704.3	1181.1
143.2	684.1	1180.5
145.4	663.8	1179.9
147.6	641.9	1179.2
149.8	618.0	1178.5
152.2	589.7	1177.6
154.4	561.3	1176.6
156.6	530.5	1175.5
158.8	497.5	1174.3
162.8	434.1	1171.6
163.2	430.0	1171.3
163.8	421.4	1170.8
167.6	358.8	1167.5
168.6	343.1	1166.6
169.8	325.6	1165.6
170.8	312.2	1164.9

Table 4-9 (cont.)	Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 11-2 – 4.6 ft^2 DER, 30% Power, Feedwater Reg Valve Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
172.0	297.4	1164.0
173.2	284.1	1163.1
174.4	272.1	1162.3
175.4	263.1	1161.7
176.0	258.2	1161.3
177.0	251.6	1160.7
178.2	242.7	1160.0
178.8	239.1	1159.7
179.8	234.1	1159.3
181.0	229.3	1158.9
182.2	225.5	1158.6
183.4	222.6	1158.3
184.4	220.7	1158.2
185.6	219.0	1158.0
187.8	217.0	1157.8
190.0	215.9	1157.7
194.6	214.7	1157.6
248.4	205.3	1156.8
302.2	193.4	1155.8
320.2	190.1	1155.6
338.2	187.9	1155.4
374.0	184.5	1155.1
391.8	183.4	1155.1
436.2	182.1	1155.0
600.2	181.9	1155.0
601.0	173.1	1154.1
604.2	68.7	1150.4
604.4	0.0	0.0
700.0	0.0	0.0

Table 4-10 Salem Unit 2 (Model 51SG) Steamline Break Mass/Energy Release, Case 19-2 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	8832.5	1192.7
0.6	8569.1	1193.5
1.0	9010.7	1132.6
1.2	9358.5	1094.3
1.4	9843.6	1048.8
1.6	10541.1	993.9
2.6	11019.5	934.9
3.0	10906.6	930.1
3.2	10999.6	931.2
4.6	10697.4	918.1
7.6	9201.4	952.1
9.0	8353.0	988.2
10.0	7838.9	1012.0
11.4	7215.5	1042.4
13.2	6610.9	1075.7
13.4	6610.9	1080.3
13.6	4281.0	1021.0
13.8	2472.1	900.2
15.0	2247.0	940.9
16.4	2014.9	988.9
17.6	1851.9	1025.2
20.0	1600.1	1084.4
22.0	1422.0	1134.6
23.4	1269.6	1199.6
23.6	1256.1	1204.5
28.6	1116.0	1204.3
33.8	1018.6	1203.9
39.0	957.7	1203.6
44.0	921.2	1203.3

Table 4-10 (cont.) Salem Unit 2 (Model 51SG) Steamline Break Mass/Energy Release, Case 19-2 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
54.2	881.5	1203.0
64.4	862.7	1202.9
105.2	834.2	1202.6
193.2	817.8	1202.4
194.4	805.7	1202.3
196.4	771.3	1201.9
198.8	713.1	1201.1
200.8	650.2	1200.0
210.2	327.1	1189.0
223.6	297.3	1187.4
258.6	292.7	1187.1
279.8	289.3	1186.9
294.4	285.8	1186.7
324.8	277.8	1186.1
354.8	266.7	1185.4
391.4	244.9	1183.7
451.6	199.5	1179.7
466.6	192.9	1179.0
481.6	188.7	1178.6
503.8	185.3	1178.2
600.4	183.8	1178.0
603.6	145.7	1173.5
604.8	132.4	1171.6
609.6	99.3	1165.6
611.8	85.1	1162.6
612.4	79.6	1161.4
613.8	68.6	1158.4
614.8	61.4	1156.3
615.8	53.3	1154.3
617.2	40.2	1151.9

Table 4-10 (cont.)	Salem Unit 2 (Model 51SG) Steamline Break Mass/Energy Release, Case 19-2 – 1.4 ft^2 DER, 30% Power, Containment Safeguards Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
618.0	31.5	1150.9
618.4	26.1	1150.6
618.6	25.5	1150.4
618.8	0.0	0.0
700.0	0.0	0.0

Table 4-11 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 23-2 – 1.4 ft^2 DER, 30% Power, AFW Runout Protection Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
0.0	0.0	0.0
0.2	8832.5	1192.7
0.6	8569.1	1193.5
1.0	9010.7	1132.6
1.4	9843.5	1048.8
1.6	10541.1	993.9
2.6	11018.7	934.9
4.6	10695.7	918.1
6.8	9562.1	943.0
9.0	8349.7	988.2
11.4	7211.8	1042.4
13.4	6606.9	1080.3
13.6	4278.3	1021.0
13.8	2470.4	900.1
16.4	2013.2	988.8
18.8	1718.9	1054.6
22.0	1420.2	1134.5
23.6	1254.4	1204.5
28.4	1118.8	1204.3
33.2	1025.7	1204.0
38.0	965.1	1203.6
42.8	926.3	1203.4
52.4	884.0	1203.1
62.0	863.7	1202.9
100.8	833.5	1202.6
198.8	814.1	1202.4
202.2	762.5	1201.8
204.8	698.6	1200.8
212.2	444.0	1194.4
214.2	383.4	1191.8

Table 4-11 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 23-2 – 1.4 ft^2 DER, 30% Power, AFW Runout Protection Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
216.2	335.8	1189.5
218.2	301.1	1187.5
219.4	287.7	1186.8
221.8	303.1	1187.7
226.2	298.3	1187.4
230.2	297.8	1187.4
234.0	297.3	1187.4
237.4	297.0	1187.4
241.0	296.9	1187.4
244.8	296.7	1187.3
248.2	296.3	1187.3
251.8	296.1	1187.3
255.4	295.8	1187.3
259.0	295.4	1187.3
262.6	295.2	1187.2
266.2	295.0	1187.2
269.6	294.5	1187.2
273.0	294.2	1187.2
275.0	289.6	1186.9
276.6	293.9	1187.2
280.0	293.5	1187.2
283.8	293.4	1187.1
345.6	287.3	1186.8
347.2	284.0	1186.6
379.4	283.1	1186.5
600.8	240.2	1183.3
603.6	200.1	1179.6
604.8	191.7	1178.9
607.8	182.7	1177.9
611.6	163.6	1175.8

Table 4-11 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 23-2 – 1.4 ft^2 DER, 30% Power, AFW Runout Protection Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
618.2	119.1	1169.2
622.6	87.0	1163.1
626.8	54.3	1154.5
627.8	45.3	1152.7
629.0	33.2	1151.1
629.4	28.2	1150.7
629.6	27.6	1150.5
629.8	0.0	0.0
700.0	0.0	0.0

Table 4-12 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 25-2 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	7576.9	1196.5
0.4	7473.2	1196.7
0.6	7399.5	1197.0
0.8	7415.8	1187.3
1.0	7536.8	1166.2
1.2	7688.1	1142.8
1.4	7877.6	1116.9
1.6	8115.3	1087.8
2.0	8336.4	1057.3
2.2	8472.7	1040.6
2.4	8630.7	1022.8
2.6	8813.5	1003.9
3.0	8851.5	992.5
3.2	9204.8	994.2
3.6	9311.7	983.5
4.2	9229.9	983.7
4.4	9180.5	985.4
6.0	8648.6	1011.7
7.2	8299.6	1030.1
8.4	7978.0	1047.3
10.8	7345.7	1078.2
13.2	6692.5	1105.4
13.4	6692.5	1108.2
13.6	4304.3	1060.7
13.8	2434.9	960.1
15.0	2259.2	987.3
16.4	2068.9	1019.4
17.8	1894.8	1052.0
18.4	1825.3	1066.2

Table 4-12 (cont.)	Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 25-2 – 1.4 ft^2 DER, 100% Power, Feedwater Reg Valve Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
19.2	1737.6	1085.2
20.4	1616.2	1114.1
21.0	1559.8	1128.6
21.2	1534.9	1137.1
21.8	1444.9	1173.8
22.2	1389.3	1198.3
22.4	1372.0	1204.4
23.2	1341.7	1204.5
25.2	1274.9	1204.5
27.0	1223.3	1204.5
28.8	1178.3	1204.4
30.4	1142.9	1204.3
32.2	1107.4	1204.2
34.0	1075.7	1204.1
35.8	1047.3	1204.0
37.4	1024.7	1203.9
39.2	1002.1	1203.8
41.0	982.4	1203.7
42.8	965.4	1203.6
46.2	939.1	1203.5
49.8	918.0	1203.3
53.4	901.8	1203.2
56.8	889.7	1203.1
60.4	879.4	1203.0
67.4	864.1	1202.9
74.4	852.8	1202.8
81.6	844.3	1202.7
95.6	833.3	1202.6
109.8	826.0	1202.5
153.4	814.2	1202.4

Table 4-12 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 25-2 – 1.4 ft² DER, 100% Power, Feedwater Reg Valve Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
188.8	810.5	1202.4
219.4	809.1	1202.3
219.8	806.9	1202.3
220.8	797.1	1202.2
230.6	656.9	1200.1
234.6	591.2	1198.8
242.4	456.5	1194.9
253.4	306.9	1187.9
261.2	249.6	1184.1
271.8	217.0	1181.3
285.4	204.1	1180.1
289.4	202.4	1180.0
297.2	200.1	1179.7
312.8	196.7	1179.4
344.2	191.1	1178.8
375.4	187.4	1178.4
406.6	184.4	1178.1
437.8	182.0	1177.9
481.2	180.6	1177.7
600.2	180.4	1177.8
600.4	181.7	1177.8
605.2	103.6	1166.3
609.0	57.6	1155.2
612.0	16.8	1150.4
612.2	0.0	0.0
700.0	0.0	0.0

Table 4-13 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 61-2 – 0.6 ft^2 Small DER, 100% Power, MSIV Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
0.0	0.0	0.0
0.2	2134.9	1196.3
0.4	2116.2	1196.5
1.0	2079.8	1196.9
1.8	2041.9	1197.3
3.4	1983.3	1198.0
6.6	1890.1	1199.0
6.8	1938.2	1198.9
7.0	1950.1	1198.8
8.4	1993.2	1198.3
10.4	2046.9	1197.6
11.4	2070.3	1197.3
12.4	2089.4	1197.0
13.4	2101.9	1196.8
14.4	2106.0	1196.8
15.6	2105.5	1196.8
17.0	2098.0	1197.4
26.8	1621.8	1198.8
31.0	1422.8	1199.5
35.2	1228.3	1200.2
39.4	1039.0	1201.1
43.6	854.3	1202.3
47.6	682.2	1203.9
51.8	660.3	1204.1
56.0	641.2	1204.2
60.2	624.6	1204.3
64.4	610.1	1204.4
68.6	597.3	1204.4
72.8	586.0	1204.4
85.6	559.5	1204.5

Table 4-13 (cont.)	Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 61-2 – 0.6 ft^2 Small DER, 100% Power, MSIV Failure	
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
97.2	542.5	1204.5
105.4	533.3	1204.5
114.4	525.5	1204.5
120.2	521.5	1204.4
135.6	514.1	1204.4
144.2	511.6	1204.4
164.4	508.7	1204.4
178.8	508.0	1204.4
332.6	509.1	1204.4
340.8	476.4	1204.3
347.6	421.9	1203.7
353.0	421.5	1203.7
368.4	407.0	1203.5
376.2	398.4	1203.4
383.8	388.7	1203.2
391.4	377.4	1203.0
399.2	364.1	1202.8
406.8	349.4	1202.4
421.0	317.7	1201.5
441.6	268.1	1199.5
457.0	235.4	1197.8
468.6	216.5	1196.6
476.4	206.8	1195.9
484.2	199.3	1195.3
491.8	193.7	1194.8
499.4	189.4	1194.4
507.2	186.1	1194.1
514.8	183.7	1193.9
522.6	181.8	1193.7
538.0	179.4	1193.5

Table 4-13 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 61-2 – 0.6 ft^2 Small DER, 100% Power, MSIV Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
553.4	177.9	1193.4
568.8	176.9	1193.3
600.2	175.9	1193.2
602.4	169.2	1192.4
610.0	115.0	1185.4
615.0	85.9	1179.7
620.4	60.8	1173.0
625.0	44.6	1166.5
630.4	30.6	1159.2
637.6	10.4	1150.4
637.8	8.9	1150.4
638.0	0.0	0.0
700.0	0.0	0.0

Table 4-14 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 67-2 – 0.88 ft^2 Split Break, 30% Power, Cont. Safeguards Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	1786.9	1192.3
3.8	1701.2	1194.0
7.6	1631.7	1195.3
15.0	1529.6	1197.1
20.8	1539.0	1197.1
26.2	1518.7	1197.4
60.0	1264.0	1201.2
62.4	1176.5	1202.3
65.2	1088.0	1203.2
69.6	981.3	1204.0
75.6	877.3	1204.4
79.2	830.8	1204.5
84.0	784.7	1204.5
89.6	747.9	1204.4
100.6	706.7	1204.3
119.0	678.6	1204.2
149.6	662.9	1204.1
238.0	649.9	1204.0
350.4	648.5	1204.0
351.8	644.2	1203.9
354.6	622.1	1203.8
357.6	586.0	1203.4
360.6	537.1	1202.8
369.4	360.7	1198.3
371.6	323.1	1196.7
373.2	300.1	1195.6
374.6	282.8	1194.7
377.6	254.0	1192.8
379.8	239.0	1191.8

Table 4-14 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 67-2 – 0.88 ft^2 Split Break, 30% Power, Cont. Safeguards Failure		
Time (sec)	**Flowrate (lbm/s)**	**Enthalpy (Btu/lbm)**
382.8	224.9	1190.7
385.6	216.4	1190.0
391.4	204.4	1189.0
397.4	197.7	1188.4
409.2	192.3	1187.9
488.0	187.1	1187.4
596.0	186.8	1187.4
604.8	185.5	1187.2
611.2	178.7	1186.6
656.0	169.2	1185.6
668.2	162.1	1184.7
674.2	157.3	1184.1
683.4	147.2	1182.8
692.6	132.4	1180.7
698.8	118.6	1178.5
703.2	106.6	1176.5
713.8	72.5	1168.5
723.6	39.4	1156.7
725.4	33.1	1154.2
728.0	21.1	1151.2
729.2	14.7	1150.4
729.4	0.0	0.0
1000.0	0.0	0.0

Table 4-15 Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 79-2 – 0.88 ft^2 Split Break, 30% Power, MSIV Failure		
Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
0.0	0.0	0.0
0.2	1786.9	1192.3
3.8	1702.8	1193.9
7.6	1634.4	1195.2
15.0	1533.2	1197.0
20.8	1541.6	1197.0
28.4	1505.1	1197.6
60.4	1260.3	1201.4
62.4	1188.1	1202.2
65.8	1088.3	1203.2
71.0	973.7	1204.1
74.8	909.5	1204.3
78.6	857.3	1204.4
82.6	814.4	1204.5
86.0	786.0	1204.5
92.0	749.2	1204.4
103.4	708.5	1204.3
122.8	679.0	1204.2
154.4	662.5	1204.1
259.4	649.2	1204.0
393.0	649.0	1204.0
396.2	631.8	1203.9
399.2	600.0	1203.6
402.2	555.0	1203.0
405.2	499.0	1202.1
409.6	407.8	1199.9
412.6	349.7	1197.9
415.6	302.6	1195.8
417.8	276.0	1194.3
420.2	253.9	1192.8

Table 4-15 (cont.) Salem Unit 2 (Model 51 SG) Steamline Break Mass/Energy Release, Case 79-2 – 0.88 ft^2 Split Break, 30% Power, MSIV Failure

Time (sec)	Flowrate (lbm/s)	Enthalpy (Btu/lbm)
423.2	234.6	1191.4
426.2	222.0	1190.4
429.2	214.0	1189.8
438.2	200.2	1188.6
441.4	197.4	1188.3
453.4	192.4	1187.9
529.8	187.0	1187.4
604.8	186.1	1187.3
622.4	180.6	1186.8
625.0	178.7	1186.6
649.2	173.0	1186.0
668.2	163.7	1184.9
681.0	152.8	1183.6
690.6	140.0	1181.8
696.8	128.5	1180.1
703.2	113.1	1177.6
706.4	104.0	1176.0
716.0	72.9	1168.6
719.4	61.0	1165.1
720.0	58.4	1164.4
723.4	47.1	1160.2
725.6	40.3	1157.1
727.6	33.5	1154.3
730.0	22.5	1151.5
731.4	15.5	1150.4
731.6	0.0	0.0
1000.0	0.0	0.0

5 LOCA MASS AND ENERGY RELEASES

The uncontrolled release of pressurized high-temperature reactor coolant, termed a loss-of-coolant accident (LOCA), will result in release of steam and water into the containment. This, in turn, will result in increases in the local subcompartment pressures, and an increase in the global containment pressure and temperature. Therefore, there are typically both long- and short-term issues reviewed relative to a postulated LOCA that must be considered for a complete containment integrity analysis. Since none of the major components of the RCS are changing (i.e., pressurizer or steam generators) and the licensed power level will remain the same, the short term issues will not need to be reviewed or reanalyzed. Only the long term LOCA transients will be analyzed.

The long-term LOCA mass and energy releases are analyzed to approximately $1x10^7$ seconds and are utilized as input to the containment integrity analysis. This demonstrates the acceptability of the containment safeguards systems to mitigate the consequences of a hypothetical large-break LOCA. The containment safeguards systems must be capable of limiting the peak containment pressure to less than the design pressure and to limit the temperature excursion to less than the acceptance limits. For this service water system enhancement program, Westinghouse generated Salem Unit 1 and Unit 2 specific LOCA mass and energy releases for containment design using the flexible multi-nodal model (hereafter referred to as "the March 1979 model") described in Reference 11. The Nuclear Regulatory Commission (NRC) review and approval letter is included with Reference 11. This section discusses the long-term LOCA mass and energy releases generated for this program. The results of this analysis were provided for use in the containment response analysis (see Section 6.3).

5.1 LONG-TERM LOCA MASS AND ENERGY RELEASES

The mass and energy release rates described in this section form the basis of further computations to evaluate the containment following the postulated accident. Discussed in this section are the long-term LOCA mass and energy releases for the hypothetical double-ended pump suction (DEPS) rupture with minimum safeguards. The maximum safeguards case for the DEPS break and the blowdown portion of the double-ended hot leg (DEHL) rupture break that are typically performed for a full spectrum of design basis cases are not needed for this program. The DEPS maximum safeguards case would not yield a limiting set of mass and energy releases for the changes to the service water system and the containment fan coolers and the DEHL case is only performed for the initial blowdown (approximately 30 seconds in duration) and none of the safety systems actuate that quickly. The mass and energy releases for the DEPS minimum safeguards case for Salem Unit 1 and Salem Unit 2 are used for the long-term containment response analyses in Section 6.3. The basis for using these cases is discussed in Section 5.1.5 and Section 5.1.6.

5.1.1 Input Parameters and Assumptions

The mass and energy release analysis is sensitive to the assumed characteristics of various plant systems, in addition to other key modeling assumptions. Where appropriate, bounding inputs are utilized and instrumentation uncertainties are included. For example, the RCS operating temperatures are chosen to bound the highest average coolant temperature range of all operating cases and a temperature uncertainty allowance of (+5.0°F) is then added. Nominal parameters are used in certain instances. For example, the

RCS pressure in this analysis is based on a nominal value of 2250 psia plus an uncertainty allowance (+50.0 psi). All input parameters are chosen consistent with accepted analysis methodology.

Some of the most critical items are the RCS initial conditions, core decay heat, safety injection flow, and primary and secondary metal mass and steam generator heat release modeling. Specific assumptions concerning each of these items are discussed in the following paragraphs. Tables 5.1-1 through 5.1-3 present key data assumed in the analysis.

The core rated power of 3459 MWt, adjusted for calorimetric error (i.e., 100.6% or 3479.75 MWt) was used in the analysis. As previously noted, the use of RCS operating temperatures to bound the highest average coolant temperature range were used as bounding analysis conditions. The use of higher temperatures is conservative because the initial fluid energy is based on coolant temperatures that are at the maximum levels attained in steady-state operation. Additionally, an allowance to account for instrument error and deadband is reflected in the initial RCS temperatures. The selection of 2250 psia as the limiting pressure is considered to affect the blowdown phase results only, since this represents the initial pressure of the RCS. The RCS rapidly depressurizes from this value until the point at which it equilibrates with containment pressure.

The rate at which the RCS blows down is initially more severe at the higher RCS pressure. Additionally the RCS has a higher fluid density at the higher pressure (assuming a constant temperature) and subsequently has a higher RCS mass available for releases. Thus, 2250 psia plus uncertainty was selected for the initial pressure as the limiting case for the long-term mass and energy release calculations.

The selection of the fuel design features for the long-term mass and energy release calculation is based on the need to conservatively maximize the energy stored in the fuel at the beginning of the postulated accident (i.e., to maximize the core stored energy). The core stored energy that was selected to bound the Westinghouse 17 x 17 RFA fuel product that will be used at Salem Unit 1 and Unit 2 was 4.23 full power seconds (FPS). The margins in the core stored energy include +15 percent in order to address the thermal fuel model and associated manufacturing uncertainties and the time in the fuel cycle for maximum fuel densification. Thus, the analysis very conservatively accounts for the stored energy in the core.

Margin in RCS volume of 3 percent (which is composed of 1.6-percent allowance for thermal expansion and 1.4-percent allowance for uncertainty) was modeled.

A uniform steam generator tube plugging level of 0 percent was modeled. This assumption maximizes the reactor coolant volume and fluid release by virtue of consideration of the RCS fluid in all steam generator tubes. During the post-blowdown period, the steam generators are active heat sources since significant energy remains in the secondary metal and secondary mass that has the potential to be transferred to the primary side. The 0-percent tube plugging assumption maximizes the heat transfer area and, therefore, the transfer of secondary heat across the steam generator tubes. Additionally, this assumption reduces the reactor coolant loop resistance, which reduces the ΔP upstream of the break for the pump suction breaks and increases break flow. Thus, the analysis conservatively accounts for the level of steam generator tube plugging.

The secondary- to primary-heat transfer is maximized by assuming conservative heat transfer coefficients. This conservative energy transfer is ensured by maximizing the initial internal energy of the inventory in the steam generator secondary side. This internal energy is based on full-power operation plus uncertainties.

Regarding safety injection flow, the mass and energy release calculation considered configurations, component failures, and offsite power assumptions to conservatively bound respective alignments. The cases include a minimum safeguards assumption (1 charging/safety injection (CHG/SI) pump, 1 intermediate head safety injection (IHSI) pump, and 1 low-head safety injection (LHSI) pump) (see Table 5.1-3). In addition, the containment backpressure is assumed to be equal to the containment design pressure. This assumption was shown in Reference 11 to be conservative for the generation of mass and energy releases. Another aspect of the safety injection system that is considered is the recirculation flow that would occur if the operators did or did not initiate recirculation spray.

In summary, the following assumptions were employed to ensure that the mass and energy releases are conservatively calculated, thereby maximizing energy release to containment:

1. Maximum expected operating temperature of the RCS (100-percent full-power conditions)

2. Allowance for RCS temperature uncertainty (+5.0°F)

3. Margin in RCS volume of 3 percent (which is composed of 1.6-percent allowance for thermal expansion, and 1.4-percent allowance for uncertainty)

4. Core rated power of 3459 MWt

5. Allowance for calorimetric error (+0.6 percent of power)

6. Conservative heat transfer coefficients (i.e., steam generator primary/secondary heat transfer, and RCS metal heat transfer)

7. Allowance in core stored energy for effect of fuel densification

8. A margin in core stored energy (+15 percent to account for manufacturing tolerances)

9. An allowance for RCS initial pressure uncertainty (+50 psi)

10. A maximum containment backpressure equal to design pressure (47.0 psig)

11. Steam generator tube plugging leveling (0-percent uniform)
    - Maximizes reactor coolant volume and fluid release
    - Maximizes heat transfer area across the steam generator tubes

- Reduces coolant loop resistance, which reduces the ΔP upstream of the break for the pump suction breaks and increases break flow

Thus, based on the previously discussed conditions and assumptions, an analysis of Salem Unit 1 and Salem Unit 2 was made for the release of mass and energy from the RCS in the event of a large break LOCA at 3479.75 MWt.

5.1.2 Description of Analyses

The evaluation model used for the long-term LOCA mass and energy release calculations is the March 1979 model described in Reference 11.

This report section presents the long-term LOCA mass and energy releases generated in support of the Salem service water enhancement program. These mass and energy releases are then subsequently used in the containment integrity analysis and qualification temperature evaluation.

5.1.3 LOCA Mass and Energy Release Phases

The containment system receives mass and energy releases following a postulated rupture in the RCS. These releases continue over a time period, which, for the LOCA mass and energy analysis, is typically divided into four phases.

1. Blowdown – the period of time from accident initiation (when the reactor is at steady-state operation) to the time that the RCS and containment reach an equilibrium state.

2. Refill – the period of time when the lower plenum is being filled by accumulator and emergency core cooling system (ECCS) water. At the end of blowdown, a large amount of water remains in the cold legs, downcomer, and lower plenum. To conservatively consider the refill period for the purpose of containment mass and energy releases, it is assumed that this water is instantaneously transferred to the lower plenum along with sufficient accumulator water to completely fill the lower plenum. This allows an uninterrupted release of mass and energy to containment. Thus, the refill period is conservatively neglected in the mass and energy release calculation.

3. Reflood – begins when the water from the lower plenum enters the core and ends when the core is completely quenched.

4. Post-reflood (Froth) – describes the period following the reflood phase. For the pump suction break, a two-phase mixture exits the core, passes through the hot legs, and is superheated in the steam generators prior to exiting the break as steam. After the broken loop steam generator cools, the break flow becomes two phase.

5.1.4 Computer Codes

The Reference 11 mass and energy release evaluation model is comprised of mass and energy release versions of the following codes: SATAN VI, WREFLOOD, FROTH, and EPITOME. These codes were used to calculate the long-term LOCA mass and energy releases for Salem Unit 1 and Salem Unit 2.

SATAN VI calculates blowdown, the first portion of the thermal-hydraulic transient following break initiation, including pressure, enthalpy, density, mass and energy flow rates, and energy transfer between primary and secondary systems as a function of time.

The WREFLOOD code addresses the portion of the LOCA transient where the core reflooding phase occurs after the primary coolant system has depressurized (blowdown) due to the loss of water through the break and when water supplied by the ECCS refills the reactor vessel and provides cooling to the core. The most important feature of WREFLOOD is the steam/water mixing model (see Subsection 5.2.2).

FROTH models the post-reflood portion of the transient. The FROTH code is used for the steam generator heat addition calculation from the broken and intact loop steam generators.

EPITOME continues the FROTH post-reflood portion of the transient from the time at which the secondary equilibrates to containment design pressure to the end of the transient. It also compiles a summary of data on the entire transient, including formal instantaneous mass and energy release tables and mass and energy balance tables with data at critical times.

5.1.5 Break Size and Location

Generic studies have been performed and documented in Reference 11 with respect to the effect of postulated break size on the LOCA mass and energy releases. The double-ended guillotine break has been found to be limiting due to larger mass flow rates during the blowdown phase of the transient. During the reflood and froth phases, the break size has little effect on the releases.

Three distinct locations in the RCS loop can be postulated for a pipe rupture for mass and energy release purposes:

- Hot leg (between vessel and steam generator)
- Cold leg (between pump and vessel)
- Pump suction (between steam generator and pump)

The break location analyzed for this program is the DEPS rupture (10.48 ft^2). Break mass and energy releases have been calculated for the blowdown, reflood, and post-reflood phases of the LOCA for the DEPS cases. The following information provides a discussion on the three possible break locations and why the DEPS break is limiting for the long term.

The DEHL rupture has been shown in previous studies to result in the highest blowdown mass and energy release rates. Although the core flooding rate would be the highest for this break location, the amount of energy released from the steam generator secondary is minimal because the majority of the fluid that exits the core vents directly to containment bypassing the steam generators. As a result, the reflood mass and energy releases are reduced significantly as compared to either the pump suction or cold leg break locations where the core exit mixture must pass through the steam generators before venting through the break. For the hot leg break, generic studies have confirmed that there is no reflood peak (i.e., from the end of the blowdown period the containment pressure would continually decrease). Therefore, only the mass and energy releases for the hot leg break blowdown phase are calculated. Since none of the powered safety systems are assumed to be operational during initial blowdown phase, the service water system enhancement program would not impact the DEHL break.

The cold leg break location has also been found in previous studies to be much less limiting in terms of the overall containment energy releases. The cold leg blowdown is faster than that of the pump suction break, and more mass is released into the containment. However, the core heat transfer is greatly reduced, and this results in a considerably lower energy release into containment. Studies have determined that the blowdown transient for the cold leg is, in general, less limiting than that for the pump suction break. During reflood, the flooding rate is greatly reduced and the energy release rate into the containment is reduced. Therefore, the cold leg break is bounded by other breaks and no further evaluation is necessary.

The pump suction break combines the effects of the relatively high core flooding rate, as in the hot leg break, and the addition of the stored energy in the steam generators. As a result, the pump suction break yields the highest energy flow rates during the post-blowdown period by including all of the available energy of the RCS in calculating the releases to containment. Thus, only the DEHL and DEPS cases are used to analyze long-term LOCA containment integrity for full scope programs. For this service water enhancement program, the DEHL break would not be impacted from the current design basis cases so it is not reanalyzed here.

5.1.6 Application of Single-Failure Criterion

An analysis of the effects of the single-failure criterion has been performed on the mass and energy release rates for each break analyzed. An inherent assumption in the generation of the mass and energy release is that offsite power is lost coincident with the pipe rupture. This results in the actuation of the emergency diesel generators. Operation of the diesel generators delays the operation of the safety injection system that is required to mitigate the transient.

The single failure that is analyzed for the LOCA mass and energy releases for the service water enhancement program is the postulated failure of an entire train of safeguards equipment. Typically, this is synonymous with the failure of an emergency diesel generator to start. However, the Salem plants have a three diesel generator system, so the loss of one diesel would be less limiting than the loss of one complete train of safeguards equipment. The loss of one entire train of safety injection pumps results in only one CHG/SI pump, one IHSI pump, and one LHSI pump available for accident mitigation. The containment heat removal equipment that is assumed to operate for this train failure scenario is discussed in Section 6.3.3.

5.1.7 Acceptance Criteria for LOCA M&E Analyses

A large break loss-of-coolant accident is classified as an American Nuclear Society (ANS) Condition IV event, an infrequent fault. To satisfy the NRC acceptance criteria presented in the Standard Review Plan, Section 6.2.1.3, the relevant requirements are the following:

- 10 CFR 50, Appendix A
- 10 CFR 50, Appendix K, paragraph I.A

To meet these requirements, the following must be addressed:

- Break size and location
- Calculation of each phase of the accident
- Sources of energy

The description of the modeling of each phase of the transient with the March 1979 model (Reference 11) and the individual sources of energy are provided in the following section. The break size and location was discussed in Section 5.1.5.

Table 5.1-1 System Parameters Initial Conditions for Salem Unit 1	
Parameters	**Value**
Core Thermal Power (MWt)	3479.75
Reactor Coolant System Total Flowrate (lbm/sec)	34805.56
Vessel Outlet Temperature (°F)	618.1
Core Inlet Temperature (°F)	547.7
Initial Steam Generator Steam Pressure (psia)	888
Steam Generator Design	Model F
Steam Generator Tube Plugging (%)	0 (bounding)
Initial Steam Generator Secondary Side Mass (lbm)	112850.0
Assumed Maximum Containment Backpressure (psia)	61.7*
Accumulator Water Volume (ft^3) per accumulator N_2 Cover Gas Pressure (psia) Temperature (°F)	 850.0 592.2 120
Safety Injection Delay, total (sec) (from beginning of event)	35.6

Notes:

* bounding assumption for mass and energy release calculation per Reference 11.

Core Thermal Power, RCS Total Flowrate, RCS Coolant Temperatures, and Steam Generator Secondary Side Mass include appropriate uncertainty and/or allowance.

Table 5.1-2 System Parameters Initial Conditions for Salem Unit 2

Parameters	Value
Core Thermal Power (MWt)	3479.75
Reactor Coolant System Total Flowrate (lbm/sec)	34805.56
Vessel Outlet Temperature (°F)	618.1
Core Inlet Temperature (°F)	547.7
Initial Steam Generator Steam Pressure (psia)	842
Steam Generator Design	Model 51
Steam Generator Tube Plugging (%)	0
Initial Steam Generator Secondary Side Mass (lbm)	127041.0
Assumed Maximum Containment Backpressure (psia)	61.7*
Accumulator Water Volume (ft^3) per accumulator N_2 Cover Gas Pressure (psia) Temperature (°F)	 850 592.2 120
Safety Injection Delay, total (sec) (from beginning of event)	35.6

Notes:

* bounding assumption for mass and energy release calculation per Reference 11.

Core Thermal Power, RCS Total Flowrate, RCS Coolant Temperatures, and Steam Generator Secondary Side Mass include appropriate uncertainty and/or allowance.

Table 5.1-3 Safety Injection Flow Minimum Safeguards	
RCS Pressure (psig)	**Total Flow (ft^3/sec)**
Injection Mode (Reflood Phase)	
0	10.92
20	10.37
40	9.79
47	9.57
60	9.16
80	8.47
100	7.70
120	6.78
140	5.56
160	3.30
180	1.95
200	1.93
RCS Pressure (psig)	**Total Flow (lbm/sec)**
Recirculation Mode	
Without Recirculation Spray at 0 psig	427.32
WITH Recirculation Spray at 0 psig	165.22

5.2 MASS AND ENERGY RELEASE DATA

5.2.1 Blowdown Mass and Energy Release Data

The SATAN-VI code is used for computing the blowdown transient. The code utilizes the control volume (element or nodal) approach with the capability for modeling a large variety of plant specific thermal fluid system configurations. The fluid properties are considered uniform and thermodynamic equilibrium is assumed in each element. A point kinetics model is used with weighted feedback effects. The major feedback effects include moderator density, moderator temperature, and Doppler broadening. A critical flow calculation for subcooled (modified Zaloudek), two-phase (Moody), or superheated break flow is incorporated into the analysis. The methodology for the use of this model is described in Reference 11. A comparison of these two critical flow correlations is shown in Section III-1 of Reference 12.

Table 5.2-1 presents the calculated mass and energy release for the blowdown phase of the DEPS break for Salem Unit 1. Table 5.2-2 presents the calculated mass and energy release for the blowdown phase of the DEPS break for Salem Unit 2. Break path 1 for the pump suction break in the mass and energy release tables refers to the mass and energy exiting from the steam generator side of the break. Break path 2 refers to the mass and energy exiting from the pump side of the break.

5.2.2 Reflood Mass and Energy Release Data

The WREFLOOD code is used for computing the reflood transient. The WREFLOOD code consists of two basic hydraulic models — one for the contents of the reactor vessel and one for the coolant loops. The two models are coupled through the interchange of the boundary conditions applied at the vessel outlet nozzles and at the top of the downcomer. Additional transient phenomena such as pumped safety injection and accumulators, reactor coolant pump performance, and steam generator release are included as auxiliary equations that interact with the basic models as required. The WREFLOOD code permits the capability to calculate variations during the core reflooding transient of basic parameters such as core flooding rate, core and downcomer water levels, fluid thermodynamic conditions (pressure, enthalpy, density) throughout the primary system, and mass flow rates through the primary system. The code permits hydraulic modeling of the two flow paths available for discharging steam and entrained water from the core to the break, i.e., the path through the broken loop and the path through the unbroken loops.

A complete thermal equilibrium mixing condition for the steam and ECCS injection water during the reflood phase has been assumed for each loop receiving ECCS water. This is consistent with the usage and application of the Reference 11 mass and energy release evaluation model in recent analyses, e.g., D. C. Cook Docket (Reference 13). Even though the Reference 11 model credits steam/water mixing only in the intact loop and not in the broken loop, the justification, applicability, and initial NRC approval for using the mixing model in the broken loop has been documented (Reference 13). Moreover, this assumption is supported by test data and is further discussed below. Please note that the steam/water mixing inside the RCS is not impacted by the containment design.

The model assumes a complete mixing condition (i.e., thermal equilibrium) for the steam/water interaction. The complete mixing process, however, is made up of two distinct physical processes. The first is a two-phase interaction with condensation of steam by cold ECCS water. The second is a single-phase mixing of condensate and ECCS water. Since the steam release is the most important influence to the containment pressure transient, the steam condensation part of the mixing process is the only part that need be considered. (Any spillage directly heats only the sump and not the atmosphere.)

The most applicable steam/water mixing test data have been reviewed for validation of the containment integrity reflood steam/water mixing model. This data was generated in 1/3-scale tests (Reference 14), which are the largest scale data available and thus most clearly simulates the flow regimes and gravitational effects that would occur in a pressurized water reactor (PWR). These tests were designed specifically to study the steam/water interaction for PWR reflood conditions.

A group of 1/3-scale steam/water mixing tests discussed in Reference 14 corresponds directly to containment integrity reflood conditions. The injection flow rates for this group cover all phases and mixing conditions calculated during the reflood transient. The data from these tests were reviewed and discussed in detail in Reference 11. For all of these tests, the data clearly indicate the occurrence of very effective mixing with rapid steam condensation. The mixing model used in the containment integrity reflood calculation is, therefore, wholly supported by the 1/3-scale steam/water mixing data.

Additionally, the following justification is also noted. The post-blowdown limiting break for the containment integrity peak pressure analysis is the pump suction double-ended rupture break. For this break, there are two flow paths available in the RCS by which mass and energy may be released to containment. One is through the outlet of the steam generator, the other via reverse flow through the reactor coolant pump. Steam that is not condensed by ECCS injection in the intact RCS loops passes around the downcomer and through the broken loop cold leg and pump in venting to containment. This steam also encounters ECCS injection water as it passes through the broken loop cold leg, complete mixing occurs and a portion of it is condensed. It is this portion of steam that is condensed that is taken credit for in this analysis. This assumption is justified based upon the postulated break location, and the actual physical presence of the ECCS injection nozzle. A description of the test and test results are contained in References 11 and 13.

Tables 5.2-3 and 5.2-4 present the calculated mass and energy releases for the reflood phase of the pump suction double-ended rupture, minimum safeguards cases for Salem Unit 1 and Salem Unit 2, respectively.

The transient response of the principal parameters during reflood are given in Tables 5.2-5 and 5.2-6 for the DEPS cases.

5.2.3 Post-Reflood Mass and Energy Release Data

The FROTH code (Reference 12) is used for computing the post-reflood transient. The FROTH code calculates the heat release rates resulting from a two-phase mixture present in the steam generator tubes. The mass and energy releases that occur during this phase are typically superheated due to the depressurization and equilibration of the broken loop and intact loop steam generators. During this phase of the transient, the RCS has equilibrated with the containment pressure. However, the steam generators contain a secondary inventory at an enthalpy that is much higher than the primary side. Therefore, there is a significant amount of reverse heat transfer that occurs. Steam is produced in the core due to core decay heat. For a pump suction break, a two-phase fluid exits the core, flows through the hot legs, and becomes superheated as it passes through the steam generator. Once the broken loop cools, the break flow becomes two phase. During the FROTH calculation, ECCS injection is addressed for both the injection phase and the recirculation phase. The FROTH code calculation stops when the secondary side equilibrates to the saturation temperature (T_{sat}) at the containment design pressure, after this point the EPITOME code completes the steam generator depressurization (see Subsection 5.2.5 for additional information).

The methodology for the use of this model is described in Reference 11. The mass and energy release rates are calculated by FROTH and EPITOME until the time of containment depressurization. After containment depressurization (14.7 psia), the mass and energy release available to containment is generated directly from core boil-off/decay heat.

Tables 5.2-7 and 5.2-8 present the two-phase post-reflood mass and energy release data for the pump suction double-ended break cases for Salem Unit 1 and Unit 2. Table 5.2-14 and Table 5.2-15 provide the variation in the Unit 1 and Unit 2 mass and energy releases when recirculation spray is modeled beginning at 4441.6 seconds into a large break LOCA with a diesel failure. The recirculation flow exiting the RHR heat exchanger (3200 gpm) splits with 1974.8 gpm diverted to spray and the remaining 1225.2 gpm going to the vessel to cool the core.

5.2.4 Decay Heat Model

On November 2, 1978, the Nuclear Power Plant Standards Committee (NUPPSCO) of the ANS approved ANS Standard 5.1 (Reference 10) for the determination of decay heat. This standard was used in the mass and energy release model for Salem. Table 5.2-9 lists the decay heat curve used in the Salem Unit 1 and Unit 2 mass and energy release analysis.

Significant assumptions in the generation of the decay heat curve for use in the LOCA mass and energy releases analysis include the following:

1. The decay heat sources considered are fission product decay and heavy element decay of U-239 and Np-239.

2. The decay heat power from fissioning isotopes other than U-235 is assumed to be identical to that of U-235.

3. The fission rate is constant over the operating history of maximum power level.

4. The factor accounting for neutron capture in fission products has been taken from Reference 10.

5. The fuel has been assumed to be at full power for 1×10^8 seconds.

6. The total recoverable energy associated with one fission has been assumed to be 200 MeV/fission.

7. Two sigma uncertainty (two times the standard deviation) has been applied to the fission product decay.

Based upon NRC staff review, (Safety Evaluation Report [SER] of the March 1979 evaluation model [Reference 11]), use of the ANS Standard-5.1, November 1979 decay heat model (Reference 10) was approved for the calculation of mass and energy releases to the containment following a LOCA.

5.2.5 Steam Generator Equilibration and Depressurization

Steam generator equilibration and depressurization is the process by which secondary-side energy is removed from the steam generators in stages. The FROTH computer code calculates the heat removal from the secondary mass until the secondary temperature is the saturation temperature (T_{sat}) at the containment design pressure. After the FROTH calculations, the EPITOME code continues the FROTH calculation for steam generator cooldown removing steam generator secondary energy at different rates (i.e., first- and second-stage rates). The first-stage rate is applied until the steam generator reaches T_{sat} at the user specified intermediate equilibration pressure, when the secondary pressure is assumed to reach the actual containment pressure. Then the second-stage rate is used until the final depressurization, when the secondary reaches the reference temperature of T_{sat} at 14.7 psia, or 212°F. The heat removal of the broken loop and intact loop steam generators are calculated separately.

During the FROTH calculations, steam generator heat removal rates are calculated using the secondary-side temperature, primary-side temperature and a secondary-side heat transfer coefficient determined using a modified McAdam's correlation. Steam generator energy is removed during the FROTH transient until the secondary-side temperature reaches saturation temperature at the containment design pressure. The constant heat removal rate used during the first heat removal stage is based on the final heat removal rate calculated by FROTH. The steam generator energy available to be released during the first stage interval is determined by calculating the difference in secondary energy available at the containment design pressure and that at the (lower) user-specified intermediate equilibration pressure, assuming saturated conditions. This energy is then divided by the first-stage energy removal rate, resulting in an intermediate equilibration time. At this time, the rate of energy release drops substantially to the second-stage rate. The second-stage rate is determined as the fraction of the difference in secondary energy available between the intermediate equilibration and final depressurization at 212°F, and the time difference from the time of the intermediate equilibration to the user-specified time of the final depressurization at 212°F. With current methodology, all of the secondary energy remaining after the intermediate equilibration is conservatively assumed to be released by imposing a mandatory cooldown and subsequent depressurization down to atmospheric pressure at 3600 seconds, i.e., 14.7 psia and 212°F (the mass and energy balance tables have this point labeled as "Available Energy").

5.2.6 Sources of Mass and Energy

The sources of mass considered in the LOCA mass and energy release analysis are given in Tables 5.2-10 and 5.2-11. These sources are the RCS, accumulators, and pumped safety injection.

The analysis used the following energy reference points:

- Available energy: 212°F; 14.7 psia [energy that could be released] (as discussed in 5.2.5)
- Total energy content: 32°F; 14.7 psia [total internal energy of the RCS]

The energy inventories considered in the LOCA mass and energy release analysis are given in Tables 5.2-12 and 5.2-13. The energy sources are the following.

- Reactor coolant system water
- Accumulator water (all four inject)
- Pumped safety injection water
- Decay heat
- Core-stored energy
- Reactor coolant system metal (includes steam generator tubes)
- Steam generator metal (includes transition cone, shell, wrapper, and other internals)
- Steam generator secondary energy (includes fluid mass and steam mass)
- Secondary transfer of energy (feedwater into and steam out of the steam generator secondary)

The mass and energy inventories are presented at the following times, as appropriate:

- Time zero (initial conditions)
- End of blowdown time
- End of refill time
- End of reflood time
- Time of broken loop steam generator equilibration to pressure setpoint
- Time of intact loop steam generator equilibration to pressure setpoint
- Time of full depressurization (3600 seconds)

In the mass and energy release data presented, no Zirc-water reaction heat was considered because the cladding temperature does not rise high enough for the rate of the Zirc-water reaction heat to proceed.

The sequence of events for each LOCA transient is shown in Table 6.3-1 and Table 6.3-2 of Section 6.3.

5.3 CONCLUSIONS

The consideration of the various energy sources listed in Section 5.2.6 for the long-term mass and energy release analysis provides assurance that all available sources of energy have been included in this analysis. By addressing all available sources of energy as well as the limiting break size and location and the specific modeling of each phase of the long term LOCA transient, the review guidelines presented in Standard Review Plan Section 6.2.1.3 have been satisfied. The results of this analysis were provided for use in the containment response analysis documented in Section 6.3.

Table 5.2-1 Unit 1 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
.00000	.0	.0	.0	.0
.00111	85650.6	46265.2	40440.7	21798.7
.101	40197.5	21734.4	21025.9	11328.2
.202	40835.4	22228.9	22904.7	12348.3
.302	41643.7	22877.3	23142.8	12487.1
.402	42545.4	23638.3	22826.5	12329.7
.502	43403.3	24424.4	22202.3	12002.3
.602	43853.2	24994.0	21551.5	11657.5
.702	43668.4	25177.7	21018.9	11374.1
.801	42739.5	24894.4	20548.3	11122.3
.902	41534.4	24427.3	20189.5	10930.2
1.00	40377.0	23966.7	19961.0	10809.0
1.10	39258.8	23523.5	19826.3	10737.9
1.20	38109.0	23064.4	19755.9	10701.1
1.30	36919.2	22576.3	19727.4	10686.3
1.40	35737.0	22074.9	19731.9	10688.9
1.50	34705.4	21636.8	19751.6	10699.5
1.60	33840.5	21277.9	19782.1	10715.8
1.70	33070.9	20966.8	19811.7	10731.7
1.80	32324.7	20664.7	19822.7	10737.5
1.90	31583.4	20356.7	19799.6	10724.8
2.00	30790.6	20007.7	19762.0	10704.6
2.10	30068.0	19695.7	19712.5	10678.2
2.20	29333.4	19365.7	19533.5	10581.2
2.30	28571.7	19007.4	19294.6	10452.5
2.40	27772.0	18614.6	19126.0	10362.2
2.50	26847.6	18125.1	18975.6	10281.8
2.60	25592.8	17393.4	18820.5	10199.0
2.70	23756.7	16237.3	18650.7	10108.4
2.80	21537.6	14793.1	18460.3	10006.7
2.90	20776.8	14359.5	18258.6	9899.0
3.00	20866.4	14477.6	18054.1	9789.8
3.10	20033.5	13914.4	17861.4	9687.2
3.20	19601.3	13641.3	17669.8	9585.3
3.30	19278.3	13431.8	17468.0	9477.8
3.40	18636.7	12993.0	17257.4	9365.4
3.50	18128.9	12652.5	17064.0	9262.6
3.60	17643.3	12322.1	16890.9	9170.9
3.70	17159.6	11987.9	16719.2	9079.9
3.80	16663.7	11643.7	16541.6	8985.6
3.90	16162.5	11297.3	16372.9	8896.3
4.00	15712.1	10988.0	16223.9	8817.7
4.20	14969.4	10472.6	15939.5	8667.7
4.40	14322.9	10018.3	15666.4	8523.7
4.60	13830.2	9667.7	15420.8	8394.5
4.80	13412.8	9360.5	15178.9	8267.1
5.00	13086.1	9113.1	14959.2	8151.7
5.20	12812.6	8896.0	14740.0	8036.6
5.40	12608.4	8721.5	14538.9	7931.2

Table 5.2-1 Unit 1 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
5.60	12450.6	8573.2	14333.6	7823.5
5.80	12358.4	8465.7	14130.6	7717.1
6.00	12316.1	8384.8	13927.0	7610.4
6.20	13317.6	9013.7	13454.7	7355.9
6.40	12396.6	8335.4	13348.4	7303.8
6.60	11373.7	8022.1	13190.1	7221.8
6.80	9740.8	7371.7	14645.6	8026.2
7.00	9288.9	7099.8	14464.3	7930.9
7.20	9444.5	7114.1	14409.5	7907.2
7.40	9641.4	7149.2	14193.3	7793.7
7.60	9823.3	7194.1	14031.0	7710.6
7.80	9941.2	7205.5	13790.9	7583.8
8.00	9985.3	7176.4	13579.2	7471.9
8.20	9999.9	7141.9	13402.5	7377.9
8.40	9916.3	7052.8	13217.7	7277.6
8.60	9699.0	6893.3	13110.1	7219.4
8.80	9427.9	6726.6	13059.1	7190.7
9.00	9142.9	6578.0	12936.4	7120.2
9.20	8867.7	6449.7	12798.1	7041.2
9.40	8612.8	6333.0	12687.7	6978.9
9.60	8399.6	6232.1	12570.5	6913.1
9.80	8217.8	6131.9	12430.9	6834.8
10.0	8082.2	6043.2	12290.7	6756.4
10.2	7972.1	5957.7	12158.6	6682.9
10.4	7873.0	5873.5	12026.9	6609.5
10.6	7777.2	5791.0	11892.1	6534.1
10.8	7681.1	5711.5	11762.5	6461.8
11.0	7579.9	5633.7	11636.3	6391.4
11.2	7472.7	5558.1	11509.1	6320.4
11.4	7361.7	5485.7	11383.4	6250.4
11.6	7246.2	5415.3	11258.9	6181.2
11.8	7127.0	5347.0	11133.8	6111.8
12.0	7004.5	5280.5	11008.2	6042.2
12.2	6880.2	5216.6	10883.6	5973.4
12.4	6752.4	5153.8	10759.4	5904.9
12.6	6623.4	5094.9	10634.6	5836.3
12.8	6492.4	5037.9	10507.8	5766.7
13.0	6361.9	4981.8	10381.8	5697.6
13.2	6234.9	4926.3	10253.4	5627.4
13.4	6111.0	4871.9	10126.8	5558.1
13.6	5989.8	4819.0	9999.3	5488.4
13.8	5870.4	4767.2	9873.2	5419.5
14.0	5752.8	4717.0	9746.2	5350.1
14.2	5636.9	4667.1	9621.5	5282.1
14.4	5523.7	4618.0	9495.4	5213.4
14.6	5413.7	4570.4	9372.4	5146.4
14.8	5305.4	4524.3	9247.7	5078.7
15.0	5199.1	4479.2	9125.2	5012.2

Table 5.2-1 Unit 1 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
15.2	5094.2	4435.5	9002.2	4945.5
15.4	4988.6	4391.4	8878.1	4878.4
15.6	4876.1	4344.1	8742.7	4805.3
15.8	4758.0	4290.0	8606.9	4732.8
16.0	4642.2	4232.2	8474.4	4662.2
16.2	4530.5	4174.1	8335.9	4588.1
16.4	4420.1	4113.9	8192.2	4511.2
16.6	4313.7	4055.8	7919.2	4362.4
16.8	4213.7	4001.6	7801.7	4292.3
17.0	4109.1	3950.0	7608.5	4154.0
17.2	4000.1	3894.0	7436.7	4003.4
17.4	3893.5	3848.3	7513.3	3969.7
17.6	3778.3	3800.8	7286.7	3772.1
17.8	3665.6	3767.3	7444.3	3771.5
18.0	3492.9	3692.0	6763.0	3361.8
18.2	3288.2	3597.6	6376.4	3085.8
18.4	3056.6	3473.9	6009.6	2842.7
18.6	2840.7	3331.0	5591.6	2584.0
18.8	2693.6	3235.6	5287.8	2386.7
19.0	2481.3	3022.2	4973.5	2197.8
19.2	2324.3	2852.1	4719.7	2043.6
19.4	2188.3	2697.9	4530.8	1924.8
19.6	2071.6	2562.5	4282.4	1786.7
19.8	1955.6	2425.4	4080.2	1669.6
20.0	1847.5	2296.6	4028.0	1614.6
20.2	1726.3	2150.0	5672.2	2233.5
20.4	1565.5	1953.7	7168.5	2833.2
20.6	1456.8	1822.9	5132.6	2045.4
20.8	1381.4	1731.4	4200.5	1684.6
21.0	1318.1	1654.2	2941.6	1179.1
21.2	1240.5	1558.3	2227.0	866.3
21.4	1154.4	1452.1	3310.0	1162.3
21.6	1076.8	1355.9	5459.1	1838.2
21.8	989.4	1247.5	5504.7	1826.8
22.0	909.7	1148.8	4712.0	1554.3
22.2	833.7	1053.8	4128.7	1353.4
22.4	766.6	969.9	3677.0	1193.2
22.6	704.1	891.5	3412.0	1089.8
22.8	638.8	809.3	3190.1	998.7
23.0	585.0	741.8	2918.4	895.2
23.2	521.8	662.0	2652.1	797.9
23.4	496.7	630.7	2364.0	698.1
23.6	465.5	591.3	2054.8	596.2
23.8	434.0	551.5	1707.7	487.5
24.0	398.4	506.5	1314.2	369.9
24.2	358.5	456.1	872.7	243.1
24.4	316.6	402.9	434.0	120.2
24.6	273.8	348.6	110.7	30.6

Table 5.2-1 Unit 1 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
SECONDS	LBM/SEC	THOUSAND BTU/SEC	LBM/SEC	THOUSAND BTU/SEC
24.8	230.6	293.7	.0	.0
25.0	189.0	240.9	.0	.0
25.2	143.3	182.9	.0	.0
25.4	96.3	123.0	135.5	38.0
25.6	54.1	69.2	122.4	34.3
25.8	15.4	19.8	98.1	27.6
26.0	.0	.0	65.0	18.3
26.2	.0	.0	.0	.0

Table 5.2-2 Unit 2 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
SECONDS	LBM/SEC	THOUSAND BTU/SEC	LBM/SEC	THOUSAND BTU/SEC
.00000	.0	.0	.0	.0
.00111	87155.8	47083.7	40441.1	21798.9
.101	40172.8	21718.5	21070.4	11352.2
.201	40815.6	22204.2	22973.4	12385.1
.302	41645.9	22845.2	23181.1	12507.9
.402	43718.0	24219.2	22860.6	12348.4
.501	43542.2	24394.1	22216.8	12010.5
.601	43920.3	24897.1	21558.1	11661.2
.701	44174.3	25320.3	21020.5	11375.0
.802	43870.1	25405.5	20541.2	11118.6
.902	42977.4	25118.5	20185.2	10927.9
1.00	41918.1	24715.1	19954.8	10805.6
1.10	40862.6	24302.0	19819.0	10733.8
1.20	39833.2	23898.7	19747.4	10696.4
1.30	38792.7	23488.6	19718.1	10681.2
1.40	37720.0	23054.9	19723.0	10684.1
1.50	36637.8	22603.6	19745.9	10696.4
1.60	35618.9	22171.6	19782.1	10715.9
1.70	34727.8	21800.6	19816.1	10734.4
1.80	33913.9	21464.4	19830.8	10742.3
1.90	33114.6	21129.4	19812.2	10732.1
2.00	32318.3	20791.6	19781.7	10715.9
2.10	31476.2	20417.1	19740.3	10694.1
2.20	30716.3	20088.6	19563.5	10598.3
2.30	29920.3	19723.5	19331.6	10473.4
2.40	29077.8	19316.3	19166.7	10385.1
2.50	28234.7	18895.7	19019.5	10306.5
2.60	27389.8	18460.2	18871.0	10227.2
2.70	26291.5	17836.0	18702.3	10137.1
2.80	24749.5	16885.5	18511.6	10035.2
2.90	22255.1	15251.8	18315.1	9930.2
3.00	20607.4	14204.9	18120.8	9826.5
3.10	20775.3	14405.1	17933.6	9726.8
3.20	20371.6	14149.2	17744.7	9626.1
3.30	19514.8	13569.0	17549.1	9521.8
3.40	19154.2	13344.6	17349.1	9415.1
3.50	18740.2	13069.3	17149.4	9308.5
3.60	18218.0	12712.0	16969.8	9213.0
3.70	17800.2	12426.6	16798.6	9122.0
3.80	17368.9	12127.1	16625.7	9030.1
3.90	16909.8	11806.6	16451.8	8937.5
4.00	16474.4	11503.8	16292.0	8852.6
4.20	15725.5	10979.4	16001.7	8698.9
4.40	15054.6	10503.1	15717.1	8547.9
4.60	14499.6	10106.5	15463.5	8413.8
4.80	14062.9	9784.1	15215.8	8282.6
5.00	13682.2	9496.5	14981.4	8158.5
5.20	13400.3	9273.4	14762.0	8042.6
5.40	13161.2	9072.3	14542.0	7926.1

Table 5.2-2 Unit 2 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
5.60	12996.3	8918.3	14340.9	7820.0
5.80	12886.1	8795.2	14114.8	7700.2
6.00	12831.6	8705.2	13887.0	7579.5
6.20	13839.7	9332.2	13411.3	7323.2
6.40	12813.8	8578.5	13308.8	7271.6
6.60	11890.4	8237.8	13603.1	7442.4
6.80	10288.2	7613.9	14649.6	8013.4
7.00	9549.6	7235.0	14395.2	7877.8
7.20	9605.7	7203.9	14337.3	7850.9
7.40	9859.1	7272.9	14139.3	7746.4
7.60	10146.4	7372.7	13959.9	7652.8
7.80	10422.7	7473.3	13749.2	7541.5
8.00	10641.1	7539.7	13523.2	7421.0
8.20	10802.4	7577.5	13325.2	7315.0
8.40	10844.9	7547.2	13192.1	7243.9
8.60	10645.0	7373.2	13128.5	7209.6
8.80	10315.1	7145.3	13015.9	7146.1
9.00	9972.0	6932.1	12878.3	7068.1
9.20	9605.4	6717.6	12776.6	7010.6
9.40	9328.5	6582.6	12681.4	6956.9
9.60	9098.0	6482.9	12556.7	6886.9
9.80	8863.8	6362.6	12422.4	6812.1
10.0	8696.3	6269.8	12297.4	6743.1
10.2	8551.0	6180.6	12173.0	6674.5
10.2	8550.1	6180.0	12172.3	6674.1
10.4	8399.4	6083.3	12046.3	6604.1
10.6	8253.5	5990.2	11911.9	6529.5
10.8	8104.6	5897.4	11787.4	6460.6
11.0	7953.4	5807.1	11667.2	6393.8
11.2	7803.6	5722.1	11539.9	6323.1
11.4	7654.7	5640.0	11415.5	6254.1
11.6	7510.5	5562.1	11291.8	6185.6
11.8	7369.9	5486.4	11166.2	6116.0
12.0	7233.3	5413.1	11040.4	6046.4
12.2	7100.3	5342.4	10915.6	5977.5
12.4	6967.7	5272.0	10790.3	5908.3
12.6	6838.7	5205.4	10668.5	5841.2
12.8	6710.3	5141.2	10541.9	5771.5
13.0	6582.9	5077.0	10418.5	5703.8
13.2	6458.9	5013.3	10293.8	5635.3
13.4	6339.2	4950.8	10170.6	5567.7
13.6	6222.9	4889.7	10047.4	5500.1
13.8	6109.4	4830.4	9926.2	5433.7
14.0	5998.4	4771.8	9805.3	5367.4
14.2	5889.6	4714.1	9686.4	5302.3
14.4	5783.2	4657.6	9568.2	5237.6
14.6	5679.1	4602.1	9451.8	5174.0
14.8	5577.3	4547.8	9335.9	5110.7

Table 5.2-2 Unit 2 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
15.0	5477.9	4494.7	9221.8	5048.5
15.2	5380.9	4443.7	9108.9	4987.1
15.4	5282.7	4391.7	8994.7	4924.9
15.6	5177.4	4334.4	8866.5	4855.3
15.8	5064.8	4270.2	8739.7	4787.0
16.0	4950.6	4199.5	8615.6	4720.6
16.2	4841.8	4125.6	8487.1	4651.6
16.4	4740.1	4051.9	8363.2	4585.2
16.6	4641.9	3977.9	8236.1	4517.2
16.8	4547.2	3905.0	8060.6	4421.9
17.0	4461.2	3837.6	7918.4	4345.0
17.2	4380.6	3774.0	7673.2	4191.5
17.4	4308.5	3721.8	7804.5	4225.8
17.6	4234.7	3672.0	7386.6	3944.1
17.8	4164.2	3631.0	7958.3	4187.8
18.0	4085.6	3591.2	7133.8	3687.6
18.2	4006.4	3559.3	8622.0	4402.9
18.4	3909.7	3523.1	6428.3	3245.2
18.6	3829.3	3509.0	9368.6	4636.0
18.8	3698.7	3460.1	12134.1	6113.5
19.0	3531.0	3400.5	11373.1	5781.2
19.2	3477.8	3463.6	4787.5	2412.1
19.4	3359.6	3451.6	11705.6	5658.1
19.6	3096.6	3333.0	9570.5	4755.8
19.8	2897.8	3276.8	4288.9	2121.9
20.0	2691.1	3157.3	4947.9	2240.9
20.2	2520.0	3041.6	4771.9	2111.4
20.4	2317.5	2832.3	4606.5	2000.7
20.6	2168.7	2666.3	4308.7	1836.5
20.8	2024.9	2499.2	4021.5	1674.8
21.0	1898.5	2350.1	3792.3	1538.8
21.2	1782.2	2211.3	3559.4	1411.4
21.4	1670.0	2076.0	3497.9	1357.7
21.6	1564.7	1948.8	3566.5	1357.6
21.8	1459.7	1820.9	3650.2	1367.9
22.0	1363.5	1703.7	3644.2	1348.1
22.2	1269.5	1588.5	3618.5	1320.5
22.4	1183.8	1483.3	3777.1	1352.1
22.6	1093.4	1371.4	4044.1	1413.1
22.8	1008.7	1267.4	4291.7	1461.3
23.0	920.3	1157.8	4109.0	1372.2
23.2	838.4	1055.8	3924.3	1289.7
23.4	759.5	957.3	3731.5	1207.9
23.6	683.9	862.6	3510.4	1119.5
23.8	603.7	762.0	3241.1	1017.7
24.0	527.3	666.2	2923.7	903.5
24.2	459.0	580.3	2633.9	801.0
24.4	400.8	507.0	2333.2	698.3

Table 5.2-2 Unit 2 Double-Ended Pump Suction Break Blowdown Mass and Energy Releases (cont.)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
24.6	362.7	459.2	2017.2	594.4
24.8	316.8	401.2	1679.8	487.9
25.0	281.5	356.7	1324.4	379.9
25.2	255.7	324.2	933.7	265.2
25.4	227.0	288.0	510.1	144.0
25.6	195.0	247.5	109.5	30.9
25.8	160.7	204.1	.0	.0
26.0	121.8	154.9	.0	.0
26.2	76.4	97.3	.0	.0
26.4	20.0	25.5	.0	.0
26.6	.0	.0	.0	.0

Table 5.2-3 Unit 1 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME SECONDS	BREAK PATH NO.1 FLOW LBM/SEC	BREAK PATH NO.1 FLOW THOUSAND BTU/SEC	BREAK PATH NO.2 FLOW LBM/SEC	BREAK PATH NO.2 FLOW THOUSAND BTU/SEC
26.2	.0	.0	.0	.0
26.7	.0	.0	.0	.0
26.9	.0	.0	.0	.0
27.0	.0	.0	.0	.0
27.1	.0	.0	.0	.0
27.2	.0	.0	.0	.0
27.2	.0	.0	.0	.0
27.3	36.8	43.3	.0	.0
27.4	15.4	18.2	.0	.0
27.5	15.0	17.7	.0	.0
27.6	20.9	24.6	.0	.0
27.7	27.6	32.5	.0	.0
27.8	32.0	37.7	.0	.0
27.9	36.0	42.4	.0	.0
28.1	40.5	47.7	.0	.0
28.2	45.0	53.0	.0	.0
28.3	48.0	56.6	.0	.0
28.4	51.1	60.2	.0	.0
28.5	54.1	63.7	.0	.0
28.6	56.9	67.0	.0	.0
28.6	58.3	68.7	.0	.0
28.7	59.6	70.3	.0	.0
28.8	62.3	73.4	.0	.0
28.9	64.8	76.4	.0	.0
29.0	67.3	79.3	.0	.0
29.1	69.8	82.2	.0	.0
29.2	72.1	85.0	.0	.0
29.3	74.4	87.7	.0	.0
30.3	94.8	111.7	.0	.0
31.3	111.9	131.9	.0	.0
32.3	126.8	149.5	.0	.0
33.3	140.1	165.3	.0	.0
33.7	148.3	175.0	14.4	2.0
34.3	303.6	359.1	3053.2	439.5
35.3	406.4	481.6	4210.5	637.4
36.3	441.0	522.9	4580.5	672.9
37.3	434.7	515.4	4520.5	666.1
38.3	428.2	507.6	4458.0	658.7
38.4	427.5	506.9	4451.7	657.9
39.3	421.8	500.0	4395.6	651.2
40.3	415.5	492.5	4334.2	643.7
41.3	409.5	485.3	4274.0	636.4
42.3	403.6	478.2	4215.2	629.3
43.3	397.9	471.5	4158.0	622.3
43.9	394.6	467.5	4124.4	618.2
44.3	392.4	464.9	4102.3	615.5
45.3	387.1	458.6	4048.2	608.9
46.3	382.0	452.5	3995.5	602.5

Table 5.2-3 (cont.) Unit 1 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
47.3	377.1	446.6	3944.3	596.3
48.3	372.3	440.9	3894.4	590.2
49.3	367.7	435.4	3845.9	584.3
50.2	363.6	430.6	3803.4	579.1
50.3	363.2	430.0	3798.7	578.5
51.3	358.9	424.9	3752.8	572.9
52.3	354.7	419.9	3708.0	567.4
53.3	350.6	415.0	3664.3	562.1
54.4	288.1	340.7	2937.9	481.5
55.4	285.2	337.2	2902.6	477.4
56.4	390.0	461.8	313.4	217.8
57.2	408.7	484.4	321.6	229.7
57.4	407.7	483.2	321.1	229.1
58.4	401.0	475.1	318.0	224.9
59.4	394.1	467.0	314.8	220.6
60.4	387.5	459.0	311.7	216.5
61.4	381.0	451.2	308.7	212.5
62.4	374.6	443.6	305.7	208.5
63.4	368.1	435.9	302.7	204.6
64.4	362.1	428.8	300.0	200.9
65.4	356.5	422.0	297.4	197.5
66.4	351.0	415.4	294.8	194.1
67.4	345.6	409.0	292.4	190.8
68.4	340.3	402.7	290.0	187.7
69.4	335.2	396.6	287.6	184.6
70.4	330.2	390.7	285.3	181.6
71.4	325.3	384.9	283.1	178.6
72.4	320.5	379.2	280.9	175.8
73.4	315.9	373.7	278.8	173.0
74.4	311.3	368.3	276.8	170.3
75.4	306.9	363.0	274.8	167.7
76.4	302.6	357.9	272.8	165.1
77.4	298.4	352.8	270.9	162.7
78.4	294.3	348.0	269.1	160.3
79.4	290.3	343.2	267.3	157.9
80.4	286.4	338.6	265.6	155.7
81.4	282.6	334.1	263.8	153.5
82.4	278.9	329.7	262.2	151.3
83.4	275.4	325.5	260.6	149.3
84.4	271.9	321.3	259.0	147.2
85.4	268.5	317.3	257.5	145.3
86.4	265.2	313.4	256.1	143.4
87.4	262.0	309.6	254.6	141.6
88.7	258.0	304.8	252.9	139.3
89.4	255.9	302.3	251.9	138.1
91.4	250.1	295.5	249.4	134.8
93.4	244.7	289.0	247.0	131.8
95.4	239.5	282.9	244.7	128.9

Table 5.2-3 (cont.) Unit 1 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
97.4	234.7	277.2	242.6	126.2
99.4	230.2	271.9	240.7	123.7
101.4	226.0	266.8	238.8	121.3
103.4	222.0	262.1	237.1	119.2
105.4	218.3	257.7	235.5	117.1
107.4	214.8	253.6	234.0	115.2
109.4	211.6	249.8	232.6	113.5
109.5	211.4	249.6	232.6	113.4
111.4	208.5	246.2	231.4	111.8
113.4	205.7	242.9	230.2	110.3
115.4	203.1	239.8	229.1	108.9
117.4	200.7	236.9	228.0	107.6
119.4	198.5	234.3	227.1	106.4
121.4	196.4	231.8	226.2	105.3
123.4	194.5	229.6	225.4	104.2
125.4	192.8	227.5	224.6	103.3
127.4	191.2	225.6	224.0	102.4
129.4	189.7	223.9	223.3	101.6
131.4	188.3	222.3	222.8	100.9
133.4	187.1	220.8	222.2	100.2
133.5	187.1	220.8	222.2	100.2
135.4	186.0	219.5	221.8	99.6
137.4	185.0	218.3	221.3	99.1
139.4	184.1	217.3	220.9	98.6
141.4	183.3	216.3	220.6	98.1
143.4	182.6	215.4	220.3	97.7
145.4	181.9	214.7	220.0	97.4
147.4	181.3	214.0	219.7	97.1
149.4	180.8	213.4	219.5	96.8
151.4	180.4	212.9	219.3	96.5
153.4	180.0	212.4	219.1	96.3
155.4	179.7	212.0	218.9	96.1
157.4	179.4	211.6	218.8	95.9
159.4	179.1	211.4	218.7	95.7
159.7	179.1	211.3	218.7	95.7
161.4	178.9	211.1	218.6	95.6
163.4	178.8	210.9	218.5	95.5
165.4	178.7	210.8	218.4	95.4
167.4	178.6	210.7	218.4	95.4
169.4	178.5	210.7	218.3	95.3
171.4	178.5	210.6	218.3	95.3
173.4	178.8	210.9	218.4	95.4
175.4	179.5	211.8	219.4	95.8
177.4	180.4	212.9	221.4	96.4
179.4	181.6	214.3	224.2	97.2
181.4	182.8	215.8	227.7	98.2
183.4	184.1	217.3	231.6	99.2
185.4	185.4	218.8	235.7	100.2
187.3	186.4	220.0	239.8	101.1

Table 5.2-4 Unit 2 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
26.6	.0	.0	.0	.0
27.2	.0	.0	.0	.0
27.3	.0	.0	.0	.0
27.4	.0	.0	.0	.0
27.5	.0	.0	.0	.0
27.6	.0	.0	.0	.0
27.6	.0	.0	.0	.0
27.7	45.4	53.4	.0	.0
27.8	17.4	20.5	.0	.0
27.9	12.9	15.2	.0	.0
28.0	14.6	17.2	.0	.0
28.1	25.3	29.9	.0	.0
28.2	29.9	35.2	.0	.0
28.3	34.1	40.1	.0	.0
28.4	38.9	45.9	.0	.0
28.5	41.3	48.7	.0	.0
28.6	45.6	53.8	.0	.0
28.7	48.8	57.5	.0	.0
28.8	51.9	61.1	.0	.0
28.9	54.8	64.6	.0	.0
29.0	57.6	67.9	.0	.0
29.1	58.3	68.7	.0	.0
29.1	60.3	71.1	.0	.0
29.2	63.0	74.2	.0	.0
29.3	65.5	77.2	.0	.0
29.4	68.0	80.1	.0	.0
29.5	70.4	82.9	.0	.0
29.6	72.7	85.7	.0	.0
30.6	93.4	110.0	.0	.0
31.6	110.6	130.4	.0	.0
32.6	125.7	148.2	.0	.0
33.6	139.1	164.1	.0	.0
34.2	146.0	172.2	.0	.0
34.6	153.9	181.5	225.1	31.4
35.7	419.5	496.7	4367.1	590.5
36.7	435.8	516.6	4418.1	655.3
37.7	430.8	510.6	4371.0	650.7
38.7	424.8	503.5	4314.1	644.0
39.0	423.0	501.4	4296.9	642.0
39.7	418.9	496.4	4256.7	637.1
40.7	413.0	489.4	4199.8	630.3
41.7	407.3	482.6	4143.8	623.5
42.7	401.8	476.0	4089.0	616.8
43.7	396.5	469.6	4035.5	610.3
44.5	392.3	464.6	3993.7	605.1
44.7	391.3	463.4	3983.4	603.9
45.7	386.3	457.4	3932.6	597.7
46.7	381.4	451.6	3883.1	591.6

Table 5.2-4 (cont.) Unit 2 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
47.7	376.7	446.0	3834.9	585.7
48.7	372.2	440.6	3788.0	579.9
49.7	367.8	435.4	3742.3	574.3
50.7	363.5	430.3	3697.8	568.9
50.9	362.7	429.3	3689.0	567.8
51.7	359.4	425.4	3654.4	563.6
52.7	355.4	420.6	3612.1	558.4
53.7	351.5	416.0	3570.8	553.3
54.7	347.7	411.5	3530.6	548.3
55.8	286.6	338.8	2821.9	469.8
56.8	283.9	335.6	2790.6	465.9
57.8	387.9	459.2	308.5	210.7
58.0	411.7	487.8	318.8	225.3
58.8	424.3	502.9	324.2	233.1
59.8	417.3	494.5	320.9	228.8
60.8	409.9	485.6	317.6	224.3
61.8	402.6	477.0	314.3	219.9
62.8	395.6	468.6	311.0	215.6
63.8	388.6	460.2	307.9	211.4
64.8	381.6	451.8	304.7	207.1
65.8	375.2	444.3	301.8	203.3
66.8	369.1	436.9	299.0	199.6
67.8	363.0	429.8	296.3	196.0
68.8	357.2	422.8	293.7	192.5
69.8	351.5	415.9	291.1	189.1
70.8	345.9	409.3	288.6	185.8
71.7	340.9	403.4	286.4	182.9
71.8	340.4	402.8	286.1	182.6
72.8	335.1	396.4	283.8	179.5
73.8	329.9	390.3	281.4	176.5
74.8	324.8	384.2	279.2	173.5
75.8	319.9	378.4	277.0	170.6
76.8	315.1	372.6	274.9	167.8
77.8	310.4	367.0	272.8	165.1
78.8	305.8	361.6	270.8	162.5
79.8	301.4	356.3	268.8	159.9
80.8	297.0	351.2	266.9	157.5
81.8	292.8	346.1	265.1	155.1
82.8	288.7	341.2	263.3	152.7
83.8	284.7	336.5	261.5	150.5
84.8	280.8	331.9	259.8	148.3
85.8	277.1	327.4	258.2	146.2
86.8	273.4	323.1	256.6	144.1
87.8	269.8	318.8	255.1	142.1
88.6	267.1	315.6	253.9	140.6
89.8	263.0	310.8	252.1	138.3
91.8	256.6	303.2	249.4	134.8
93.8	250.6	296.0	246.8	131.5

Table 5.2-4 (cont.) Unit 2 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
95.8	244.9	289.3	244.4	128.4
97.8	239.6	283.0	242.1	125.5
99.8	234.6	277.1	240.0	122.8
101.8	230.0	271.6	238.0	120.3
103.8	225.6	266.4	236.2	118.0
105.8	221.6	261.6	234.5	115.8
107.8	217.8	257.1	232.9	113.8
109.0	215.6	254.6	232.0	112.7
109.8	214.3	252.9	231.5	111.9
111.8	211.0	249.0	230.1	110.2
113.8	207.9	245.4	228.8	108.6
115.8	205.1	242.1	227.7	107.1
117.8	202.5	239.0	226.6	105.8
119.8	200.1	236.2	225.6	104.5
121.8	197.9	233.6	224.7	103.4
123.8	195.9	231.2	223.9	102.3
125.8	194.0	229.0	223.1	101.3
127.8	192.3	226.9	222.4	100.4
129.8	190.8	225.1	221.7	99.6
131.8	189.3	223.4	221.2	98.9
132.7	188.8	222.7	220.9	98.6
133.8	188.1	221.9	220.6	98.2
135.8	186.9	220.5	220.1	97.6
137.8	185.9	219.3	219.7	97.1
139.8	184.9	218.2	219.3	96.6
141.8	184.1	217.2	219.0	96.1
143.8	183.3	216.3	218.6	95.7
145.8	182.7	215.5	218.4	95.3
147.8	182.1	214.8	218.1	95.0
149.8	181.6	214.2	217.9	94.7
151.8	181.1	213.7	217.7	94.5
153.8	180.7	213.2	217.5	94.3
155.8	180.4	212.8	217.4	94.1
157.8	180.1	212.5	217.2	93.9
158.8	180.0	212.4	217.2	93.8
159.8	179.9	212.2	217.1	93.8
161.8	179.7	212.0	217.0	93.6
163.8	179.6	211.8	216.9	93.5
165.8	179.5	211.7	216.9	93.5
167.8	179.4	211.7	216.8	93.4
169.8	179.4	211.6	216.8	93.4
171.8	179.4	211.6	216.8	93.3
173.8	179.4	211.7	216.8	93.3
175.8	179.5	211.7	216.8	93.3
177.8	179.8	212.2	216.9	93.5
179.8	180.7	213.2	218.1	94.0
181.8	181.7	214.4	220.2	94.6

Table 5.2-4 (cont.) Unit 2 Double-Ended Pump Suction Break Reflood Mass and Energy Releases (Minimum Safeguards)

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
183.8	182.9	215.9	223.1	95.5
185.8	184.3	217.5	226.7	96.5
186.4	184.7	217.9	227.8	96.8

Table 5.2-5 Unit 1 Double-Ended Pump Suction Break Principle Parameters During Reflood (Minimum Safeguards)

TIME	FLOODING TEMP	FLOODING RATE	CARRYOVER FRACTION	CORE HEIGHT	DOWNCOMER HEIGHT	FLOW FRACTION	INJECTION TOTAL	INJECTION ACCUMULATOR	INJECTION SPILL	ENTHALPY
SECONDS	DEGREE F	IN/SEC		FT	FT		(POUNDS MASS PER SECOND)			BTU/LBM
26.2	183.6	.000	.000	.00	.00	.250	.0	.0	.0	.00
26.9	182.1	20.934	.000	.50	1.16	.000	6835.6	6835.6	.0	89.48
27.2	180.6	24.747	.000	1.09	1.23	.000	6775.7	6775.7	.0	89.48
27.5	180.2	2.715	.111	1.32	1.84	.198	6688.5	6688.5	.0	89.48
27.6	180.2	2.815	.130	1.34	2.06	.226	6669.6	6669.6	.0	89.48
28.6	180.4	2.360	.301	1.50	4.26	.321	6483.1	6483.1	.0	89.48
29.3	180.6	2.287	.380	1.58	5.72	.335	6371.8	6371.8	.0	89.48
33.7	181.9	2.565	.618	2.00	15.18	.364	5723.1	5723.1	.0	89.48
36.3	182.6	4.293	.684	2.29	16.12	.587	5382.1	4849.2	.0	87.35
37.3	182.9	4.169	.696	2.40	16.12	.585	5289.4	4754.9	.0	87.31
38.4	183.2	4.058	.706	2.51	16.12	.583	5194.0	4657.7	.0	87.26
43.9	185.4	3.692	.728	3.00	16.12	.574	4783.0	4238.3	.0	87.03
50.2	188.4	3.428	.737	3.50	16.12	.563	4403.7	3851.3	.0	86.79
55.4	191.1	2.919	.738	3.87	16.12	.518	3384.9	2814.7	.0	85.86
56.4	191.7	3.577	.742	3.94	16.07	.586	547.8	.0	.0	68.00
57.2	192.2	3.658	.742	4.00	15.95	.589	540.1	.0	.0	68.00
64.4	197.1	3.278	.743	4.53	14.98	.581	551.1	.0	.0	68.00
71.4	202.7	2.984	.743	5.00	14.30	.574	559.2	.0	.0	68.00
80.4	210.5	2.676	.743	5.55	13.70	.563	567.1	.0	.0	68.00
88.7	217.9	2.452	.743	6.00	13.37	.554	572.0	.0	.0	68.00
99.4	227.2	2.233	.743	6.54	13.20	.543	576.3	.0	.0	68.00
109.5	234.6	2.084	.744	7.00	13.22	.533	579.0	.0	.0	68.00
121.4	242.1	1.964	.746	7.51	13.41	.525	581.1	.0	.0	68.00
133.5	248.6	1.886	.748	8.00	13.72	.519	582.3	.0	.0	68.00
147.4	255.1	1.834	.751	8.54	14.18	.515	583.1	.0	.0	68.00
159.7	260.2	1.808	.755	9.00	14.62	.514	583.4	.0	.0	68.00
171.4	264.4	1.794	.759	9.43	15.07	.514	583.5	.0	.0	68.00
173.4	265.1	1.794	.759	9.50	15.15	.514	583.5	.0	.0	68.00
187.3	269.6	1.822	.764	10.00	15.62	.524	582.4	.0	.0	68.00

Table 5.2-6 Unit 2 Double-Ended Pump Suction Break Principle Parameters During Reflood (Minimum Safeguards)

TIME	FLOODING TEMP	FLOODING RATE	CARRYOVER FRACTION	CORE HEIGHT	DOWNCOMER HEIGHT	FLOW FRACTION	INJECTION TOTAL	INJECTION ACCUMULATOR	INJECTION SPILL	ENTHALPY
SECONDS	DEGREE F	IN/SEC		FT	FT		(POUNDS MASS PER SECOND)			BTU/LBM
26.6	176.6	.000	.000	.00	.00	.250	.0	.0	.0	.00
27.4	175.0	22.231	.000	.65	1.13	.000	6463.8	6463.8	.0	89.48
27.6	174.1	23.689	.000	1.04	1.16	.000	6428.2	6428.2	.0	89.48
27.9	173.8	2.578	.104	1.31	1.70	.188	6347.7	6347.7	.0	89.48
28.1	173.8	2.770	.141	1.35	2.13	.250	6313.8	6313.8	.0	89.48
29.1	174.0	2.341	.299	1.50	4.10	.325	6154.9	6154.9	.0	89.48
30.6	174.5	2.270	.459	1.69	7.41	.351	5919.2	5919.2	.0	89.48
34.2	175.9	2.526	.615	2.00	14.50	.369	5463.2	5463.2	.0	89.48
36.7	176.8	4.285	.680	2.26	16.12	.584	5227.9	4690.5	.0	87.27
37.7	177.2	4.163	.693	2.37	16.12	.583	5138.3	4599.8	.0	87.23
39.0	177.8	4.035	.705	2.51	16.12	.581	5033.0	4492.6	.0	87.17
44.5	180.5	3.684	.728	3.00	16.12	.572	4649.3	4101.4	.0	86.95
50.9	184.2	3.427	.737	3.51	16.12	.562	4288.0	3733.1	.0	86.70
56.8	187.6	2.915	.738	3.92	16.12	.517	3270.6	2698.7	.0	85.72
57.8	188.2	3.586	.743	3.99	16.09	.589	552.8	.0	.0	68.00
58.0	188.4	3.704	.743	4.00	16.06	.593	544.0	.0	.0	68.00
58.8	188.9	3.752	.743	4.07	15.93	.595	538.7	.0	.0	68.00
64.8	193.5	3.406	.744	4.52	15.05	.589	548.8	.0	.0	68.00
71.7	199.4	3.083	.744	5.00	14.30	.581	557.7	.0	.0	68.00
79.8	206.8	2.773	.743	5.51	13.67	.572	565.7	.0	.0	68.00
88.6	215.0	2.505	.743	6.00	13.26	.561	571.6	.0	.0	68.00
99.8	225.1	2.253	.743	6.57	13.04	.548	576.5	.0	.0	68.00
109.0	232.1	2.105	.744	7.00	13.05	.539	579.2	.0	.0	68.00
121.8	240.4	1.965	.745	7.56	13.24	.529	581.5	.0	.0	68.00
132.7	246.4	1.891	.747	8.00	13.52	.523	582.7	.0	.0	68.00
145.8	252.8	1.837	.750	8.51	13.94	.519	583.5	.0	.0	68.00
158.8	258.3	1.807	.754	9.00	14.41	.518	583.8	.0	.0	68.00
173.8	263.9	1.791	.758	9.55	14.99	.517	583.9	.0	.0	68.00
175.8	264.6	1.790	.759	9.62	15.07	.517	583.9	.0	.0	68.00
186.4	268.1	1.810	.763	10.00	15.47	.524	583.3	.0	.0	68.00

Table 5.2-7 Unit 1 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) without Recirculation Sprays

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
187.4	217.6	271.3	375.7	134.4
192.4	217.3	271.0	376.0	134.3
197.4	217.1	270.7	376.2	134.1
202.4	215.9	269.2	377.4	134.1
207.4	215.9	269.2	377.4	133.9
212.4	214.9	267.9	378.4	133.9
217.4	214.8	267.9	378.5	133.7
222.4	214.8	267.8	378.5	133.5
227.4	213.7	266.5	379.6	133.6
232.4	213.6	266.3	379.7	133.3
237.4	213.5	266.2	379.9	133.1
242.4	212.3	264.8	381.0	133.2
247.4	212.2	264.5	381.2	133.0
252.4	211.9	264.3	381.4	132.8
257.4	210.8	262.8	382.5	132.9
262.4	210.5	262.5	382.8	132.7
267.4	210.2	262.1	383.1	132.6
272.4	209.9	261.7	383.4	132.4
277.4	209.6	261.3	383.7	132.3
282.4	209.2	260.9	384.1	132.1
287.4	207.9	259.2	385.4	132.2
292.4	207.5	258.7	385.9	132.1
297.4	207.0	258.1	386.3	132.0
302.4	206.5	257.5	386.8	131.9
307.4	205.9	256.8	387.4	131.8
312.4	205.4	256.1	388.0	131.7
317.4	205.6	256.3	387.7	131.4
322.4	204.9	255.5	388.4	131.3
327.4	204.2	254.6	389.1	131.2
332.4	203.4	253.6	389.9	131.2
337.4	203.4	253.6	389.9	131.0
342.4	202.5	252.5	390.8	130.9
347.4	202.3	252.3	391.0	130.7
352.4	201.3	251.0	392.0	130.8
357.4	201.0	250.6	392.3	130.6
362.4	200.6	250.1	392.7	130.4
367.4	200.1	249.5	393.2	130.3
372.4	199.5	248.8	393.8	130.2
377.4	198.8	247.9	394.5	130.2
382.4	198.0	246.8	395.3	130.1
387.4	197.7	246.5	395.6	129.9
392.4	197.3	246.0	396.0	129.8
397.4	196.7	245.3	396.6	129.7
402.4	196.0	244.4	397.3	129.6
407.4	195.1	243.3	398.2	129.6
412.4	194.7	242.7	398.7	129.5
417.4	194.5	242.5	398.8	129.3
422.4	204.3	254.7	389.0	131.8

Table 5.2-7 (cont.)	Unit 1 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) without Recirculation Sprays			
TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
427.4	203.7	254.0	389.6	131.7
432.4	203.4	253.6	389.9	131.5
437.4	202.7	252.7	390.6	131.5
442.4	202.2	252.1	391.1	131.3
447.4	201.7	251.5	391.6	131.2
452.4	200.8	250.4	392.5	131.1
457.4	200.2	249.7	393.1	131.0
462.4	90.6	113.0	502.7	159.7
647.6	90.6	113.0	502.7	159.7
647.7	92.9	115.1	500.4	153.9
652.4	92.8	114.9	500.5	153.6
1411.1	92.8	114.9	500.5	153.6
1411.2	77.7	89.4	515.6	43.5
1748.3	73.7	84.8	519.6	44.2
1748.4	73.7	84.8	353.7	78.7
3000.0	64.9	74.7	362.4	80.2
3000.1	64.9	74.7	366.6	68.0
3600.0	61.3	70.5	370.2	68.7
3600.1	50.8	58.5	380.7	55.2
7000.0	41.1	47.3	390.5	56.6
7000.1	40.5	46.7	391.5	51.7
10000.0	36.5	42.0	395.5	52.2
10000.1	36.2	41.6	395.8	49.1
50000.0	23.7	27.2	408.3	50.6
50000.1	23.1	26.6	408.9	40.9
100000.0	18.9	21.8	413.1	41.3
100000.1	18.7	21.5	413.3	35.5
500000.0	10.8	12.4	421.2	36.2
500000.1	10.7	12.4	421.3	33.7
800000.0	8.7	10.0	423.3	33.9
800000.1	8.7	10.0	423.3	32.2
1000000.0	7.9	9.1	424.1	32.2
1000000.1	7.9	9.1	424.1	31.8
5000000.0	3.8	4.3	428.2	32.1
5000000.1	3.7	4.3	428.3	30.0
10000000.0	2.5	2.8	429.5	30.1

Table 5.2-8 **Unit 2 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) without Recirculation Sprays**

TIME SECONDS	BREAK PATH NO.1 FLOW LBM/SEC	BREAK PATH NO.1 FLOW THOUSAND BTU/SEC	BREAK PATH NO.2 FLOW LBM/SEC	BREAK PATH NO.2 FLOW THOUSAND BTU/SEC
186.4	227.9	284.0	365.4	135.2
191.4	227.3	283.3	366.0	135.1
196.4	226.7	282.5	366.6	135.0
201.4	226.2	281.9	367.1	134.9
206.4	225.8	281.4	367.5	134.7
211.4	225.5	280.9	367.8	134.6
216.4	225.1	280.4	368.2	134.4
221.4	224.6	279.9	368.7	134.3
226.4	224.2	279.4	369.1	134.2
231.4	223.7	278.8	369.6	134.1
236.4	223.2	278.2	370.1	133.9
241.4	222.7	277.5	370.6	133.8
246.4	222.2	276.8	371.2	133.7
251.4	221.6	276.1	371.7	133.6
256.4	221.0	275.4	372.3	133.5
261.4	220.4	274.6	373.0	133.5
266.4	220.4	274.6	372.9	133.2
271.4	219.7	273.8	373.6	133.1
276.4	219.0	272.9	374.3	133.1
281.4	218.9	272.8	374.4	132.9
286.4	218.1	271.7	375.2	132.8
291.4	217.9	271.5	375.4	132.6
296.4	217.0	270.4	376.3	132.6
301.4	216.8	270.1	376.6	132.4
306.4	216.4	269.7	376.9	132.3
311.4	216.0	269.2	377.3	132.1
316.4	214.9	267.8	378.4	132.1
321.4	214.4	267.2	378.9	132.0
326.4	214.5	267.3	378.8	131.8
331.4	213.8	266.4	379.5	131.7
336.4	213.1	265.5	380.2	131.6
341.4	212.9	265.3	380.4	131.4
346.4	212.0	264.1	381.3	131.4
351.4	211.6	263.6	381.8	131.2
356.4	211.0	263.0	382.3	131.1
361.4	210.4	262.1	382.9	131.0
366.4	210.1	261.8	383.2	130.8
371.4	209.2	260.7	384.1	130.8
376.4	208.6	260.0	384.7	130.7
381.4	208.4	259.6	384.9	130.5
386.4	207.9	259.1	385.4	130.4
391.4	207.2	258.1	386.2	130.3
396.4	206.6	257.5	386.7	130.2
401.4	206.2	257.0	387.1	130.0
406.4	205.5	256.1	387.8	130.0
411.4	204.8	255.2	388.5	129.9
416.4	204.3	254.6	389.0	129.8
421.4	203.9	254.1	389.4	129.6

Table 5.2-8 (cont.) Unit 2 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) without Recirculation Sprays

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
426.4	203.2	253.2	390.1	129.6
431.4	202.6	252.4	390.7	129.5
436.4	202.0	251.7	391.3	129.4
441.4	201.7	251.3	391.7	129.2
446.4	200.8	250.2	392.5	129.2
451.4	91.0	113.4	502.3	157.9
638.8	91.0	113.4	502.3	157.9
638.9	93.4	115.6	499.9	154.8
641.4	93.4	115.5	500.0	154.7
1429.2	93.4	115.5	500.0	154.7
1429.3	77.7	89.4	515.6	44.5
1748.3	73.9	85.0	519.4	45.2
1748.4	73.9	85.0	353.4	79.6
3000.0	65.2	75.0	362.2	81.2
3000.1	65.2	75.0	366.4	69.0
3600.0	61.6	70.8	370.0	69.6
3600.1	50.8	58.5	380.7	55.2
7000.0	41.1	47.3	390.5	56.6
7000.1	40.5	46.7	391.5	51.7
10000.0	36.5	42.0	395.5	52.2
10000.1	36.2	41.6	395.8	49.1
50000.0	23.7	27.2	408.3	50.6
50000.1	23.1	26.6	408.9	40.9
100000.0	18.9	21.8	413.1	41.3
100000.1	18.7	21.5	413.3	35.5
500000.0	10.8	12.4	421.2	36.2
500000.1	10.7	12.3	421.3	32.9
800000.0	8.7	10.0	423.3	33.0
800000.1	8.7	10.0	423.3	31.3
1000000.0	7.9	9.1	424.1	31.4
1000000.1	7.9	9.1	424.1	30.5
5000000.0	3.7	4.3	428.3	30.8
5000000.1	3.7	4.3	428.3	30.0
10000000.0	2.5	2.8	429.5	30.1

Table 5.2-9 LOCA Mass and Energy Release Analysis Core Decay Heat Fraction	
Time (sec)	Decay Heat Generation Rate (Btu/Btu)
10	0.053876
15	0.050401
20	0.048018
40	0.042401
60	0.039244
80	0.037065
100	0.035466
150	0.032724
200	0.030936
400	0.027078
600	0.024931
800	0.023389
1000	0.022156
1500	0.019921
2000	0.018315
4000	0.014781
6000	0.013040
8000	0.012000
10000	0.011262
15000	0.010097
20000	0.009350
40000	0.007778
60000	0.006958
80000	0.006424
100000	0.006021
150000	0.005323

Table 5.2-9 LOCA Mass and Energy Release Analysis Core Decay Heat Fraction (cont.)

Time (sec)	Decay Heat Generation Rate (Btu/Btu)
200000	0.004847
400000	0.003770
600000	0.003201
800000	0.002834
1000000	0.002580
2000000	0.001909
4000000	0.001355
6000000	0.001091
8000000	0.000927
10000000	0.000808

Table 5.2-10 Unit 1 Double-Ended Pump Suction Break Mass Balance (Minimum Safeguards)

	TIME (SECONDS)	.00	26.20	26.20	187.31	647.69	1411.09	3600.00
		MASS (THOUSAND LBM)						
INITIAL	IN RCS AND ACC	728.06	728.06	728.06	728.06	728.06	728.06	728.06
ADDED MASS	PUMPED INJECTION	.00	.00	.00	86.71	359.81	812.74	1806.61
	TOTAL ADDED	.00	.00	.00	86.71	359.81	812.74	1806.61
*** TOTAL AVAILABLE ***		728.06	728.06	728.06	814.78	1087.88	1540.81	2534.68
DISTRIBUTION	REACTOR COOLANT	509.07	55.52	79.78	148.67	148.67	148.67	148.67
	ACCUMULATOR	219.00	163.79	139.52	.00	.00	.00	.00
	TOTAL CONTENTS	728.06	219.30	219.30	148.67	148.67	148.67	148.67
EFFLUENT	BREAK FLOW	.00	508.74	508.74	666.09	939.19	1392.12	2386.00
	ECCS SPILL	.00	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	508.74	508.74	666.09	939.19	1392.12	2386.00
*** TOTAL ACCOUNTABLE ***		728.06	728.05	728.05	814.76	1087.86	1540.79	2534.67

Table 5.2-11 Unit 2 Double-Ended Pump Suction Break Mass Balance (Minimum Safeguards)

	TIME (SECONDS)	.00	26.60	26.60	186.36	638.89	1429.18	3600.00
		MASS (THOUSAND LBM)						
INITIAL	IN RCS AND ACC	748.99	748.99	748.99	748.99	748.99	748.99	748.99
ADDED MASS	PUMPED INJECTION	.00	.00	.00	86.26	354.73	823.62	1806.75
	TOTAL ADDED	.00	.00	.00	86.26	354.73	823.62	1806.75
*** TOTAL AVAILABLE ***		748.99	748.99	748.99	835.25	1103.72	1572.61	2555.74
DISTRIBUTION	REACTOR COOLANT	530.29	46.25	77.49	145.99	145.99	145.99	145.99
	ACCUMULATOR	218.70	169.11	137.87	.00	.00	.00	.00
	TOTAL CONTENTS	748.99	215.36	215.36	145.99	145.99	145.99	145.99
EFFLUENT	BREAK FLOW	.00	533.62	533.62	689.24	957.71	1426.60	2409.74
	ECCS SPILL	.00	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	533.62	533.62	689.24	957.71	1426.60	2409.74
*** TOTAL ACCOUNTABLE ***		748.99	748.98	748.98	835.23	1103.70	1572.59	2555.73

Table 5.2-12 Unit 1 Double-Ended Pump Suction Break Energy Balance (Minimum Safeguards)

	TIME (SECONDS)	.00	26.20	26.20	187.31	647.69	1411.09	3600.00
		ENERGY (MILLION BTU)						
INITIAL ENERGY	IN RCS,ACC,S GEN	853.70	853.70	853.70	853.70	853.70	853.70	853.70
ADDED ENERGY	PUMPED INJECTION	.00	.00	.00	5.90	24.47	55.27	200.02
	DECAY HEAT	.00	8.01	8.01	27.21	68.79	124.74	250.57
	HEAT FROM SECONDARY	.00	8.68	8.68	8.68	16.73	27.80	27.80
	TOTAL ADDED	.00	16.69	16.69	41.79	109.99	207.80	478.39
*** TOTAL	AVAILABLE ***	853.70	870.40	870.40	895.49	963.69	1061.51	1332.09
DISTRIBUTION	REACTOR COOLANT	299.35	12.06	14.23	38.61	38.61	38.61	38.61
	ACCUMULATOR	19.60	14.66	12.48	.00	.00	.00	.00
	CORE STORED	25.60	13.30	13.30	4.85	4.64	4.30	3.33
	PRIMARY METAL	153.38	145.78	145.78	119.57	84.56	64.78	50.05
	SECONDARY METAL	102.67	102.65	102.65	93.89	73.13	50.77	39.18
	STEAM GENERATOR	253.11	268.48	268.48	241.69	189.88	140.75	112.11
	TOTAL CONTENTS	853.70	556.92	556.92	498.62	390.82	299.22	243.28
EFFLUENT	BREAK FLOW	.00	312.89	312.89	388.23	564.23	750.24	1078.22
	ECCS SPILL	.00	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	312.89	312.89	388.23	564.23	750.24	1078.22
*** TOTAL	ACCOUNTABLE ***	853.70	869.81	869.81	886.85	955.05	1049.45	1321.51

Table 5.2-13 Unit 2 Double-Ended Pump Suction Break Energy Balance (Minimum Safeguards)

	TIME (SECONDS)	.00	26.60	26.60	186.36	638.89	1429.18	3600.00
		ENERGY (MILLION BTU)						
INITIAL ENERGY	IN RCS,ACC,S GEN	881.82	881.82	881.82	881.82	881.82	881.82	881.82
ADDED ENERGY	PUMPED INJECTION	.00	.00	.00	5.87	24.12	56.01	200.03
	DECAY HEAT	.00	8.09	8.09	27.13	68.10	125.97	250.61
	HEAT FROM SECONDARY	.00	8.97	8.97	8.97	16.89	28.32	28.32
	TOTAL ADDED	.00	17.06	17.06	41.96	109.11	210.30	478.95
*** TOTAL	AVAILABLE ***	881.82	898.88	898.88	923.78	990.92	1092.12	1360.77
DISTRIBUTION	REACTOR COOLANT	311.53	10.52	13.32	37.98	37.98	37.98	37.98
	ACCUMULATOR	19.57	15.13	12.34	.00	.00	.00	.00
	CORE STORED	25.60	12.98	12.98	4.85	4.64	4.29	3.33
	PRIMARY METAL	156.23	147.74	147.74	121.42	86.22	65.88	50.95
	SECONDARY METAL	92.82	93.10	93.10	85.24	66.74	46.36	35.77
	STEAM GENERATOR	276.06	292.38	292.38	264.21	209.04	154.48	122.77
	TOTAL CONTENTS	881.82	571.85	571.85	513.70	404.63	308.99	250.81
EFFLUENT	BREAK FLOW	.00	326.45	326.45	401.46	577.67	771.44	1099.73
	ECCS SPILL	.00	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	326.45	326.45	401.46	577.67	771.44	1099.73
*** TOTAL	ACCOUNTABLE ***	881.82	898.30	898.30	915.16	982.30	1080.44	1350.54

Table 5.2-14 **Unit 1 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) with Recirculation Spray Actuated**

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
3600.1	50.8	58.5	380.7	55.2
4441.6	47.2	54.3	384.3	55.7
4441.7	47.1	54.2	118.1	16.9
7000.0	41.0	47.2	124.2	17.8
7000.1	40.8	46.9	124.4	17.2
10000.0	36.7	42.2	128.5	17.7
10000.1	36.5	42.0	128.7	17.1
50000.0	23.9	27.5	141.3	18.8
50000.1	23.4	26.9	141.9	15.6
100000.0	19.1	22.0	146.1	16.1
100000.1	18.9	21.7	146.3	14.3
500000.0	10.9	12.6	154.3	15.1
500000.1	10.8	12.4	154.4	13.3
1000000.0	8.0	9.2	157.2	13.5
1000000.1	7.9	9.1	157.3	12.3
5000000.0	3.8	4.3	161.5	12.6
5000000.1	3.7	4.3	161.5	11.6
10000000.0	2.5	2.8	162.7	11.7

Table 5.2-15 Unit 2 Double-Ended Pump Suction Break Post-Reflood Mass and Energy Releases (Minimum Safeguards) with Recirculation Spray Actuated

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
3600.1	50.8	58.5	380.7	55.2
4441.6	47.2	54.3	384.3	55.7
4441.7	47.1	54.2	118.1	16.9
7000.0	41.0	47.2	124.2	17.8
7000.1	40.8	46.9	124.4	17.2
10000.0	36.7	42.2	128.5	17.7
10000.1	36.5	42.0	128.7	17.1
50000.0	23.9	27.5	141.3	18.8
50000.1	23.4	26.9	141.9	15.6
100000.0	19.1	22.0	146.1	16.1
100000.1	18.9	21.7	146.3	14.3
500000.0	10.9	12.6	154.3	15.1
500000.1	10.8	12.4	154.4	13.3
1000000.0	8.0	9.2	157.2	13.5
1000000.1	7.9	9.1	157.3	12.3
5000000.0	3.8	4.3	161.5	12.6
5000000.1	3.7	4.3	161.5	11.6
10000000.0	2.5	2.8	162.7	11.7

6 CONTAINMENT RESPONSE ANALYSES

6.1 DESCRIPTION OF COCO MODEL

Calculation of containment pressure and temperature is accomplished by use of the digital computer code COCO (Reference 5). COCO is a mathematical model of a generalized containment; the proper selection of various options in the code allows the creation of a specific model for particular containment design. The values used in the specific model for different aspects of the containment are derived from plant-specific input data. Transient phenomena within the reactor coolant system affect containment conditions by means of convective mass and energy transport through the pipe break.

For analytical rigor and convenience, the containment air-steam-water mixture is separated into a water (pool) phase and a steam-air phase. Sufficient relationships to describe the transient are provided by the equations of conservation of mass and energy as applied to each system, together with appropriate boundary conditions. As thermodynamic equations of state and conditions may vary during the transient, the equations have been derived for all possible cases of superheated or saturated steam and subcooled or saturated water. Switching between states is handled automatically by the code.

Passive Heat Removal

The significant heat removal source during the early portion of the transient is the containment structural heat sinks. Provision is made in the containment pressure response analysis for heat transfer through, and heat storage in, both interior and exterior walls. Every wall is divided into a large number of nodes. For each node, a conservation of energy equation expressed in finite-difference form accounts for heat conduction into and out of the node and temperature rise of the node. Table 6.1-1 is the summary of the containment structural heat sinks used in the analysis. The thermal properties of each heat sink material are shown in Table 6.1-2.

The heat transfer coefficient to the containment structure for the early part of the event is calculated based primarily on the work of Tagami (Reference 15). From this work, it was determined that the value of the heat transfer coefficient can be assumed to increase parabolically to a peak value. In COCO, the value then decreases exponentially to a stagnant heat transfer coefficient which is a function of steam-to-air-weight ratio.

The h for stagnant conditions is based upon Tagami's steady state results.

Tagami presents a plot of the maximum value of the heat transfer coefficient, h, as function of "coolant energy transfer speed," defined as follows:

$$h = \frac{\text{total coolant energy transferred into containment}}{\text{(containment volume)(time interval to peak pressure)}}$$

From this, the maximum heat transfer coefficient of steel is calculated:

$$h_{max} = 75\left(\frac{E}{t_p V}\right)^{0.60} \qquad \text{(Equation 1)}$$

where:

h_{max}	=	maximum value of h (Btu/hr ft^2 °F).
t_p	=	time from start of accident to end of blowdown for LOCA and steamline isolation for secondary breaks (sec).
V	=	containment net free volume (ft^3).
E	=	total coolant energy discharge from time zero to t_p (Btu).
75	=	material coefficient for steel.

(Note: Paint is accounted for by the thermal conductivity of the material (paint) on the heat sink structure, not by an adjustment on the heat transfer coefficient.)

The basis for the equations is a Westinghouse curve fit to the Tagami data.

The parabolic increase to the peak value is calculated by COCO according to the following equation:

$$h_s = h_{max}\left(\frac{t}{t_p}\right)^{0.5}, 0 \le t \le t_p \qquad \text{(Equation 2)}$$

where:

h_s	=	heat transfer coefficient between steel and air/steam mixture (Btu/hr ft^2 °F).
t	=	time from start of event (sec).

For concrete, the heat transfer coefficient is taken as 40 percent of the value calculated for steel during the blowdown phase.

The exponential decrease of the heat transfer coefficient to the stagnant heat transfer coefficient is given by:

$$h_s = h_{stag} + (h_{max} - h_{stag})e^{-0.05(t-t_p)} \qquad \text{(Equation 3)}$$

where:

$t > t_p$

h_{stag}	=	$2 + 50X, 0 < X < 1.4$.
h_{stag}	=	h for stagnant conditions (Btu/hr ft^2 °F).
X	=	steam-to-air weight ratio in containment.

Active Heat Removal

For a large break, the engineered safety features are quickly brought into operation. Because of the brief period of time required to depressurize the reactor coolant system or the main steam system, the containment safeguards are not a major influence on the blowdown peak pressure; however, they reduce the containment pressure after the blowdown and maintain a low long-term pressure and a low long-term temperature.

Safety Injection - RWST

During the injection phase of post-accident operation, the emergency core cooling system pumps water from the refueling water storage tank into the reactor vessel. Since this water enters the vessel at refueling water storage tank temperature, which is less than the temperature of the water in the vessel, it is modeled as absorbing heat from the core until the saturation temperature is reached. Safety injection and containment spray can be operated for a limited time, depending on the refueling water storage tank (RWST) capacity.

Safety Injection – RHR/Sump Recirculation

After the supply of refueling water is exhausted, the recirculation system is operated to provide long term cooling of the core. In this operation, water is drawn from the sump, cooled in a residual heat removal (RHR) exchanger, then pumped back into the reactor vessel to remove core residual heat and energy stored in the vessel metal. The heat is removed from the RHR heat exchanger by the component cooling water (CCW). The RHR Hxs and CCW Hxs are coupled in a closed loop system, where the ultimate heat sink is the service water cooling the CCW Hx.

Containment Spray

Containment spray (CS) is an active removal mechanism which is used for rapid pressure reduction and for containment iodine removal. During the injection phase of operation, the containment spray pumps draw water from the RWST and spray it into the containment through nozzles mounted high above the operating deck. As the spray droplets fall, they absorb heat from the containment atmosphere. Since the water comes from the RWST, the entire heat capacity of the spray from the RWST temperature to the temperature of the containment atmosphere is available for energy absorption. During the recirculation phase the analysis credits available spray flow.

When a spray droplet enters the hot, saturated, steam-air containment environment, the vapor pressure of the water at its surface is much less than the partial pressure of the steam in the atmosphere. Hence, there will be diffusion of steam to the drop surface and condensation on the droplet. This mass flow will carry energy to the droplet. Simultaneously, the temperature difference between the atmosphere and the droplet will cause the droplet temperature and vapor pressure to rise. The vapor pressure of the droplet will eventually become equal to the partial pressure of the steam, and the condensation will cease. The temperature of the droplet will essentially equal the temperature of the steam-air mixture.

The equations describing the temperature rise of a falling droplet are as follows.

$$\frac{d}{dt}(Mu) = mh_g + q \qquad \text{(Equation 4)}$$

where:

M	=	droplet mass
u	=	internal energy
m	=	diffusion rate
h_g	=	steam enthalpy
q	=	heat flow rate
t	=	time

$$\frac{d}{dt}(Mu) = m \qquad \text{(Equation 5)}$$

where:

q	=	$h_cA * (T_s - T)$
m	=	$k_gA * (P_s - Pv)$
A	=	area
h_c	=	coefficient of heat transfer
k_g	=	coefficient of mass transfer
T	=	droplet temperature
T_s	=	steam temperature
P_s	=	steam partial pressure
P_v	=	droplet vapor pressure

The coefficients of heat transfer (h_c) and mass transfer (k_g) are calculated from the Nusselt number for heat transfer, Nu, and the Nusselt number for mass transfer, Nu'.

Both Nu and Nu' may be calculated from the equations of Ranz and Marshall (Reference 16).

$$Nu = 2 + 0.6(Re)^{1/2}(Pr)^{1/3} \qquad \text{(Equation 6)}$$

where:

Nu	=	Nusselt number for heat transfer
Pr	=	Prandtl number
Re	=	Reynolds number

$$Nu' = 2 + 0.6(\mathrm{Re})^{1/2}(Sc)^{1/3} \qquad \text{(Equation 7)}$$

where:

Nu′	=	Nusselt number for mass transfer
Sc	=	Schmidt number

Thus, Equations 4 and 5 can be integrated numerically to find the internal energy and mass of the droplet as a function of time as it falls through the atmosphere. Analysis shows that the temperature of the (mass) mean droplet produced by the spray nozzles rises to a value within 99 percent of the bulk containment temperature in less than 2 seconds. Detailed calculations of the heatup of spray droplets in post-accident containment atmospheres by Parsly (Reference 17) show that droplets of all sizes encountered in the containment spray reach equilibrium in a fraction of their residence time in a typical pressurized water reactor containment. These results confirm the assumption that the containment spray will be 100 percent effective in removing heat from the atmosphere.

CFCU

The containment fan cooler units (CFCUs) are an additional means of heat removal. The main aspects of a fan cooler from the heat removal standpoint are the fan and the banks of cooling coils. The fans draw the dense containment atmosphere (steam/air mixture) through banks of finned cooling coils and discharge the cooled steam/air mixture through the containment ventilation ducting to mix with the rest of the containment atmosphere. The coils are kept at a low temperature by a constant flow of cooling water. Under accident conditions, the cooling water is provided by the Service Water System. Since this system does not use water from the RWST, the mode of operation remains the same both before and after the spray system and emergency core cooling system change to recirculation mode. See Table 6.1-3 for the CFCU heat removal capability assumed for the containment response analyses.

Table 6.1-1 Containment Heat Sinks			
No.	Material	Heat Transfer Area ft^2	Thickness ft
1	Paint Coating #1 Carbon Steel Concrete	45,169	0.000625 0.03125 4.5
2	Insulation Carbon Steel Concrete	14,206	0.2083 0.03125 4.5
3	Paint Coating #1 Carbon Steel Concrete	29,249	0.000625 0.04167 3.5
4	In contact with the sump Paint Coating #2 Concrete	11,611	 0.0015 3.5
5	Paint Coating #2 Concrete	6,806	0.0015 1.5
6	Paint Coating #2 Concrete	9,424	0.0015 1.71
7	Paint Coating #3 Concrete	31,660	0.00117 1.5
8	Stainless Steel Concrete	13,278.68	0.01773 1.9
9	Paint Coating #1 Carbon Steel	47,589.8	0.000625 0.011
10	Paint Coating #1 Carbon Steel	76,741.2	0.000625 0.02102
11	Paint Coating #1 Carbon Steel	19,348	0.000625 0.0437
12	Paint Coating #1 Carbon Steel	9,330	0.000625 0.0611
13	Paint Coating #1 Carbon Steel	7,451.5	0.000625 0.086
14	Paint Coating #1 Carbon Steel	3,217.7	0.000625 0.11124
15	Paint Coating #1 Carbon Steel	1,553.18	0.000625 0.217
16	Paint Coating #1 Carbon Steel	43,740	0.000625 0.0052
17	Stainless Steel	4,272	0.0329
18	Paint Coating #1 Carbon Steel	53,745	0.000625 0.0211
19	Paint Coating #1 Carbon Steel	11,243.59	0.000625 0.0379
20	Paint Coating #1 Carbon Steel	2,989.4	0.000625 0.15806

Table 6.1-2 Thermophysical Properties of Containment Heat Sinks		
Material	**Thermal Conductivity (Btu/hr-ft – °F)**	**Volumetric Heat Capacity (Btu/ft^3 – °F)**
Carbon Steel	27.0	58.8
Stainless Steel	8.0	53.6
Concrete	0.92	22.6
Insulation	0.024	3.94
Paint Coating #1	0.083	39.6
Paint Coating #2	0.083	39.6
Paint Coating #3	0.083	39.6

Table 6.1-3 Containment Fan Cooler Performance	
Containment Temperature (°F)	**Heat Removal Rate [Btu/sec] Per Reactor Containment Fan Cooler**
105	648.6
120	1620.8
140	3198.7
160	4982.6
180	6908.8
200	8856.4
220	10817.0
240	12706.5
260	14625.6
271	15662.5
280	16500.1

Notes:
Service Water Temperature = 93.0°F
Service Water Flow = 1200 gpm
Tube Fouling = 0.0015

Table 6.1-4 Containment Response Analysis Parameters	
Service water temperature (°F)	93
RWST water temperature (°F)	100
Initial containment temperature (°F)	120
Initial containment pressure (psia)	15.0
Initial relative humidity (%)	20
Net free volume (ft^3)	2.62×10^6
Containment Fan Coolers	
Total	5
Analysis maximum (bounding configuration following AST* implementation)	3
Analysis minimum (bounding configuration following AST* implementation)	2
Containment High setpoint (psig)	5.5
Delay time (sec) With Offsite Power Without Offsite Power	 100.0 100.0
Containment Spray Pumps	
Total	2
Analysis maximum	2
Analysis minimum	1
Flowrate (gpm) Injection phase (per pump) Recirculation phase (total)	 Variable see Table 6.1-5
Containment Hi hi setpoint (psig)	17.0
Delay time (sec) With Offsite Power (delay after Hi hi setpoint) Without Offsite Power (delay after Hi-hi setpoint)	 85.0 85.0
ECCS Recirculation Switchover, sec Minimum Safeguards	1748.3[y]
Containment Spray Termination (injection phase) time, (sec) Minimum Safeguards	4141.6[y]
Containment Spray – Recirculation (gpm) For minimum safeguards, with recirculation spray, only 1225.2 gpm goes to the core from the total RHR flow of 3200 gpm a delay of 5 minutes (i.e. 300 seconds) will be assumed for operator action to start spray	1974.8

Table 6.1-4 Containment Response Analysis Parameters (cont.)	
Residual Heat Removal System	
RHR Heat Exchangers	
Modeled in analysis[z]	1
Minimum Safeguards Recirculation switchover time, sec	1748.3
UA, 106 Btu/hr-°F[z]	1.75
Flows - Tube Side and Shell Side – gpm	
Tube Side CCW Flow (Minimum Safeguards)	4000.0
Shell Side RHR Flow (Minimum Safeguards)	3200.0
Component Cooling Water Heat Exchangers	
Modeled in analysis	1
UA, 106 Btu/hr-°F[z]	4.013
Flows - Shell Side and Tube Side – gpm	
Shellside[z]	4140.0
Tubeside (service water)[z]	8000.0
Additional heat loads, Btu/hr	2.0×10^6

Notes:

- * PSE&G is performing an alternate source term (AST) dose analysis
- y these values were determined by Westinghouse using conservative flow assumptions and PSEG supplied RWST inventory data
- z Minimum safeguards data representing the loss of a safeguards train

Table 6.1-5 Containment Spray Performance (Injection Phase)

Containment Pressure (psig)	with 1 Pump (gpm)	with 2 Pumps (gpm)
0	3117.0	6234.0
10	3017.0	6034.0
20	2913.0	5826.0
30	2720.0	5440.0
40	2687.0	5374.0
47	2600.0	5200.0

6.2 CONTAINMENT RESPONSE TO STEAMLINE BREAK

The containment response to a steamline break was calculated with the COCO model described in Section 6.1 and the mass and energy releases from Section 4.4. The peak containment pressures and temperatures are summarized in Table 6.2-1. The limiting containment pressure case is a 1.4 ft^2 DER initiated at 30% power with a containment safeguards failure. The limiting containment temperature case is 0.88 ft^2 split rupture initiated at 30% power with a MSIV failure. For Unit 1, the peak pressure is 40.2 psig and the peak temperature is 345.7°F. For Unit 2, the peak pressure is 42.2 psig and the peak temperature is 345.4°F.

The containment air temperature composite profile from all the cases is in Table 6.2-2. The composite temperature transient is compared to the EQ temperature limit from Section 3.3 in Figure 6.2-1.

Table 6.2-1 Summary of Steamline Break Peak Containment Pressures and Temperatures

Case Description			Unit 1 Model F SGs			Unit 2 Model 51 SGs		
Break	Power	Failure	Case	Peak Press (psig @ sec)	Peak Temp (°F @ sec)	Case	Peak Press (psig @ sec)	Peak Temp (°F @ sec)
4.6 DER	100	FRV	--	--	--	9-2	39.0 @ 124	260.1 @ 124
4.6 DER	30	FRV	--	--	--	11-2	41.0 @ 165	263.1 @ 164
1.4 DER	30	CSF	19-1	40.2 @ 603	261.9 @ 603	19-2	42.2 @ 603	265.0 @ 603
1.4 DER	30	AFW	23-1	37.5 @ 602	257.5 @ 602	23-2	39.3 @ 602	260.4 @ 602
1.4 DER	100	FRV	25-1	39.2 @ 225	260.4 @ 225	25-2	40.5 @ 250	262.4 @ 250
Small DER	100	MSIV	61-1	30.5 @ 649	331.5 @ 119	61-2	31.6 @ 452	327.7 @ 111
Split	30	CSF	67-1	40.0 @ 690	345.0 @ 113	67-2	41.9 @ 681	344.6 @ 113
Split	30	MSIV	79-1	40.1 @ 378	345.7 @ 113	79-2	41.7 @ 415	345.4 @ 113

Table 6.2-2 Containment Air Temperature Composite from SLB Analyses for CFCU/SW Enhancement Program

Time (sec)	Maximum Containment Temperature (°F)	
	Unit 1	Unit 2
0.00	120.0	120.0
0.10	122.0	123.2
0.25	125.9	127.8
0.50	135.3	135.2
0.75	144.2	143.7
1.00	152.7	149.9
2.00	176.0	163.2
3.00	184.9	174.2
4.00	191.5	182.1
5.00	196.1	187.0
6.00	199.1	189.7
7.00	200.8	193.5
8.00	201.6	197.8
9.00	201.6	201.5
10.00	202.1	204.8
12.00	209.6	210.4
13.00	212.9	214.5
14.00	215.0	220.2
16.00	216.3	231.0
17.00	217.6	236.1
18.00	221.7	240.9
20.00	229.5	249.9
22.00	236.8	257.8
25.00	247.1	268.0
27.00	253.4	273.9
29.00	259.3	279.1
32.00	267.5	285.9
36.00	277.4	293.2
39.00	284.0	297.5

Table 6.2-2 (cont.) Containment Air Temperature Composite from SLB Analyses for CFCU/SW Enhancement Program		
	Maximum Containment Temperature (°F)	
Time (sec)	Unit 1	Unit 2
43.00	292.1	302.0
46.00	297.6	304.5
53.00	308.8	308.6
57.00	314.4	314.0
64.00	322.7	322.4
71.00	328.7	328.5
78.00	333.1	333.0
85.00	336.5	336.4
99.00	341.6	341.5
113.00	345.7	345.4
119.00	344.6	344.2
133.00	343.9	343.2
151.00	331.7	330.8
164.00	323.8	322.7
190.00	309.7	308.3
216.00	297.7	296.0
242.00	287.5	285.5
268.00	278.7	276.4
294.00	271.1	268.6
320.00	264.5	262.0
331.00	260.6	262.2
354.00	260.8	262.7
378.00	261.8	264.0
403.00	261.2	263.9
415.00	260.9	264.2
429.00	260.6	264.0
603.00	261.9	265.0
627.00	261.3	264.4
680.00	261.6	264.5

Table 6.2-2 (cont.)	Containment Air Temperature Composite from SLB Analyses for CFCU/SW Enhancement Program	
	Maximum Containment Temperature (°F)	
Time (sec)	Unit 1	Unit 2
720.00	261.4	264.0
1000.00	251.3	253.8

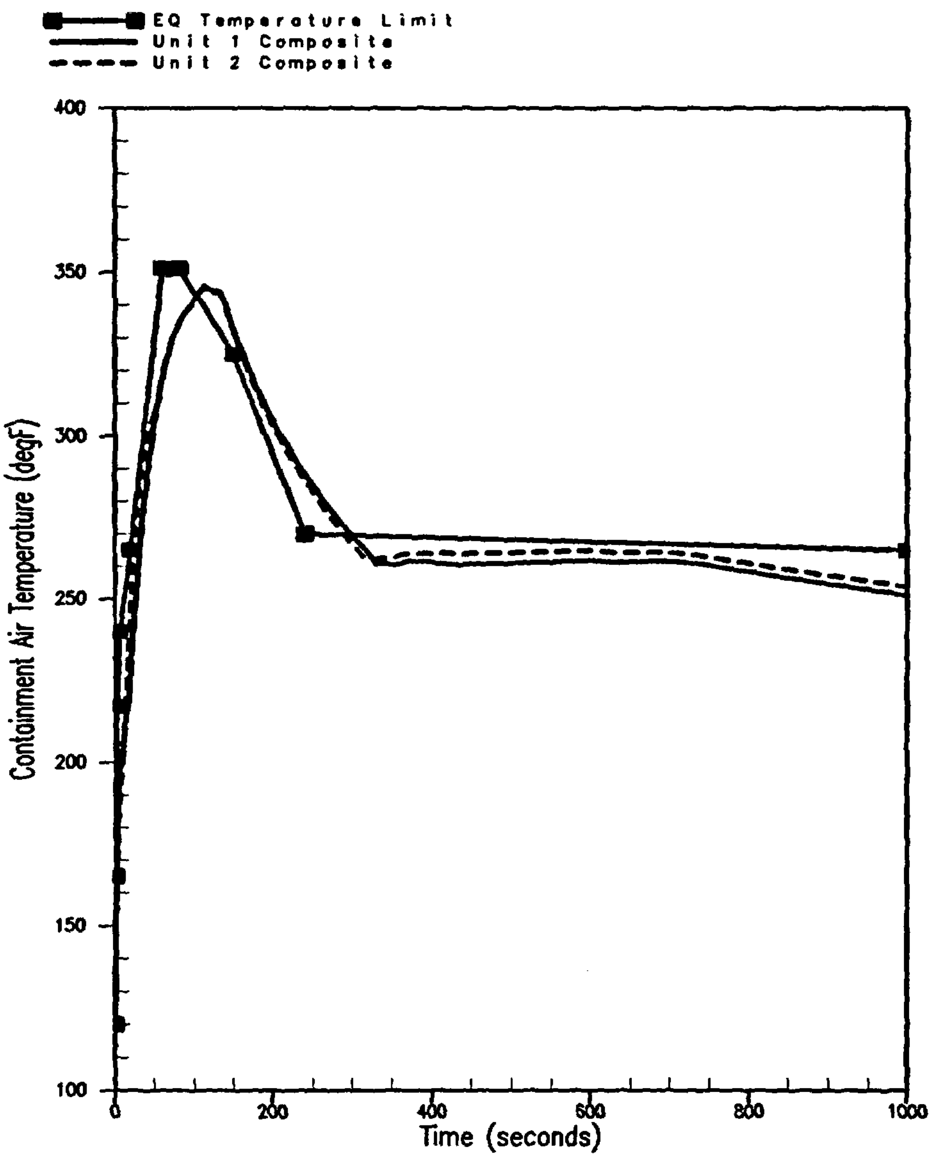


Figure 6.2-1 Containment Temperature Composite Results for Steamline Break

6.3 CONTAINMENT RESPONSE TO LOCA

The Salem containment system is designed such that for all loss-of-coolant accident (LOCA) break sizes, up to and including the double-ended severance of a reactor coolant pipe, the containment peak pressure remains below the design pressure. This section details the containment response subsequent to a hypothetical LOCA. The containment response analysis uses the long term mass and energy release data from Section 5.

The containment response analysis demonstrates the acceptability of the containment safeguards systems to mitigate the consequences of a LOCA inside containment. The impact of LOCA mass and energy releases on the containment pressure is addressed to assure that the containment pressure remains below its design pressure at the licensed core power conditions. In support of equipment design and licensing criteria (e.g., qualified operating life), with respect to post accident environmental conditions, long term containment pressure and temperature transients are generated to conservatively bound the potential post-LOCA containment conditions.

6.3.1 Input Parameters and Assumptions

An analysis of containment response to the rupture of the RCS must start with knowledge of the initial conditions in the containment. The pressure, temperature, and humidity of the containment atmosphere prior to the postulated accident are specified in the analysis as shown in Table 6.1-1.

Also, values for the initial temperature of the service water (SW) and refueling water storage tank (RWST) are assumed, along with containment spray (CS) pump flowrate and containment fan cooler unit (CFCU) heat removal performance. All of these values are chosen conservatively, as shown in Table 6.1-4. Long term sump recirculation is addressed via Residual Heat Removal System (RHR) heat exchanger performance. The primary function of the RHR system is to remove heat from the core by way of Emergency Core Cooling System (ECCS). Table 6.1-4 provides the RHR system parameters assumed in the analysis.

Several cases were performed for the LOCA containment response. Section 5 documented the LOCA M&E releases for the minimum safeguards cases for the DEPS break for Salem Unit 1 and Unit 2. Table 6.1-5 provides the performance data for the containment spray pumps. Emergency safeguards equipment data is given in Table 6.1-4. The minimum safeguards case was based upon a diesel train failure (which leaves available as active heat removal systems one containment spray pump and 2 CFCUs).

The calculations for all of the DEPS cases were performed for 10 million seconds (approximately 116 days). The sequence of events for each of these cases is shown in Tables 6.3-1 and 6.3-2.

The following are the major assumptions made in the analysis.

1. The mass and energy released to the containment are described in Section 5 for LOCA.

2. Homogeneous mixing is assumed. The steam-air mixture and the water phases each have uniform properties. More specifically, thermal equilibrium between the air and the steam is assumed. However, this does not imply thermal equilibrium between the steam-air mixture and the water phase.

3. Air is taken as an ideal gas, while compressed water and steam tables are employed for water and steam thermodynamic properties.

4. For the blowdown portion of the LOCA analysis, the discharge flow separates into steam and water phases at the breakpoint. The saturated water phase is at the total containment pressure, while the steam phase is at the partial pressure of the steam in the containment. For the post-blowdown portion of the LOCA analysis, steam and water releases are input separately.

5. The saturation temperature at the partial pressure of the steam is used for heat transfer to the heat sinks, the fan coolers, and the spray droplets.

6.3.2 Acceptance Criteria

The containment response for design-basis containment integrity is an ANS Condition IV event, an infrequent fault. The relevant requirements to satisfy Nuclear Regulatory Commission acceptance criteria are as follows.

1. GDC 16 and GDC 50: In order to satisfy the requirements of GDC 16 and 50, the peak calculated containment pressure should be less than the containment design pressure of 47 psig;

2. GDC 38: In order to satisfy the requirements of GDC 38, the calculated pressure at 24 hours should be less than 50% of the peak calculated value. (This is related to the criteria for doses at 24 hours.)

Note that the Salem UFSAR does not reference the general design criteria (GDCs), but lists the draft/interim general design criteria that was proposed by the Atomic Energy Commission (AEC). These do not provide specific system requirements and refer back to the various sections of the UFSAR for the design bases. Meeting the above GDC requirements along with the Technical Specification design features for pressure and temperature and equipment qualifications temperature limits will ensure all containment design limits remain bounded under the proposed CFCU system modifications.

6.3.3 Analysis Results

The containment pressure, steam temperature and water (sump) temperature profiles from each of the LOCA cases are shown in Figures 6.3-1 through 6.3-6 for the DEPS break cases without recirculation spray actuated. The long term containment response for Unit 1 and Unit 2 with recirculation spray modeled at 1974.8 gpm is shown in Figures 6.3-7 through 6.3-12.

6.3.3.1 Unit 1 – Double Ended Pump Suction Break with Minimum Safeguards

This analysis assumes a loss of offsite power coincidence with a double ended rupture of the RCS piping between the steam generator outlet and the RCS pump inlet (suction). The associated single failure assumption is the failure of a complete train of safeguards equipment. As discussed in Section 5.1.6 for the safety injection pumps, this single failure assumption is conservative because both Salem units have three emergency diesel generators. The loss of a single diesel generator would result in the loss of only a few components. This combination results in a conservative minimum set of safeguards being available. The containment heat removal systems that are assumed to be available are one RHR heat exchanger, one containment spray pump, and two CFCUs. Further, loss of offsite power delays the actuation times of the safeguards equipment due to the required diesel startup time after receipt of the safety injection signal.

The postulated RCS break results in a rapid release of mass and energy to the containment with a resulting rapid rise in both the containment pressure and temperature. This rapid rise in containment pressure results in the generation of a containment Hi-1 signal at 1.1 seconds and a containment Hi-2 signal at 4.6 seconds. The containment pressure continues to rise rapidly in response to the release of mass and energy until the end of blowdown at 26.2 seconds. The end of blowdown marks a time when the initial inventory in the RCS has been exhausted and a slow process of filling the RCS downcomer in preparation for reflood has begun. Since the mass and energy release during this period is low, pressure decreases slightly and then increases in response to the reflood mass and energy release out to a second peak which occurred at 100 seconds.

The turn around in containment pressure at 100 seconds is a result of the initiation of the containment spray pump at 89.6 seconds and the containment fan cooler units (CFCUs) at 101.1 seconds. Reflood continues at a reduced flooding rate due to the buildup of mass in the RCS core which offsets the downcomer head. This reduction in flooding rate and the continued action of the CFCUs and Spray leads to a slowly decreasing pressure out to the end of reflood, which occurs at 187.3 seconds.

At this juncture, by design of the Reference 2 model, energy removal from the SG secondary side begins at a very high rate, resulting in a rise in containment pressure from 187.4 seconds out to 461.0 seconds when the ultimate peak pressure of 40.1 psig is reached. Energy continues to be removed from the secondary side of the faulted loop and intact loop steam generators until 1411.1 seconds. The containment pressure at the end of this steam generator energy release period is similar to peak pressure. After 1411.1 seconds, the containment pressure decreases through the initiation of cold leg recirculation at 1748.3 seconds. At this time, the ECCS is realigned for cold leg recirculation resulting in an increase in the SI temperature due to delivery from the hot sump. At 4141.6 seconds, the containment spray is terminated from the RWST. Without crediting recirculation spray, the containment pressure and temperature will begin to increase out to approximately 30,000 seconds. At this time, the energy removal from the two operating CFCUs exceeds the energy release and the pressure and temperature turn around. This trend continues to the end of the transient at 1×10^7 seconds. This can be seen in Figures 6.3-1 through 6.3-3. This is not acceptable from both the aspect of GDC 38 or EQ requirements, but is provided to demonstrate the need for recirculation spray under the proposed CFCU configuration.

When 1974.8 gpm of recirculation sprays are modeled for Salem Unit 1 beginning at 4441.6 seconds (which is a 5 minute delay from the time that the injection spray was terminated to allow the operators enough time to reposition the necessary valves), the containment pressure and temperature do not increase and the containment conditions at 24 hours are significantly lower. The detailed containment conditions can be seen in Table 6.3-3 and Figures 6.3-7 through 6.3-9 for the containment pressure, steam temperature and sump temperature. Figure 6.3-8 shows that there are two periods of time where the steam temperature exceeds the temperature profile. The first is from about 1500 seconds to about 3500 seconds and the other is from about 4500 seconds to 10,000 seconds. Therefore, the steam temperature transient with recirculation spray exceeds the profile for about 7500 seconds (i.e. approximately 2 hours 5 minutes).

6.3.3.2 Unit 2 – Double Ended Pump Suction Break with Minimum Safeguards

This analysis assumes a loss of offsite power coincidence with a double ended rupture of the RCS piping between the steam generator outlet and the RCS pump inlet (suction). The associated single failure assumption is the same as the Unit 1 description in Section 6.3.3.1. The associated single failure assumption is the failure of a complete train of safeguards equipment. As discussed in Section 5.1.6 for the safety injection pumps, this single failure assumption is conservative because both Salem units have three emergency diesel generators. The loss of a single diesel generator would result in the loss of only a few components. This combination results in a conservative minimum set of safeguards being available. The containment heat removal systems that are assumed to be available are one RHR heat exchanger, one containment spray pump, and two CFCUs. Further, loss of offsite power delays the actuation times of the safeguards equipment due to the required diesel startup time after receipt of the safety injection signal.

The postulated RCS break results in a rapid release of mass and energy to the containment with a resulting rapid rise in both the containment pressure and temperature. This rapid rise in containment pressure results in the generation of a containment Hi-1 signal at 1.1 seconds and a containment Hi-2 signal at 4.4 seconds. The containment pressure continues to rise rapidly in response to the release of mass and energy until the end of blowdown at 26.6 seconds. The end of blowdown marks a time when the initial inventory in the RCS has been exhausted and a slow process of filling the RCS downcomer in preparation for reflood has begun. Since the mass and energy release during this period is low, pressure decreases slightly and then increases in response to the reflood mass and energy release out to a second peak which occurred at 100 seconds.

The turn around in containment pressure at 100 seconds is a result of the initiation of the containment spray pump at 89.4 seconds and the containment fan cooler units (CFCUs) at 101.1 seconds. Reflood continues at a reduced flooding rate due to the buildup of mass in the RCS core which offsets the downcomer head. This reduction in flooding rate and the continued action of the CFCUs and Spray leads to a slowly decreasing pressure out to the end of reflood, which occurs at 186.4 seconds.

At this juncture, by design of the Reference 2 model, energy removal from the SG secondary side begins at a very high rate, resulting in a rise in containment pressure from 186.4 seconds out to 449.8 seconds when the ultimate peak pressure of 41.6 psig is reached. Energy continues to be removed from the secondary side of the faulted loop and intact loop steam generators until 1429.2 seconds. The containment pressure at the end of this steam generator energy release period is similar to peak pressure. After 1429.2 seconds, the containment pressure decreases through the initiation of cold leg recirculation at 1748.3 seconds out to 4141.6 seconds when the containment spray is terminated from the RWST. Without crediting recirculation spray, the containment pressure and temperature will begin to increase out to approximately 30,000 seconds. At this time, the energy removal from the two operating CFCUs exceeds the energy release and the pressure and temperature turn around. This trend continues to the end of the transient at $1\text{x}10^7$ seconds. This can be seen in Figures 6.3-4 through 6.3-6. As with Unit 1 and the "no recirculation spray" assumption, this is not acceptable from both the aspect of GDC 38 or EQ requirements, but is provided to demonstrate the need for recirculation spray under the proposed CFCU configuration.

When 1974.8 gpm of recirculation spray flow is modeled for Salem Unit 2 beginning at 4441.6 seconds (which is a 5 minute delay from the time that the injection spray was terminated to allow the operators enough time to reposition the necessary valves), the containment pressure and temperature do not increase and the containment conditions at 24 hours are significantly lower. The detailed containment conditions can be seen in Table 6.3-4 and Figures 6.3-10 through 6.3-12 for the containment pressure, steam temperature and sump temperature. Figure 6.3-11 shows that there are two periods of time where the steam temperature exceeds the temperature profile. The first is from about 1500 seconds to about 3500 seconds and the other is from about 5000 seconds to 10,000 seconds. Therefore, the steam temperature transient with recirculation spray exceeds the profile for about 7000 seconds (i.e. approximately 1 hour 57 minutes).

Table 6.3-1	Double-Ended Pump Suction Break Sequence of Events (Salem Unit 1)
Time (sec)	**Event Description**
0.0	Break Occurs, Reactor Trip and Loss of Offsite Power are assumed
1.1	Containment HI-1 Pressure Setpoint Reached
3.6	Low Pressurizer Pressure SI Setpoint = 1715 psia Reached (Safety Injection Begins coincident with Low Pressurizer Pressure SI Setpoint)
4.6	Containment HI-2 Pressure Setpoint Reached
16.5	Broken Loop Accumulator Begins Injecting Water
16.8	Intact Loop Accumulator Begins Injecting Water
26.2	End of Blowdown Phase
35.6	Pumped Safety Injection Begins (after a 32 second delay from the setpoint)
54.0	Broken Loop Accumulator Water Injection Ends
55.9	Intact Loop Accumulator Water Injection Ends
89.6	Containment Spray (RWST) Begins Pumps
101.1	Containment Fan Coolers Actuate
187.3	End of Reflood for MIN SI Case
461.0	Peak Temperature Occurs
647.7	Mass and Energy Release Assumption: Broken Loop SG Equilibration to 51.7 psia
1411.1	Mass and Energy Release Assumption: Intact Loop SG Equilibration to 41.7 psia
1748.3	Cold Leg Recirc Begins
4141.6	Containment Spray from RWST is Terminated
4441.6	Recirculation Spray Begins
1.0E+7	Transient Modeling Terminated

Table 6.3-2	Double-Ended Pump Suction Break Sequence of Events (Salem Unit 2)
Time (sec)	**Event Description**
0.0	Break Occurs, Reactor Trip and Loss of Offsite Power are assumed
1.1	Containment HI-1 Pressure Setpoint Reached
3.6	Low Pressurizer Pressure SI Setpoint = 1715 psia Reached (Safety Injection Begins co-incident with Low Pressurizer Pressure SI Setpoint)
4.4	Containment HI-2 Pressure Setpoint Reached
16.8	Broken Loop Accumulator Begins Injecting Water
17.1	Intact Loop Accumulator Begins Injecting Water
26.6	End of Blowdown Phase
35.6	Pumped Safety Injection Begins (after a 32 second delay from the setpoint)
54.9	Broken Loop Accumulator Water Injection Ends
57.4	Intact Loop Accumulator Water Injection Ends
89.4	Containment Spray Pump (RWST) Begins
101.1	Containment Fan Coolers Actuate
186.4	End of Reflood for MIN SI Case
449.7	Peak Temperature Occurs
449.8	Peak Pressure Occurs
638.9	Mass and Energy Release Assumption: Broken Loop SG Equilibration to 51.7 psia
1429.2	Mass and Energy Release Assumption: Intact Loop SG Equilibration to 41.7 psia
1748.3	Cold Leg Recirc Begins
4141.6	Containment Spray from RWST is Terminated
4441.6	Recirculation Spray Begins
1.0E+7	Transient Modeling Terminated

Table 6.3-3 LOCA Containment Response Results (Loss of Offsite Power Assumed)				
Case	Peak Press. (psig)	Peak Temp. (°F)	Pressure (psig) @ 24 hours	Temperature (°F) @ 24 hours
Unit 1 DEPS Break Minimum Safeguards Model F SGs	40.1 @ 461.0 sec	260.8 @ 461.0 sec	16.7	208.4
Unit 1 DEPS Break Minimum Safeguards with Recirculation Spray Model F SGs	40.1 @ 461.0 sec	260.8 @ 461.0 sec	7.3	164.9
Unit 2 DEPS Break Minimum Safeguards Model 51 SGs	41.6 @ 449.8sec	263.1 @ 449.7sec	16.8	208.4
Unit 2 DEPS Break Minimum Safeguards with Recirculation Spray Model 51 SGs	41.6 @ 449.8sec	263.1 @ 449.7sec	7.3	164.9

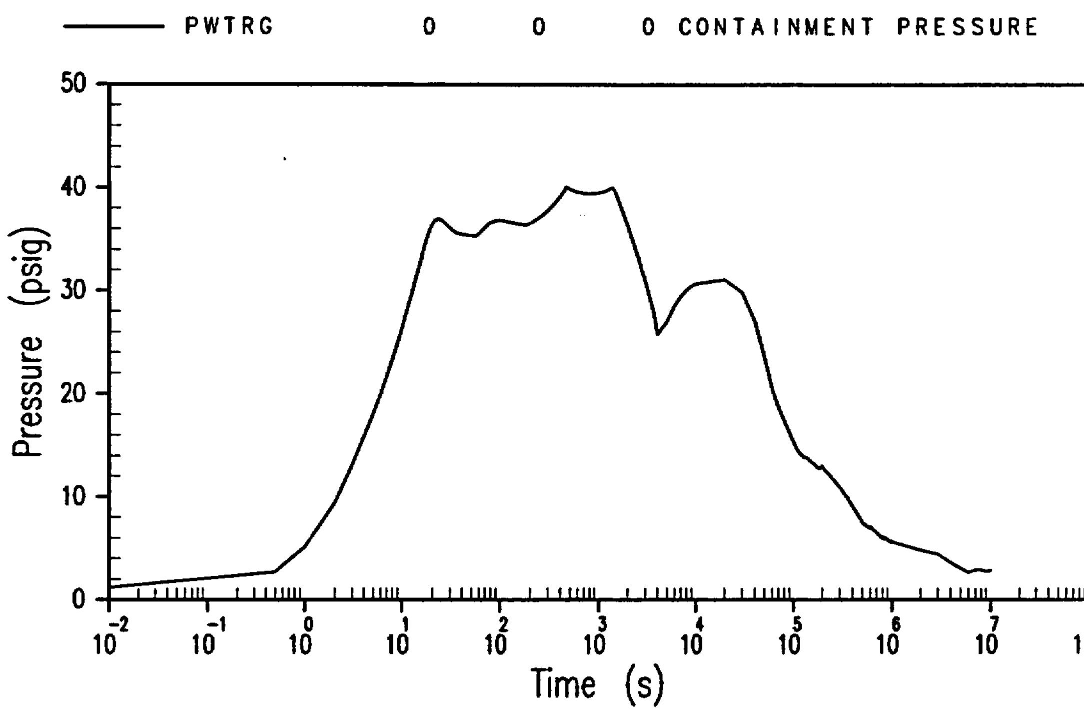


Figure 6.3-1 Containment Pressure – Double-ended Pump Suction Break at Salem Unit 1 WITHOUT Recirculation Spray

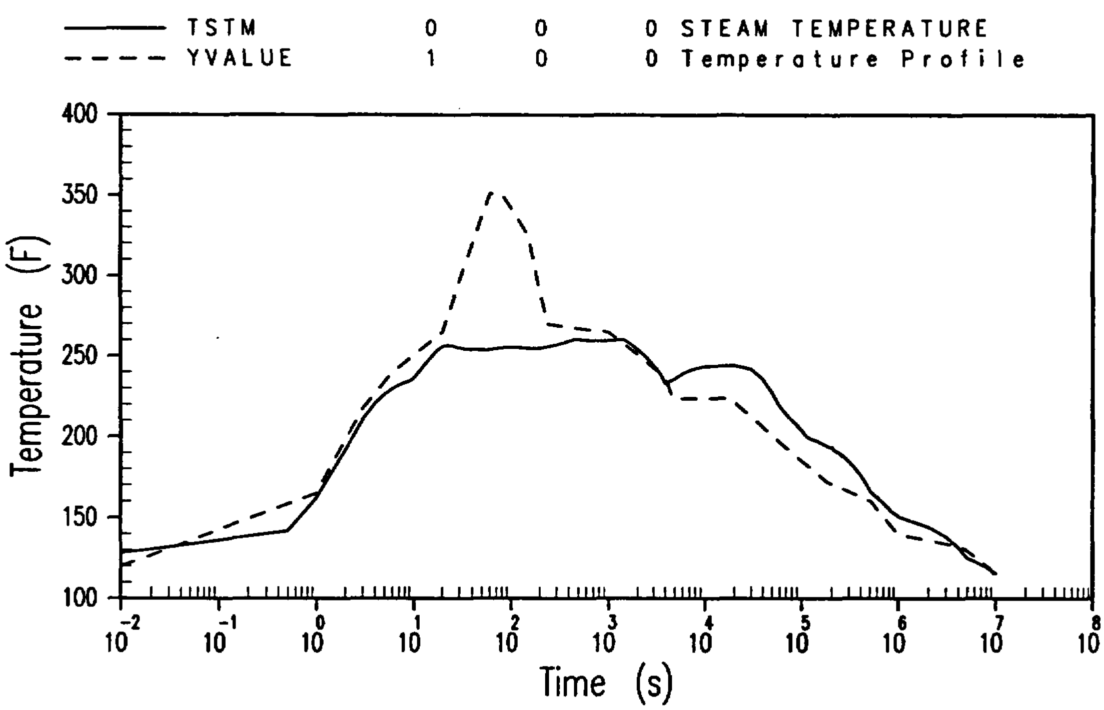


Figure 6.3-2 Containment Temperature – Double-ended Pump Suction Break at Salem Unit 1 WITHOUT Recirculation Spray

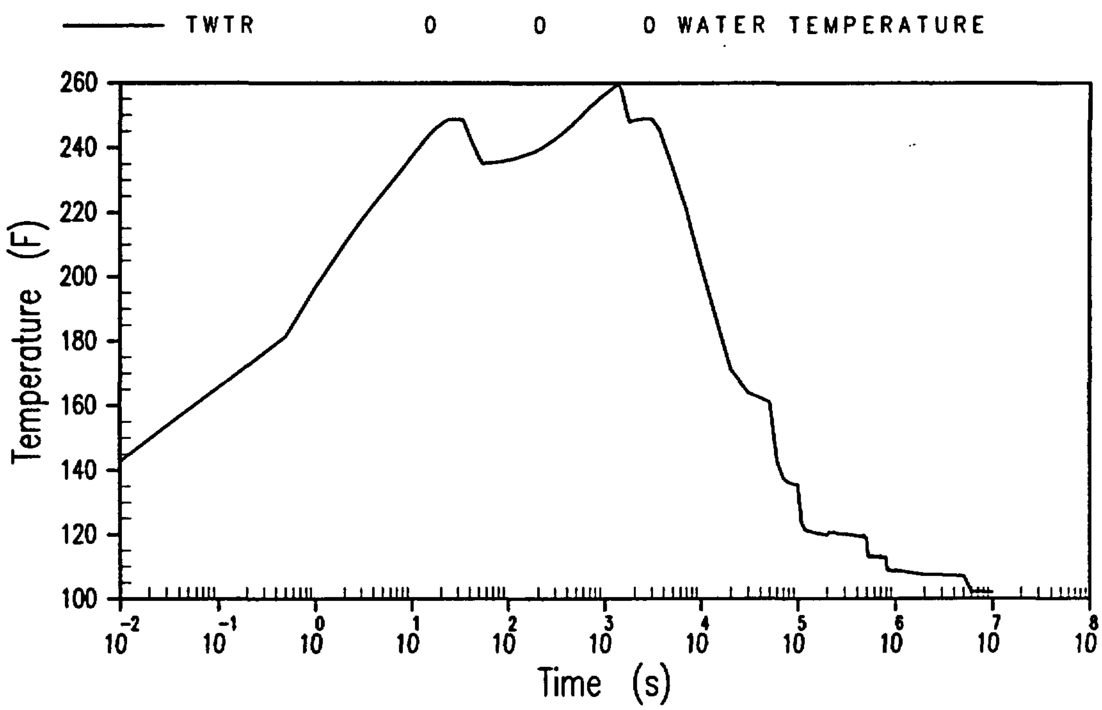


Figure 6.3-3 Containment Sump Temperature – Double-ended Pump Suction Break at Salem Unit 1 WITHOUT Recirculation Spray

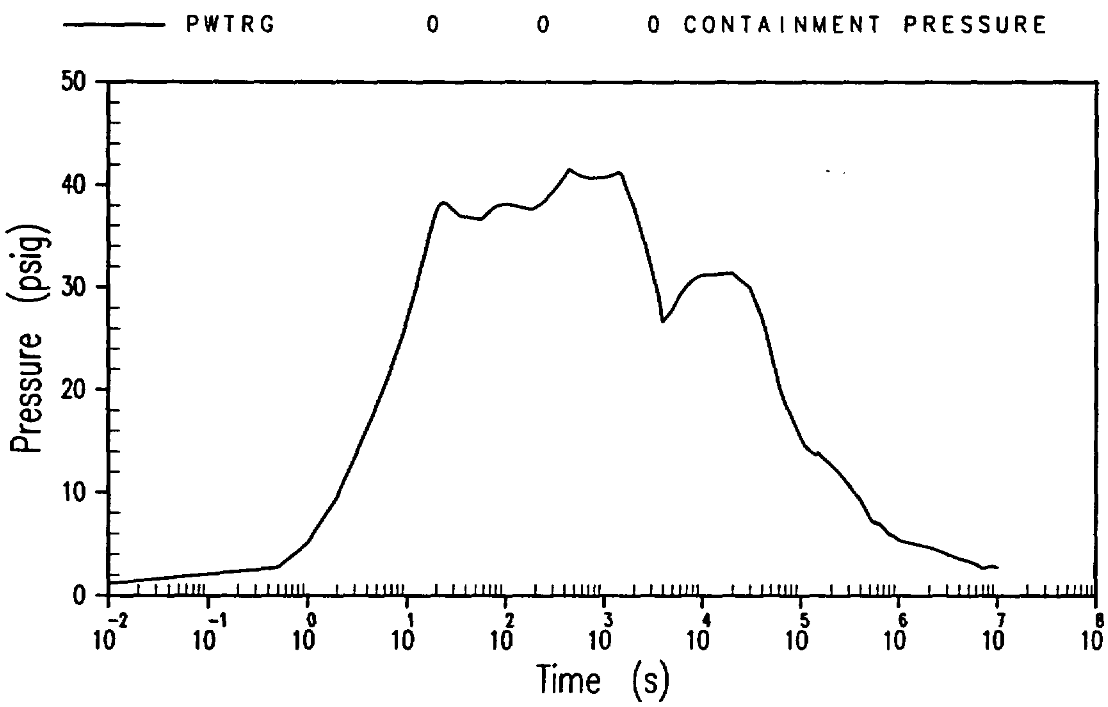


Figure 6.3-4 Containment Pressure – Double-ended Pump Suction Break at Salem Unit 2 WITHOUT Recirculation Spray

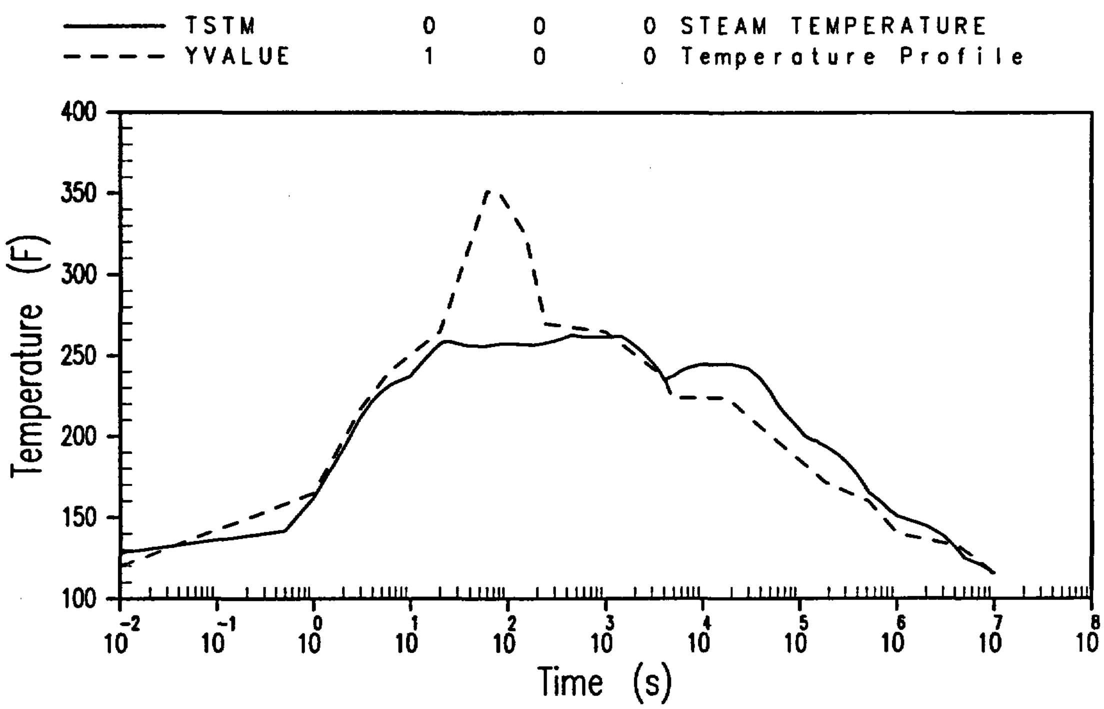


Figure 6.3-5 Containment Temperature – Double-ended Pump Suction Break at Salem Unit 2 WITHOUT Recirculation Spray

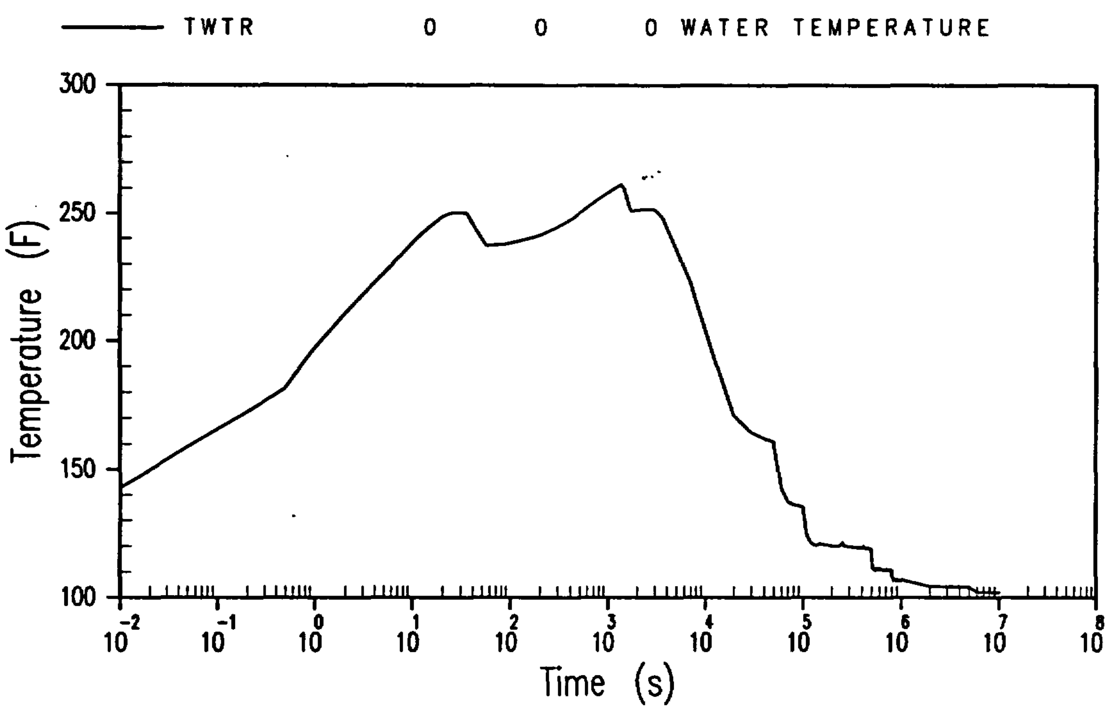


Figure 6.3-6 Containment Sump Temperature – Double-ended Pump Suction Break at Salem Unit 2 WITHOUT Recirculation Spray

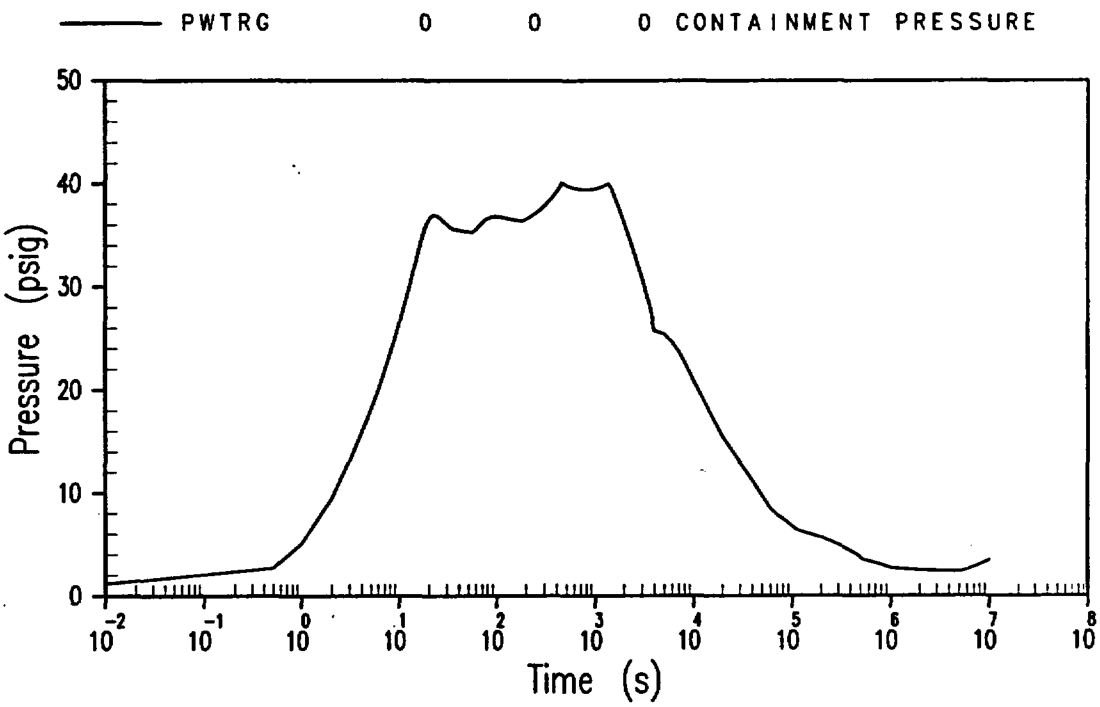


Figure 6.3-7 Containment Pressure – Double-ended Pump Suction Break at Salem Unit 1 WITH Recirculation Spray

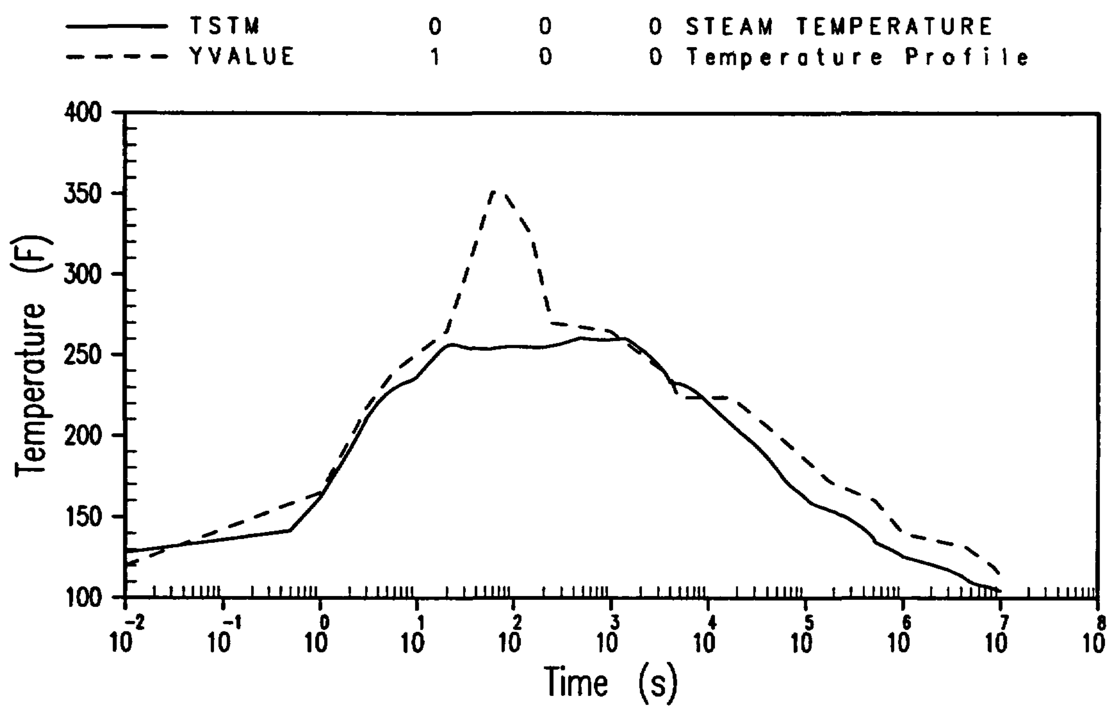


Figure 6.3-8 Containment Temperature – Double-ended Pump Suction Break at Salem Unit 1 WITH Recirculation Spray

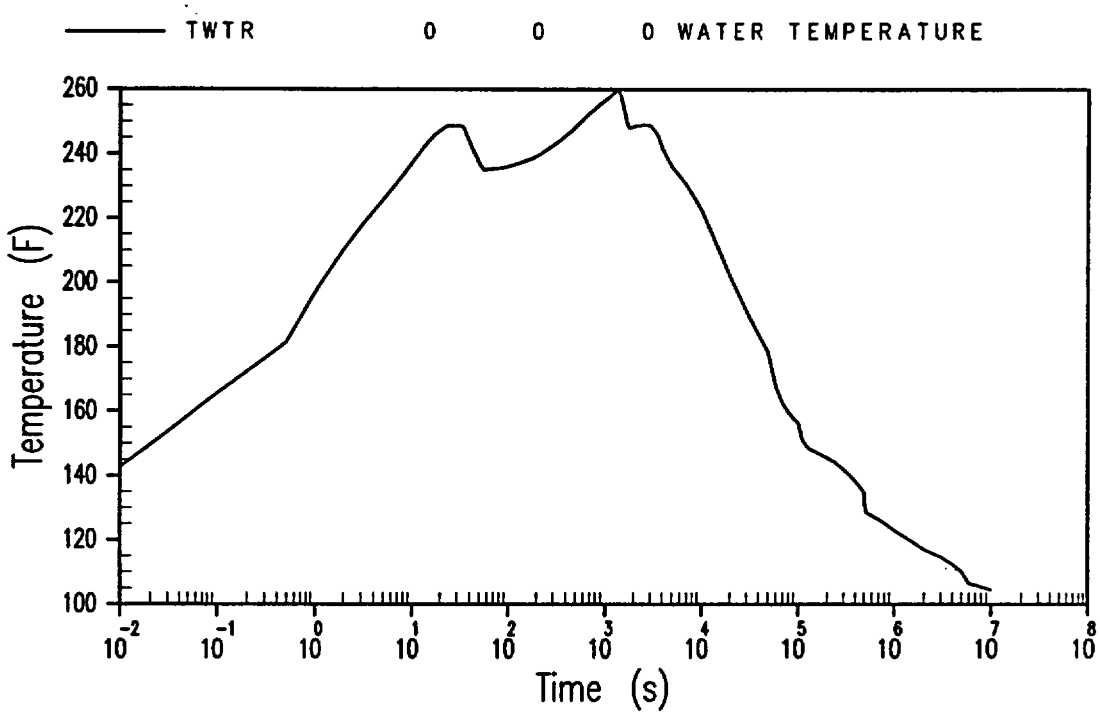


Figure 6.3-9 Containment Sump Temperature – Double-ended Pump Suction Break at Salem Unit 1 WITH Recirculation Spray

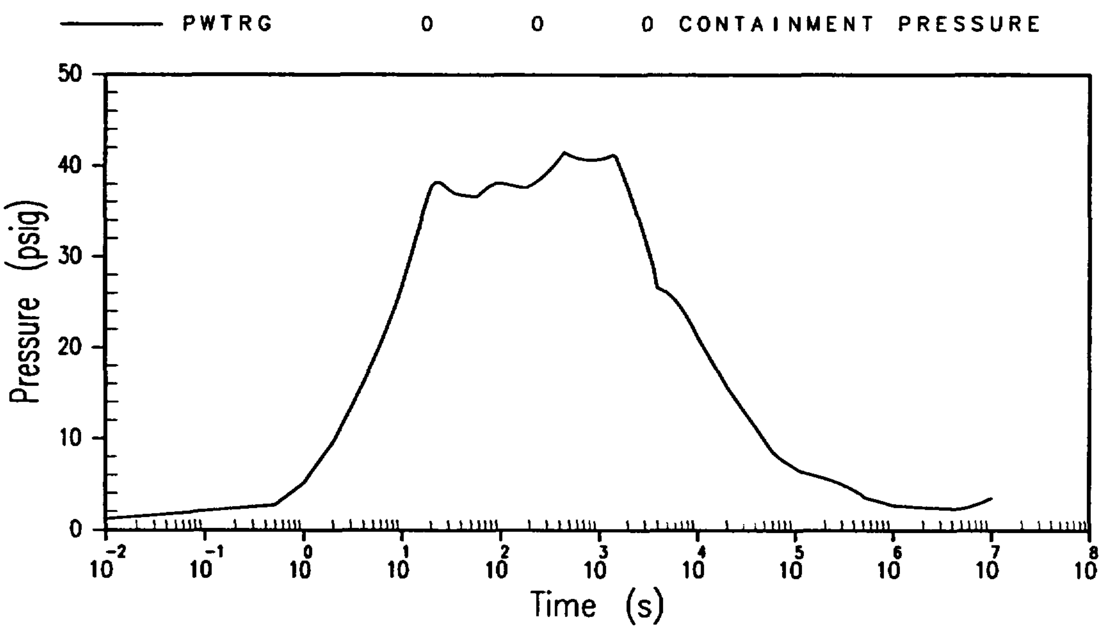


Figure 6.3-10 Containment Pressure – Double-ended Pump Suction Break at Salem Unit 2 WITH Recirculation Spray

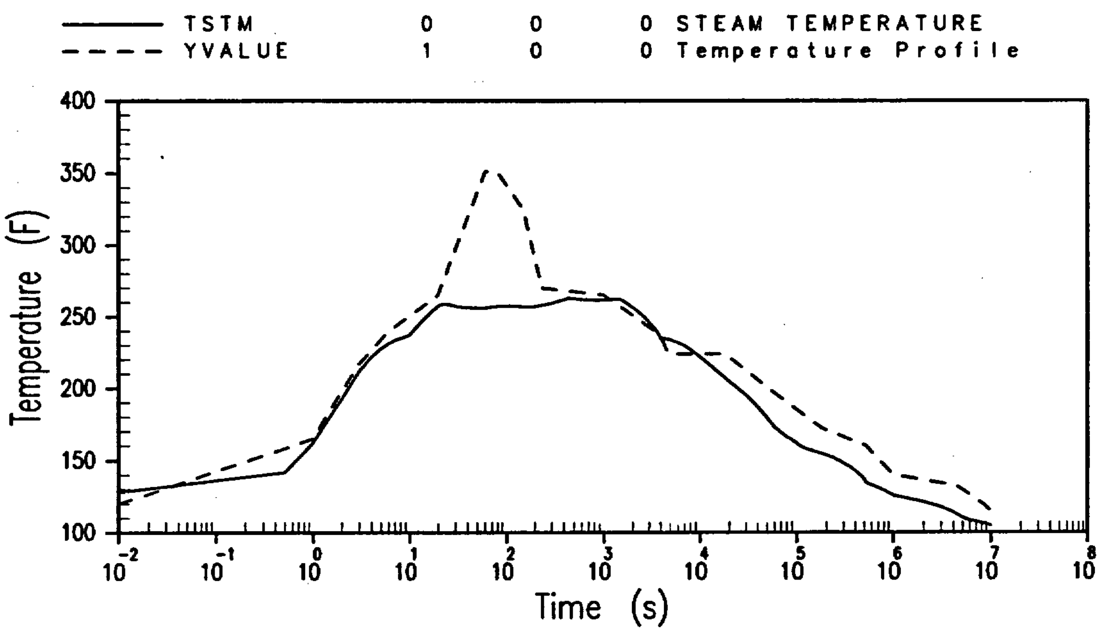


Figure 6.3-11 Containment Temperature – Double-ended Pump Suction Break at Salem Unit 2 WITH Recirculation Spray

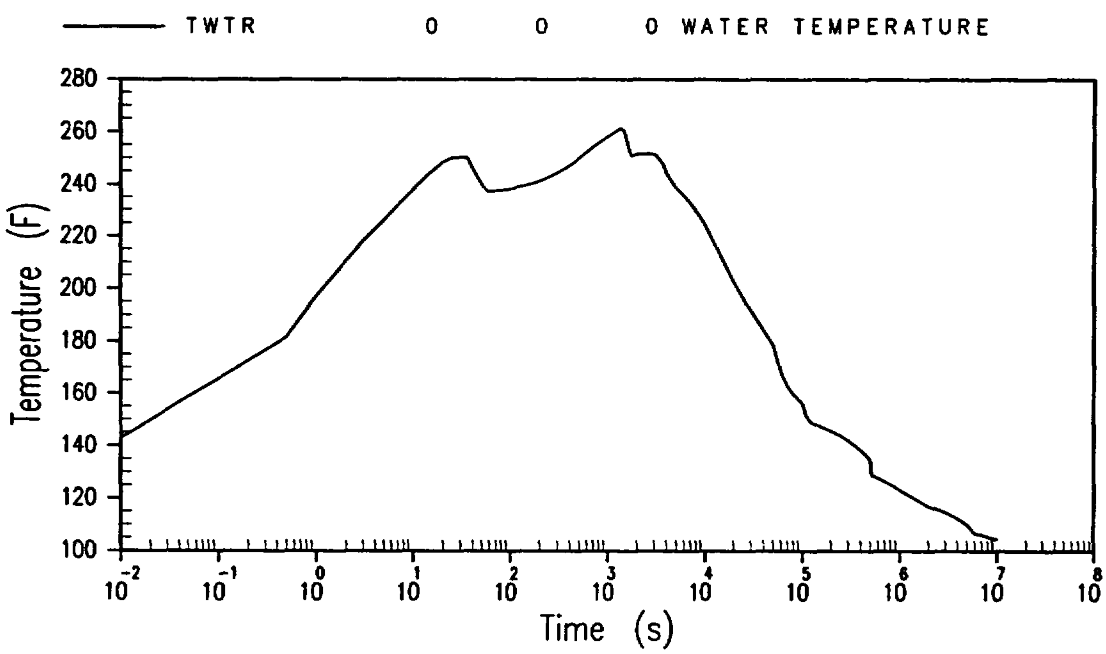


Figure 6.3-12 Containment Sump Temperature – Double-ended Pump Suction Break at Salem Unit 2 WITH Recirculation Spray

Table 6.3-4 Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.0000000E-03	3.0000001E-01	1.2000000E+02	1.2000000E+02
5.0000101E-01	2.7260156E+00	1.4165230E+02	1.8137114E+02
1.0000020E+00	5.1062460E+00	1.6173720E+02	1.9665706E+02
2.0000031E+00	9.4392405E+00	1.9153883E+02	2.1013640E+02
3.0000041E+00	1.3097981E+01	2.1036015E+02	2.1741302E+02
4.0000048E+00	1.5868888E+01	2.2062317E+02	2.2213249E+02
5.0000062E+00	1.8069145E+01	2.2629613E+02	2.2569394E+02
6.0000072E+00	1.9960789E+01	2.2968062E+02	2.2866058E+02
7.0000081E+00	2.1704916E+01	2.3197597E+02	2.3121120E+02
8.0000086E+00	2.3342367E+01	2.3356621E+02	2.3341003E+02
9.0000095E+00	2.4860209E+01	2.3451663E+02	2.3545322E+02
1.0000011E+01	2.6309299E+01	2.3633391E+02	2.3723018E+02
1.1000012E+01	2.7723980E+01	2.3938966E+02	2.3881845E+02
1.2000013E+01	2.9036766E+01	2.4211263E+02	2.4026927E+02
1.3000014E+01	3.0265560E+01	2.4457111E+02	2.4157213E+02
1.4000015E+01	3.1423462E+01	2.4681372E+02	2.4272820E+02
1.5000016E+01	3.2516171E+01	2.4886853E+02	2.4375357E+02
1.6000017E+01	3.3547142E+01	2.5075580E+02	2.4465933E+02
1.7000017E+01	3.4505260E+01	2.5246750E+02	2.4544768E+02
1.8000019E+01	3.5360104E+01	2.5396187E+02	2.4614850E+02
1.9000019E+01	3.6008636E+01	2.5507603E+02	2.4669174E+02
2.0000021E+01	3.6436409E+01	2.5580182E+02	2.4710703E+02
2.1000023E+01	3.6746380E+01	2.5632297E+02	2.4760428E+02
2.2000023E+01	3.6890816E+01	2.5656421E+02	2.4798822E+02
2.3000025E+01	3.6932072E+01	2.5663239E+02	2.4835863E+02
2.4000025E+01	3.6896519E+01	2.5657230E+02	2.4859210E+02
2.5000027E+01	3.6807278E+01	2.5642252E+02	2.4865271E+02
2.6000027E+01	3.6673508E+01	2.5619772E+02	2.4865120E+02
2.7000029E+01	3.6517330E+01	2.5593443E+02	2.4864276E+02
2.8000029E+01	3.6369461E+01	2.5568431E+02	2.4863477E+02
2.9000031E+01	3.6234234E+01	2.5545480E+02	2.4862434E+02
3.0000031E+01	3.6108845E+01	2.5524138E+02	2.4861436E+02
3.1000032E+01	3.5992043E+01	2.5504201E+02	2.4860246E+02
3.2000034E+01	3.5882744E+01	2.5485495E+02	2.4859102E+02
3.3000034E+01	3.5780552E+01	2.5467963E+02	2.4857799E+02
3.4000034E+01	3.5684834E+01	2.5451505E+02	2.4856465E+02
3.5000034E+01	3.5619915E+01	2.5440268E+02	2.4803056E+02
3.6000038E+01	3.5582115E+01	2.5433661E+02	2.4720964E+02
3.7000038E+01	3.5554710E+01	2.5428833E+02	2.4630370E+02
3.8000038E+01	3.5530315E+01	2.5424522E+02	2.4542055E+02
3.9000038E+01	3.5507725E+01	2.5420523E+02	2.4457846E+02
4.0000042E+01	3.5486542E+01	2.5416766E+02	2.4377774E+02
4.1000042E+01	3.5466942E+01	2.5413283E+02	2.4301257E+02
4.2000042E+01	3.5448586E+01	2.5410013E+02	2.4228400E+02
4.3000046E+01	3.5431641E+01	2.5406989E+02	2.4158641E+02
4.4000046E+01	3.5415802E+01	2.5404155E+02	2.4092123E+02
4.5000046E+01	3.5401234E+01	2.5401541E+02	2.4028320E+02
4.6000046E+01	3.5387657E+01	2.5399101E+02	2.3967398E+02
4.7000050E+01	3.5375229E+01	2.5396860E+02	2.3908859E+02
4.8000050E+01	3.5363686E+01	2.5394772E+02	2.3852901E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
4.9000050E+01	3.5353180E+01	2.5392865E+02	2.3799042E+02
5.0000050E+01	3.5343464E+01	2.5391095E+02	2.3747504E+02
5.1000053E+01	3.5334686E+01	2.5389488E+02	2.3697826E+02
5.2000053E+01	3.5326611E+01	2.5388005E+02	2.3650243E+02
5.3000053E+01	3.5319378E+01	2.5386668E+02	2.3604315E+02
5.4000053E+01	3.5311989E+01	2.5385307E+02	2.3561331E+02
5.5000057E+01	3.5300194E+01	2.5382684E+02	2.3530933E+02
5.6000057E+01	3.5292027E+01	2.5380034E+02	2.3507285E+02
5.7000057E+01	3.5335617E+01	2.5382901E+02	2.3516068E+02
5.8000057E+01	3.5404121E+01	2.5390103E+02	2.3517375E+02
5.9000061E+01	3.5472454E+01	2.5397266E+02	2.3519133E+02
6.0000061E+01	3.5540066E+01	2.5404298E+02	2.3520706E+02
6.1000061E+01	3.5606815E+01	2.5411172E+02	2.3522562E+02
6.2000065E+01	3.5672672E+01	2.5417886E+02	2.3524348E+02
6.3000065E+01	3.5737595E+01	2.5424431E+02	2.3526189E+02
6.4000069E+01	3.5801594E+01	2.5430811E+02	2.3527962E+02
6.5000069E+01	3.5864700E+01	2.5437032E+02	2.3529790E+02
6.6000069E+01	3.5927032E+01	2.5443111E+02	2.3531552E+02
6.7000069E+01	3.5988567E+01	2.5449049E+02	2.3533368E+02
6.8000069E+01	3.6049355E+01	2.5454854E+02	2.3535121E+02
6.9000069E+01	3.6109375E+01	2.5460519E+02	2.3536926E+02
7.0000069E+01	3.6168671E+01	2.5466058E+02	2.3538670E+02
7.1000069E+01	3.6227226E+01	2.5471465E+02	2.3540466E+02
7.2000076E+01	3.6285084E+01	2.5476746E+02	2.3542204E+02
7.3000076E+01	3.6342228E+01	2.5481902E+02	2.3543991E+02
7.4000076E+01	3.6398697E+01	2.5486937E+02	2.3545721E+02
7.5000076E+01	3.6450424E+01	2.5491783E+02	2.3548083E+02
7.6000076E+01	3.6497726E+01	2.5496397E+02	2.3549503E+02
7.7000076E+01	3.6522552E+01	2.5500514E+02	2.3551445E+02
7.8000076E+01	3.6545975E+01	2.5504501E+02	2.3553262E+02
7.9000076E+01	3.6568787E+01	2.5508382E+02	2.3554945E+02
8.0000084E+01	3.6590973E+01	2.5512154E+02	2.3556860E+02
8.1000084E+01	3.6612629E+01	2.5515833E+02	2.3558339E+02
8.2000084E+01	3.6633797E+01	2.5519427E+02	2.3560089E+02
8.3000084E+01	3.6654354E+01	2.5522917E+02	2.3561945E+02
8.4000084E+01	3.6674374E+01	2.5526314E+02	2.3563690E+02
8.5000084E+01	3.6693821E+01	2.5529611E+02	2.3565538E+02
8.6000084E+01	3.6712757E+01	2.5532820E+02	2.3567278E+02
8.7000092E+01	3.6731155E+01	2.5535938E+02	2.3569116E+02
8.8000092E+01	3.6749077E+01	2.5538971E+02	2.3570850E+02
8.9000092E+01	3.6766495E+01	2.5541919E+02	2.3572681E+02
9.0000092E+01	3.6778671E+01	2.5543973E+02	2.3575922E+02
9.1000092E+01	3.6783600E+01	2.5544791E+02	2.3579132E+02
9.2000092E+01	3.6788151E+01	2.5545546E+02	2.3582971E+02
9.3000092E+01	3.6792297E+01	2.5546231E+02	2.3586685E+02
9.4000092E+01	3.6796066E+01	2.5546852E+02	2.3590382E+02
9.5000099E+01	3.6799480E+01	2.5547415E+02	2.3594064E+02
9.6000099E+01	3.6802547E+01	2.5547917E+02	2.3597729E+02
9.7000099E+01	3.6805286E+01	2.5548364E+02	2.3601378E+02
9.8000099E+01	3.6807701E+01	2.5548756E+02	2.3605031E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
9.9000099E+01	3.6809826E+01	2.5549100E+02	2.3608649E+02
1.0000010E+02	3.6811657E+01	2.5549393E+02	2.3612251E+02
1.0100010E+02	3.6813221E+01	2.5549640E+02	2.3615837E+02
1.0200011E+02	3.6809452E+01	2.5548984E+02	2.3619455E+02
1.0300011E+02	3.6804913E+01	2.5548196E+02	2.3622992E+02
1.0400011E+02	3.6800186E+01	2.5547377E+02	2.3626541E+02
1.0500011E+02	3.6795261E+01	2.5546524E+02	2.3630319E+02
1.0600011E+02	3.6790127E+01	2.5545634E+02	2.3633835E+02
1.0700011E+02	3.6784817E+01	2.5544717E+02	2.3637576E+02
1.0800011E+02	3.6779324E+01	2.5543767E+02	2.3641061E+02
1.0900011E+02	3.6773682E+01	2.5542792E+02	2.3644769E+02
1.1000011E+02	3.6767868E+01	2.5541788E+02	2.3648248E+02
1.1100011E+02	3.6761929E+01	2.5540762E+02	2.3651784E+02
1.1200011E+02	3.6755856E+01	2.5539714E+02	2.3655325E+02
1.1300011E+02	3.6749691E+01	2.5538651E+02	2.3658643E+02
1.1400011E+02	3.6743439E+01	2.5537572E+02	2.3662123E+02
1.1500011E+02	3.6737083E+01	2.5536475E+02	2.3665622E+02
1.1600011E+02	3.6730640E+01	2.5535362E+02	2.3669069E+02
1.1700011E+02	3.6724113E+01	2.5534236E+02	2.3672534E+02
1.1800012E+02	3.6717514E+01	2.5533098E+02	2.3675949E+02
1.1900012E+02	3.6710854E+01	2.5531949E+02	2.3679381E+02
1.2000012E+02	3.6704140E+01	2.5530791E+02	2.3682762E+02
1.2100012E+02	3.6697376E+01	2.5529623E+02	2.3686162E+02
1.2200012E+02	3.6690578E+01	2.5528452E+02	2.3689511E+02
1.2300012E+02	3.6683750E+01	2.5527274E+02	2.3692877E+02
1.2400012E+02	3.6676907E+01	2.5526091E+02	2.3696196E+02
1.2500013E+02	3.6670044E+01	2.5524907E+02	2.3699530E+02
1.2600013E+02	3.6663177E+01	2.5523721E+02	2.3702818E+02
1.2700013E+02	3.6656307E+01	2.5522536E+02	2.3706122E+02
1.2800012E+02	3.6649452E+01	2.5521352E+02	2.3709378E+02
1.2900014E+02	3.6642605E+01	2.5520171E+02	2.3712651E+02
1.3000014E+02	3.6635780E+01	2.5518991E+02	2.3715878E+02
1.3100014E+02	3.6628983E+01	2.5517818E+02	2.3719119E+02
1.3200014E+02	3.6622219E+01	2.5516649E+02	2.3722318E+02
1.3300014E+02	3.6615494E+01	2.5515486E+02	2.3725529E+02
1.3400014E+02	3.6608810E+01	2.5514331E+02	2.3728697E+02
1.3500014E+02	3.6602177E+01	2.5513184E+02	2.3731880E+02
1.3600014E+02	3.6595600E+01	2.5512047E+02	2.3735020E+02
1.3700014E+02	3.6589081E+01	2.5510918E+02	2.3738174E+02
1.3800014E+02	3.6582626E+01	2.5509802E+02	2.3741286E+02
1.3900014E+02	3.6576237E+01	2.5508696E+02	2.3744412E+02
1.4000014E+02	3.6569927E+01	2.5507603E+02	2.3747496E+02
1.4100014E+02	3.6563686E+01	2.5506522E+02	2.3750595E+02
1.4200014E+02	3.6557533E+01	2.5505457E+02	2.3753651E+02
1.4300014E+02	3.6551460E+01	2.5504404E+02	2.3756723E+02
1.4400015E+02	3.6545475E+01	2.5503366E+02	2.3759753E+02
1.4500015E+02	3.6539581E+01	2.5502344E+02	2.3762798E+02
1.4600015E+02	3.6533787E+01	2.5501338E+02	2.3765802E+02
1.4700015E+02	3.6528088E+01	2.5500348E+02	2.3768820E+02
1.4800015E+02	3.6522491E+01	2.5499377E+02	2.3771799E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.4900015E+02	3.6516994E+01	2.5498422E+02	2.3774791E+02
1.5000015E+02	3.6511608E+01	2.5497485E+02	2.3777745E+02
1.5100015E+02	3.6506325E+01	2.5496567E+02	2.3780711E+02
1.5200015E+02	3.6501156E+01	2.5495668E+02	2.3783641E+02
1.5300015E+02	3.6496098E+01	2.5494788E+02	2.3786583E+02
1.5400015E+02	3.6491154E+01	2.5493927E+02	2.3789488E+02
1.5500015E+02	3.6486320E+01	2.5493085E+02	2.3792406E+02
1.5600015E+02	3.6481609E+01	2.5492262E+02	2.3795288E+02
1.5700015E+02	3.6477013E+01	2.5491461E+02	2.3798183E+02
1.5800015E+02	3.6472542E+01	2.5490680E+02	2.3801041E+02
1.5900015E+02	3.6468189E+01	2.5489920E+02	2.3803912E+02
1.6000017E+02	3.6463966E+01	2.5489182E+02	2.3806747E+02
1.6100017E+02	3.6459862E+01	2.5488463E+02	2.3809595E+02
1.6200017E+02	3.6455887E+01	2.5487769E+02	2.3812408E+02
1.6300017E+02	3.6452042E+01	2.5487094E+02	2.3815234E+02
1.6400017E+02	3.6448326E+01	2.5486443E+02	2.3818027E+02
1.6500017E+02	3.6444736E+01	2.5485812E+02	2.3820830E+02
1.6600017E+02	3.6441284E+01	2.5485205E+02	2.3823601E+02
1.6700017E+02	3.6437958E+01	2.5484621E+02	2.3826382E+02
1.6800017E+02	3.6434772E+01	2.5484059E+02	2.3829132E+02
1.6900017E+02	3.6431713E+01	2.5483519E+02	2.3831894E+02
1.7000017E+02	3.6428799E+01	2.5483003E+02	2.3834622E+02
1.7100017E+02	3.6426010E+01	2.5482510E+02	2.3837363E+02
1.7200017E+02	3.6423367E+01	2.5482042E+02	2.3840071E+02
1.7300017E+02	3.6420879E+01	2.5481601E+02	2.3842792E+02
1.7400017E+02	3.6418568E+01	2.5481189E+02	2.3845482E+02
1.7500018E+02	3.6416462E+01	2.5480812E+02	2.3848186E+02
1.7600018E+02	3.6414589E+01	2.5480475E+02	2.3850862E+02
1.7700018E+02	3.6412937E+01	2.5480176E+02	2.3853558E+02
1.7800018E+02	3.6411526E+01	2.5479918E+02	2.3856230E+02
1.7900018E+02	3.6410355E+01	2.5479701E+02	2.3858926E+02
1.8000018E+02	3.6409435E+01	2.5479527E+02	2.3861604E+02
1.8100018E+02	3.6408764E+01	2.5479396E+02	2.3864307E+02
1.8200018E+02	3.6408352E+01	2.5479309E+02	2.3866994E+02
1.8300018E+02	3.6408184E+01	2.5479265E+02	2.3869708E+02
1.8400018E+02	3.6408279E+01	2.5479263E+02	2.3872946E+02
1.8500018E+02	3.6408596E+01	2.5479301E+02	2.3875655E+02
1.8600018E+02	3.6409145E+01	2.5479379E+02	2.3878383E+02
1.8700018E+02	3.6409916E+01	2.5479495E+02	2.3881088E+02
1.8800018E+02	3.6416286E+01	2.5480566E+02	2.3884401E+02
1.8900018E+02	3.6426018E+01	2.5482211E+02	2.3888037E+02
1.9000020E+02	3.6435829E+01	2.5483870E+02	2.3891797E+02
1.9100020E+02	3.6445728E+01	2.5485545E+02	2.3895572E+02
1.9200020E+02	3.6455685E+01	2.5487228E+02	2.3899428E+02
1.9300020E+02	3.6465733E+01	2.5488925E+02	2.3903183E+02
1.9400020E+02	3.6475830E+01	2.5490633E+02	2.3907018E+02
1.9500020E+02	3.6486019E+01	2.5492354E+02	2.3910753E+02
1.9600020E+02	3.6496258E+01	2.5494083E+02	2.3914568E+02
1.9700020E+02	3.6506580E+01	2.5495827E+02	2.3918285E+02
1.9800020E+02	3.6516956E+01	2.5497580E+02	2.3922079E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.9900020E+02	3.6527386E+01	2.5499341E+02	2.3925778E+02
2.0900020E+02	3.6633911E+01	2.5517308E+02	2.3960063E+02
2.1900020E+02	3.6747734E+01	2.5536473E+02	2.3996521E+02
2.2900020E+02	3.6865688E+01	2.5556288E+02	2.4031891E+02
2.3900020E+02	3.6987389E+01	2.5576685E+02	2.4066481E+02
2.4900020E+02	3.7112648E+01	2.5597626E+02	2.4100420E+02
2.5900021E+02	3.7241314E+01	2.5619080E+02	2.4133661E+02
2.6900021E+02	3.7371418E+01	2.5640714E+02	2.4165730E+02
2.7900021E+02	3.7505718E+01	2.5662985E+02	2.4198532E+02
2.8900021E+02	3.7641098E+01	2.5685373E+02	2.4229327E+02
2.9900021E+02	3.7777912E+01	2.5707928E+02	2.4259952E+02
3.0900021E+02	3.7915432E+01	2.5730536E+02	2.4291023E+02
3.1900021E+02	3.8054379E+01	2.5753308E+02	2.4320731E+02
3.2900021E+02	3.8194233E+01	2.5776163E+02	2.4350847E+02
3.3900021E+02	3.8334248E+01	2.5798975E+02	2.4379712E+02
3.4900021E+02	3.8473942E+01	2.5821664E+02	2.4409009E+02
3.5900021E+02	3.8614056E+01	2.5844354E+02	2.4437105E+02
3.6900021E+02	3.8753578E+01	2.5866879E+02	2.4465623E+02
3.7900021E+02	3.8892998E+01	2.5889319E+02	2.4493008E+02
3.8900021E+02	3.9030643E+01	2.5911407E+02	2.4520836E+02
3.9900021E+02	3.9168457E+01	2.5933459E+02	2.4547566E+02
4.0900021E+02	3.9304729E+01	2.5955197E+02	2.4574715E+02
4.1900021E+02	3.9439934E+01	2.5976703E+02	2.4600844E+02
4.2900021E+02	3.9600636E+01	2.6002222E+02	2.4627594E+02
4.3900021E+02	3.9764610E+01	2.6028174E+02	2.4652217E+02
4.4900021E+02	3.9926823E+01	2.6053760E+02	2.4676793E+02
4.5900021E+02	4.0084110E+01	2.6078479E+02	2.4701418E+02
4.6900021E+02	4.0050648E+01	2.6072995E+02	2.4731490E+02
4.7900021E+02	3.9994385E+01	2.6063898E+02	2.4760281E+02
4.8900024E+02	3.9943695E+01	2.6055673E+02	2.4788303E+02
4.9900024E+02	3.9897419E+01	2.6048138E+02	2.4816048E+02
5.9900024E+02	3.9602200E+01	2.5999207E+02	2.5053304E+02
6.9900024E+02	3.9490055E+01	2.5979343E+02	2.5246033E+02
7.9900024E+02	3.9436481E+01	2.5968823E+02	2.5403699E+02
8.9900024E+02	3.9448772E+01	2.5968863E+02	2.5538013E+02
9.9900024E+02	3.9506386E+01	2.5976163E+02	2.5650922E+02
1.0990002E+03	3.9603664E+01	2.5989801E+02	2.5749307E+02
1.1990002E+03	3.9730034E+01	2.6008054E+02	2.5836865E+02
1.2990002E+03	3.9877201E+01	2.6029568E+02	2.5914996E+02
1.3990002E+03	4.0039463E+01	2.6053415E+02	2.5986090E+02
1.4990002E+03	3.9538601E+01	2.5971658E+02	2.5694885E+02
1.5990002E+03	3.8848415E+01	2.5858279E+02	2.5304994E+02
1.6990002E+03	3.8203465E+01	2.5750647E+02	2.4955194E+02
1.7990002E+03	3.7569813E+01	2.5643890E+02	2.4802039E+02
1.8990002E+03	3.6946438E+01	2.5537949E+02	2.4825662E+02
1.9990002E+03	3.6344620E+01	2.5434198E+02	2.4844145E+02
2.0990002E+03	3.5757961E+01	2.5331633E+02	2.4859222E+02
2.1990002E+03	3.5186543E+01	2.5230331E+02	2.4871127E+02
2.2990002E+03	3.4626736E+01	2.5129712E+02	2.4880214E+02
2.3990002E+03	3.4079124E+01	2.5029924E+02	2.4886653E+02

Table 6.3-4 (cont.) **Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray**

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
2.4990002E+03	3.3540970E+01	2.4930510E+02	2.4890723E+02
2.5990002E+03	3.3013031E+01	2.4831644E+02	2.4892546E+02
2.6990002E+03	3.2493073E+01	2.4732938E+02	2.4892352E+02
2.7990002E+03	3.1981947E+01	2.4634576E+02	2.4890233E+02
2.8990002E+03	3.1477737E+01	2.4536217E+02	2.4886378E+02
2.9990002E+03	3.0981331E+01	2.4438048E+02	2.4880859E+02
3.0990002E+03	3.0491455E+01	2.4339839E+02	2.4847218E+02
3.1990002E+03	3.0010233E+01	2.4242035E+02	2.4790459E+02
3.2990002E+03	2.9535343E+01	2.4144186E+02	2.4734714E+02
3.3990002E+03	2.9065716E+01	2.4046080E+02	2.4679865E+02
3.4990002E+03	2.8600178E+01	2.3947475E+02	2.4625851E+02
3.5990002E+03	2.8139786E+01	2.3848590E+02	2.4572610E+02
3.6990002E+03	2.7584276E+01	2.3727641E+02	2.4491057E+02
3.7990002E+03	2.6965515E+01	2.3590576E+02	2.4385629E+02
3.8990002E+03	2.6365526E+01	2.3455046E+02	2.4282724E+02
3.9990002E+03	2.5781137E+01	2.3320457E+02	2.4182153E+02
4.9990005E+03	2.5467739E+01	2.3246004E+02	2.3615184E+02
5.9990005E+03	2.4711176E+01	2.3067358E+02	2.3322934E+02
6.9990005E+03	2.3783638E+01	2.2841882E+02	2.3049898E+02
7.9990005E+03	2.2770773E+01	2.2586980E+02	2.2772287E+02
8.9990000E+03	2.1790558E+01	2.2330971E+02	2.2505815E+02
9.9990000E+03	2.0837652E+01	2.2072533E+02	2.2250249E+02
1.9999000E+04	1.5545770E+01	2.0422050E+02	2.0209698E+02
2.9999000E+04	1.3084527E+01	1.9485435E+02	1.9120732E+02
3.9999000E+04	1.1282461E+01	1.8700775E+02	1.8419492E+02
4.9999000E+04	9.7582741E+00	1.7951279E+02	1.7853201E+02
5.9999000E+04	8.5464277E+00	1.7284229E+02	1.6771574E+02
6.9999000E+04	7.9333830E+00	1.6917615E+02	1.6264641E+02
7.9999000E+04	7.5116539E+00	1.6652383E+02	1.5986708E+02
8.9999000E+04	7.1420197E+00	1.6410327E+02	1.5789368E+02
9.9999000E+04	6.8098474E+00	1.6184392E+02	1.5633223E+02
1.0999900E+05	6.4717684E+00	1.5945985E+02	1.5140636E+02
1.1999900E+05	6.3056817E+00	1.5826003E+02	1.4955331E+02
1.2999900E+05	6.2046227E+00	1.5752470E+02	1.4850555E+02
1.3999900E+05	6.1011190E+00	1.5676228E+02	1.4791800E+02
1.4999900E+05	6.0381112E+00	1.5629259E+02	1.4765912E+02
1.5999900E+05	5.9505854E+00	1.5563820E+02	1.4705800E+02
1.6999900E+05	5.8770161E+00	1.5508237E+02	1.4692900E+02
1.7999900E+05	5.8033247E+00	1.5452374E+02	1.4630753E+02
1.8999900E+05	5.7414117E+00	1.5404649E+02	1.4605373E+02
1.9999900E+05	5.6768575E+00	1.5354349E+02	1.4572557E+02
2.0999900E+05	5.6447368E+00	1.5330322E+02	1.4523669E+02
2.1999900E+05	5.5292363E+00	1.5238893E+02	1.4488057E+02
2.2999900E+05	5.4688549E+00	1.5190778E+02	1.4463622E+02
2.3999900E+05	5.3858562E+00	1.5124127E+02	1.4432556E+02
2.4999900E+05	5.3273826E+00	1.5077419E+02	1.4378133E+02
2.5999900E+05	5.2801900E+00	1.5039076E+02	1.4360468E+02
2.6999900E+05	5.2025514E+00	1.4974837E+02	1.4317856E+02
2.7999900E+05	5.1234341E+00	1.4909151E+02	1.4285222E+02
2.8999900E+05	5.0720429E+00	1.4866269E+02	1.4243784E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
2.9999900E+05	5.0029111E+00	1.4807993E+02	1.4210835E+02
3.0999900E+05	4.9385910E+00	1.4753726E+02	1.4162247E+02
3.1999900E+05	4.8797202E+00	1.4703093E+02	1.4135573E+02
3.2999900E+05	4.8175278E+00	1.4649115E+02	1.4099384E+02
3.3999900E+05	4.7485585E+00	1.4588962E+02	1.4064523E+02
3.4999900E+05	4.6930542E+00	1.4540103E+02	1.4026433E+02
3.5999900E+05	4.6315389E+00	1.4485324E+02	1.3990932E+02
3.6999900E+05	4.5707202E+00	1.4430710E+02	1.3954803E+02
3.7999900E+05	4.5100060E+00	1.4375717E+02	1.3918646E+02
3.8999900E+05	4.4500704E+00	1.4320973E+02	1.3882401E+02
3.9999900E+05	4.3902178E+00	1.4265831E+02	1.3846220E+02
4.0999900E+05	4.3311605E+00	1.4210963E+02	1.3809969E+02
4.1999900E+05	4.2721529E+00	1.4155664E+02	1.3773784E+02
4.2999900E+05	4.2139592E+00	1.4100671E+02	1.3737527E+02
4.3999900E+05	4.1557841E+00	1.4045215E+02	1.3701337E+02
4.4999900E+05	4.0983644E+00	1.3990018E+02	1.3665076E+02
4.5999900E+05	4.0390520E+00	1.3932430E+02	1.3628275E+02
4.6999900E+05	3.9798856E+00	1.3874458E+02	1.3590523E+02
4.7999900E+05	3.9205589E+00	1.3815787E+02	1.3552539E+02
4.8999900E+05	3.8620405E+00	1.3757399E+02	1.3514378E+02
4.9999900E+05	3.8034835E+00	1.3698428E+02	1.3476236E+02
5.0999900E+05	3.6409869E+00	1.3529176E+02	1.3028830E+02
5.1999900E+05	3.5791481E+00	1.3464789E+02	1.2911061E+02
5.2999900E+05	3.5461357E+00	1.3431201E+02	1.2872115E+02
5.3999900E+05	3.5204611E+00	1.3405519E+02	1.2846901E+02
5.4999900E+05	3.4933145E+00	1.3378624E+02	1.2828516E+02
5.5999900E+05	3.4771163E+00	1.3363170E+02	1.2814478E+02
5.6999900E+05	3.4502132E+00	1.3336435E+02	1.2799187E+02
5.7999900E+05	3.4281323E+00	1.3314337E+02	1.2793654E+02
5.8999900E+05	3.4128430E+00	1.3299763E+02	1.2777354E+02
5.9999900E+05	3.3916128E+00	1.3279294E+02	1.2759531E+02
6.0999900E+05	3.3735938E+00	1.3261484E+02	1.2749806E+02
6.1999900E+05	3.3529289E+00	1.3241527E+02	1.2734690E+02
6.2999900E+05	3.3411689E+00	1.3230734E+02	1.2723758E+02
6.3999900E+05	3.3165784E+00	1.3206030E+02	1.2710819E+02
6.4999900E+05	3.3009677E+00	1.3190846E+02	1.2704033E+02
6.5999900E+05	3.2782815E+00	1.3168372E+02	1.2687099E+02
6.6999900E+05	3.2624838E+00	1.3152867E+02	1.2679495E+02
6.7999900E+05	3.2443173E+00	1.3134641E+02	1.2667471E+02
6.8999900E+05	3.2265754E+00	1.3116847E+02	1.2655743E+02
6.9999900E+05	3.2089186E+00	1.3099104E+02	1.2644072E+02
7.0999900E+05	3.1913440E+00	1.3081407E+02	1.2632439E+02
7.1999900E+05	3.1738501E+00	1.3063757E+02	1.2620844E+02
7.2999900E+05	3.1564336E+00	1.3046149E+02	1.2609283E+02
7.3999900E+05	3.1390910E+00	1.3028578E+02	1.2597753E+02
7.4999900E+05	3.1218188E+00	1.3011043E+02	1.2586253E+02
7.5999900E+05	3.1046133E+00	1.2993539E+02	1.2574780E+02
7.6999900E+05	3.0874720E+00	1.2976064E+02	1.2563331E+02
7.7999900E+05	3.0703917E+00	1.2958612E+02	1.2551904E+02
7.8999900E+05	3.0533700E+00	1.2941185E+02	1.2540498E+02

Table 6.3-4 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 1 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
7.9999900E+05	3.0364044E+00	1.2923776E+02	1.2529109E+02
8.0999900E+05	3.0194931E+00	1.2906386E+02	1.2517738E+02
8.1999900E+05	3.0026340E+00	1.2889012E+02	1.2506383E+02
8.2999900E+05	2.9858253E+00	1.2871651E+02	1.2495041E+02
8.3999900E+05	2.9690657E+00	1.2854303E+02	1.2483713E+02
8.4999900E+05	2.9523535E+00	1.2836966E+02	1.2472396E+02
8.5999900E+05	2.9356875E+00	1.2819638E+02	1.2461091E+02
8.6999900E+05	2.9190667E+00	1.2802319E+02	1.2449795E+02
8.7999900E+05	2.9024899E+00	1.2785007E+02	1.2438509E+02
8.8999900E+05	2.8859558E+00	1.2767700E+02	1.2427232E+02
8.9999900E+05	2.8694642E+00	1.2750400E+02	1.2415961E+02
9.0999900E+05	2.8541934E+00	1.2733717E+02	1.2405628E+02
9.1999900E+05	2.8385956E+00	1.2716589E+02	1.2394580E+02
9.2999900E+05	2.8229558E+00	1.2699364E+02	1.2383414E+02
9.3999900E+05	2.8073316E+00	1.2682110E+02	1.2372221E+02
9.4999900E+05	2.7917364E+00	1.2664846E+02	1.2361022E+02
9.5999900E+05	2.7761745E+00	1.2647576E+02	1.2349822E+02
9.6999900E+05	2.7606480E+00	1.2630303E+02	1.2338625E+02
9.7999900E+05	2.7451572E+00	1.2613027E+02	1.2327428E+02
9.8999900E+05	2.7297025E+00	1.2595750E+02	1.2316235E+02
9.9999900E+05	2.7147422E+00	1.2579842E+02	1.2304974E+02
1.9999990E+06	2.4768684E+00	1.2097065E+02	1.1700172E+02
2.9999990E+06	2.4380393E+00	1.1761262E+02	1.1469793E+02
3.9999990E+06	2.3855824E+00	1.1397727E+02	1.1243826E+02
4.9999990E+06	2.3760688E+00	1.1001505E+02	1.1014834E+02
5.9999990E+06	2.5356617E+00	1.0823864E+02	1.0651961E+02
6.9999990E+06	2.7736161E+00	1.0739161E+02	1.0596532E+02
7.9999990E+06	3.0092115E+00	1.0644176E+02	1.0541958E+02
8.9999990E+06	3.2432728E+00	1.0542276E+02	1.0492331E+02
9.9999990E+06	3.5016551E+00	1.0451715E+02	1.0440598E+02
1.0000000E+07	3.5016904E+00	1.0451775E+02	1.0440579E+02

Table 6.3-5 Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.0000000E-03	3.0000001E-01	1.2000000E+02	1.2000000E+02
5.0000101E-01	2.7377696E+00	1.4175690E+02	1.8153883E+02
1.0000020E+00	5.1343589E+00	1.6196132E+02	1.9689900E+02
2.0000031E+00	9.5709763E+00	1.9239671E+02	2.1060091E+02
3.0000041E+00	1.3359940E+01	2.1180504E+02	2.1798988E+02
4.0000048E+00	1.6182543E+01	2.2211842E+02	2.2268262E+02
5.0000062E+00	1.8444284E+01	2.2791052E+02	2.2625830E+02
6.0000072E+00	2.0376295E+01	2.3131262E+02	2.2923253E+02
7.0000081E+00	2.2145123E+01	2.3356015E+02	2.3180357E+02
8.0000086E+00	2.3787363E+01	2.3503026E+02	2.3399254E+02
9.0000095E+00	2.5342987E+01	2.3602611E+02	2.3608826E+02
1.0000011E+01	2.6780718E+01	2.3736647E+02	2.3791733E+02
1.1000012E+01	2.8206589E+01	2.4040240E+02	2.3953009E+02
1.2000013E+01	2.9531761E+01	2.4311273E+02	2.4097713E+02
1.3000014E+01	3.0770304E+01	2.4555682E+02	2.4227254E+02
1.4000015E+01	3.1930042E+01	2.4777309E+02	2.4343179E+02
1.5000016E+01	3.3016243E+01	2.4978954E+02	2.4447365E+02
1.6000017E+01	3.4032555E+01	2.5162741E+02	2.4540987E+02
1.7000017E+01	3.4970993E+01	2.5328467E+02	2.4624951E+02
1.8000019E+01	3.5811737E+01	2.5473863E+02	2.4701794E+02
1.9000019E+01	3.6636105E+01	2.5613721E+02	2.4788234E+02
2.0000021E+01	3.7398861E+01	2.5740851E+02	2.4859787E+02
2.1000023E+01	3.7851036E+01	2.5815213E+02	2.4898529E+02
2.2000023E+01	3.8112339E+01	2.5857825E+02	2.4931332E+02
2.3000025E+01	3.8260201E+01	2.5881793E+02	2.4968272E+02
2.4000025E+01	3.8293922E+01	2.5887186E+02	2.5002792E+02
2.5000027E+01	3.8238850E+01	2.5878183E+02	2.5024706E+02
2.6000027E+01	3.8128895E+01	2.5860266E+02	2.5031232E+02
2.7000029E+01	3.7980820E+01	2.5836093E+02	2.5030611E+02
2.8000029E+01	3.7825226E+01	2.5810614E+02	2.5030029E+02
2.9000031E+01	3.7680557E+01	2.5786841E+02	2.5028958E+02
3.0000031E+01	3.7548203E+01	2.5765027E+02	2.5028166E+02
3.1000032E+01	3.7424873E+01	2.5744641E+02	2.5027269E+02
3.2000034E+01	3.7309559E+01	2.5725531E+02	2.5026326E+02
3.3000034E+01	3.7201584E+01	2.5707593E+02	2.5025294E+02
3.4000034E+01	3.7100319E+01	2.5690729E+02	2.5024231E+02
3.5000034E+01	3.7005581E+01	2.5674915E+02	2.5021291E+02
3.6000038E+01	3.6947170E+01	2.5665094E+02	2.4955557E+02
3.7000038E+01	3.6914814E+01	2.5659589E+02	2.4861476E+02
3.8000038E+01	3.6886406E+01	2.5654739E+02	2.4777684E+02
3.9000038E+01	3.6859982E+01	2.5650220E+02	2.4697656E+02
4.0000042E+01	3.6835258E+01	2.5645987E+02	2.4621265E+02
4.1000042E+01	3.6812187E+01	2.5642026E+02	2.4548227E+02
4.2000042E+01	3.6790600E+01	2.5638315E+02	2.4478413E+02
4.3000046E+01	3.6770481E+01	2.5634851E+02	2.4411566E+02
4.4000046E+01	3.6751686E+01	2.5631607E+02	2.4347580E+02
4.5000046E+01	3.6734200E+01	2.5628583E+02	2.4286221E+02
4.6000046E+01	3.6717907E+01	2.5625760E+02	2.4227408E+02
4.7000050E+01	3.6702797E+01	2.5623135E+02	2.4170927E+02
4.8000050E+01	3.6688751E+01	2.5620691E+02	2.4116724E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
4.9000050E+01	3.6675770E+01	2.5618427E+02	2.4064600E+02
5.0000050E+01	3.6663750E+01	2.5616324E+02	2.4014519E+02
5.1000053E+01	3.6652687E+01	2.5614380E+02	2.3966302E+02
5.2000053E+01	3.6642483E+01	2.5612585E+02	2.3919925E+02
5.3000053E+01	3.6633137E+01	2.5610934E+02	2.3875224E+02
5.4000053E+01	3.6624565E+01	2.5609412E+02	2.3832187E+02
5.5000057E+01	3.6616764E+01	2.5608023E+02	2.3790663E+02
5.6000057E+01	3.6611145E+01	2.5605908E+02	2.3758192E+02
5.7000057E+01	3.6601173E+01	2.5603027E+02	2.3733751E+02
5.8000057E+01	3.6616737E+01	2.5602713E+02	2.3734253E+02
5.9000061E+01	3.6687080E+01	2.5610001E+02	2.3736633E+02
6.0000061E+01	3.6758919E+01	2.5617529E+02	2.3738217E+02
6.1000061E+01	3.6829876E+01	2.5624905E+02	2.3739824E+02
6.2000065E+01	3.6899700E+01	2.5632080E+02	2.3741827E+02
6.3000065E+01	3.6968307E+01	2.5639044E+02	2.3743396E+02
6.4000069E+01	3.7035988E+01	2.5645847E+02	2.3744989E+02
6.5000069E+01	3.7102520E+01	2.5652451E+02	2.3746970E+02
6.6000069E+01	3.7167934E+01	2.5658859E+02	2.3748518E+02
6.7000069E+01	3.7232414E+01	2.5665106E+02	2.3750320E+02
6.8000069E+01	3.7296055E+01	2.5671207E+02	2.3751768E+02
6.9000069E+01	3.7358849E+01	2.5677161E+02	2.3753720E+02
7.0000069E+01	3.7420605E+01	2.5682935E+02	2.3755241E+02
7.1000069E+01	3.7481644E+01	2.5688586E+02	2.3756743E+02
7.2000076E+01	3.7541904E+01	2.5694104E+02	2.3758411E+02
7.3000076E+01	3.7601307E+01	2.5699472E+02	2.3760112E+02
7.4000076E+01	3.7659889E+01	2.5704703E+02	2.3761775E+02
7.5000076E+01	3.7717648E+01	2.5709790E+02	2.3763472E+02
7.6000076E+01	3.7771122E+01	2.5714691E+02	2.3765675E+02
7.7000076E+01	3.7819515E+01	2.5719342E+02	2.3767015E+02
7.8000076E+01	3.7867302E+01	2.5723886E+02	2.3768607E+02
7.9000076E+01	3.7891651E+01	2.5727908E+02	2.3770618E+02
8.0000084E+01	3.7915112E+01	2.5731781E+02	2.3772354E+02
8.1000084E+01	3.7937843E+01	2.5735532E+02	2.3774089E+02
8.2000084E+01	3.7959869E+01	2.5739166E+02	2.3775821E+02
8.3000084E+01	3.7981209E+01	2.5742682E+02	2.3777550E+02
8.4000084E+01	3.8001888E+01	2.5746091E+02	2.3779265E+02
8.5000084E+01	3.8021915E+01	2.5749387E+02	2.3780971E+02
8.6000084E+01	3.8041363E+01	2.5752588E+02	2.3782535E+02
8.7000092E+01	3.8060329E+01	2.5755707E+02	2.3784048E+02
8.8000092E+01	3.8078720E+01	2.5758731E+02	2.3785786E+02
8.9000092E+01	3.8096554E+01	2.5761661E+02	2.3787473E+02
9.0000092E+01	3.8107521E+01	2.5763455E+02	2.3790787E+02
9.1000092E+01	3.8112530E+01	2.5764264E+02	2.3793829E+02
9.2000092E+01	3.8117176E+01	2.5765012E+02	2.3797371E+02
9.3000092E+01	3.8121258E+01	2.5765668E+02	2.3801244E+02
9.4000092E+01	3.8124866E+01	2.5766245E+02	2.3804808E+02
9.5000099E+01	3.8128056E+01	2.5766751E+02	2.3808357E+02
9.6000099E+01	3.8130829E+01	2.5767191E+02	2.3811909E+02
9.7000099E+01	3.8133224E+01	2.5767569E+02	2.3815408E+02
9.8000099E+01	3.8135231E+01	2.5767883E+02	2.3818939E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
9.9000099E+01	3.8136913E+01	2.5768143E+02	2.3822437E+02
1.0000010E+02	3.8138214E+01	2.5768338E+02	2.3826228E+02
1.0100010E+02	3.8139217E+01	2.5768488E+02	2.3829367E+02
1.0200011E+02	3.8134823E+01	2.5767746E+02	2.3832855E+02
1.0300011E+02	3.8129536E+01	2.5766858E+02	2.3836238E+02
1.0400011E+02	3.8124046E+01	2.5765936E+02	2.3839572E+02
1.0500011E+02	3.8118382E+01	2.5764987E+02	2.3843002E+02
1.0600011E+02	3.8112450E+01	2.5763992E+02	2.3846609E+02
1.0700011E+02	3.8106323E+01	2.5762964E+02	2.3850009E+02
1.0800011E+02	3.8099964E+01	2.5761899E+02	2.3853580E+02
1.0900011E+02	3.8093433E+01	2.5760806E+02	2.3856946E+02
1.1000011E+02	3.8086693E+01	2.5759677E+02	2.3860481E+02
1.1100011E+02	3.8079819E+01	2.5758527E+02	2.3863817E+02
1.1200011E+02	3.8072758E+01	2.5757346E+02	2.3867316E+02
1.1300011E+02	3.8065582E+01	2.5756146E+02	2.3870619E+02
1.1400011E+02	3.8058247E+01	2.5754919E+02	2.3874084E+02
1.1500011E+02	3.8050819E+01	2.5753677E+02	2.3877356E+02
1.1600011E+02	3.8043255E+01	2.5752411E+02	2.3880786E+02
1.1700011E+02	3.8035622E+01	2.5751135E+02	2.3884027E+02
1.1800012E+02	3.8027874E+01	2.5749838E+02	2.3887424E+02
1.1900012E+02	3.8020077E+01	2.5748535E+02	2.3890634E+02
1.2000012E+02	3.8012188E+01	2.5747214E+02	2.3893997E+02
1.2100012E+02	3.8004265E+01	2.5745889E+02	2.3897177E+02
1.2200012E+02	3.7996273E+01	2.5744553E+02	2.3900508E+02
1.2300012E+02	3.7988270E+01	2.5743213E+02	2.3903658E+02
1.2400012E+02	3.7980209E+01	2.5741864E+02	2.3906956E+02
1.2500013E+02	3.7972157E+01	2.5740518E+02	2.3910077E+02
1.2600013E+02	3.7964066E+01	2.5739163E+02	2.3913344E+02
1.2700013E+02	3.7955997E+01	2.5737811E+02	2.3916435E+02
1.2800012E+02	3.7947906E+01	2.5736459E+02	2.3919670E+02
1.2900014E+02	3.7939850E+01	2.5735110E+02	2.3922734E+02
1.3000014E+02	3.7931793E+01	2.5733759E+02	2.3925938E+02
1.3100014E+02	3.7923782E+01	2.5732419E+02	2.3928973E+02
1.3200014E+02	3.7915779E+01	2.5731076E+02	2.3932149E+02
1.3300014E+02	3.7907837E+01	2.5729745E+02	2.3935155E+02
1.3400014E+02	3.7899914E+01	2.5728418E+02	2.3938301E+02
1.3500014E+02	3.7892071E+01	2.5727103E+02	2.3941281E+02
1.3600014E+02	3.7884258E+01	2.5725793E+02	2.3944397E+02
1.3700014E+02	3.7876530E+01	2.5724496E+02	2.3947350E+02
1.3800014E+02	3.7868847E+01	2.5723206E+02	2.3950438E+02
1.3900014E+02	3.7861259E+01	2.5721933E+02	2.3953365E+02
1.4000014E+02	3.7853722E+01	2.5720667E+02	2.3956424E+02
1.4100014E+02	3.7846291E+01	2.5719418E+02	2.3959325E+02
1.4200014E+02	3.7838921E+01	2.5718182E+02	2.3962357E+02
1.4300014E+02	3.7831665E+01	2.5716962E+02	2.3965233E+02
1.4400015E+02	3.7824478E+01	2.5715753E+02	2.3968237E+02
1.4500015E+02	3.7817413E+01	2.5714566E+02	2.3971089E+02
1.4600015E+02	3.7810425E+01	2.5713391E+02	2.3974068E+02
1.4700015E+02	3.7803562E+01	2.5712234E+02	2.3976894E+02
1.4800015E+02	3.7796787E+01	2.5711096E+02	2.3979846E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.4900015E+02	3.7790142E+01	2.5709976E+02	2.3982649E+02
1.5000015E+02	3.7783588E+01	2.5708871E+02	2.3985576E+02
1.5100015E+02	3.7777172E+01	2.5707791E+02	2.3988356E+02
1.5200015E+02	3.7770851E+01	2.5706726E+02	2.3991257E+02
1.5300015E+02	3.7764671E+01	2.5705682E+02	2.3994014E+02
1.5400015E+02	3.7758591E+01	2.5704657E+02	2.3996890E+02
1.5500015E+02	3.7752651E+01	2.5703656E+02	2.3999625E+02
1.5600015E+02	3.7746819E+01	2.5702670E+02	2.4002477E+02
1.5700015E+02	3.7741131E+01	2.5701709E+02	2.4005190E+02
1.5800015E+02	3.7735554E+01	2.5700766E+02	2.4008018E+02
1.5900015E+02	3.7730125E+01	2.5699847E+02	2.4010710E+02
1.6000017E+02	3.7724808E+01	2.5698947E+02	2.4013515E+02
1.6100017E+02	3.7719646E+01	2.5698074E+02	2.4016185E+02
1.6200017E+02	3.7714596E+01	2.5697217E+02	2.4018968E+02
1.6300017E+02	3.7709705E+01	2.5696390E+02	2.4021617E+02
1.6400017E+02	3.7704929E+01	2.5695578E+02	2.4024379E+02
1.6500017E+02	3.7700314E+01	2.5694794E+02	2.4027007E+02
1.6600017E+02	3.7695820E+01	2.5694031E+02	2.4029747E+02
1.6700017E+02	3.7691483E+01	2.5693295E+02	2.4032355E+02
1.6800017E+02	3.7687267E+01	2.5692578E+02	2.4035074E+02
1.6900017E+02	3.7683216E+01	2.5691888E+02	2.4037662E+02
1.7000017E+02	3.7679287E+01	2.5691217E+02	2.4040359E+02
1.7100017E+02	3.7675522E+01	2.5690576E+02	2.4042931E+02
1.7200017E+02	3.7671879E+01	2.5689954E+02	2.4045607E+02
1.7300017E+02	3.7668404E+01	2.5689359E+02	2.4048158E+02
1.7400017E+02	3.7665054E+01	2.5688785E+02	2.4050815E+02
1.7500018E+02	3.7661869E+01	2.5688239E+02	2.4053348E+02
1.7600018E+02	3.7658810E+01	2.5687714E+02	2.4055986E+02
1.7700018E+02	3.7655933E+01	2.5687219E+02	2.4058501E+02
1.7800018E+02	3.7653221E+01	2.5686752E+02	2.4061119E+02
1.7900018E+02	3.7650738E+01	2.5686322E+02	2.4063620E+02
1.8000018E+02	3.7648468E+01	2.5685928E+02	2.4066225E+02
1.8100018E+02	3.7646461E+01	2.5685577E+02	2.4068718E+02
1.8200018E+02	3.7644676E+01	2.5685266E+02	2.4071318E+02
1.8300018E+02	3.7643162E+01	2.5684998E+02	2.4073811E+02
1.8400018E+02	3.7641891E+01	2.5684769E+02	2.4076414E+02
1.8500018E+02	3.7640896E+01	2.5684589E+02	2.4078915E+02
1.8600018E+02	3.7640148E+01	2.5684448E+02	2.4081528E+02
1.8700018E+02	3.7644314E+01	2.5685123E+02	2.4084459E+02
1.8800018E+02	3.7655922E+01	2.5687036E+02	2.4088112E+02
1.8900018E+02	3.7667603E+01	2.5688962E+02	2.4091638E+02
1.9000020E+02	3.7679321E+01	2.5690894E+02	2.4095256E+02
1.9100020E+02	3.7691116E+01	2.5692838E+02	2.4098766E+02
1.9200020E+02	3.7702950E+01	2.5694788E+02	2.4102367E+02
1.9300020E+02	3.7714863E+01	2.5696747E+02	2.4105862E+02
1.9400020E+02	3.7726810E+01	2.5698715E+02	2.4109447E+02
1.9500020E+02	3.7738834E+01	2.5700696E+02	2.4112927E+02
1.9600020E+02	3.7750893E+01	2.5702679E+02	2.4116496E+02
1.9700020E+02	3.7763023E+01	2.5704675E+02	2.4119963E+02
1.9800020E+02	3.7775188E+01	2.5706677E+02	2.4123517E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
1.9900020E+02	3.7787430E+01	2.5708691E+02	2.4126968E+02
2.0900020E+02	3.7912720E+01	2.5729269E+02	2.4158899E+02
2.1900020E+02	3.8045818E+01	2.5751083E+02	2.4193111E+02
2.2900020E+02	3.8182438E+01	2.5773413E+02	2.4226828E+02
2.3900020E+02	3.8322491E+01	2.5796237E+02	2.4258461E+02
2.4900020E+02	3.8467411E+01	2.5819791E+02	2.4291200E+02
2.5900021E+02	3.8613510E+01	2.5843463E+02	2.4323012E+02
2.6900021E+02	3.8761776E+01	2.5867413E+02	2.4352977E+02
2.7900021E+02	3.8914639E+01	2.5892032E+02	2.4383749E+02
2.8900021E+02	3.9067951E+01	2.5916644E+02	2.4413802E+02
2.9900021E+02	3.9223305E+01	2.5941504E+02	2.4443173E+02
3.0900021E+02	3.9379341E+01	2.5966391E+02	2.4472960E+02
3.1900021E+02	3.9536758E+01	2.5991418E+02	2.4501567E+02
3.2900021E+02	3.9693714E+01	2.6016287E+02	2.4530608E+02
3.3900021E+02	3.9851971E+01	2.6041284E+02	2.4558521E+02
3.4900021E+02	4.0009895E+01	2.6066147E+02	2.4586845E+02
3.5900021E+02	4.0167667E+01	2.6090900E+02	2.4614134E+02
3.6900021E+02	4.0324749E+01	2.6115466E+02	2.4641826E+02
3.7900021E+02	4.0481602E+01	2.6139920E+02	2.4668520E+02
3.8900021E+02	4.0637718E+01	2.6164175E+02	2.4695602E+02
3.9900021E+02	4.0793339E+01	2.6188278E+02	2.4721730E+02
4.0900021E+02	4.0947842E+01	2.6212134E+02	2.4748244E+02
4.1900021E+02	4.1101254E+01	2.6235742E+02	2.4773849E+02
4.2900021E+02	4.1253361E+01	2.6259079E+02	2.4799832E+02
4.3900021E+02	4.1404278E+01	2.6282159E+02	2.4824939E+02
4.4900021E+02	4.1553745E+01	2.6304950E+02	2.4850412E+02
4.5900021E+02	4.1497303E+01	2.6296097E+02	2.4881248E+02
4.6900021E+02	4.1430805E+01	2.6285684E+02	2.4910609E+02
4.7900021E+02	4.1369747E+01	2.6276099E+02	2.4939644E+02
4.8900024E+02	4.1313580E+01	2.6267255E+02	2.4967177E+02
4.9900024E+02	4.1261456E+01	2.6259024E+02	2.4994598E+02
5.9900024E+02	4.0906193E+01	2.6202094E+02	2.5228282E+02
6.9900024E+02	4.0755516E+01	2.6176740E+02	2.5418265E+02
7.9900024E+02	4.0700222E+01	2.6166217E+02	2.5572978E+02
8.9900024E+02	4.0707073E+01	2.6165396E+02	2.5705524E+02
9.9900024E+02	4.0759869E+01	2.6171753E+02	2.5816846E+02
1.0990002E+03	4.0852558E+01	2.6184323E+02	2.5914160E+02
1.1990002E+03	4.0974525E+01	2.6201425E+02	2.6000595E+02
1.2990002E+03	4.1118595E+01	2.6221915E+02	2.6078186E+02
1.3990002E+03	4.1278618E+01	2.6244812E+02	2.6148544E+02
1.4990002E+03	4.1017441E+01	2.6202448E+02	2.5994913E+02
1.5990002E+03	4.0285900E+01	2.6085962E+02	2.5601941E+02
1.6990002E+03	3.9608444E+01	2.5976334E+02	2.5250253E+02
1.7990002E+03	3.8944416E+01	2.5867813E+02	2.5095050E+02
1.8990002E+03	3.8291840E+01	2.5760190E+02	2.5116582E+02
1.9990002E+03	3.7661934E+01	2.5654797E+02	2.5133128E+02
2.0990002E+03	3.7047935E+01	2.5550603E+02	2.5146365E+02
2.1990002E+03	3.6449875E+01	2.5447679E+02	2.5156519E+02
2.2990002E+03	3.5863979E+01	2.5345436E+02	2.5163931E+02
2.3990002E+03	3.5290825E+01	2.5244023E+02	2.5168765E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
2.4990002E+03	3.4727585E+01	2.5142979E+02	2.5171295E+02
2.5990002E+03	3.4175045E+01	2.5042479E+02	2.5171637E+02
2.6990002E+03	3.3630894E+01	2.4942137E+02	2.5170013E+02
2.7990002E+03	3.3096016E+01	2.4842136E+02	2.5166512E+02
2.8990002E+03	3.2568432E+01	2.4742134E+02	2.5161319E+02
2.9990002E+03	3.2049065E+01	2.4642320E+02	2.5154500E+02
3.0990002E+03	3.1536585E+01	2.4542465E+02	2.5119759E+02
3.1990002E+03	3.1033150E+01	2.4443004E+02	2.5062053E+02
3.2990002E+03	3.0537096E+01	2.4343636E+02	2.5005373E+02
3.3990002E+03	3.0049261E+01	2.4244547E+02	2.4949631E+02
3.4990002E+03	2.9567591E+01	2.4145345E+02	2.4894762E+02
3.5990002E+03	2.9090975E+01	2.4045804E+02	2.4840680E+02
3.6990002E+03	2.8516722E+01	2.3924219E+02	2.4756549E+02
3.7990002E+03	2.7877245E+01	2.3786467E+02	2.4647102E+02
3.8990002E+03	2.7256548E+01	2.3650125E+02	2.4540343E+02
3.9990002E+03	2.6651463E+01	2.3514609E+02	2.4436050E+02
4.9990005E+03	2.6178232E+01	2.3405884E+02	2.3856117E+02
5.9990005E+03	2.5339073E+01	2.3212007E+02	2.3547710E+02
6.9990005E+03	2.4339323E+01	2.2973772E+02	2.3259241E+02
7.9990005E+03	2.3263578E+01	2.2707968E+02	2.2967346E+02
8.9990000E+03	2.2228136E+01	2.2442082E+02	2.2687349E+02
9.9990000E+03	2.1225840E+01	2.2174495E+02	2.2419339E+02
1.9999000E+04	1.5686809E+01	2.0466176E+02	2.0291525E+02
2.9999000E+04	1.3152152E+01	1.9506615E+02	1.9160211E+02
3.9999000E+04	1.1323038E+01	1.8712329E+02	1.8439781E+02
4.9999000E+04	9.7869539E+00	1.7958183E+02	1.7864931E+02
5.9999000E+04	8.5745497E+00	1.7291682E+02	1.6786551E+02
6.9999000E+04	7.9483247E+00	1.6917464E+02	1.6274123E+02
7.9999000E+04	7.5054259E+00	1.6638631E+02	1.5992181E+02
8.9999000E+04	7.1604381E+00	1.6412579E+02	1.5792720E+02
9.9999000E+04	6.8242469E+00	1.6183994E+02	1.5629884E+02
1.0999900E+05	6.5069389E+00	1.5960550E+02	1.5168483E+02
1.1999900E+05	6.3363085E+00	1.5837563E+02	1.4955984E+02
1.2999900E+05	6.2105260E+00	1.5745557E+02	1.4860063E+02
1.3999900E+05	6.1286964E+00	1.5684990E+02	1.4809610E+02
1.4999900E+05	6.0476475E+00	1.5624471E+02	1.4761789E+02
1.5999900E+05	5.9640379E+00	1.5562007E+02	1.4706854E+02
1.6999900E+05	5.8988228E+00	1.5512570E+02	1.4677753E+02
1.7999900E+05	5.8281584E+00	1.5459109E+02	1.4630420E+02
1.8999900E+05	5.7537870E+00	1.5402026E+02	1.4608250E+02
1.9999900E+05	5.6720600E+00	1.5338788E+02	1.4557355E+02
2.0999900E+05	5.6194324E+00	1.5297566E+02	1.4536119E+02
2.1999900E+05	5.5402665E+00	1.5235068E+02	1.4506827E+02
2.2999900E+05	5.4775329E+00	1.5185699E+02	1.4451189E+02
2.3999900E+05	5.4301362E+00	1.5147841E+02	1.4433202E+02
2.4999900E+05	5.3300710E+00	1.5066556E+02	1.4396130E+02
2.5999900E+05	5.2775216E+00	1.5024387E+02	1.4343665E+02
2.6999900E+05	5.2232108E+00	1.4979723E+02	1.4322131E+02
2.7999900E+05	5.1444354E+00	1.4914409E+02	1.4285654E+02
2.8999900E+05	5.0872226E+00	1.4866550E+02	1.4244060E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
2.9999900E+05	5.0107307E+00	1.4801920E+02	1.4211250E+02
3.0999900E+05	4.9592161E+00	1.4758203E+02	1.4171783E+02
3.1999900E+05	4.8942966E+00	1.4702687E+02	1.4137230E+02
3.2999900E+05	4.8119421E+00	1.4631352E+02	1.4091867E+02
3.3999900E+05	4.7697425E+00	1.4594711E+02	1.4063461E+02
3.4999900E+05	4.7076173E+00	1.4539867E+02	1.4027435E+02
3.5999900E+05	4.6466541E+00	1.4485605E+02	1.3991220E+02
3.6999900E+05	4.5853105E+00	1.4430522E+02	1.3955141E+02
3.7999900E+05	4.5251970E+00	1.4376102E+02	1.3918872E+02
3.8999900E+05	4.4646673E+00	1.4320816E+02	1.3882761E+02
3.9999900E+05	4.4054332E+00	1.4266273E+02	1.3846471E+02
4.0999900E+05	4.3457227E+00	1.4210799E+02	1.3810342E+02
4.1999900E+05	4.2873678E+00	1.4156143E+02	1.3774042E+02
4.2999900E+05	4.2284708E+00	1.4100484E+02	1.3737904E+02
4.3999900E+05	4.1709909E+00	1.4045724E+02	1.3701595E+02
4.4999900E+05	4.1128626E+00	1.3989842E+02	1.3665451E+02
4.5999900E+05	4.0542269E+00	1.3932947E+02	1.3628542E+02
4.6999900E+05	3.9943228E+00	1.3874249E+02	1.3590909E+02
4.7999900E+05	3.9357214E+00	1.3816333E+02	1.3552811E+02
4.8999900E+05	3.8764186E+00	1.3757158E+02	1.3514766E+02
4.9999900E+05	3.8186336E+00	1.3699005E+02	1.3476503E+02
5.0999900E+05	3.6517601E+00	1.3525125E+02	1.3032204E+02
5.1999900E+05	3.5937085E+00	1.3464824E+02	1.2912463E+02
5.2999900E+05	3.5588541E+00	1.3429265E+02	1.2871294E+02
5.3999900E+05	3.5347478E+00	1.3405292E+02	1.2847656E+02
5.4999900E+05	3.5080819E+00	1.3378906E+02	1.2829155E+02
5.5999900E+05	3.4869697E+00	1.3358002E+02	1.2817790E+02
5.6999900E+05	3.4674938E+00	1.3338892E+02	1.2803493E+02
5.7999900E+05	3.4476156E+00	1.3319281E+02	1.2790218E+02
5.8999900E+05	3.4281061E+00	1.3300021E+02	1.2777282E+02
5.9999900E+05	3.4088912E+00	1.3281035E+02	1.2764587E+02
6.0999900E+05	3.3899238E+00	1.3262271E+02	1.2752081E+02
6.1999900E+05	3.3711684E+00	1.3243692E+02	1.2739730E+02
6.2999900E+05	3.3525989E+00	1.3225269E+02	1.2727509E+02
6.3999900E+05	3.3341939E+00	1.3206979E+02	1.2715397E+02
6.4999900E+05	3.3159375E+00	1.3188808E+02	1.2703381E+02
6.5999900E+05	3.2978151E+00	1.3170738E+02	1.2691446E+02
6.6999900E+05	3.2798157E+00	1.3152759E+02	1.2679585E+02
6.7999900E+05	3.2619290E+00	1.3134860E+02	1.2667786E+02
6.8999900E+05	3.2441471E+00	1.3117032E+02	1.2656046E+02
6.9999900E+05	3.2264619E+00	1.3099266E+02	1.2644357E+02
7.0999900E+05	3.2088671E+00	1.3081557E+02	1.2632712E+02
7.1999900E+05	3.1913571E+00	1.3063896E+02	1.2621109E+02
7.2999900E+05	3.1739268E+00	1.3046281E+02	1.2609542E+02
7.3999900E+05	3.1565716E+00	1.3028708E+02	1.2598009E+02
7.4999900E+05	3.1392877E+00	1.3011168E+02	1.2586506E+02
7.5999900E+05	3.1220710E+00	1.2993661E+02	1.2575030E+02
7.6999900E+05	3.1049190E+00	1.2976183E+02	1.2563579E+02
7.7999900E+05	3.0878279E+00	1.2958730E+02	1.2552150E+02
7.8999900E+05	3.0707958E+00	1.2941299E+02	1.2540742E+02

Table 6.3-5 (cont.) Containment Response Time History LOCA DEPS Minimum Safeguards Unit 2 with Recirculation Spray

TIME, SECONDS	PRESSURE, PSIG	STEAM TEMP, F	WATER TEMP, F
7.9999900E+05	3.0538201E+00	1.2923891E+02	1.2529352E+02
8.0999900E+05	3.0368989E+00	1.2906497E+02	1.2517979E+02
8.1999900E+05	3.0200295E+00	1.2889122E+02	1.2506622E+02
8.2999900E+05	3.0032113E+00	1.2871761E+02	1.2495280E+02
8.3999900E+05	2.9864416E+00	1.2854410E+02	1.2483951E+02
8.4999900E+05	2.9697199E+00	1.2837071E+02	1.2472633E+02
8.5999900E+05	2.9530442E+00	1.2819743E+02	1.2461327E+02
8.6999900E+05	2.9364138E+00	1.2802422E+02	1.2450031E+02
8.7999900E+05	2.9198272E+00	1.2785108E+02	1.2438744E+02
8.8999900E+05	2.9032838E+00	1.2767801E+02	1.2427466E+02
8.9999900E+05	2.8867826E+00	1.2750499E+02	1.2416196E+02
9.0999900E+05	2.8703227E+00	1.2733202E+02	1.2404933E+02
9.1999900E+05	2.8539033E+00	1.2715907E+02	1.2393678E+02
9.2999900E+05	2.8386970E+00	1.2699222E+02	1.2383377E+02
9.3999900E+05	2.8231702E+00	1.2682097E+02	1.2372340E+02
9.4999900E+05	2.8076012E+00	1.2664874E+02	1.2361184E+02
9.5999900E+05	2.7920470E+00	1.2647621E+02	1.2350002E+02
9.6999900E+05	2.7765210E+00	1.2630357E+02	1.2338812E+02
9.7999900E+05	2.7610278E+00	1.2613087E+02	1.2327621E+02
9.8999900E+05	2.7455690E+00	1.2595813E+02	1.2316431E+02
9.9999900E+05	2.7305019E+00	1.2579782E+02	1.2305104E+02
1.9999990E+06	2.4957139E+00	1.2113444E+02	1.1695563E+02
2.9999990E+06	2.4334910E+00	1.1745471E+02	1.1475826E+02
3.9999990E+06	2.3778954E+00	1.1381356E+02	1.1248933E+02
4.9999990E+06	2.3807366E+00	1.1010735E+02	1.1012410E+02
5.9999990E+06	2.5233934E+00	1.0808177E+02	1.0659528E+02
6.9999990E+06	2.7762849E+00	1.0750563E+02	1.0629495E+02
7.9999990E+06	2.9947212E+00	1.0628163E+02	1.0548473E+02
8.9999990E+06	3.2582438E+00	1.0561956E+02	1.0494935E+02
9.9999990E+06	3.4866848E+00	1.0448335E+02	1.0438900E+02
1.0000000E+07	3.4867876E+00	1.0448510E+02	1.0438864E+02

6.4 CONCLUSIONS

The MSLB and LOCA containment response analyses have been performed as part of the service water system enhancement program for Salem Unit 1 and Unit 2. The analyses included long-term pressure and temperature profiles for each unit. As illustrated in the results in Section 6.2 and 6.3, all cases resulted in a peak containment pressure that was less than 47 psig. In addition, all long-term cases were well below 50% of the peak value within 24 hours. Based on the results, all applicable SRP criteria for Salem Unit 1 and Unit 2 have been met.

The peak calculated pressure for the DEPS minimum safeguards LOCA case for Salem Unit 1 with Model F steam generators was 40.1 psig. The peak calculated pressure for the DEPS minimum safeguards LOCA case for Salem Unit 2 with Model 51 steam generators was 41.6 psig.

For MSLB, the limiting containment pressure case is a 1.4 ft^2 DER initiated at 30% power with a containment safeguards failure. The limiting containment temperature case is 0.88 ft^2 split rupture initiated at 30% power with a MSIV failure. For Unit 1, the peak pressure is 40.2 psig and the peak temperature is 345.7°F. For Unit 2, the peak pressure is 42.2 psig and the peak temperature is 345.4°F.

From the standpoint of the acceptability of the service water enhancement project, the operation of the recirculation sprays are necessary for the long term LOCA containment temperature to be less than the qualification temperature profile in Table 3.3-1. However the EQ limits are slightly exceeded for a short duration (about two hours for both units). Also, while the peak temperature from the composite of all of the steamline break cases is less than 351.3°F and the long term temperature is less than the current profile, there is a period from approximately 140 seconds to 320 seconds where the new composite exceeds the envelop from about 6°F to as much as 18°F. The noted EQ temperature limit issues are being addressed by PSEG Nuclear outside of this report.

7 REFERENCES

1. Westinghouse Project Letter, PSEBO-97-022, "Safety Evaluation for Revised Fan Cooler Delay Time (SECL-96-178, Revision 2)," 9-2-97.

2. Westinghouse Project Letter, PSE-97-509, "Steam Generator Replacement Project (LOCA/Containment Assessment)," 1-10-97.

3. Westinghouse Project Letter, PSE-01-524, "Containment Capability Study – Phase 1," 7-9-01.

4. Westinghouse Project Letter, PSE-02-19, "Summary Report for Phase 2 of Containment Capability Study for Salem Unit 1 and Unit 2," 3-6-02.

5. "Containment Pressure Analysis Code (COCO)," WCAP-8327, July, 1974 (Proprietary), WCAP-8326, July, 1974 (Non-Proprietary).

6. "LOFTRAN Code Description," WCAP-7907-P-A (Proprietary) and WCAP-7907-A (Nonproprietary), Burnett, T.W.T., et al., April 1984.

7. Moody, F.J., "Maximum Flow Rate of a Single Component, Two-Phase Mixture," Journal of Heat Transfer, 87, 134 (1965).

8. Letter from Cecil O. Thomas (NRC), "Acceptance for Referencing of Licensing Topical Report WCAP-8821(P)/8859(NP)," "TRANFLO Steam Generator Code Description," and WCAP-8822(P)/8860(NP), "Mass and Energy Release Following a Steam Line Rupture," August 1983

9. "Mass and Energy Releases Following a Steam Line Rupture," WCAP-8822 (Proprietary), WCAP-8860 (Nonproprietary), Land, R.E., September 1976

10. ANSI/ANS-5.1 1979, "American National Standard for Decay Heat Power in Light Water Reactors," August 1979

11. "Westinghouse LOCA Mass and Energy Release Model for Containment Design - March 1979 Version," WCAP-10325-P-A, May 1983 (Proprietary), WCAP-10326-A (Nonproprietary).

12. "Westinghouse Mass and Energy Release Data For Containment Design," WCAP-8264-P-A, Rev. 1, August 1975 (Proprietary), WCAP-8312-A (Nonproprietary).

13. Docket No. 50-315, "Amendment No. 126, Facility Operating License No. DPR-58 (TAC No. 71062), for D. C. Cook Nuclear Plant Unit 1," June 9, 1989.

14. EPRI 294-2, "Mixing of Emergency Core Cooling Water with Steam; 1/3-Scale Test and Summary," (WCAP-8423), Final Report, June 1975

15. Takashi Tagami, "Interim Report on Safety Assessments and Facilities Establishment Project in Japan for Period Ending June 1965," No. 1

16. E. W. Ranz and W. R. Marshall, Jr., "Evaporation for Drops," Chemical Engineering Progress, 48, pp. 141-146, March 1952

17. Parsly, L. F., "Design Consideration of Reactor Containment Spray System. Part VI, The Heating of Spray Drops in Air-Steam Atmospheres," ORNL-TM-2412 Part VI, January 1970

APPENDIX A

The information that follows is a copy of the PSEG Nuclear LLC transmittal letter EA-CFCU-03-004, dated July 10, 2003. This information was transmitted to Westinghouse as the PSEG Nuclear LLC confirmation of the analysis input assumptions for the work presented in the main body of this report.

Portions of EA-CFCU-03-004 and its attachments contain Westinghouse proprietary information. This information has been designated by brackets (i.e., [ ]^{a,c}).

PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, New Jersey 08038-0236

PSEG
Nuclear LLC

EA-CFCU-03-004
July 10, 2003

Customer Projects Manager
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
Attn: Mr. Jerold Kusky

Dear Mr. Kusky:

PSEG Nuclear Response to Westinghouse Input Request for CFCU Project Containment Mass and Energy Release Analyses

PSEG Nuclear has validated and/or provided the specific input requested by Westinghouse (Reference 1) needed to perform the LOCA and Main Steam Line Break (MSLB) containment response analyses proposed as described in References 2 and 3. This information was transmitted via e-mail to Mr. Robert Jakub on July 2, 2003.

Note that some items, too large to fit in the available space, were noted and provided as attachments at the end. There are some items that will require further discussion between Westinghouse and PSEG, specific Westinghouse references or possible follow-up calculations. Some items of note include Safety Injection (SI) switchover to recirculation with minimum safeguards, time for recirculation spray to be initiated and some SI flows not matching ~~current references under certain alignments, RHR heat exchanger flow~~ during recirculation (subsequent UA values will then be provided by PSEG). Additionally, information provided to Westinghouse regarding the main feedwater pump trip and coastdown for MSLB with a single failure of the feedwater control valve (Reference 4) needs to be validated by Westinghouse as it dates back to 1992.

To further support the filled in Westinghouse input request document, the following are also provided: Attachment 1 provides information regarding the concurrent vessel head change-out project, including the increased metal mass associated with the integrated head package; Attachment 2 provides additional information regarding AFW flow rates; Attachment 3 is the hard copy of the EXCEL file that provides Proto-Flo AFW results and curve fits; Attachment 4 contains the SI information; Attachment 5 covers the Accumulators; Attachment 6 covers Containment Spray Pumps; Attachment 7 is the validation of the various data tables, Attachment 8 covers the Bypass Flow Control Valve set points. Attachment 9 provides information data for the Heater Drain Pump Curves. Also included are P&ID's for Salem Unit 1 and 2 Bleed Steam and Heater Drains. Item C.5 Lo-lo Tavg set point value will be provided later.

Note that all the Replacement Steam Generator data has been provided with the exception of the secondary side fluid mass at various power levels (Framatome only has performed calculation at 100% power). PSEG will provide this information later as it becomes available. Also, PSEG is evaluating a reduction in the maximum moderator density coefficient (currently set at 0.52 delta-k/gm/cc) to recover some MSLB containment pressure margin. The final value that is acceptable to the core design engineers will be provided to Westinghouse under a separate letter.

Following your review of this input information, could you provide an update to the analysis schedule, with the various deliverables (even preliminary results) in terms of actual dates. Please distribute this letter with attachments to Robert Jakub, Debra Ohkawa and William Turkowski.

If you have any questions, please contact Mr. Kiran Mathur (CFCU Project Engineer) at 856 339-7215, or Mr. Glenn Schwartz (Nuclear Fuel) at 856 339-1216.

Very truly yours,

Ashok K. Moudgill

Ashok Moudgill
CFCU Project Manager
(Original signed and on File)

C Dave Hughes
John O Connor
Mike Mannion
Tom Ross
Ken Fleischer
Greg Morrison
Doug McCollum
Glenn Schwartz
Kent Halac
Michael Crawford
John Rowey
Kevin King
Scott Beckham
Tina Nolte
Paul Finch
John Pehush

References:

1) Westinghouse letter PSE-03-25, CFCU/Service Water Enhancement Project Input Request for LOCA and MSLB Mass & Energy Releases and Containment Integrity Analyses, June 24, 2003

2) Westinghouse letter LTR-NEM-03-403, Containment Response Analysis to Support the Containment Fan Cooler Unit Service Water Enhancement Project, April 29, 2003

3) Westinghouse letter LTR-NEM-03-458, Revised Offer for Containment Response Analysis to Support the Containment Fan Cooler Unit Service Water Enhancement Project, May 15, 2003

PSEG Letter NFU-92-173, Salem Units 1 & 2 Feedwater Control Valve / Main Feedwater Pump Trip Assumption, March 9, 1992

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
A. CORE PARAMETERS				
1. Nominal Reactor Core Power, MWt (100% power)	3459.0	n/a	OK – PCWG-2541	Increased value is conservative.
2. Pump heat, MWt	n/a	20	OK - 20MWth max (bounding) 12 MWth nominal (WCAP-15553 and PCWG)	
3. NSSS Power, MWt	n/a	3479	OK based on maximum pump heat	Increased value is conservative.
4. Calorimetric uncertainty	0.6%	0.6%	OK – Licensing Amendments 243 and 224	
5. Fuel Type & Fuel Mechanical Design Values	17 x 17 RFA Fuel	17 x 17 RFA Fuel	urrent core designs will tilize RFA, but will likely ave one V5H assembly in the enter location for the next ycle of each Salem unit essentially through 2005).	
6. Core Stored Energy, Full Power Seconds	4.23	n/a	n/a – Westinghouse scope	
7. Total Peaking Factor, F_QT	2.4	n/a	K – current core limits Westinghouse letters NF-PSE-2-45, 01PSE-G-094). owever, LOCA analyses hould use FqT = 2.5 to rovide for future core design lexibility	
8. Core Enthalpy Rise Factor, FΔh	1.65	n/a	OK – current core limits	

a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response					
Design and Licensing Parameters		Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
9.	Core Radial Peaking Factor, P_{HA}	1.469	n/a	OK – actual parameter is the "relative power in hot assembly", value consistent with the current core limits	
10.	Shutdown margin, %Δk	n/a	1.3%	OK – Tech Spec 3/4.1.1	[ ] a,c
11.	Moderator density feedback, Δk/gm/cc	n/a	0.52	[ ]	Increased value is conservative. a,c
B.	*REACTOR COOLANT SYSTEM (See Attachment 1 for information regarding additional metal mass added by the Replacement Reactor Head Project)*				a,c
1.	Thermal Design Flow, gpm/loop	82,500	82,500	OK – Margin Recovery Program RTSR report	[
2.	Vessel/Outlet Temperature, °F	613.1	n/a	OK – PCWG-2541	
3.	Vessel/Core Inlet Temperature, °F	542.7	n/a	OK – PCWG-2541	
4.	Steam Generator Outlet Temperature, °F	542.5	n/a	OK – PCWG-2541	]

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
5. RCS Average Temperature, °F • Full Power • 70% Power • 30% Power • 0% Power	n/a	577.9 573.6 556.3 547.0	[ ]	a,c
6. Vessel Average Temperature Uncertainty, °F	+5.0	+5.0	OK – consistent with Minimum Measured Flow	[ ] a,c
7. Pressurizer Pressure, psia	2250	2250	OK – PCWG-2541	[ ] a,c
8. Pressurizer Pressure Uncertainty, psia	+50	N/a	OK – consistent with Margin Recovery Program	[ ] a,c
C. PROTECTION SYSTEM LOGIC, SETPOINTS, DELAYS				

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
1. Steamline break protection logic (SI and SLI signals)	n/a	See Fig. C-1	Fig. C-1 correct Ref. Dwg. Series 221050	
2. Low steamline pressure setpoint	n/a	358.5 psia 575 psia	Analytical Limit = 500psig Ref. SC-CN002-01	a,c
3. Lead/lag on low steamline pressure signal	n/a	50/5	50/5 VTD 304209	
4. High steam flow setpoint	n/a	Power (FON) / Setpoint (FON) 0.0 / 0.6454 0.2 / 0.6454 .3143 / 0.8022 .4286 / 0.9236 .5429 / 1.0264 .6572 / 1.1172 .7715 / 1.1993 .8858 / 1.2750 1.0 / 1.4589 1.2 / 1.4589	No analytical Value Power Flow 0-20% <=40% >=100% <=110% Ref. SC-CN007-01	
5. Lo-lo Tavg setpoint, °F	n/a	537.7	Will be provided later	
6. High steamline differential pressure, psi	n/a	200.	Allowable Value 112.0 Ref. SC-CN002-01	
7. Number of loops required for: • high steamline differential pressure • high steamline • low-low Tavg • low steamline pressure	n/a	 2 2 2 2	Verified per Dwg 221056, 221054, 221056	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes	
8. Low pressurizer pressure SI setpoint, psia	1715	1700	Analytical Limit 1700psig Ref SC-RC005-01	[ ]	a,c
9. Low pressurizer pressure reactor trip setpoint, psia	1880	1840	Analytical Limit 1825psig Ref SC-RC005-01		
10. Lead/Lag For Compensated Pressurizer Pressure Reactor Trip	Lead = 10.0 Lag = 1.0	N/a	Lead = 10.0 Lag = 2.8 Ref. S1(2).IC-CC.RCP-0017	[ ]	a,c
11. Compensated Pressurizer Pressure Trip Setpoint, psig	1865.0	N/a	Westinghouse should determine this value based on the above parameters	[ ]	a,c
12. SG Throttle Valve Closure Signal	0.0	N/a	OK – use bounding value	[ ]	a,c
13. SG Throttle Valve Stroke Time, sec	0.0	N/a	OK – use bounding value	[ ]	a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
14. SG Throttle Valve Signal Processing Delays for Loss of Offsite Power, sec	0.0	N/a	OK – use bounding value	[ ] a,c
15. Hi containment pressure setpoint, psig	6.0	6.0	Analytical Limit 5.5psig Ref. SC-CS002-01	Setpoint for Fan Cooler Initiation (see Section K) and SI signal
16. Hi-hi containment pressure setpoint, psig	17.0	17.0	Analytical Limit 17psig Ref. SC-CS002-01	Setpoint for Spray Pump Initiation (see Section J) and Steamline Isolation.
17. Reactor trip electronic delay		2.0 sec	<= 2.0 SEC Tech. Spec 3/4 3	

D. STEAM GENERATORS

1. Unit 1 Model	Model F	Model F	Ok Model F	
a) Full power operating Pressure, psia	869.0	874	Unit 1 – 852 psia, based on PCWG-2541	[ ] a,c
b) Tube Plugging, %	0.0	0.0	[ ] a,c	[ ] a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
c) Secondary Side Total Fluid Mass, Lbs per SG	TBD	TBD	Based on Westinghouse calc CN-TA-99-13 GENF results for maximum mass: 100% - 108394 lb 70% - 120172 30% - 141273 10% - 158447 0% - 169474.8 These should be acceptable for 1.4% power rerate.	[ ] a,c
d) Main Feed/steam total flow rate, 10^6 Lb/hr	15.10	n/a	OK – PCWG-2541	
2. Unit 2 Model	Model 51	Model 51	OK Model 51	
a) Full power operating Pressure, psia	822.0	827.4	822 psia, based on PCWG-2541	[ ] a,c
b) Tube Plugging, %	0.0	0.0	[ ] a,c	[ ] a,c
c) Secondary Side Total Fluid Mass, Lbs per SG	TBD	TBD	Based on Westinghouse calc CN-TA-00-30 GENF results for maximum mass: 102% - 114771 lb 100% - 116042 60% - 132605 10% - 157754 0% - 157890 These should be acceptable for 1.4% power rerate, but Westinghouse will need to determine values at 30 and 70% RTP.	[ ] a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
d) Main Feed/steam total flow rate, 10^6 Lb/hr	15.08	n/a	OK – PCWG-2541	
3. Unit 2 RSG Model			Framatome model 61/19-T	
a) Full power operating Pressure, psia	n/a	n/a	High = 911 psia saturated @100% power, 82,500 gpm, Tavg = 577.9 deg-F, nominal = 880 psia (based on Framatome calc NFPMG DC 6, Rev A, still under PSEG review)	[ ] a,c
b) Tube Plugging, %	n/a	n/a	[ ] a,c	[ ] a,c
c) Secondary Side Total Fluid Mass, Lbs per SG	n/a	n/a	All data is not yet available. Current Framatome calculations cover 100% power at [ ] a,c 99,600 gpm mechanical design flow at 577.9 deg-F = 111610 lbs. No plans in place to change current program level.	For LOCA [ ] a,c For MSLB, the mass is a function of 0%, 30%, 70% and 100% power. At 20% power the programmed level changes.
d) Main Feed/steam total flow rate, 10^6 Lb/hr	n/a	n/a	15.12 – Framatome design calc	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
e) Total Dry Weight of RSG, lbm per SG	n/a	n/a	661,400 lbs based on Framatome drawings (NFPMG-DB-002 Rev B is for one of the four SGs, all have the same weight)	
f) Total Number of Tubes per SG	n/a	n/a	5048, Framatome design calc NFPMG DC 6, Rev A	
g) Tube Diameter, inches or feet	n/a	n/a	0.75 in OD, 0.0429 in thick (NFPMG DC 6, Rev A)	
h) Total Tube Bundle Surface Area, ft^2 per SG	n/a	n/a	66,236 (NFPMG DC 6, Rev A)	
E. STEAMLINE				
1. Main steamline cross-sectional area, ft^2	n/a	4.6	OK Ref. VTD 140319 Ref. Stress Isometric 267130A & 267132A	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
2. Flow restrictor flow area, ft^2	n/a	1.4 (unit 1 – integral flow restrictor unit 2 – in-line flow restrictor)	OK – consistent with Salem UFSAR. Per Framatome-ANP Technical Proposal, No. 02.5073, Rev. 3, Framatome has confirmed the 1.4 ft^2 steam flow area. Exact value is 1.398ft^2 for the seven venturies.	Also need flow restrictor area/location for Unit 2 RSG
3. MSIV flow area, ft^2	n/a	3.2 ft^2	OK Ref. VTD 140319	
4. MSIV closure time, sec	n/a	12.0	OK Ref. VTD 140319 & 135830	Includes electronic delay and stroke time of main and bypass valves
5. Steamline volumes: • between SG and MSIV (1 loop) • downstream of MSIVs to turbine isolation valve or check valve (plant total)	n/a	 542 9541	542 OK Ref. Stress Isometric 267130A & 267132A 9541 OK by Westinghouse comparison with other similar plants (Westinghouse to document this conclusion)	[ ] a, c
F. MAIN AND AUXILIARY FEEDWATER				

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
1. Main Feedwater Temperature, °F • Full Power • 70% Power • 30% Power • 0% Power	432.8	432.8 395.0 329.8 100.0	Based on data from the PSEG Nuclear Thermal Performance Engineer, the current full power feedwater temperatures are: Unit 1 – 427.4 deg-F Unit 2 – 428.4 deg-F Westinghouse values are consistent with the Unit 1 Base Deck (CN-TA-99-13). The feedwater enthalpy values for Unit 2 differ from Unit 1 at 10 and 60% RTP (same at 100 and 0%). The Unit 2 Base Deck calc (CN-TA-00-30) did not include values at 30 and 70% RTP. 100% - 411.4 Btu/lb (U1) - 411 (U2) 60% - 355.2 (U1) - 360.0 (U2) 10% - 239.1 (U1) - 232.0 (U2) 0% - 70.7	[ ] a,c
2. Feedwater control valve closure time, sec	n/a	10.0	OK Ref. Operations Procedure S1(2).RA-ST.MS-0002(Q)	Includes an electronic delay and the time for the valve to fully close. This is a safety-grade valve.
3. Feedwater isolation valve closure time, sec	n/a	32.0	OK Ref. Operations Procedure S1(2).RA-ST.MS-0002(Q)	Includes an electronic delay and the time for the valve to fully close.
4. Feedwater isolation valve closure characteristic	n/a	Flowrate is linearly ramped down over the last 20 seconds	VTD 124574	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
5. Coastdown of main feedwater pumps	n/a	MFW pump trip is not credited in current analysis	As per PSEG letter NFU-92-173 to Westinghouse (3/09/1992), the trip of the main feedwater pumps can be credited as follows: 2.0 second signal processing delay, then 10 pump coastdown (bounding high) Per Westinghouse telcon, this a typical coastdown value for feed pumps (Westinghouse to confirm)	For cases with FCV failure, would be helpful to credit MFW pump trip, and need information on coastdown of MFW pumps (FON flow vs. time)
6. Feedline volume, ft³: • Between SG and FCV • Between SG and FIV	n/a	 381.0 438.0	Assumed values are very conservative; actual pipe volume calculations are: Unit 1: 356/399 (S-1-BF-MDC-1808) Unit 2: 325/376 (S-2-BF-MDC-1804)	[ ] a,c
7. Number of main feedwater pumps running: • Full power • 70% power • 30% power • 0% power	n/a	 2 2 1 1	OK Ref. S1(2).OP-AB.CN-0001(Q)	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes	
8. Number of condensate pumps running: • Full power • 70% power • 30% power • 0% power	n/a	 3 3 2 1	OK Ref. S1(2).OP-AB.CN-0001(Q)		
9. Auxiliary Feedwater Flow per SG, gpm	190.0	Table III and Table IV in NFU-93-083	See Attachments 2 & 3	[ ]	a,c
10. Auxiliary Feedwater System Purge Volume – Maximum of any single loop, ft^3	Unit 1 = 151.0 Unit 2 = 131.0 Latest Source is: NFS-99-179	1.0	Unit 1 = 172 (S-1-BF-MDC-1808), if this is over-conservative, the average of all four loops is 141.5 ft^3. Unit 2 = 131 (S-2-BF-MDC-1804)	[ ] Volume of piping that needs to be flushed of high enthalpy main feedwater before credit can be taken for lower enthalpy aux. feed. [ ]	a,c a,c
11. Auxiliary Feedwater Temperature, °F	120.0	120	Confirmed	[ ]	a,c
12. Heater drain pump performance curve	n/a		Ref. VTD 123779		

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
13. Number of Heater drain pumps running	n/a		OK Ref. S1(2).OP-AB.CN-0001(Q)	
• Full Power		3		
• 70% Power		3		
• 30% Power		0		
• 0% Power		0		
14. Main feedwater control valve (FCV) full open Cv	n/a	1450	OK Ref. VTD 119162	
15. Main feedwater bypass control valve (BFCV) size and full open Cv	n/a	72	Cv is 72 Ref. VTD 120968	
16. Normal position of BFCV at ≥30% power	n/a	Closed	Ref. Design Change Package 1EC-3206 Advanced Digital System	
17. Accident operation of BFCV	n/a	~~Open~~ Closed	The BFCV remains closed when FCV goes full open. See Attachment 8 for more information.	Refers to position of faulted loop BFCV when FCV goes full open
18. Significant differences in Unit 1 and 2 condensate and feedwater systems affecting hydraulic modeling	n/a	None Assumed	U1 has an inoperable cross tie for heater drain system. Unit 1 has different style of 13, 14, and 15 heater drain bypass valve. This bypass valve will be replaced with Unit 2 design in 1R17 refueling outage.	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
19. Significant changes to condensate and feedwater system components since 1989 impacting hydraulic modeling (e.g. condensate or feedwater pump performance curves, FCV trim, etc.)	n/a	None Assumed	Digital feedwater modification	
20. Availability of drain tank pumps, post turbine trip			#21 Heater Drain pump trips automatically. The remaining pumps for Units 1 & 2 are manually tripped by operator. (Ref. S1.OP-SO.TD-0001)	PSEG to confirm that pumps are tripped
21. Operator action time to re-align AFW from faulted SG, sec	n/a	600	OK Ref. EOP S1(2)-EOP-TRIP-1	
G. SAFETY INJECTION (PUMPED SI)				
1. Safety Injection Configuration for both the injection and recirculation phases (Minimum Safeguards)		n/a	See Attachment 4	Assuming the loss of offsite power, the limiting single failure of the limiting bus or the limiting diesel, whichever results in minimum flows (this data should be biased low for conservatism).
2. Safety Injection Configuration for both the injection and recirculation phases (Maximum Safeguards)		n/a	See Attachment 4	
3. Minimum Deliverable RWST Volume, gallons	313,000. Total 193,000 Low Level 120,000 Low-low Level	n/a	See Attachment 4	Decreased values are conservative

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response					
Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes	
4. Maximum Safety Injection Water Temperature during the Injection Phase, °F	100.0	100	See Attachment 4	The maximum RWST water temperature. This value must be consistent with the injection phase SI flows and Containment Spray Flows (see section J).	
5. Maximum delay to reach full flow for the minimum safeguards configuration (including Loss of Offsite Power, diesel start-up time, signal processing times, valve stroke times for ALL SI pumps), sec	32.0	22.0	See Attachment 4	Increased value is conservative. [ ]	a,c
6. Minimum delay to reach full flow for the maximum safeguards configuration (including Loss of Offsite Power, diesel start-up time, signal processing times, valve stroke times for all SI pumps), sec	32.0	n/a	See Attachment 4	For loss of offsite power, the minimum time and maximum time should be similar. [ ]	a,c
7. Time of safety injection switchover to recirculation with minimum safeguards (after SI setpoint is reached), sec	1704.6	n/a	See Attachment 4	[ ]	a,c
8. Time of safety injection switchover to recirculation with maximum safeguards (after SI setpoint is reached), sec	1090.0	n/a	See Attachment 4	[ ]	a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
9. Safety Injection Flows for ECCS Train Failure (configuration for both the injection and recirculation phases) with No Spilling Line [LOCA]	Table G-1	n/a	See Attachment 4	decreased values are conservative. See NFU-91-508 for IHSI flow rates
10. Safety Injection Flows for all ECCS pumps operational (configuration for both the injection and recirculation phases) with No Spilling Line [LOCA]	Table G-2	n/a	See Attachment 4	increased values are conservative.
11. Minimum Safety Injection Flow Rates from 1 Charging/SI pump and 1 IHSI pump with No Spilling Line (SLB)	n/a	Table G-3	See Attachment 4	decreased values are conservative
12. SI volume between RWST and RCS, ft^3	n/a	197.1	See Attachment 4	decreased value is conservative. [ ] a,c
13. SI line initial boron concentration, ppm	n/a	0	See Attachment 4	
14. Boron Injection Tank boron concentration, ppm	n/a	0	See Attachment 4	Has BIT been physically removed, valved out, or boron concentration lowered?
15. Minimum Containment Sump Elevation, ft.	70.0	n/a	See Attachment 4	
16. RHR Pump Suction Centerline elevation, ft.	46.83	n/a	See Attachment 4	
17. RHR Pump Discharge Centerline elevation, ft	46.83	n/a	See Attachment 4	

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
18. RCS Cold Leg Elevations, ft.	97.0	n/a	See Attachment 4	
19. RCS Hot Leg Elevations, ft.	97.0		See Attachment 4	
20. Minimum CCP Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
21. Minimum SI Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
22. Minimum RHR Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
23. Maximum CCP Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
24. Maximum SI Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
25. Maximum RHR Pump Curve			See Attachment 4	See e-mail from 11-12-01 in Attachment A
26. RWST boron concentration, ppm	n/a	2300	See Attachment 4	
H. SAFETY INJECTION (ACCUMULATORS)				
1. Number of Accumulators	4	4	See Attachment 5	
2. Maximum Water / Gas Temperature, °F	120.0	120.	See Attachment 5	increased value is conservative. Should be equal to the initial containment temperature

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
3. Nominal Accumulator Water Volume, ft^3	850.0	n/a	See Attachment 5	Should NOT include any line volume or any undeliverable volume.
4. Range of Accumulator Water Volume, ft^3		n/a	See Attachment 5	
5. Uncertainty on Accumulator Water Volume, ft^3		n/a	See Attachment 5	
6. Minimum Gas Cover Pressure, psig	595.5	595.5	See Attachment 5	Value WITHOUT any uncertainty. Decreased value is conservative. [ ] a,c
7. Uncertainty on Gas Cover Pressure, psi	15.0	n/a	See Attachment 5	
8. Range of Gas Cover Pressure, psig	595.5 to 647.5	n/a	See Attachment 5	
9. Nominal Tank Volume, ft3	1350.0	1350.	See Attachment 5	Should not include any line volume
10. Individual Line Volumes, ft3	See List of Drawings in Table H-1	n/a	See Attachment 5	Should review for both units.
I. GENERAL CONTAINMENT ASSUMPTIONS AND LIMITS				
1. Containment Net Free Volume, ft^3	2.62×10^6	2.62×10^6	OK- Ref. TS 5.2.1.g	decreased value is conservative.
2. Initial Containment Temperature, °F	120.0	120.0	OK- Ref .TS 3/4.6.1.5	increased value is conservative. [ ] a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
3. Initial Containment Pressure, psia (Max)	15.0	15.0	OK- Ref. TS 3/4.6.1.4 14.7 psig +0.3/ -1.5 psi	[ ] a,c Input is typically atmospheric pressure plus the Tech Spec maximum allowable value.
4. Initial Containment Relative. Humidity, %	20.0	20.0	20% RH is documented in PSEG fuels S-C-VAR-NZZ-0020, R0, page 95 of 219 (attachment C table 2-1 to Westinghouse PSE 97-516).	[ ] a,c
5. Containment Walls / Heat Sink Properties	Table I-1 and Table I-2 Note, accumulators excluded	Table I-1 and Table I-2	See footnote[1]	decreased value is conservative.
6. Containment Design Pressure, psig	47.0	47.0	OK- Ref. TS 5.2.2	
7. Containment Temperature Limit, °F	Table I-3	Table I-3	Values in Table I-3 are the current Salem EQ temperature profile. While it is desirable to remain within this profile to avoid EQ impact, the values may shift due to reduced heat removal. However, TS Section 5.2.2 identifies the single design temperature of 351.3 °F.	

[1] Westinghouse Key Input Assumption table is consistent with UFSAR Table 15.4-20 (Passive Heat Sinks). This is based on the Salem UFSAR Revision 9 (1989). This table is calculated by Westinghouse using the best estimate values provided in Table 15.4-21 (Structural Heat Sinks). However, Table 15.4-21 has been updated a number of times since Revision 9. Westinghouse will need to review the current UFSAR (Revision 20) to evaluate whether current passive heat sink values are acceptable.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
8. Worst containment safeguards failure: • with offsite power • without offsite power	n/a diesel failure, lose 1 spray pump and 2 fan coolers	lose 1 spray and 2 fan coolers n/a	For the proposed new design, the failure of "C" vital bus results in the loss of 1 containment spray pump and 1 CFCU (from the new total of 3 CFCUs)	
J. CONTAINMENT SPRAY PUMPS				
1. Number of Containment Spray Pumps Operating • with offsite power and no failure • with offsite power and single failure • without offsite power and no failure • without offsite power and diesel failure	 2 n/a 2 1	 2 1 n/a n/a	See Attachment 6	decreased value is conservative.
2. Containment Spray Ring Nozzle Elevations, ft.	Upper 2 rings = 266.5 Lower 2 rings = 244.5	Upper 2 rings = 266.5 Lower 2 rings = 244.5	See Attachment 6	
3. Containment Spray Flowrate during the injection phase, gpm (1 pump & 2 pumps)	Table J-1 2600 / 5200 gpm @ 47 psig	Table J-1	See Attachment 6	decreased value is conservative.
4. Containment Spray Flowrate per pump during the recirculation phase with minimum safeguards and maximum safeguards, gpm	1974.8/2436.2	n/a	See Attachment 6	decreased value is conservative.
5. Maximum post accident delay time for effective spray flow to enter containment <u>after</u> the setpoint is reached with and without offsite power available, sec.	n/a / 85.0	85.0 / n/a	See Attachment 6	increased value is conservative.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
6. Time injection spray flow is terminated with minimum safeguards/maximum safeguards (after SI setpoint is reached), sec	4473.86/4073.86	n/a	See Attachment 6	[ ] a, c
7. Time recirculation spray flow is initiated with minimum safeguards/maximum safeguards (after SI setpoint is reached), sec	4473.86/4073.86	n/a	See Attachment 6	consistent with previous item. Include any period without flow.
8. RWST Temperature, °F	100.0	100.0	See Attachment 6	Increased value is conservative. Value must be consistent with injection phase SI flows and Containment Spray Flows. See item G.3.
K. CONTAINMENT FAN COOLERS				
1. Number of Containment Fan Coolers Operating • with offsite power and no failure • with offsite power and single failure • without offsite power and no failure • without offsite power and diesel failure	 5 n/a 5 3	 5 3 n/a n/a	3 cfcu's in new design. Any bus or cfcu failure leaves 2 3 2 3 2	Decreased value is conservative.
2. Fan Cooler Heat Removal Rate, BTU/sec per Fan Cooler	Table K-1	Table K-1	See revised Table K-1 based on new PSEG calc. S-C-SW-MDC-1968, 0IR0	decreased value is conservative.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
3. Maximum post accident delay time for effective Fan Cooler Performance after the setpoint is reached with offsite power available/without offsite power available, sec.	n/a / 60.0	60.0 / n/a	120 second delay for new design	increased value is conservative.
L. HEAT EXCHANGER				
1. Sketch illustrating the service water system as it relates to the safety equipment, including containment fan coolers, containment sprays, SI, CCW Heat Exchanger, RHR Heat Exchanger, etc.			Simplified P&ID's provided for U2 ECCS, RHR CS SW and SI.	For both the injection and recirculation phases.
2. Minimum number of available CCW Heat Exchangers	1	n/a	Confirmed. There are two CCHXs (one per train). – Reference P&ID 205231). Minimum safeguards based on single failure of one train.	decreased value is conservative.
3. CCW Heat Exchanger UA, 10^6 BTU/hr-°F	4.013	n/a	Confirmed Reference Proto-HX CCHX model from PSEG Calc S-C-CC-MDC-1798, Rev. 3, with the following inputs: SW inlet temp = 90°F; SW flow = 8000 gpm; CC inlet temp = 170°F; CC flow = 4140 gpm; Total fouling = 0.0016; 2% tube plugging	[ ] a,c

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response				
Design and Licensing Parameters	**Westinghouse LOCA Value**	**Westinghouse SLB Value**	**PSEG Confirmed Value**	**Notes**
4. CCW flow through CCW Heat Exchanger, gpm	4140.0	n/a	Confirmed. This is a conservative minimum value based on 4000 gpm to RHRHX and 140 gpm to miscellaneous components on a single CC train.	Decreased value is conservative. Value appears to be based on a System Description PSE/PNJ-200/C/3, Table 8.2-1 dated prior to 1989.
5. Maximum Service Water Temperature, °F	95.0	95.0	Use 93°F for consistency with CFCUs.	Increased value is conservative. All other references indicate that the maximum value should be 85.0. 85.0 Degrees would be consistent with the heat removal data for the fan coolers.
6. Minimum Service Water Flow per CCW Heat Exchanger, gpm	8000.0	n/a	Confirmed – Reference Westinghouse Transmittal PSE-94-605, Section 8.0.	decreased value is conservative.
7. Minimum number of available RHR Heat Exchangers	1	n/a	Confirmed. There are two RHRHXs (one per train). – Reference P&ID 205232). Minimum safeguards based on single failure of one train.	decreased value is conservative.
8. RHR Heat Exchanger UA (recirculation and post recirculation spray), 10^6 BTU/hr-°F;	1.75/1.375	n/a	Cannot confirm at this time – need further information.	[ ] a,c
9. RHR flow through RHR Heat Exchanger (recirculation and post recirculation spray), gpm	3287.5/7367.6	n/a	Cannot confirm at this time – need further information.	decreased value is conservative.
10. CCW flow per RHR Heat Exchanger, gpm	4000.0	n/a	Confirmed. Minimum CC flow in prior Containment analyses. (Eg: Westinghouse Transmittal PSE-94-605), Section 8.0). Flow setting in field based on obtaining this value under limiting conditions.	decreased value is conservative.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Design and Licensing Parameters	Westinghouse LOCA Value	Westinghouse SLB Value	PSEG Confirmed Value	Notes
11. Additional heat loads on the CCW system in addition to the RHR Heat Exchanger loads, such as miscellaneous equipment loads (i.e., Oil Coolers for SI pumps, Spent Fuel Pool, etc.), 10^6 BTU/hr	2.0	n/a	Confirmed. Assumed value in prior Containment analyses (Eg: Westinghouse Transmittal PSE-94-605, Section 8.0).	[ ] a, c

Figure C-1 Salem Steamline Break Protection System Logic

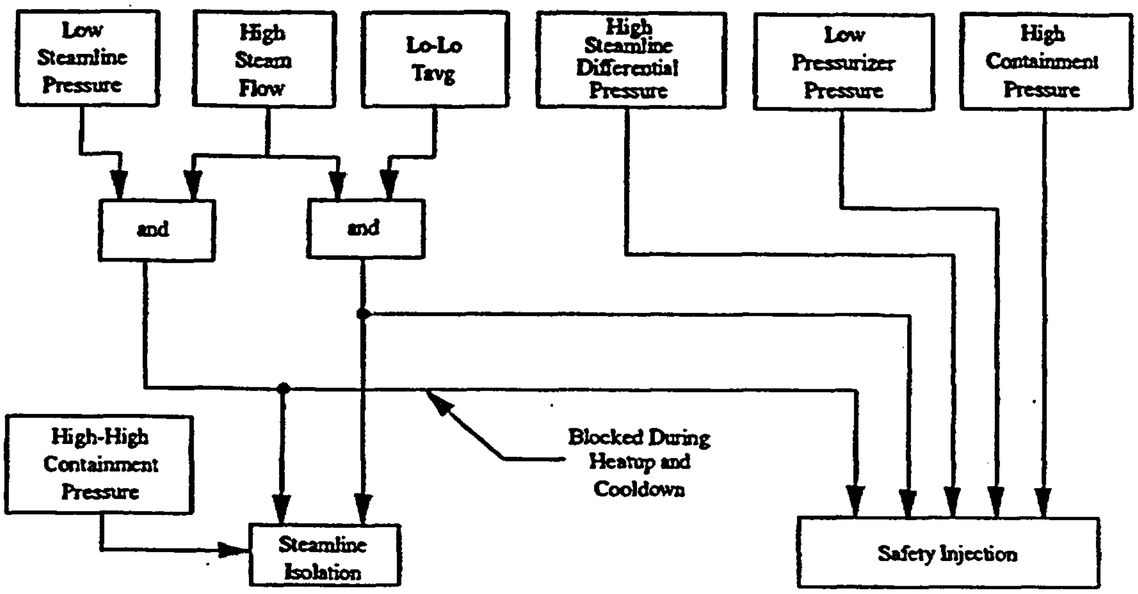


TABLE G-1
SALEM UNIT 1 & UNIT 2
PUMPED SAFETY INJECTION
INJECTION PHASE DATA
(MINIMUM SAFEGUARDS, a.k.a. Train Failure or Diesel Failure)
[No Lines Spilling Assumed]

RCS Pressure [psia]	Flow [lbm/sec]		
	CHG/SI* lbm/sec [GPM]	IHSI* lbm/sec [GPM]	LHSI lbm/sec [GPM]
14.7	50.97 [369.0]	76.79 [555.8]	549.22 [3975.92]
34.7	50.73	76.18 [551.7]	515.99 [3735.39]
54.7	50.49	75.57 [547.1]	480.72 [3480.01]
74.7	50.26	74.96 [542.8]	442.66 [3304.54]
94.7	50.02	74.36 [538.3]	400.89 [2902.15]
114.7	49.78 [360.4]	73.75 [533.8]	353.69 [2560.43]
134.7	49.54	73.25	297.51 2153.71]
154.7	49.30	72.76	222.69 [1612.08]
174.7	49.06	72.28	82.94 [600.39]
194.7	48.82	71.79	0
214.7	48.58 [351.7]	71.30 [516.0]	0

* Several values determined by interpolation
ρ = 62.0 lbm/ft3

TABLE G-1 (cont.) SALEM UNIT 1 & UNIT 2 PUMPED FLOW DURING RECIRCULATION PHASE* (MINIMUM SAFEGUARDS)	
RCS & Containment Pressure [psia]	Flow [gpm]
	Total Pumped Flow* No spilling line
14.7	3209.8

* Flow is the total pump RHR flow through the pump/heat exchanger. Flow to the reactor vessel is less if recirculation sprays are operational.

TABLE G-2
SALEM UNIT 1 & UNIT 2
PUMPED SAFETY INJECTION
INJECTION PHASE DATA
(MAXIMUM SAFEGUARDS, a.k.a. No Failure)
[No Lines Spilling Assumed]

RCS Pressure [psia]	Flow [lbm/sec]		
	2 CHG/SI * lbm/sec [GPM]	2 IHSI * lbm/sec [GPM]	2 LHSI lbm/sec [GPM]
14.7	121.02 [876.10]	114.06 [825.68]	1155.01 [8367.18]
34.7	120.62	113.34	1099.0 [7955.88]
54.7	120.22	112.62	1038.8 [7520.13]
74.7	119.81	111.9	974.57 [7055.13]
94.7	119.41	111.18	905.39 [6554.29]
114.7	119.0 [861.44]	110.46 [799.62]	829.98 [6008.39]
134.7	118.59	109.72	746.47 [5403.85]
154.7	118.18	108.98	651.92 [4719.36]
174.7	117.77	108.3	541.33 [3918.77]
194.7	117.36	107.62	405.2 [2933.45]
214.7	116.94 [846.55]	106.74 [772.73]	223.23 [1616.01]

* Several values determined by interpolation
ρ = 62.0 lbm/ft3

TABLE G-2 (cont.) SALEM UNIT 1 & UNIT 2 PUMPED FLOW DURING RECIRCULATION PHASE* (MAXIMUM SAFEGUARDS)	
RCS & Containment Pressure [psia]	Flow [gpm]
	Total Pumped Flow* No spilling line
14.7	7367.6

* Flow is the total pump RHR flow through the pump/heat exchanger. Flow to the reactor vessel is less if recirculation sprays are operational.

TABLE G-3 SALEM UNIT 1 & UNIT 2 SI Flow Assumed for SLB (1 CHG/SI & 1 IHSI) [No Lines Spilling Assumed]	
RCS Pressure [psia]	Flow [lbm/sec]
15	128.37
415	111.4
615	101.41
915	84.4
1315	45.65
1415	31.04
1815	23.10
2115	15.91
2315	5.29
2340	0.0

Table H-1
PSEG Document References for Accumulator Line Volumes

Unit 1

1) Calc Note #267211
1) Drawing 307036
2) Calc Note #267241
3) Calc Note #267246
4) Calc Note #267241C
5) Calc Note #267242
6) Calc Note #267243
7) Calc Note #267244

Unit 2

1) Drawing 138128
2) Calc Note #267241, Rev. 2
3) Calc Note #5671203LSI, Rev. 1
4) Calc Note #5671218, Rev. 1
5) Calc Note #567122, Rev. 1
6) Calc Note #5671223, Rev. 1
7) ~~Calc Note #5671225, Rev. 1~~

Table I-1

Salem Unit 1 and Unit 2 Structural Heat Sink Assumptions For Containment Integrity [1,2,&3]

Sink	SURFACES Description	Material	TOTAL EXPOSED AREA (ft^2)	THICKNESS (ft)
1	Paint Coating #1	Paint, Carbon Steel, & Concrete	45,169	0.03125, 4.5
2		Insulation, Carbon Steel, & Concrete	14,206	0.2083, 0.03125, 4.5
3	Paint Coating #1	Paint, Carbon Steel, & Concrete	29,249	0.04167 3.5
4	In contact with the sump; Paint Coating #2	Paint & Concret	11,611	3.5
5	Paint Coating #2	Paint & Concrete	6,806	1.5
6	Paint Coating #2	Paint & Concrete	9,424	1.71
7	Paint Coating #3	Paint & Concrete	31,660	1.5
8		Stainless Steel & Concrete	13,278.68	0.01773 1.9
9	Paint Coating #1	Paint & Carbon Steel	47,589.8	0.011
10	Paint Coating #1	Paint & Carbon Steel	76,741.2	0.02102
11	Paint Coating #1	Paint & Carbon Steel	19,348	0.0437
12	Paint Coating #1	Paint & Carbon Steel	9,330	0.0611
13	Paint Coating #1	Paint & Carbon Steel	7,451.5	0.086
14	Paint Coating #1	Paint & Carbon Steel	3,217.7	0.11124
15	Paint Coating #1	Paint & Carbon Steel	1,553.18	0.217
16	Paint Coating #1	Paint & Carbon Steel	43,740	0.0052
17		Stainless	4,272	0.0329
18	Paint Coating #1	Paint & Carbon Steel	53,745	0.0211
19	Paint Coating #1	Paint & Carbon Steel	11,243.59	0.0379
20	Paint Coating #1	Paint & Carbon Steel	2,989.4	0.15806

NOTES:

PAINT COATING SYSTEM THICKNESS:

Coating #1: 0.000625 ft Coating #2: 0.0015 ft Coating #3: 0.00117 ft

Table I-2

Structural Heat Sink Assumptions For Containment Integrity

MATERIAL	CONDUCTIVITY (Btu/hr-ft-°F)	VOLUMETRIC HEAT CAPACITY (Btu/ft³-°F)
Carbon Steel	27.0	58.8
Stainless Steel	8.0	53.6
Concrete	0.92	22.6
Insulation	0.024	3.94
Paint Coating #1	0.083	39.6
Paint Coating #2	0.083	39.6
Paint Coating #3	0.083	39.6

Table I-3
Containment Temperature Limit Profile

Time (seconds)	Temperature (deg-F)
0	120
1	165
3	217
6	240
20	265
60	351
80	351
150	325
240	270
1,000	265
4,000	237
4,800	224
18,000	224
180,000	172
518,400	160
1,000,000	140
4,406,400	132
8,640,000	119
10,368,000	113.2

TABLE J-1

**MINIMUM DELIVERED SPRAY FLOW
(INJECTION PHASE)**

Containment Pressure (PSIG)	Flow (GPM)	
	Current Value (with 1 Pump)	Current Value (with 2 Pumps)
0	3117.0	6234.0
10	3017.0	6034.0
20	2913.0	5826.0
30	2720.0	5440.0
40	2687.0	5374.0
47	2600.0	5200.0

TABLE K-1
MINIMUM FAN COOLER HEAT REMOVAL RATE vs. CONTAINMENT TEMPERATURE

Containment Temperature [°F]	Heat Removal Rate [BTU/sec per Fan Cooler]	
	Current Design Basis Value*	PSEG Confirmed Value
	LOCA/MSLB	PSEG Confirmed Value
105	100.0	606.6
120	1600.0	1502.3
140	3355.56	2922.8
160	5388.89	4522.1
180	7666.66	6205.2
200	9897.22	7888.0
240	14511.11	11257.2
260	16858.33	12950.8
271	18047.22	13869.6
280	19052.77	14588.8

Basis: Service Water Temperature 93.0°F
Service Water Flow 1000 gpm

- ~~Current Design Basis includes a 50% degradation in heat removal during the first 2 minutes of operation due to nitrogen from the service water system accumulators.~~
- **All values taken from PSEG calculation S-C-SW-MDC-1968, 0IR0.**

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Signatures

Section	Items	Prepared By	Reviewed By
A. Core Parameters	1 thru 11	Fuels Group O.S. Schwartz	Fuels Group
B. Reactor Coolant System	1 thru 8	Fuels Group O.S. Schwartz	Fuels Group
C. Protection System Logic, Setpoints, Delays	1 thru 17	Paul Finch	John Pehush
D. Steam Generators	1 & 2	Fuels Group O.S. Schwartz	Fuels Group
	3	SG Group T. Scott Bell	SG Group Tina M Nolte
E. Steamline	1, 3, 4	Valve Engineering Group DJW 7/11/03	Valve Engineering Group Ozzy McCollum
	2	Fuels Group O.S. Schwartz	Fuels Group
	5	Kiran Mathur	Paul Finch
F. Main & Auxiliary Feedwater	6, 10,	Fuels Group O.S. Schwartz	~~James Murphy~~ Kiran Mathur
	1, 5	Fuels Group O.S. Schwartz	Fuels Group
	2, 3, 4, 7, 8, 12 thru 20	Valve Engineering Group M.J. Parker	Valve Engineering Group Ozzy McCollum
	9, 11	Kevin King Kevin King	John Rowey
	21	Kiran Mathur	Paul Finch
G. Safety Injection (Pumped SI)	1 thru 26	Mike Crawford	John Rowey
H. Safety Injection (Accumulators)	1 thru 10	Mike Crawford	John Rowey
I. General Containment Assumptions & Limits	1 thru 8	John Rowey	Kevin King Kevin King
J. Containment Spray Pumps	1 thru 8	Mike Crawford	John Rowey
K. Containment Fan Coolers	1 thru 3	John Rowey	Kiran Mathur
L. Heat Exchangers	1 thru 11	Kevin King Kevin King	John Rowey

Attachment A

E-mail Verifying that Plant Configuration has not changed

From: Ted DelGaizo [mailto:[redacted]@mlea.com]
Sent: Monday, November 12,2001 456 PM
To: '[redacted]@westinghouse.com'
cc: ' Rob DeNight
Subject: FW: 3604.tif

Chuck: The attached TIF file (3604tif) provides copies of the Salem RHR pump curves (from the CBD). I compared these curves with the individual pump curves in the Salem (DMS) data base (for the 3 of 4 pumps that were located -- also attached as TIF files), and the curves were identical to the attached CBD curves. Also, discussions with the System Manager and RHR Design Engineer confirm that the original RHR pumps are still installed.
A search of the Salem DMS system and my review of the RHR CBD did not uncover any modifications to the system throughout the 1990s that would impact the RHR PEGISYS model. Discussions with the System Manager and RHR Design Engineer also confirmed that piping, valves, or equipment elevations have not been changed since 1991 that would otherwise invalidate the flow model.

Please contact me if you have further questions. Regards, Ted DelGaizo, Main Line Engineering Associates

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 1

Vessel Head Changes

Both Salem reactor vessel heads are being replaced during the 2005 refueling outages. In general, the primary change to the heads is that the excess penetrations are being removed. For Unit 1, there will be 53 CRDM penetrations in addition to head vent and RVLIS penetrations. For Unit 2, there will be 57 CRDM penetrations (with 53 CRDMs/RCCAs installed) in addition to head vent and RVLIS penetrations.

Regarding dimensions, the new head will be roughly the same as the old head such that it mates up with the vessel and RCCAs properly. Below are a few of the critical dimensions, locations, movements, and modifications.

Inner Head Radius = 83.72 inches - 0.25 inch cladding
Radius Rotation Point = 3.38 inches above bottom of vessel head
Head Height (Flat Plane of CRDM Penetrations Top to Bottom of Head) = 108.00 inches
Penetration Housing Protrusion Depth Below Head Inner ID = 2.00 inches
Penetration Housing OD = 4.00 inches
Penetration Housing ID = Unchanged Head Thickness = 7.00 inches + 0.25 inch cladding
Head Flange Height = 29.00 inches
Head OD at Flange = 205.00 inches
Number of Stud Holes = 54 equally spaced
Stud Hole Diameter = 7.50 inches

CRDM Penetration Locations for Unit 1

B6, B8, B10, C3, C5, C7, C9, C11, C13, D4, D8, D12, E3, E9, E13, F2, F6, F8, F10, F14, G3, G5, G13, H2, H4, H6, H8, H10, H12, H14, J3, J11, J13, K2, K6, K8, K10, K14, L3, L7, L13, M4, M8, M12, N3, N5, N7, N9, N11, N13, P6, P8, P10

CRDM Penetration Locations for Unit 2

B4, B6, B8, B10, B12 (Old / Spare), C5, C7, C9, C11, D2 (Old / Spare), D4, D8, D10 (New), D12, D14, E3, E13, F2, F4 (New), F6, F8, F10, F14, G3, G13, H2, H4, H6, H8, H10, H12, H14, J3, J13, K2, K6, K8, K10, K12 (New), K14, L3, L13, M2, M4, M6 (New), M8, M12, M14 (Old / Spare), N5, N7, N9, N11, P4 (Old / Spare), P6, P8, P10, P12

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 1

The plan is to move four Shutdown Bank A RCCAs from the "Old / Spare" locations to the "New" locations listed above for Unit 2. The "Old / Spare" locations will be penetrations in the head, but no CRDM will be mounted at those locations.

While the information above may change with the final as-built vessel heads, it is considered acceptable to access impacts to the CFCU containment analyses. This also holds true for the descriptions of the vessel internals modifications and integrated head assembly provided below.

Internals Modifications

Since all part-length RCCAs are being removed, the internals will have to be modified accordingly. For Unit 1, plates will be mounted on the top of the internals locations for all eight part-length RCCAs since the will no longer be installed and penetrations will not be created in those locations.

For Unit 2, the "New" CRDM locations are where four of the old part-length RCCAs were installed. Thus, eight plates will be installed at the top of the internals similar to Unit 1, but four will be in the other part-length locations. The other four will be installed in the "Old / Spare" locations listed above since no RCCAs will be installed in these penetration locations.

Integrated Head Assembly (IHA) Package

In addition to the changes noted above, PSEG plans to install a Framatome-designed IHA which is similar to those used at other Westinghouse plants (such as Shearon Harris, Vogtle, Seabrook, South Texas, Byron, and Braidwood). The salient difference in light of containment response post-LOCA / post-SLB relates to the weight of the new structure in comparison to the currently installed structure. The new IHA is expected to be approximately 60,000 pounds heavier than the current control rod drive service structure. This extra weight is attributable to the integral missile shield, which is being added. Consistent with the current structure, the IHA will be adequately cooled via three properly sized fans at the top of the structure. Thus, with respect to modeling of this structure in the Westinghouse containment models in relation to heat sinks / sources, the modeling should be consistent in nature with that used in the current licensing-basis analyses, only with a larger mass assumption.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 2

Item F-9: Auxiliary Feedwater Flow Rates

LOCA

190 gpm is a conservative minimum. Value based on PSEG Fuels Letter NFU-93-083 for MDAFP failure, which states 1120 gpm total, with a minimum of 190 gpm to any one SG. Thus a higher value could be supported, if necessary. Note that the flow is higher for a non-AFW failure – 320 gpm per SG, 1280 gpm total; flow is lower for a TDAFP failure – 700 gpm total.

MSLB

Use flow rates determined from Proto-Flo AFW model per PSEG Calculation S-C-AF-MDC-0445, Rev. 2, with 5% margin added – see Table F-9 on Pages 2 and 3 of this attachment. Except for the cases where faulted SG pressure = non-faulted SG pressure, the flows are less than those from NFU-93-083, and will provide margin for the MSLB analysis. Note that the peak SG pressure is reduced from 1133 psia to 1117 psia.

To our understanding, it is desired by Westinghouse to input individual SG AFW flows for the non-faulted SGs. Due to the limitations of Proto-Flo, only select cases from the faulted/non-faulted SG pressure matrix were performed. The flows for the remaining cases were determined using curve-fits (Reference Jandel Scientific "TableCurve Windows", ver. 1.0). For the non-faulted SG flow, the curve-fits were done on the sum of the three non-faulted SG flows, rather than individually. Thus, the only individual SG flows available are from the specific Proto-Flo cases run. For individual SG flows for all the matrix cases, additional curve-fits will be needed. Included in Pages ### of this attachment are the Proto-Flo results per SG (with model error included), curve-fits and resultant flow matrix (with and without the added 5% margin). This data can be used to support development of the additional curve-fits required for the individual SG flows.

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 3

Table F-9A: MSLB AFW flows with no AFW-failure

Unfaulted SG — Faulted SG ↓	500	600	650	700	750	800	850	900	1000	1117
1117										638 1601
1000									711 1802	855 1454
900								754 1956	856 1705	1010 1349
850							769 2018	811 1916	919 1662	1062 1321
800						781 2068	821 1982	865 1880	980 1621	1117 1288
750					791 2106	828 2033	870 1948	914 1847	1030 1586	1166 1258
700				800 2139	835 2073	870 2001	916 1915	961 1815	1079 1553	1210 1232
650			810 2171	842 2108	876 2042	912 1970	957 1885	1002 1786	1123 1523	1248 1210
600		820 2202	851 2141	882 2078	920 2008	956 1936	997 1856	1041 1759	1161 1497	1271 1205
500	840 2260	897 2144	929 2082	961 2019	991 1954	1027 1883	1066 1803	1110 1711	1236 1445	1343 1157
400	914 2206	971 2090	999 2029	1029 1967	1061 1901	1096 1830	1133 1754	1175 1663	1298 1402	1392 1129
300	982 2156	1036 2040	1064 1981	1093 1918	1123 1853	1156 1784	1192 1708	1233 1620	1354 1363	1445 1091
200	1046 2109	1097 1994	1126 1933	1155 1871	1186 1806	1218 1737	1246 1666	1285 1581	1402 1328	1483 1069
100	1105 2064	1156 1950	1182 1891	1211 1829	1240 1764	1270 1696	1299 1624	1337 1540	1451 1293	1533 1030
15	1152 2029	1201 1916	1226 1857	1253 1796	1282 1732	1311 1664	1345 1589	1382 1505	1494 1263	1581 991

Note: 1) Top Number is AFW flow to faulted SG (gpm)
2) Bottom Number is total AFW flow to 3 non-faulted SGs (gpm)

Table F-9B: MSLB AFW flows with runout protection failure

Unfaulted SG → Faulted SG ↓	500	600	650	700	750	800	850	900	1000	1117
1117										644 1676
1000									753 1846	864 1516
900								892 1840	930 1699	1028 1425
850							959 1832	965 1787	1006 1645	1083 1397
800						1005 1853	1020 1798	1031 1744	1085 1598	1143 1371
750					1036 1887	1058 1830	1077 1769	1093 1710	1138 1569	1198 1351
700				1066 1922	1089 1864	1109 1808	1133 1745	1153 1681	1195 1542	1249 1334
650			1096 1956	1117 1899	1138 1843	1158 1787	1182 1723	1202 1659	1246 1521	1295 1320
600		1123 1988	1145 1934	1166 1877	1189 1821	1210 1765	1230 1704	1251 1639	1283 1510	1323 1312
500	1176 2052	1218 1945	1240 1890	1260 1834	1278 1781	1297 1726	1317 1668	1335 1608	1378 1475	1414 1283
400	1269 2010	1308 1905	1327 1852	1346 1797	1365 1743	1383 1688	1400 1635	1418 1576	1451 1448	1483 1257
300	1355 1972	1391 1868	1409 1815	1427 1762	1444 1707	1460 1654	1477 1598	1493 1541	1523 1412	1558 1219
200	1435 1936	1469 1833	1487 1780	1505 1726	1522 1673	1538 1619	1547 1559	1560 1505	1585 1381	1615 1188
100	1511 1901	1544 1800	1560 1748	1575 1695	1592 1641	1607 1588	1617 1525	1630 1470	1656 1345	1687 1154
15	1571 1874	1602 1773	1617 1722	1632 1669	1648 1616	1662 1563	1677 1509	1692 1453	1720 1329	1752 1140

Note: 1) Top Number is AFW flow to faulted SG (gpm)
2) Bottom Number is total AFW flow to 3 non-faulted SGs (gpm)

G. Safety Injection (Pumped SI)

1. Minimum Safeguards
   - ✓ LOCA:

INJECTION PHASE

Vital Bus Fails → Operating ESF Pumps

- Bus A Fails: #2 (B) RHRP, #2 (C) IHSIP, #1 (B) and #2 (C) HHSIP; #2 (C) CSP
- Bus B Fails: #1 (A) RHRP, #1 (A) and #2 (C) IHSIP, #2 (C) HHSIP; #1 (A) and #2 (C) CSPs
- Bus C Fails: #1 (A) and #2 (B) RHRP, #1 (A) IHSIP, #1 (B) HHSIP; #1 (A) CSP if > Hi-Hi on 2/4 Containment Pressure
- Ref. Dwg. 205350

RECIRC. PHASE

Vital Bus Fails → Operating ESF Pumps

- Bus A Fails: #2 (B) RHRP, #2 (C) IHSIP, #1 (B) HHSIP; #1 (A) CC16 No power to Open → No CCW for #1 RHRHX; Open #2 (B) CS36 for RHR Recirc Spray
- Bus B Fails: #1 (A) RHRP, #1 (A) IHSIP, #2 (C) HHSIP; #2 (B) CC16 No power to Open → No CCW for #2 RHRHX; Open #1 (A) CS36 for RHR Recirc Spray
- Bus C Fails: Start #2 (B) RHRP, #1 (A) IHSIP, #1 (B) HHSIP; Close #1 (A) CC16 → no CCW to #1 RHRHX; #2 (B) CC16 Open, CCW to #2 RHRHX; Close #2 (B) SJ49 valve; Open #2 (B) CS36 for Recirc Spray.

  The resulting alignment has 1 RHRP, 1IHSIP, 1 HHSIP, and 1 recirc spray and no RHR cold leg injection.

- At 14 hours post-LOCA, commence hot leg injection with operating IHSIP by closing associated SJ134 valve and opening associated SJ40 valve.
- Per W: 3 lines inject and lowest resistance line spills into containment backpressure; RHRP and IHSIP inject into Accumulator line which then injects into cold leg; HHSIP injects directly into cold leg; pump performance degraded and line resistances calculated conservatively high; RCP seal flow not included in delivered flow.

SLB:

- ✓ For the circumstance where offsite power is lost, the EDGs are relied on to supply emergency power to the safeguards equipment. If one EDG fails in this situation, power will be lost to the RCPs and one train of SI as well as one train of containment safeguards equipment.
- ✓ Minimum SI flow assumed in all cases because reduced boron addition maximizes return-to-power resulting from RCS cooldown and the higher power generation increases heat transfer to the secondary side, maximizing steam flow out break
- ✓ SI delay time = 22 seconds with offsite power available (42 seconds without offsite power available)
- ✓ Effect of reduced containment safeguards accounted for in the Containment Response analyses
- ✓ The assumption of a trip of all RCPs coincident with reactor trip is less limiting than with offsite power available because the mass and energy releases are reduced due to the loss of forced reactor coolant flow resulting in less primary-to-secondary heat transfer

Containment Response:

- ✓ Same as for LOCA except that assume no injected flow spills before entering core; i.e., break on hot leg side of reactor vessel so that all of injected flow first passes through core before passing out break in RCPB.

References:

1) EOP-LOCA-3
2) Ref. Dwg. 205350

2. Maximum Safeguards
   - ✓ LOCA:

     INJECTION PHASE:

     LBLOCA:

     - ✓ No safety-related equipment or bus failure or single active failure
     - ✓ 2 RHRP, 2 IHSIP, 2 HHSIP; and 2 CSPs; 3 lines inject and highest resistance line spills into containment backpressure

Attachment 4

- ✓ RHRPs and IHSIPs inject into Accumulator line which then injects into cold leg
- ✓ HHSIPs injects directly into cold leg
- ✓ Pump performance increased by 10 percent and line resistances calculated conservatively low
- ✓ RCP seal flow is considered in developing SI flows and seal injection is included in delivered flow for maximum safeguards cases.
- ✓ Maximum Fan Cooler Heat Removal Capacity per cooler (NFU-92-804).

  NOTE: the maximum CFCU heat removal rates will ultimately be reduced, since our intent is to reduce the number of operable Fan Coolers from 5 to 3. Also, cooling water flow to each Fan Cooler will be reduced.

  It is our understanding that maximum CFCU heat transfer was used only in the LOCA PCT analysis. If needed by Westinghouse, PSEG can provide new (i.e. lower) maximum heat transfer rates OR if not overly penalizing, the current values can be used recognizing that they are conservative. Westinghouse to advise.

- ✓ Safety Injection Flows ~~based on data provided~~ by ~~NFUI-91-~~ 151, PSE-91-038, and WCAP-12491

SBLOCA:

- ✓ Maximum seal injection flow considered in developing SI flows but is not credited as an RCS injection path for safety injection
- ✓ Containment Spray System and Containment Fan Coolers not modelled
- ✓ Typically RCS pressure does not fall to RHR pump shutoff head during modelled portion of transient so RHR pump flow is not included
- ✓ Pump performance degraded 5% and line resistances are calculated conservatively high

✓ 3 lines inject and minimum resistance line spills to RCS backpressure

RECIRC. PHASE:

LOCA:

✓ No safety-related equipment or bus failure or single active or passive failure

✓ 2RHRP, 2IHSIP, 2HHSIP and 1 CS Header

✓ One RHR pump is feeding suction of both HHSI and IHSI pumps and a containment spray header but isolated from low head cold leg injection. One RHR pump is feeding suction of both HHSI and IHSI pumps and low head cold leg injection.

SLB:

✓ N/A (from W Table)

Containment Response:

✓ Same as for LOCA except that assume no spillage of injected flow; i.e., all injected flow passes through core before passing out break to maximize energy release to containment.

3. Minimum Deliverable RWST Volume (gal)

✓ Salem Unit 1

(1) Total Usable Volume (T/S Min @ 40.5') = 338,446
(2) Low Level Alarm Usable Volume (@15.25') = 124,543
(3) Low-Low Level Usable Volume (@ 1.0') = 6062
(4) Total Contained Volume (T/S Min @ 40.5') = 364,500
(5) Low Level Alarm Contained Volume (@15.25') = 150,597 (150,153 @ 15.2' per Ref. 3)
(6) Low-Low Level Contained Volume (@ 1.0') = 19089 (29,691 @ 1.0' Low-Low per Ref. 3)
(7) Process Limit between T/S Min and Low Level Alarm = 207,800 gal (Ref. 3)
(8) Process Limit between Low Level Alarm and Low-Low Level Alarm = 105,192 gal (Ref. 3)

✓ Salem Unit 2

(1) Total Usable Volume (T/S Min @40.5') = 338,446
(2) Low Level Alarm Usable Volume (@15.25') = 124,543

(3) Low-Low Level Usable Volume (@1.0') = 5,677
(4) Total Contained Volume (T/S Min @ 40.5') = 364,500
(5) Low Level Alarm Contained Volume (@15.25) = 150,597 (150,577 @ 15.25' per Ref. 4)
(6) Low-Low Level Contained Volume (@ 1.0') = 31,731 (31,727 @ 1.24' Low-Low per Ref. 4)
(7) Process Limit between T/S Min and Low Level Alarm = 204,500 gal (Ref. 4)
(8) Process Limit between Low Level Alarm and Low-Low Level Alarm = 108,500 gal (Ref. 3)

✓ Minimum Initial RWST Volume = 313,000 gallons

(1) T/S 3.5.5
(2) W ELE-93-0314
(3) Sums of Process Limits in items (7) and (8) above for both Salem Units are (approximately for Unit 1) = 313,000 gal – Process Limit volumes account for instrument uncertainty in RWST Level instrumentation (for Unit 1: LT-920 and LT-921; and for Unit 2: LT-960, LT-961, LT-962, and LT-963)
(4) Volumes from Ref. 1 are calculated based on RWST diameter measurement and heights of alarms wrt bottom of tank
(5) $\Delta V/\Delta h$ = 8483.2 gal/ft (Ref. 1 and 2)

✓ Reference:

(1) S-C-VAR-MDC-1429 (Basis for Usable Volumes)
(2) S1(2).OP-TM.ZZ-0002
(3) SC-SJ006-01, Salem Unit 1 RWST Level Uncertainty Calculation (Page 63)
(4) SC-SJ007-01, Salem Unit 2 RWST Level Uncertainty Calculation (Page 52)

✓ Volumes same for LOCA, MSLB, or Containment Response.

4. Maximum Safety Injection Water Temperature during Injection Phase (°F)

✓ 100 °F (Range 40 to 100 °F)
✓ Reference: S-C-CS-MEE-0561, Maximum Temperature of RWST

5. Maximum Delay Analysis Time to Reach Full Flow for Minimum Safeguards (LOP, EDG S/U, Signal Process Time, Valve Stroke Times, etc.)

✓ 32 seconds for LOCA
✓ 22 seconds for MSLB with Offsite Power
✓ 42 seconds for MSLB without Offsite Power

- ✓ Reference: Page 5-161 of Fuel Upgrade & Margin Recovery Reload Transition Report and Page 54 of S-C-VAR-NZZ-0020.

6. Minimum Delay Time to Reach Full Flow for Maximum Safeguards (LOP, EDG S/U, Signal Process Time, Valve Stroke Times, etc.)

   - ✓ 32 seconds

7. Time for SI Switchover to Recirculation with Minimum Safeguards

   - ✓ Total time unknown and requires calculation to determine. (See VTDs 323585 and 323001 for possible times)

8. Time for SI Switchover to Recirculation with Maximum Safeguards

   - ✓ Total time unknown and requires calculation to determine.

9. Safety Injection Flows for ECCS Train Failure (LOCA)

   - ✓ See Data Tables below: Item #1, Table G-1.

10. Safety Injection Flows for all ECCS Pumps (LOCA)

    - ✓ See Data Tables below: Item #2, Table G-2.

11. Minimum SI Flow Rates from 1 HHSI and 1 IHSI with no spill (SLB)

    - ✓ See Data Tables below: Item #3, Table G-3.

    W to advise and/or provide reference for data to be confirmed. Combined data from two cases based on different W letters.

12. SI Volume between RWST and RCS (ft^3)
    (For HHSI only because RCS pressure for SLB remains greater than shutoff head of LHSI (RHR) pumps and probably IHSI pumps, also.)

    - ✓ See Discussion under Data Tables below: Item #4, Table G-12.
    - ✓ From NFS 98-170 (S-C-VAR-NZZ-0020, pg. 54 and Figure 5-1)

High Head Safety Injection System Volumes	
Section Boundaries	Volume (ft^3)
RWST to HHSI Pump Suction Hdr. Isol. (SJ1 and SJ2)	28.8

HHSI Pump Suction to BIT disch. (Dwnstm. SJ4/SJ5)	41.2
BIT Path (Volume between SJ4/SJ5 and SJ12/SJ13)	120.0
Common Header From SJ12/SJ13 to Individual C/Ls	2.5
C/L Injection Path	1.11
C/L Injection Path	0.83
C/L Injection Path	1.34
C/L Injection Path	1.31

Total volume in SI lines from RWST to RCS = approximately 197 ft^3

13. SI Line Initial Boron Concentration (ppm)

 ✓ 0 ppm. Concentration may vary from 0 to 2500 ppm.

14. Boron Injection Tank Boron Concentration (ppm)

 ✓ 0 ppm. Concentration may vary from 0 to 2500 ppm.

15. Minimum Containment Sump Elevation (ft)

 ✓ ~70 ft is bottom of sump. For RHR switchover, sump level must be > 62% or 80'-11" (includes uncertainty) per EOP-LOCA-3 to ensure RHR NPSHR met.

 ✓ RHR NPSH Requirements from UFSAR Table 6.3-13: (See Calculation S-C-RHR-MDC-1711 for NPSHA)

 a. Unit 1:
 - C/L Recirculation = 25.0 ft
 - *H/L Recirculation = 24.0 ft*

 b. Unit 2:
 - C/L Recirculation = 22.8 ft
 - H/L Recirculation = 24.0 ft

 c. Reference:
 - W PSE-97-527 (02/21/1997)

16. RHR Pump Suction Centerline Elevation (ft)

 ✓ 46'-10" ()

17. RHR Pump Discharge Centerline Elevation (ft)

- ✓ 46'-10" (267202, 267202)

18. RCS Cold Leg Elevations (ft)

    - ✓ 97'-0"

19. RCS Hot Leg Elevations (ft)

    - ✓ 97'-0"

20. Minimum HHSI Pump Curve

    - ✓ See Data Tables below: Item #5, Table G-20.

21. Minimum IHSI Pump Curve

    - ✓ See Data Tables below: Item #6, Table G-21.

22. Minimum RHR Pump Curve

    - ✓ See Data Tables below: Item #7, Table G-22.

23. Maximum HHSI Pump Curve

    - ✓ See Data Tables below: Item #8, Table G-23.

24. Maximum IHSI Pump Curve

    - ✓ See Data Tables below: Item #9, Table G-24.

25. Maximum RHR Pump Curve

    - ✓ See Data Tables below: Item #10, Table G-25.

26. RWST Boron Concentration (ppm)

    2300 to 2500 ppm (T/S 3.5.5.b; S1(2).OP-ST.CVC-0010; UFSAR Table 6.3-4)

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 5

H. Safety Injection Accumulators

1. Number of Accumulators

   ✓ 4

2. Maximum Water/Gas Temperature (°F)

   ✓ 120 °F

3. Nominal Accumulator Water Volume (ft^3)

   ✓ 850 ft^3

4. Range of Accumulator Water Volume (ft^3)

   ✓ 831.95 to 868.98 ft^3 (6223 to 6500 gal)

5. Uncertainty on Accumulator Water Volume (ft^3)

   ✓ Normal Uncertainty = 81.89 gal (Rounded to 85 gal)
   Max = 893.85 ft^3 and Min = 807.09 ft^3 (includes 101 gal tank uncert.)
   T/S High = 868.98 ft^3 and T/S Min = 831.95 ft^3

   ✓ Accident Uncertainty = 348.59 gal (Rounded to 350 gal)

   ✓ Post-Accident Uncertainty =207.33 gal (Rounded to 210 gal)

   ✓ W indicated enough margin exists in Safety Analysis to allow 100 gal instrument uncertainty
   Max = 895.86 ft^3 and Min = 805.08 ft^3 (includes 101 gal tank uncert.)
   T/S High = 868.98 ft^3 and T/S Min = 831.95 ft^3

References:

1) SC-SJ001-01
2) W ELE-92-0587
3) T/S 3.5.1
4) S-C-VAR-MDC-1429

6. Minimum Gas Cover Pressure (psig)

   ✓ 577.5 psig (Accident Analysis)

- ✓ 595.5 psig (T/S Minimum = Accident Analysis + Overall Channel Uncertainty)

- ✓ 600 psig (UFSAR Table 6.3-2)

Reference:
VTD 304209

7. Uncertainty on Gas Cover Pressure (psi)

   - ✓ Overall Channel Uncertainty = 18 psi (W)

   - ✓ Instrument Uncertainty as calculated by PSEG Calc SC-SJ002-01 = 15 psi

References:
1) W ELE-92-0578
2) SC-SJ002-01

8. Range of Gas Cover Pressure

   - ✓ 595.5 to 647.5 psig

9. Nominal Tank Volume (ft^3)

   - ✓ Total Volume = 1350 ft^3

References:
VTDs 107630, 107633, 109845, and 109847

10. Individual Line Volumes (ft^3)

    See Data Tables below: Item #11, Table H-1, Document References for Accumulator Line Volumes.

J. Containment Spray Pumps

1. Number of Containment Spray Pumps Operating (Injection Phase Only)

   - With offsite power and no failure:
     ✓ 2 CSPs
   - With offsite power and single failure:
     ✓ For single failure of either CSP or failure of either A or B bus, 1 CSP; otherwise, 2 CSPs
   - Without offsite power and no failure:
     ✓ 2 CSPs
   - Without offsite power and EDG failure:
     ✓ For A or C EDG failure, 1 CSP; for B EDG failure, 2 CSPs

2. Containment Spray Ring Nozzle Elevations (ft)

   Salem Unit 1 Spray Headers:
   - 12A Header 269'-0", 67 spray nozzles
   - 11A Header 266'-6", 67 spray nozzles
   - 12B Header 247'-0", 96 spray nozzles
   - 11B Header 244'-6", 96 spray nozzles

   Salem Unit 2 Spray Headers:
   - 22A Header 269'-0", 68 spray nozzles
   - 21A Header 266'-6", 68 spray nozzles
   - 22B Header 247'-0", 96 spray nozzles
   - 21B Header 244'-6", 96 spray nozzles

   Reference:
   Dwgs. 237435, 237438, 207466, 218216
   Construction Iso's CS12A, Sheet 1; CS12B, Sheet 1; CS23, Sheets 3-6

   Per PSEG Letter, PSE-416 (05/17/75), Westinghouse informed that one nozzle in both upper spray ring headers was eliminated in Salem Unit 1. W iodine analysis (BURL-3149 dated 06/06/75) assumes 68 spray nozzles. Negative impact of less spray nozzles offset by higher spray efficiency caused by reduction in droplet size due to increased differential pressure across remaining nozzles.

3. Containment Spray Flowrate during Injection Phase (gpm)

Containment Spray Header Flow Rates (gpm)		
Containment Pressure (psig)	1 CS Pump Flow (gpm)	2 CS Pump Flow (gpm)
0.0	3117.0	6234.0
10.0	3017.0	6034.0
20.0	2913.0	5826.0
30.0	2720.0	5440.0
40.0	2687.0	5374.0
47.0	2600.0	5200.0

References:
1) S-C-VAR-NZZ-0020
2) W SECL 96-178

Same as Table J-1 in W LTR-CRA-03-XYZ (06/16/03)

a. In addition, see Table 12: J-3 Containment Spray Pump Flow-Head Curves during Injection Phase.

b. Nominal Spray flow = 2600 gpm for one pump (Containment Integrity) except for dose calculations (RG 1.4) only in which spray flow is degraded = 2460 gpm and = 2469 gpm for containment sump pH (7 to 10) during recirculation phase.

c. Maximum Spray header flowrate = 7138 gpm for minimum system resistance and containment backpressure = 10 psig.

NOTE: In order to agree with assumptions in LOCA analyses about containment backpressure applied to the fluid that is escaping via the RCPB break, CS system flow rate must not exceed 3800 gpm (single pump) or 7600 gpm (two pump)

Unit 1 RWST Drain Down Analysis, W PSEBO-97-024 (12/23/1997)
Unit 2 RWST Drain Down Analysis, W PSEBO-97-014 (05/15/1997)

d. (UFSAR Table 15.4-3; S-C-VAR-NZZ-0020, Attachment A; W PSE-95-837)

4. Containment Spray Flowrate Per Pump During Recirc Phase with Minimum and Maximum Safeguards (gpm)

a. There is no Containment Spray Pump flow during the Recirculation Phase. At the RWST low level (~15.25 feet), if two CSPs running, one is secured. The other runs until the RWST low-low level (~1 feet) is reached at which point it is secured. During the Recirculation Phase, containment spray is provided by one RHR pump via the CS36 valve to one containment spray header. The RHR pump is also supplying the suction of the HHSI and IHSI pumps, but its cold leg injection path is blocked (SJ49 closed).

b. The minimum case would have one RHR pump providing 1 HHSI and 1 IHSI pump suction plus spray and no low head cold leg injection.

c. The maximum case would have 2 RHR pumps providing 2 HHSI and 2 IHSI pump suctions (via the SJ45s and SJ113s). One RHR pump would also provide spray (via its CS36) but no cold leg injection (its SJ49 closed) and the other RHR pump would provide no spray (its CS36 closed) but two low head cold leg injection (its SJ49 valve open).

d. Caveat: for RHR to inject, RCS pressure must be low enough for low head to overcome accumulator pressure that prevents low head injection by seating the SJ43 check valves until accumulator pressure decreases below RHR SOH or SJ54 is closed. For LBLOCA, assume delay of 45 seconds for accumulator Blowdown before RHR cold leg injection flow can commence.

5. Maximum Post-Accident Delay Time for Effective Spray Flow to Enter Containment After the Hi-Hi Containment Pressure Setpoint Reached

- With Offsite Power (seconds)
  85 seconds

- Without Offsite Power (seconds)
  85 seconds

6. Time Injection Spray is Terminated with Minimum and Maximum Safeguards

a. Minimum Safeguards Time (seconds) = at time reach Low-Low RWST Level in EOP-LOCA-3—one CSP, 1 HHSI, and 1 IHSI pumps running from Low to Low-Low Level in RWST. The HHSI and IHSI pumps are supposed to be switched over to recirculation before reaching Low-Low Level. The RHR pump may be stopped during switchover and the means for switchover differs between Salem Units 1 (manual) and 2 (semi-automatic). Drain down times from T/S minimum level (40.5 ft) to Low Level (15.2/15.25 ft) based on 1 CSP + 1 HHSI + 1 IHSI + 1 RHR pumps injecting at 0 RCS pressure backpressure.

b. Maximum Safeguards Time (seconds) = at time reach Low-Low RWST Level in EOP-LOCA-3—one CSP, 2 HHSI, and 2 IHSI pumps running from Low to Low-

Low Level in RWST. The HHSI and IHSI pumps are supposed to be switched over to recirculation before reaching Low-Low Level. The RHR pumps may be stopped during switchover and the means for switchover differs between Salem Units 1 (manual) and 2 (semi-automatic). Drain down times from T/S minimum level (40.5 ft) to Low Level (15.2/15.25 ft) based on 2 CSP + 2 HHSI + 2 IHSI + 2 RHR pumps injecting at 0 RCS pressure. For Unit 1, the minimum duration to reach Low Level is 12.9 minutes; for Unit 2, the minimum duration is 12.5 minutes.

c. Operator Action Times:

For Unit 1:

- ≤ 4.0 minutes from RWST Low Level to initiate RH4 closure
- ≤ 11.7 minutes for transition to sump recirculation

For Unit 2:

- ≤ 2 minutes 43 seconds for Operators to push Auto Arm Semi- Automatic Switchover
- ≤ 3.0 minutes from RWST Low Level alarm to initiating SJ69 closure
- ≤ 5.5 minutes from RWST Low Level alarm to only one CS pump in operation
- ≤ 11.2 minutes for transition to sump recirculation
(Accumulator Line Small Break LOCA assuming 2-minute stroke time for RH4)

d. References:

(1) VTDs 323585 and 323001, RWST Drain Down and Cold Leg Recirculation Report
(2) Manual Operator actions for Salem Unit 2 are ≤ 5.5 minutes maximum after RWST Low Level alarm per SC.CE-BD.CS-0001, pg. 17.
(3) EOP-LOCA-3
(4) UFSAR Table 6.3-6

7. Time Recirculation Spray Initiated with Minimum and Maximum Safeguards

a. Maximum Safeguards Time (seconds) = at time that associated CS36 valve is opened in EOP-LOCA-3. Probably will be greatest for Unit 1 with manual switchover.

b. Minimum Safeguards Times (seconds) = at time that associated CS36 valve is opened in EOP-LOCA-3. Probably will be greatest for Unit 1 with manual switchover.

c. Spray Time Delays:

LBLOCA: 85 seconds Spray Delay Time (fastest initiation = 35 seconds)
SBLOCA: Not Modeled
Non-LOCA: 85 seconds Spray Delay Time

d. Times not available and would require calculations to determine. Times would change with conditions assumed in analyses.

NOTE: Items 6 and 7 are calculated times that depend on analysis assumptions and cannot be verified without knowledge of ECCS alignment. The times depend on RCS pressure that controls the actual ECCS flows. The RWST Drain Down analyses assume maximum flows to generate shortest times for Operator action. For less than maximum flow, the time to recirculation increases and may not be bounded. The analysis may end before recirculation begins. This is certainly the case for SLB and for some SBLOCA depending on break size. Westinghouse to advise.

8. RWST Temperature (°F)

a. 100 °F

Reference: S-C-CS-MEE-0561, Maximum Temperature of RWST

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 7

Data Tables

1. Table G-1: Minimum Safeguards SI Injection

Minimum Safeguards Injection Data (No Spill Cases)			
RCS Pressure (psig)	**1 HHSI Pump (gpm)**	**1 IHSI Pump (gpm)**	**1 LHSI (RHR) Pump (lb/sec)**
0	369.0	555.8	0 psig, 549.22
100	360.4	533.8	20 psig, 515.99
200	351.7	516.0	40 psig, 480.72
300	343.0	492.7	60 psig, 442.68
400	334.0	468.6	80 psig, 400.89
500	324.1	443.0	100 psig, 353.69
600	314.1	416.5	120 psig, 297.51
700	303.8	389.1	140 psig, 222.69
800	293.4	359.6	160 psig, 82.94
900	282.5	325.6	180 psig, 0.00
1000	271.5	289.6	
1100	259.6	246.0	
1200	247.9	187.9	
1300	235.9	93.0	
1400	223.6	0.0	
1500	211.0		
1600	198.1		
1700	182.5		
1800	166.4		
1900	149.8		
2000	132.5		
2100	114.6		
2200	81.6		

References: (The LHSI or RHR Flows are from Ref. "c" only)

a. LCR 91-03 (04/24/92)
b. W PSE-91-038 (02/28/91)
c. FSA-II-M-2533 (02/21/74) ECCS Flowrates for Containment Energy Releases

NOTE: The HHSI flows do not match those in FSE/SS-PSE-1557 (1/18/91), FSE/SS-PSE-6769 (01/23/91), or FSA-II-M-2533 (02/21/74). PSE-1557 differs, for example, in C/SI pump runout flow assumed,

increasing flow from 550 gpm to 560 gpm. Westinghouse to advise. Same question pertains to Table G-3 for SLB.

d. Actuation Delay = 42 seconds for Non-LOCA events

2. Table G-2: Maximum Safeguards SI Injection

Maximum Safeguards Injection Data (No Spill Cases)			
RCS Pressure (psig)	**2 HHSI Pump (gpm)**	**2 IHSI Pump (gpm)**	**2 LHSI (RHR) Pump (lb/sec)***
0	953.5	896.4	0 psig, 1155.81
100	934.6	863.8	20 psig, 1099.00
200	915.5	830.4	40 psig, 1038.80
300	895.9	796.1	60 psig, 974.57
400	873.8	758.4	80 psig, 905.39
500	851.6	718.4	100 psig, 829.98
600	828.9	676.7	120 psig, 746.47
700	806.0	633.1	140 psig, 651.92
800	781.5	592.6	160 psig, 541.33
900	756.2	550.0	180 psig, 405.22
1000	730.6	503.9	200 psig, 223.23
1100	704.7	454.4	220 psig, 0.00
1200	678.1	400.3	
1300	651.1	327.9	
1400	623.6	231.9	
1500	594.9	95.2	
1600	560.9	0.0	
1700	526.0		
1800	498.7		
1900	472.9		
2000	446.2		
2100			
2200			

References: (*LHSI from Ref. "a" Only)

a. W FSA-II-M-2533 (02/21/74), ECCS Flowrates for Containment Energy Releases
b. LCR 91-03 (04/24/92)
c. W PSE-91-038 (02/28/91)
d. W FSE/SS-PSE-6769 (01/23/91)

e. Actuation Delay = 42 seconds for Non-LOCA events

3. Table G-3: 1 HHSI and 1 IHSI – No Spill

SLB: 1 HHSI and 1 IHSI—No Spill								
RCS Pressure (psig)	Case (1) 1 HHSI No Spill (gpm)	Case (2) 1 HHSI No Spill (gpm)	Both Cases *1 IHSI* No Spill (gpm)	Case (1) 1 HHSI + 1 IHSI (gpm)	Case (2) 1 HHSI +1 IHSI (gpm)	Case (1) GPM to lbm/s (lbm/s)	Case (2) GPM to lbm/s (lbm/s)	*W* Ref. Data (lbm/s)
0	369.0	374.6	555.8	924.8	930.4	127.73	128.51	128.37
100	360.4	366.2	533.8	894.2	900.0	123.51	124.31	
200	351.7	357.8	516.0	867.7	873.8	119.85	120.69	
300	343.0	349.4	492.7	835.7	842.1	115.43	116.31	
400	334.0	340.2	468.6	802.6	808.8	110.86	111.71	111.40
500	324.1	330.6	443.0	767.1	773.6	105.95	106.85	
600	314.1	320.8	416.5	730.6	700.0	100.91	101.84	101.41
700	303.8	310.9	389.1	692.9	660.4	95.70	96.68	
800	293.4	300.8	359.6	653.0	660.4	90.19	91.21	
900	282.5	289.9	325.6	608.1	615.5	83.99	85.01	84.40
1000	271.5	278.8	289.6	561.1	568.4	77.50	78.51	
1100	259.6	267.6	246.0	505.6	513.6	69.83	70.94	
1200	247.9	256.2	187.9	435.8	444.1	60.19	61.34	
1300	235.9	244.5	93.0	328.9	337.5	45.43	46.62	45.65
1400	223.6	232.5	0.0	223.6	232.5	30.88	32.11	32.04
1500	211.0	220.4		211.0	220.4	29.14	30.44	
1600	198.1	207.1		198.1	207.1	27.36	28.60	
1700	182.5	192.0		182.5	192.0	25.21	26.52	
1800	166.4	176.4		166.4	176.4	22.98	24.36	23.10
1900	149.8	160.3		149.8	160.3	20.69	22.14	
2000	132.5	143.7		132.5	143.7	18.30	19.85	
2100	114.6	126.4		114.6	126.4	15.83	17.46	15.91

SLB: 1 HHSI and 1 IHSI—No Spill								
RCS Pressure (psig)	**Case (1) 1 HHSI No Spill (gpm)**	**Case (2) 1 HHSI No Spill (gpm)**	**Both Cases** *1 IHSI* No Spill **(gpm)**	**Case (1) 1 HHSI + 1 IHSI (gpm)**	**Case (2) 1 HHSI +1 IHSI (gpm)**	**Case (1) GPM to lbm/s (lbm/s)**	**Case (2) GPM to lbm/s (lbm/s)**	*W* **Ref. Data (lbm/s)**
2200	81.6	92.8		81.6	92.8	11.27	12.82	
2300	38.1	0.0		38.1	0.0	5.26	0.0	5.29
2325	0.0			0.0		0.0		0.0

References:

For Case (1):

a. W PSE-91-038 (02/28/91)

b. LCR 91-03 (04/24/92)

For Case (2):

c. W FSE/SS-PSE-1557 (01/18/91)

d. W FSE/SS-PSE-6769 (01/23/91)

NOTE: Case (1) and Case (2) reflect the discrepancy noted in the flows for the HHSI pumps earlier. Salem Licensing basis is Case (1). The difference may be related to the assumed HHSI runout flow. For Case (1) the runout flow is 550 gpm and for Case (2) the runout flow is 560 gpm. Current Design Basis is to limit HHSI runout flow to no more than 554 gpm. See W PSE-94-759 (11/08/94). Westinghouse to advise.

4. Table G-12: RWST to RCS Volumes

✓ Salem does not have system dimensional isometric drawings. There are small bore piping spool drawings and large bore piping spool drawings that are dimensional but which would require review of several thousand drawings to tabulate the volume and would not show any of the small diameter piping. The Stress Calculation isometrics, which are not always updated when plant changes are made, could be used. These would require review of approximately 500 drawings; however, they are the best choice for modeling in that they provide the information in the most concentrated form.

✓ At present, there is no calculation that provides the volume of ESF piping from the RWST to the RCS for the containment spray, high head safety injection, intermediate head safety injection, and low head safety injection piping from the

RWST to the RCS. To compile the data for computing these volumes is a monumental task that would involve converting data from perhaps a 1000 Stress Calculation isometric drawings—too many to list here. (See Table H-1 under Item 11 below for just the piping volume from the accumulators to the RCS, for example.)

✓ The values given are taken from S-C-VAR-NZZ-0020, UFSAR Chapter 15 DB/LB Accident Analysis Input Assumptions, citing W PSE-93-645, Consolidated Input Assumptions Document for Accident Analyses, Salem Units 1 and 2, Fuel Upgrade / Margin Recovery Program, Non-LOCA Transient Analyses, Rev. 3, June, 1993.

5. Table G-20: Minimum HHSI Curve

Centrifugal Charging Pumps (HHSI)	
Flow (gpm)	**Minimum Head (feet H_2O)**
0	5414
100	5394
200	5094
300	4284
400	3194
425	2884
450	2569
500	1794
525	1464
550	1014
560	704

References:

(1) W PSE-91-038 (02-28-91)
(2) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model
(3) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model

6. Table G-21: Minimum IHSI Curve

Safety Injection Pumps (IHSI)	
Flow (gpm)	**Minimum Head (feet H_2O)**
0	3200
100	3070
200	3000
300	2835

Safety Injection Pumps (IHSI)	
Flow (gpm)	**Minimum Head (feet H_2O)**
400	2520
500	2100
525	1985
550	1870
575	1755
600	1635
650	1400
675	1260

References:

(1) W PSE-91-038 (02-28-91)

(2) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model

(3) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model

7. Table G-22: Minimum RHR Curve

Residual Heat Removal Pumps (RHR)	
Flow (gpm)	**Minimum Head (feet H_2O)**
0	383
500	382
1000	379
1500	377
2000	375
2500	368
3000	354
3500	338
4000	318
4500	296
5000	267
5500	232

References:

(1) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model Documentation

(2) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model Documentation

8. Table G-23: Maximum HHSI Curve

Centrifugal Charging Pumps (HHSI)	
Flow (gpm)	**Maximum Head (feet H_2O)**
0	6200
100	6155
200	5811
300	5000
400	3910
425	3610
450	3250
500	2470
525	2070
550	1640
560	1495

References:

(1) W PSE-91-038 (02-28-91)
(2) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model
(3) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model

9. Table G-24: Maximum IHSI Curve

Safety Injection Pumps (IHSI)	
Flow (gpm)	**Maximum Head (feet H_2O)**
0	3560
100	3450
200	3385
300	3165
400	2855
500	2455
525	2355
550	2270
575	2150
600	2025
650	1785
675	1645

References:

(1) W PSE-91-038 (02-28-91)
(2) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model
(3) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model

10. Table G-25: Maximum RHR Curve

Residual Heat Removal Pumps (RHR)	
Flow (gpm)	Maximum Head (feet H_2O)
0	502
500	492
1000	478
1500	462
2000	449
2500	448
3000	439
3500	425
4000	398
4500	374
5000	348
5500	321

References:

(1) W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model Documentation

(2) W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model Documentation

11. Table H-1: PSEG Document References for Accumulator Line Volumes

Salem does not have system dimensional isometric drawings. There are small bore piping spool drawings and large bore piping spool drawings that are dimensional but which would require approximately 250 drawings to tabulate volume and would not show any of the small diameter piping. The Stress Calculation isometrics are not always updated when plant changes are made; however, they are the best choice for modeling in that they provide the information in the most concentrated form.

Salem Unit 1 Accumulator Piping Stress Calculation Isometrics			
No. 11 (1SJE6)	No. 12 (1SJE7)	No. 13 (1SJE8)	No. 14 (1SJE9)
267241B	267241C	267243	267244
267241F	267241CC	267243CC	267244BC
267246	267242	267246	267242
2671277	2671283	2671272	2671270
2671293	2671300	2671274	2671292
2671297	2671285	2671278	2671282

2671291A	2671299	267241E	2671279A
2671211	2671280		2671269
2671296	2671279		267241E
267241E	267241E		

Salem Unit 2 Accumulator Piping Stress Calculation Isometrics

No. 21 (2SJE6)	No. 22 (2SJE7)	No. 23 (2SJE8)	No. 24 (2SJE9)
5671217	5671218	5671223	5671225
5671294	5671296	5671293	5671295
5671203	5671221	5671203	5671221
5671254	5671261	5671249	5671248
5671220	5671289	5672326	5671275
5671277	5671263	5671251	5671260
5672333A	5671288	5671251	5671257
5671287	5671258	5672327	5671220
5671211	5671256	5671255	233442, Sh. 23
5672334	5671220	5671220	233442, Sh. 24
5671285			233442, Sh. 25

Accumulator Line L/Ds and Volumes

Loop	(1) Total L/D (ft)	(2) L/D (ft)	(3) Total Volume (ft^3)	(4) Volume (ft^3)
1	536	208	31.7	4.0
2	542	205	34.8	3.8
3	502	175	27.6	3.9
4	519	209	23.5	4.2

(1) Accumulator Line Total
(2) Line L/D from RHR injection point to RCS
(3) Volume between Accumulator to check valve closest to RCS (SJ56s)
(4) Volume between the two check valves (SJ55s and SJ56s) in the Accumulator line
(5) Assumes a friction factor of 0.01436 for 10-inch Schedule 160 pipe

Reference:
FSSE/SS-PSE-1230 (12-21-88)

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 7

(Superceded by FSSE/SS-PSE-1230 above) Accumulator Line Piping Volumes Drawings 207463, 207464, 218269		
Loop	Volume from bottom of Accumulator to 2nd Check (ft^3)	Volume from 2nd Check to RCS Loop (ft^3)
1	37.17	7.63
2	37.85	7.63
3	31.93	6.51
4	34.82	7.64

Reference:
W FSA-II-BU-2576, Accumulator Line Piping (05/13/74)

12. Table J-3A (Unit1) and J-3B (Unit 2): Containment Spray Pump Head-Flow Curves

Salem Unit 1: Containment Spray Pump Flow-Head Curves			
Flow (gpm)	Minimum (feet H_2O)	#11 Pump Nominal TDH (feet H_2O)	#12 Pump Nominal TDH (feet H_2O)
0	472	506	502
400	471	506	502
800	469	506	501
1200	465	506	500
1600	459	500	499
2000	451	491	492
2400	439	473	481
2800	422	454	455
3200	399	432	431
3600	362	399	390

Reference:
W FSE/SS-PSE-1671 (11/25/91) Salem Unit 1 PEGISYS Model

Salem Unit 2: Containment Spray Pump Flow-Head Curves			
Flow (gpm)	Minimum (feet H_2O)	#21 Pump Nominal TDH (feet H_2O)	#22 Pump Nominal TDH (feet H_2O)
0	472	501	500
400	471	500	499
800	469	497	498
1200	465	493	493

Attachment 7

Salem Unit 2: Containment Spray Pump Flow-Head Curves			
Flow (gpm)	**Minimum (feet H_2O)**	**#21 Pump Nominal TDH (feet H_2O)**	**#22 Pump Nominal TDH (feet H_2O)**
1600	459	489	487
2000	451	479	481
2400	439	467	478
2800	422	450	458
3200	399	427	435
3600	362	407	402

Reference:

W FSE/SS-PNJ-1662 (11/02/91) Salem Unit 2 PEGISYS Model

13. Table 13: RHR Flow verses RCS Pressure: (Containment Mass and Energy Release)

Minimum RHR Flow (gpm) Verses RCS Pressure	
RCS Pressure (psig)	**RHR Flow (lb/sec)**
0	393
20	318
40	241
60	165
80	114
100	51.9
120	0

References:

(1) W SAE/FSE-PSE-0487 (09/08/96)
(2) W FSE/SS-PSE-7505 (01/08/97)
(3) VTD 323585 (Unit 1) and 323001 (Unit 2)

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 7

Additional Information:

Relative Valve/Line Elevations for Salem	
Component	**Elevation**
SI Suction RWST	101'-9"
HHSIP Suction	87'-5"
IHSIP Suction	86'-6"
LHSIP Suction	46'-10"
SJ1 and SJ2	85"-3"
SJ3	91'-7 5/16"
SJ30	85'-3"
SJ31	85'-1 ¾"
SJ45s	85'-3"
SJ113s	87'-8 ¼ / 86'-5 5/8"
CS36s	86'-0" / 87'-0 1/8"
SJ49s	86'-0 ¾"
RH26	80'-5"
2RH75	46'-10"
2RH76	46'-10"
21RH4	58'-9"
22RH4	56'-8"
2SJ70	58'-9"
2SJ69	60'-5"
21SJ44	51'-9"
22SJ44	51'-9"
Cont Sump bottom	69'-11 ¾"
SJ43's	98'-8 1/8"
SJ55s and SJ56s	112'-0"
21SJ144	82'-3"
22SJ144	81'-3"
23SJ145	79'-4 7/8"
24SJ144	80'-3"

July 03, 2003
[CFCU Project Letter #]

Mr. Jerold Kusky

Customer Projects Manager
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355

Dear Mr. Kusky:

PSEG Nuclear Response to Westinghouse Input Request for CFCU Project Containment Mass and Energy Release Analyses

PSEG Nuclear has validated and/or provided the specific input requested by Westinghouse (Reference 1) needed to perform the LOCA and Main Steam Line Break (MSLB) containment response analyses proposed as described in References 2 and 3. This information was transmitted via e-mail to Mr. Robert Jakub on July 2, 2003.

Note that some items, too large to fit in the available space, were noted and provided as attachments at the end. There are some items that will require further discussion between Westinghouse and PSEG, specific Westinghouse references or possible follow-up calculations. Some items of note include Safety Injection (SI) switchover to recirculation with minimum safeguards, time for recirculation spray to be initiated and some SI flows not matching current references under certain alignments, RHR heat exchanger flow during recirculation (subsequent UA values will then be provided by PSEG). Additionally, information provided to Westinghouse regarding the main feedwater pump trip and coastdown for MSLB with a single failure of the feedwater control valve (Reference 4) needs to be validated by Westinghouse as it dates back to 1992.

To further support the filled in Westinghouse input request document, the following are also provided: Attachment 1 provides information regarding the concurrent vessel head change-out project, including the increased metal mass associated with the integrated head package: Attachment 2 provides additional information regarding AFW flow rates; Attachment 3 is the hard copy of the EXCEL file that provides Proto-Flo AFW results and curve fits; Attachment 4 contains the SI information; Attachment 5 covers the Accumulators; Attachment 6 covers Containment Spray Pumps; Attachment 7 is the validation of the various data tables, Attachment 8 covers the Bypass Flow Control Valve set points.

Note that all the Replacement Steam Generator data has been provided with the exception of the secondary side fluid mass at various power levels (Framatome only has performed calculation at 100% power). PSEG will provide this information later as it becomes available. Also, PSEG is evaluating a reduction in the maximum moderator density coefficient (currently set at 0.52 delta-k/gm/cc) to recover some MSLB containment pressure margin. The final value that is acceptable to the core design engineers will be provided to Westinghouse under a separate letter.

Following your review of this input information, could you provide an update to the analysis schedule, with the various deliverables (even preliminary results) in terms of actual dates.

If you have any questions, please contact Mr. Kiran Mathur (CFCU Project Engineer) at 856 339-7215, or Mr. Glenn Schwartz (Nuclear Fuel) at 856 339-1216.

Very truly yours,

Ashok Moudgill
CFCU Project Manager

C Dave Hughes
John O Connor
Mike Mannion
Tom Ross
Ken Fleischer
Greg Morrison
Doug McCollum
Glenn Schwartz
Kent Halac
Michael Crawford
John Rowey
Kevin King

Key Input Assumptions for LOCA and Steamline Break Mass & Energy and Containment Response

Attachment 7

Scott Beckham
Tina Nolte
Paul Finch
John Pehush

W – Robert Jakub
W – Debra Ohkawa
W – William Turkowski

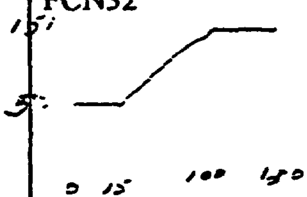
References:

1) Westinghouse letter PSE-03-25, CFCU/Service Water Enhancement Project Input Request for LOCA and MSLB Mass & Energy Releases and Containment Integrity Analyses, June 24, 2003

2) Westinghouse letter LTR-NEM-03-403, Containment Response Analysis to Support the Containment Fan Cooler Unit Service Water Enhancement Project, April 29, 2003

3) Westinghouse letter LTR-NEM-03-458, Revised Offer for Containment Response Analysis to Support the Containment Fan Cooler Unit Service Water Enhancement Project, May 15, 2003

4) PSEG Letter NFU-92-173, Salem Units 1 & 2 Feedwater Control Valve / Main Feedwater Pump Trip Assumption, March 9, 1992

Description	Reference	Value	
1.2 Main Feedwater Pumps ΔP Controller			
PI Proportional Gain	K_{33}	1 rad / sec / psi (0.203400)	
PI Integral Tme Constant	τ_{35}	100 sec / (rad / sec / psi) (493)	
(Feed Header - SG Exit) Pressure ΔP Program	FCN32  	<u>ΔP Setpt (psid)</u> 50 50 151 151	<u>Steam flow (%)</u> 0.0 15.0 100.0 120.0
Lag on Total Steam Flow	τ_{34}	120 seconds	
1.3 C_V Demand Calculation			
Dynamic Pressure Loss Coefficient	K_L	0.0072 psi / (% flow)^2	
Static Head Loss	$_\Delta P_{EL}$	9.0 psi	
Valve C_V Scaling Factor	K_V	80.95 gpm / % flow	
Lag on Computed Valve Pressure Drop	τ_6	5 seconds	
1.4 Control Valve Sequencing and Tracking Logic			
Bypass Valve Demand (BF40)	X_{BD} FCN7	<u>Lift Demand (%)</u> 0 20 30 40 50 70 80 90 100	<u>C_V Demand (gpm / psi$^{1/2}$)</u> 0.0 14.4 21.6 28.8 36.0 50.4 57.6 64.8 72.0

Description	Reference	Value	
Main Valve Demand (BF19)	X_{MD} FCN8	Lift Demand (%)	C_V Demand (gpm / psi$^{1/2}$)
		0	0.0
		17	145.0
		30	290.0
		40	435.0
		58	725.0
		66	870.0
		75	1015.0
		84	1160.0
		100	1450.0
Bypass Valve C_V	C_{VB} FCN9	C_V Demand (gpm / psi$^{1/2}$)	Lift Demand (%)
		0.0	0
		14.4	20
		21.6	30
		28.8	40
		36.0	50
		50.4	70
		57.6	80
		64.8	90
		72.0	100
Main Valve C_V	C_{VM} FCN10	C_V Demand (gpm / psi$^{1/2}$)	Lift Demand (%)
		0.0	0
		145.0	17
		290.0	30
		435.0	40
		725.0	58
		870.0	66
		1015.0	75
		1160.0	84
		1450.0	100

Description	Reference	Value	
C_V Distribution Function (Bypass Valve)	FCN11	Bypass Valve C_V Demand (gpm / psi$^{1/2}$) 0.0 36.0 72.0 72.0 0.0 0.0	Total C_V Demand (gpm / psi$^{1/2}$) 0.0 36.0 108.0 507.0 647.0 1450.0
C_V Distribution Function (Main Valve)	FCN12	Main Valve C_V Demand (gpm / psi$^{1/2}$) 0.0 0.0 36.0 435.0 647.0 1450.0	Total C_V Demand (gpm / psi$^{1/2}$) 0.0 36.0 108.0 507.0 647.0 1450.0
1.5 Notch Gains			
Notch Gain on Narrow Range Level	FCN16	NR Level Error (%) -100.0 -1.0 0.0 1.0 100.0	Gain Out 1.0 1.0 0.0 1.0 1.0
Notch Gain on FW Pump ΔP Error	FCN17	DP Error (psid) -250.0 -5.0 -2.5 0.0 2.5 5.0 250.0	Gain Out 1.0 1.0 0.25 0.0 0.25 1.0 1.0

ATTACHMENT 9

A

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
ELECTRIC ENGINEERING DEPARTMENT

PRINT NO. 123779 NO. 9 OF 9

PRINT NO. 123779

LOCATION SALEM NUCLEAR GENERATING STATION

AUTHORIZATION NO. U-267 Camden MARK NO.

CONT. NO. PS. ORD. NO. E-157370 REQ. NO.

MFG. ORD. NO. 031-53527 REQ. NO.

USED FOR Heater Drain Pumps No. 1 Unit

DESCRIPTION OF DRAWING Performance Curves and Test Data of Pumps #11, #12, #13 and Spare Rotor

MAKER Cameron Pump Div. of Ingersoll-Rand Co.

MAKER'S SHEET NO. See Below REV.

THIS PRINT IS — ☐ PRELIMINARY ☒ OFFICIAL ☐ ADDITIONAL ☐ REVISED

REMARKS

ENGINEER Schlnecker ROOM NO. 3355 DATE 2-22-71

DISTRIBUTION RECORD							SQUAD CHECK					
ISSUE	DR FILE	DR SQUAD	OPER DEPT	MFG	FIELD	OTHERS	ARCH	ELECTRICAL LAYOUT	ELECTRICAL D/A	MECH	CONTROLS	STRUC
1	1		5			1HE 1ES						

FILED UNDER

1. NUMERICAL
2. Pumps - Heater Drain
3.
4.
5.

APPROVED
AS TO GENERAL ARRANGEMENT ONLY

BY RLH/ES DATE 2/22/71

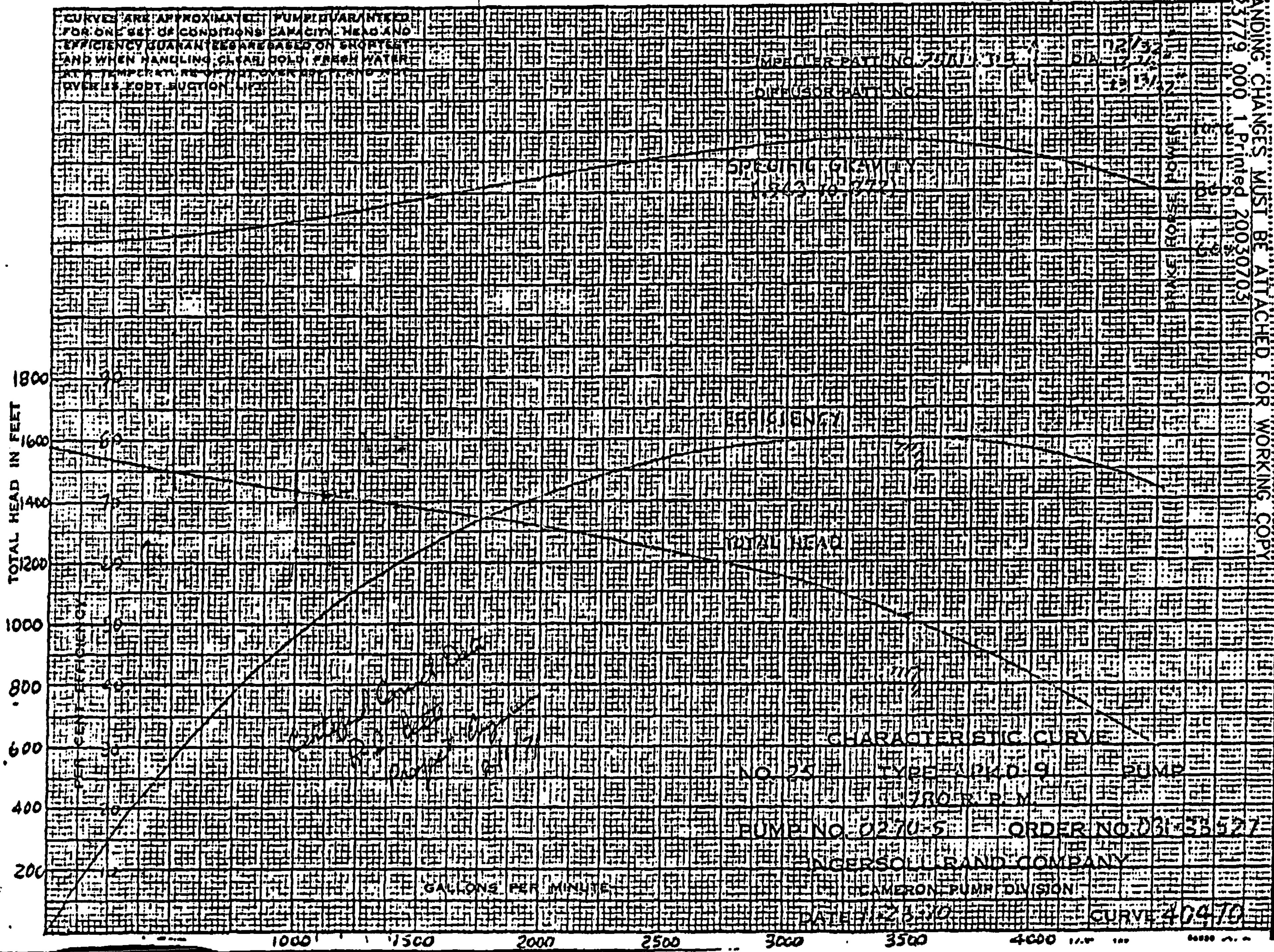
RECEIVED DRAFTING DIVISION

PLATE NO. 860—REVISED

Curves No.
40470, 40490, 40489, 40491

2/24/71 LH

CURVE NO. 40470
DATE 11-23-70



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ATTACHMENT 9

ATTACHMENT 9

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CAMERON PUMP DIVISION — INGERSOLL-RAND COMPANY — TEST RECORD

HEAD	DISCHARGE HEAD	AS READ	455	6[illegible]	773	947	1108	1220	1300	1408	15[illegible]5	686	14[illegible]
		CORRECTED	477	713	[illegible]	768	1128	1238	1317	[illegible]24	15[illegible]	709	14[illegible]
	SUCTION LIFT FT. ZERO DEPRESSED +6.1 FT.		6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	[illegible]
	CHANGE IN VELOCITY HEAD IN FEET 12" Disc.		3	2	2	2	1	1	—	—	—	2	—
	TOTAL HEAD		484	721	825	976	1135	1245	1323	1430	1586	717	1491
CAPACITY	VENTURI TUBES SIZES AND READINGS	16 X 9	[illegible]50	4500									
		12 X 6			4000	3570	3020	2550	1930	1060	0	4250	500
	TOTAL G.P.M.												
WATER H.P.			571	8[illegible]1	833	880	766	803	646	382	0		
POWER	DYNAMOMETER	AS READ	.331	.358	.362	.369	.365	.345	.310	.260	.230	.355	.250
	K=2400/1=KW	CORRECTED FOR ZERO	794.4	859.2	868.8	885.6	876	828	744	624	552		
	O=	R.P.M.											
	BRAKE H.P.		997	1072	[illegible]	1101	1091	1037	931	776	692		
OET VIBRATION MILS						1.7							
PUMP EFFICIENCY %			51.3	74.5	76.9	79.9	[illegible]	77.4	[illegible]9.4	[illegible]	0		

DRIVER 1800 H.P. MOTOR	FULL LOAD SPEED R.P.M.	PUMP NO. 02705	SIZE [illegible]	TYPE HP[illegible]	STAGES 7		
LIQUID CONDS.	NOTES— WIT. TEST	G.P.M. [illegible]	TOTAL HEAD IN FT. [illegible]	SUCT.	R.P.M. [illegible]	EFF. % [illegible]	
TEMP. 200-250°F		IMPELLER [illegible]	DIA. 12 1/32, 13 7/8	VANE DIA	DIFFUSOR		
[illegible]OS.	WATER TEMP. 81.5 °F	SUCTION CONNECTION TO C.L. PUMP	C.L. PUMP TO C.L. DISC. GAUGE +6.0' [illegible]				
GRAVITY .963-.842							
STAND SPECIAL		CUSTOMER PUB SERVICE ELECTRIC [illegible]					
TESTED [illegible]		ORDER NO. 031-33[illegible]2 "	ITEM NO.				
BY		DATE " " "	TEST NO.				

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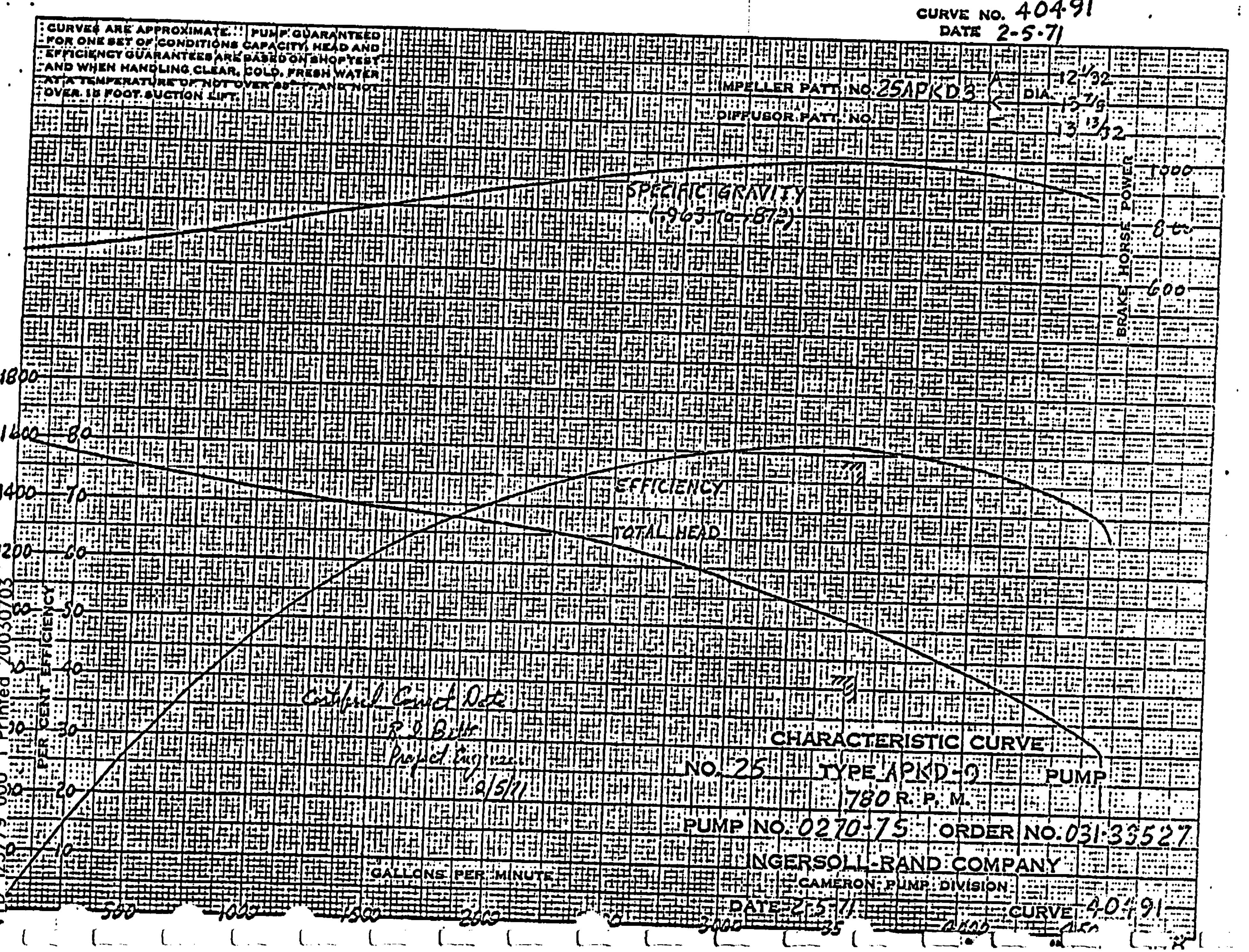
G-1826 5M 4-60



ATTACHMENT 9

RR CAMERON PUMP DIVISION

INGERSOLL-RAND COMPANY

TEST RECORD RR

HEAD	DISCHARGE HEAD AS READ [illegible]	385	[illegible]10	771	983	1145	1275	1374	1435	[illegible]
	DISCHARGE HEAD CORRECTED	408	[illegible]	801	1003	1165	129[illegible]	1410	145[illegible]	[illegible]
	SUCTION LIFT FT. ZERO DEPRESSED [illegible] FT.	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	CHANGE IN VELOCITY HEAD IN FEET 12" DISC	2.5	2.4	2.0	1.6	1.1	.6	.2	–	
	TOTAL HEAD	416.5	640.4	809.0	1010.6	1172.1	1298.6	1416.3	1458.0	[illegible]
CAPACITY	VENTURI TUBES SIZES AND READINGS 16 X 9	4500	4425	4050						
	12 X 6				3550	2970	2190	1370	450	0
	TOTAL G.P.M.									
	WATER H.P.	472	715	827	907	879	719	[illegible]	276	
DYNAMOMETER K=2400/1=KW O=	AS READ	.328	.360	.370	.378	.366	.327	.285	2.50	.243
	CORRECTED FOR ZERO	787.2	864.0	888.0	907.2	878.4	784.8	684.0	600.0	583.2
	R.P.M.									
	BRAKE H.P.	987	1029	1105	1125	1095	984	854	746	723
	VIBRATION MILS	1.0	1.5		1.0	1.2	1.1	1.4	1.5	
	PUMP EFFICIENCY %	47.9	66.3	74.8	80.6	80.3	73.2	63.0	37.0	

2000 H.P. MOTOR	FULL LOAD SPEED R.P.M.	PUMP NO. 02.706 · SIZE 2.5 · TYPE HPS-T · STAGES 9
CONDS.	NOTES— WIT. TEST	G.P.M. 3550 · TOTAL HEAD IN FT. [illegible] · SUCT. · R.P.M. 1180 · EFF. % 77
200-250°F		IMPELLER [illegible] · DIA. 12 1/32, 13 7/8 · VANE DIA · DIFFUSOR
		SUCTION CONNECTION TO C.L. PUMP 13 3/32 · C.L. PUMP TO C.L. DISC. GAUGE 6' ELEV.
763-542		
SPECIAL		CUSTOMER PUB SERVICE ELECTRIC & GAS
		ORDER NO. 031-33324 · ITEM NO.
		DATE 11-25-70 · TEST NO.

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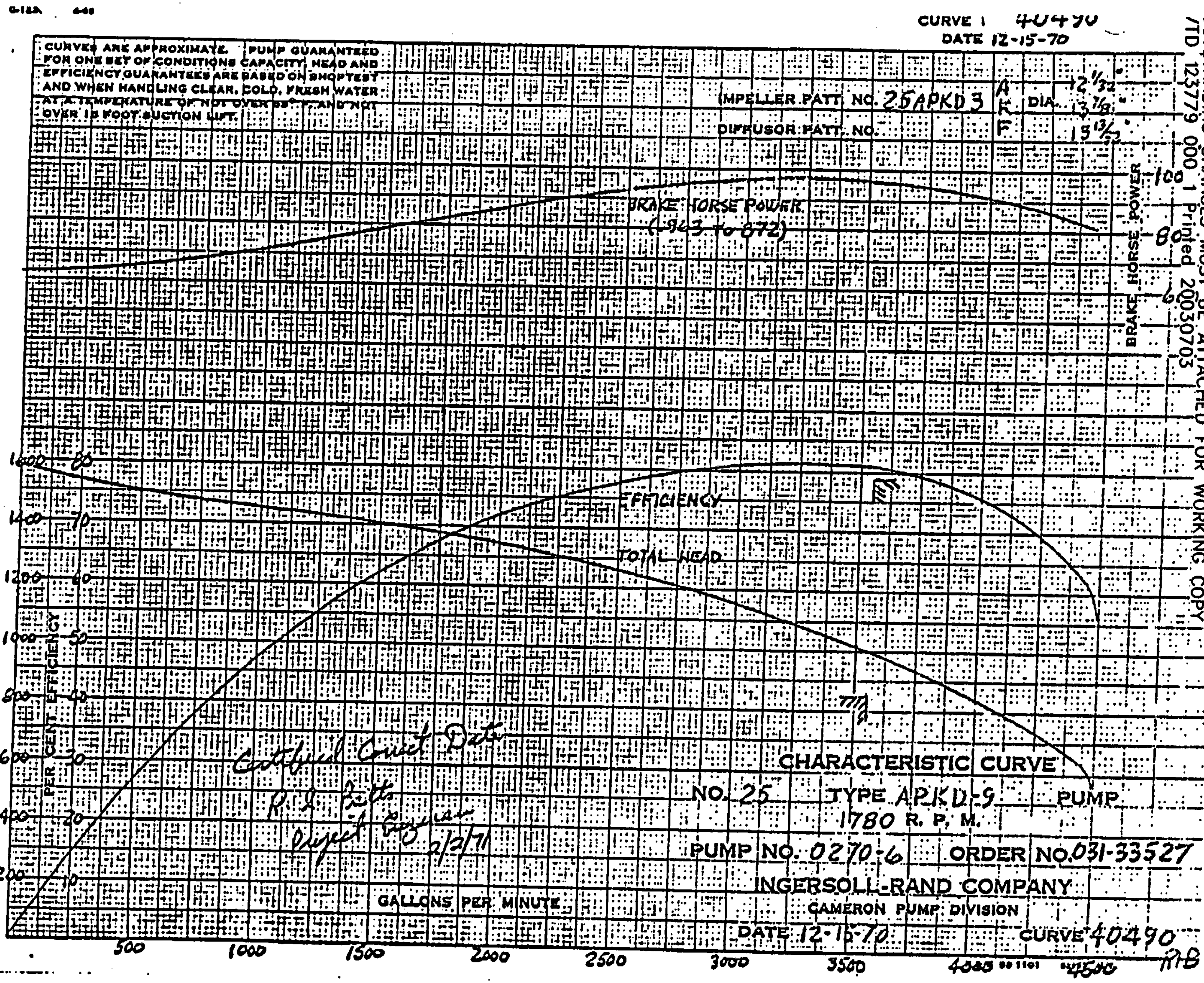

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CAMERON PUMP DIVISION

INGERSOLL-RAND COMPANY

TEST RECORD

HEAD	DISCHARGE HEAD	FC-11-1800 AS READ 25.52	275	705	[illegible]	1025	1152	[illegible]	13[illegible]	[illegible]	15[illegible]	884
		CORRECTED	417	727	892	1016	1163	1286	1361	1467	1577	
	SUCTION LIFT FT. ZERO DEPRESSED 26.2 FT.		6.0	6.0	6.0	6.0	6.0	6.0	6.0	[illegible]	[illegible]	
	CHANGE IN VELOCITY HEAD IN FEET 12" DISC		2.7	2.5	2.0	1.6	1.2	.8	.4	.1		
	TOTAL HEAD		425.7	735.5	901.0	1023.6	1170.2	1292.8	1367.4	1473.1	[illegible]	
CAPACITY	VENTURI TUBES	16 X 9	11650	4450								
		12 X 6			4010	3530	3060	2460	1820	870	[illegible]	3950
	SIZES AND READINGS											
	TOTAL G.P.M.											
	WATER H.P.		500	827	913	911	935	804	632	3[illegible]		
POWER	DYNAMOMETER	AS READ	.330	.372	.378	.382	.372	.344	.348	.287	.250	.378
	K=2400/1=K1	CORRECTED FOR ZERO	792.0	892.8	[illegible]	916.8	892.8	[illegible]	[illegible]	[illegible]	[illegible]	
	O=	R.P.M.										
	BRAKE H.P.		995	1110	1125	1135	1110	1035	920	772	746	
SHAFT VIBRATION MILS						2.1						1.9
PUMP EFFICIENCY %			51.3	74.5	81.2	80.3	81.9	77.6	68.[illegible]	41.5		

DRIVER	1000 H.P. MOTOR
FULL LOAD SPEED R.P.M.	
LIQUID	COND.S.
TEMP.	200-380°F
VIS.	
GRAVITY	.963-.872
STAND	SPECIAL
TESTED	S.N.
BY	

NOTES: WIT. TEST ✓

RETEST-(8/1/71

Witnessed

PUMP NO.	02-707
SIZE	2.5
TYPE	APKD
STAGES	[illegible]
G.P.M.	3550
TOTAL HEAD IN FT.	855
SUCT.	
R.P.M.	1780
EFF. %	
IMPELLER	2.5 APKD 23 K
DIA.	12 1/32 / 13 7/8
VANE DIA	
DIFFUSOR	
SUCTION CONNECTION TO C. L. PUMP	
C. L. PUMP TO C. L. DISC. GAUGE	
CUSTOMER	PUB SERVICE ELECTRIC [illegible]
ORDER NO.	031-33527
ITEM NO.	
DATE	1-28-71
TEST NO.	

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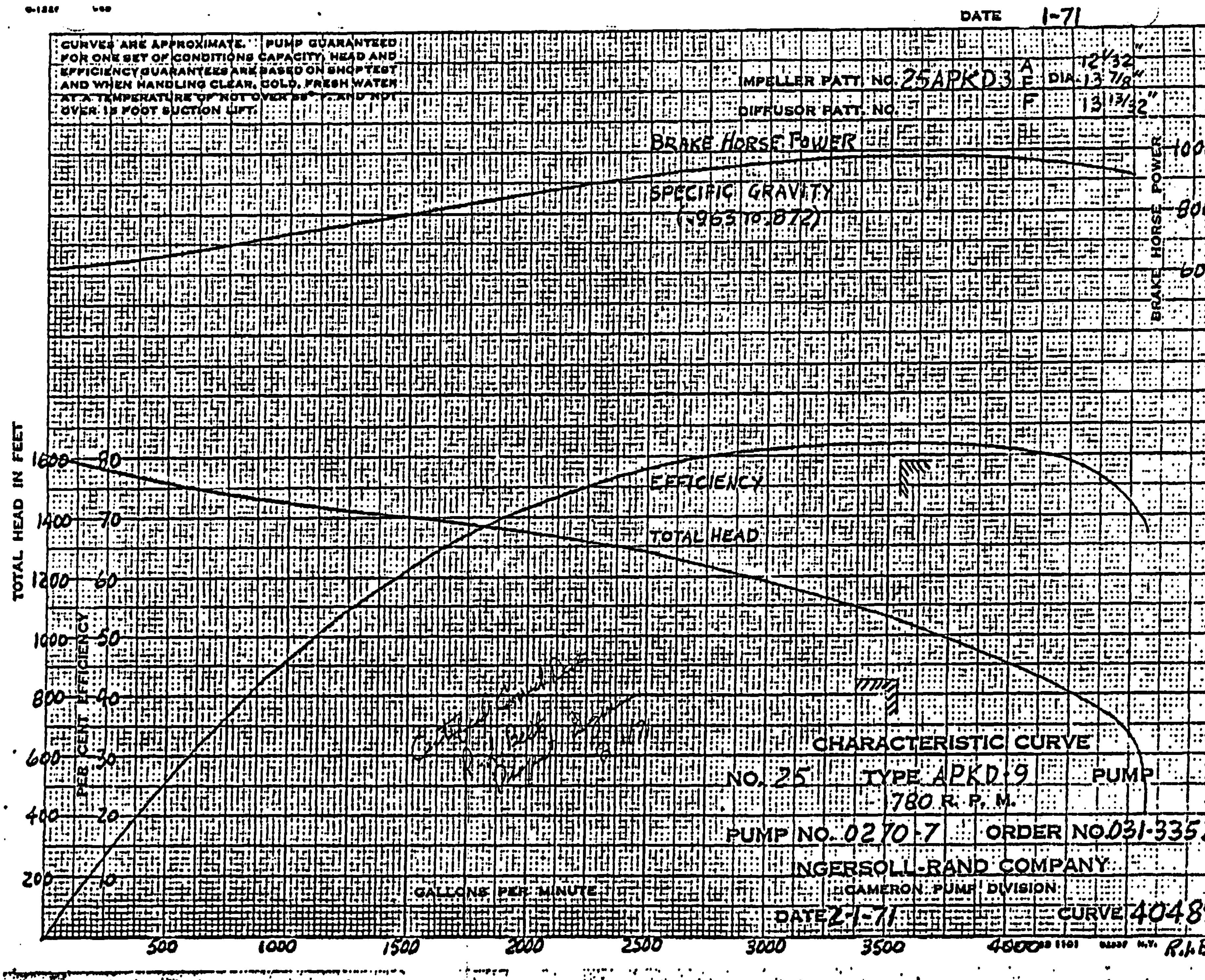

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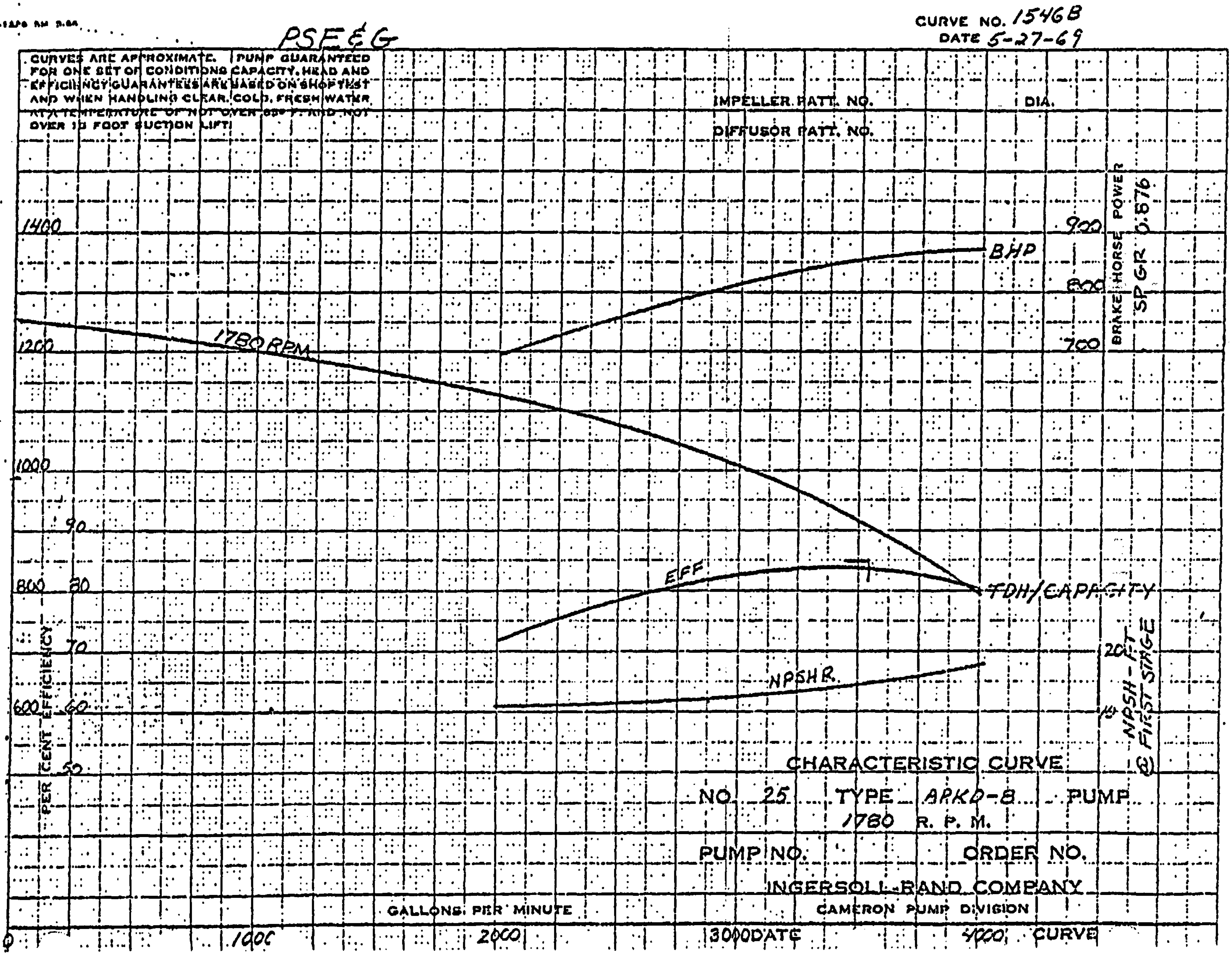


CAMERON PUMP DIVISION **INGERSOLL-RAND COMPANY** TEST RECORD

HEAD – DISCHARGE HEAD	AC-11-1800 AS READ	391	670	845	970	1129	[illegible]	1335	1430	15[illegible]		644
	CORRECTED	418	692	868	991	1150	1264	1359	1453	1523		
SUCTION LIFT FT. ZERO DEPRESSED +6.0 FT.		6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0		6.0
CHANGE IN VELOCITY HEAD IN FEET 12" Disc		2.7	2.5	1.9	1.6	1.1	.4	.2	.1			
TOTAL HEAD		426.7	700.5	875.9	998.6	1157.1	1270.7	1365.2	1459.1	1529.0		
CAPACITY – VENTURI TUBES SIZES AND READINGS	16 X 9	4625	4450									4390
	12 X 6			3940	3580	3025	2430	1730	850	0		
TOTAL G.P.M.												
WATER H.P.		495	489	870	903	884	780	[illegible]	313			
DYNAMOMETER Watt K=2400/1=K.W.	AS READ	.325	.313	.373	.375	.365	.340	.298	.251	.240		.358
	CORRECTED FOR ZERO	780	751.2	895.2	900	876	816	715.2	[illegible]	[illegible]		
O–	R.P.M.											
BRAKE H.P.		978	1085	1113	1118	1092	[illegible]	[illegible]	[illegible]	715		
...et Vibration Mils				1.9	1.9		1.7		2.0			1.5
...MP EFFICIENCY %		[illegible]	72.7	78.[illegible]	80.8	[illegible]	[illegible]	[illegible]	[illegible]			

...ER 900 H.P. Motor	FULL LOAD SPEED R.P.M.	PUMP NO. 02707	SIZE 2.5 · TYPE APKD · STAGES
...ID Conds.	NOTES: Wit. Test 2-7	G.P.M. 2550	TOTAL HEAD IN FT. 855 · SUCT. · R.P.M. 1780 · EFF. % 7?
...P. 201-380°F		IMPELLER 2.5APKD3 H	DIA. 12 3/32, 13 7/8 · VANE DIA · DIFFUSOR
...OS.	Spare Pumping Element	SUCTION CONNECTION TO C.L. PUMP	C.L. PUMP TO C.L. DISC. GAUGE
...VITY .963-.872			
...D Special		CUSTOMER Pub Service Electric [illegible]	
...ED S.N.		ORDER NO. 031-33527	ITEM NO.
BY		DATE 2-[illegible]	TEST NO.

ATTACHMENT 9

OUTSTANDING CHANGES MUST BE ATTACHED FOR WORKING COPY

TD 123779 000 1 Printed 20030703

CAMERON PUMP DIVISION

INGERSOLL-RAND COMPANY

TEST RECORD

HEAD – DISCHARGE HEAD	AC-11-1800 AS READ 26.52	391	670	845	970	1129	[illegible]	1335	1430	15[illegible]		644
	CORRECTED	418	692	868	991	1150	1264	1359	1459	[illegible]		
SUCTION LIFT FT. ZERO DEPRESSED +6.0 FT.		6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0		6.0
CHANGE IN VELOCITY HEAD IN FEET 12" Disc		2.7	2.5	1.9	1.6	1.1	.7	.2	.1			
TOTAL HEAD		426.7	700.5	875.9	998.6	1157.1	1270.7	1365.[illegible]	14[illegible].1	15[illegible]		
CAPACITY – VENTURI TUBES	16 X 9	4625	4450									4390
	12 X 6			3940	3580	3025	2430	1730	850	0		
SIZES AND READINGS												
TOTAL G.P.M.												
WATER H.P.		495	789	870	903	884	750	[illegible]	313			
DYNAMOMETER WATT K=2400/1=KW	AS READ	.325	.313	.373	.375	.365	.340	.298	.251	.240		.358
	CORRECTED FOR ZERO	780	871.2	895.2	900	876	816	[illegible]	[illegible]	[illegible]		
O–	R.P.M.											
BRAKE H. P.		978	1085	1113	1118	1092	1023	890	759	715		
[illegible] Vibration Mils				1.9	1.9		1.7		2.0			1.5
PUMP EFFICIENCY %		[illegible]	72.7	78.2	80.8	[illegible]	[illegible]	66.[illegible]	[illegible]			

ER 900 H.P. Motor	FULL LOAD SPEED	R.P.M.	PUMP NO. 03.707	SIZE 2.5	TYPE APKD	STAGES	
ID Conds.	NOTES:– Wit. Test 2-7		G.P.M. 3550	TOTAL HEAD IN FT. 875	SUCT.	R.P.M. 1780	EFF. % [illegible]
P. 200-380°F			IMPELLER 2.5APKD3 K	DIA. 12 1/32 13 7/8	VANE DIA	DIFFUSOR	
OS.	SPARE PUMPING ELEMENT		SUCTION CONNECTION TO C. L. PUMP		C. L. PUMP TO C. L. DISC. GAUGE		
VITY .963-.872							
D Special			CUSTOMER Pub Service Electric [illegible]				
ED S.N.			ORDER NO. 031-83527		ITEM NO.		
BY			DATE 2-[illegible]-7		TEST NO.		

APPENDIX B

The information that follows is a copy of the PSEG Nuclear LLC transmittal letter EA-CFCU-03-005, dated October 20, 2003. This information was transmitted to Westinghouse by PSEG Nuclear LLC for revision and clarification of several of the analysis input assumptions. The information contained in Appendix B supercedes the information contained in EA-CFCU-03-004 for the work presented in the main body of this report.

Please note that the service water flow in Item 5 should read "...increased from 1000 gpm to 1200 gpm" based on the data provided in Attachment 4 of EA-CFCU-03-005.

PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, New Jersey 38-0236

PSEG *Nuclear LLC*

October 20, 2003
EA-CFCU-03-005

Mr. Jerold Kusky
Customer Projects Manager
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

Dear Mr. Kusky:

Additional Clarification for CFCU Project Containment Analyses Input Parameters

Based on further review of the CFCU project containment analyses input data (Reference 1), it was determined that some further clarifications and input values are required.

1. The Westinghouse values for the high steam flow setpoint assumptions (trip setpoint as a function of power level, Item C.4) included an environmental allowance that is not required. This resulted in analytical trip setpoint values that were significantly over-conservative. Attachment 1 provides the appropriate uncertainty allowance to apply to the trip setpoint along with the necessary basis and reference.

2. With respect to the input data required for the Salem Unit 2 replacement steam generators, the secondary side fluid mass as a function of power level (Item D.3.c), needed to be provided by Framatome and was not available at the time the containment analysis input data was transmitted to Westinghouse. This information has recently been provided and we have modified it to be consistent with current level program and temperature range. This information is provided in Attachment 2.

3. To provide additional margin for the limiting steamline break cases, PSEG has determined that a reduction in the end-of-cycle moderator density coefficient (MDC), Reference 1 Item A.11, from 0.52 to 0.45 delta-k/gm/cc is acceptable from a core design standpoint.

4. PSEG has developed Residual Heat Exchanger UA values for the recirculation phase of the LBLOCA event. These values, provided in Attachment 3 are based on the RHR flow rates recently transmitted by Westinghouse. The information provided covers both active and passive failure situations. Note that to reduce potential equipment qualification impacts, the containment response to LBLOCA will credit recirculation spray flow, and the attachment also provides the minimum spray flow for both the noted scenarios.

5. To provide additional margin in the containment response results, PSEG has recalculated the CFCU heat transfer rates with Service Water System flow increased from 1000 gpm to 12 gpm. Other parameters such as fouling factor and Service Water temperature were not changed from the initial values provided in Table K-1. The revised CFCU heat removal rates are provided in Attachment 4. Note that these differ slightly from the preliminary values provided informally back in early September.

6. The CFCU system actuation time (Reference 1, Item K.3), has be shortened from 120 seconds to 100 seconds.

The first three items are applicable for the steam line break mass and energy release cases. The fourth item is only pertinent to the LOCA containment response cases, and items 5 and 6 apply to both LOCA and MSLB calculations. Please distribute this letter and attachments to all the appropriate functional organizations.

If you have any questions, please contact Mr. Glenn Schwartz at (856) 339-1216, or Kent Halac at (856) 339-1280.

Very truly yours,

Ashok C. Moudgill

Ashok Moudgill
CFCU Project Manager

Reference:

1) EA-CFCU-03-004, PSEG Nuclear Response to Westinghouse Input Request for CFCU Project Containment Mass and Energy Release Analyses

GSS

C K. Halac
K. Mathur
L. Gonzalez
P. Finch
T. Nolte
S. Beckham
K. King
J. Rowey
J. Arias
T. DelGaizo

ATTACHMENT 1

High Steam Flow Trip Setpoint Uncertainty

In the determination of the trip uncertainty, Westinghouse currently assumes a 14.75% span environmental allowance. This is not consistent with WCAP-12103 (Setpoint Methodology, PSEG Calc S-C-RCP-CDC-0440), Table 3-24 (High Steam Flow), which shows an environmental allowance of 0.0% span. Note that Table 3-11 (Steam/Feedwater Flow Mismatch) and Table 3-18 Low Steamline Pressure include 14.75% span environmental allowance.

PSEG Nuclear is the holder of the setpoint calculation of record and has regenerated the rack-up of the channel uncertainty for steam flow safety injection in Section 7.9 of Engineering Calculation SC-CN007-01. The following is a summary of the channel uncertainty determination that is considered appropriate for the steamline break events (transmitter through rack/bistable):

Process Measurement Allowance =	3.000% span
Steam Flow Transmitter =	2.77% span
Turbine 1st Stage Pressure Transmitter =	1.05% span
Rack 1 (with bistable) =	1.328% span
Rack 2 (without bistable) =	1.230% span

Channel uncertainty $= \pm [(2.77\%)^2 + (1.05\%)2 + (1.328\%)^2 + (1.23)^2]^{1/2} \pm 3.000$
$= 6.472\%$ span (where span = 120% of nominal steam flow)

This uncertainty is applied to the trip setpoint as defined in the Salem Technical Specifications:

Steam flow in two steam lines – High coincident with steam line pressure– Low is ≤ to a function defined as: a Δp corresponding to 40% of full steam flow between 0% and 20% load and then a Δp increasing linearly to a Δp corresponding to 110% of full steam flow at full load.

ATTACHMENT 2

Salem Unit 2 Replacement Steam Generator Secondary Side Fluid Mass

Below is an array for steam generator total mass inventory (steam plus water masses) as a function of power level for maximum RSG masses, per the original AIS request.

Power (FON)	Fluid Mass (lbs)
0.0	152761
0.10	152159
0.20	148543
0.30	142115
0.40	136591
0.50	131570
0.60	126548
0.70	122530
0.80	118513
0.90	114496
1.00	111543

This data is consistent with 0% SGTP, full power Tavg of 577.9°F, and NRS + 5% (49% = 44% + 5%). The data points for 0% and 10% span are at span levels higher than the current program in an effort to ensure that the data is conservative (37.8% NRS instead of 22% NRS for 0% power and 43.4% NRS instead of 33% NRS for 10% power).

If the Westinghouse methodology requires that use of any additional biases, these will need to be applied to the above listed data as appropriate.

ATTACHMENT 3

Salem Residual Heat Exchanger UA Data for LBLOCA Recirculation Phase

(The following provides clarification to input assumptions L 8 and 9)

The RHR heat exchanger UA values are based on flow calculations performed by Westinghouse and provided electronically to PSEG Nuclear in late September 2003. For the maximum safeguards alignment (passive failure scenario), the minimum RHR pump flow is 3141.6 gpm (rounded down to 3100 gpm for UA determination). For the minimum safeguards alignment (Emergency diesel failure or loss of a safeguards train), the minimum RHR pump flow is 3200 gpm. In all cases, the flow through Salem Unit 2 Train A provides a minimum bounding flow rate for either Salem Unit.

The following table summarizes the minimum spray flow, RHR flow and RHR UA values for both the limiting single failure (minimum safeguards) and CFCU passive failure (maximum safeguards) scenarios:

Case	Min Spray Flow (gpm)	Min RHR Pump Flow (rounded down; gpm)	RHRHX UA (Btu/hr-°F)
Min Safeguards (EDG failure)	1974.8 (Unit 2 Train A)	3200 (Unit 2 Train A)	1.765E+06
Max Safeguards	1181.7 (Unit 2 Train B)	3100 (Unit 2 Train A)	1.757E+06

As stated in a previous E-mail, the RHRHX UA values were determined using the Proto-HX model from S-C-CC-MDC-1798, Rev. 3. The following inputs and assumptions are common to both cases:

- CC flow = 4000 gpm
- CC inlet temperature = 120°F
- RHR inlet temperature = 260°F
- Design fouling
- 1% tube plugging

Notes:

While the passive failure or "maximum" safeguards case has two running RHR pumps with one recirculation spray path OPEN, there is also one RHR cold leg injection path OPEN (SJ49). Since the RHR cold injection path provides little flow resistance, flow from both RHR pumps is "in effect" diverted from recirculation spray to this path.

For this case, there would be no other failures and both containment spray pumps would be running in the injection phase along with all three CFCUs. The CFCUs would continue to run until the 24 hour point.

ATTACHMENT 4

Revised Containment Fan Cooler Heat Removal Rates

Containment Temperature [°F]	Heat Removal Rate [Btu/Sec per Fan Cooler]		Percent Increase above Current Value
	Current PSEG Confirmed Value at 93°F and 1000 gpm. Fouling at 0.0015 (from Table K-1)	Revised PSEG Confirmed Value at 93°F and 1200 gpm. Fouling at 0.0015	
105	606.6	648.6	6.9%
120	1502.3	1620.8	7.9%
140	2922.8	3198.7	9.4%
160	4522.1	4982.6	10.2%
180	6205.2	6908.8	11.3%
200	7888.0	8856.4	12.2%
220	9617.3	10817.0	12.4%
240	11257.2	12706.5	12.8%
260	12950.8	14625.6	12.9%
271	13869.6	15662.5	12.9%
280	14588.8	16500.1	13.1%

Attachment 4

SALEM UNITS 1 AND 2

SYSTEM DESCRIPTION

CFCU/SW ENHANCEMENT PROJECT

April 2004

System Description

CFCU CH System

(Including Modification on SW System)

Salem Generating Station

Ashok Moudgill,

Project Manager

Prepared by:

Harold Trenka, Project Engineer

Reviewed by:

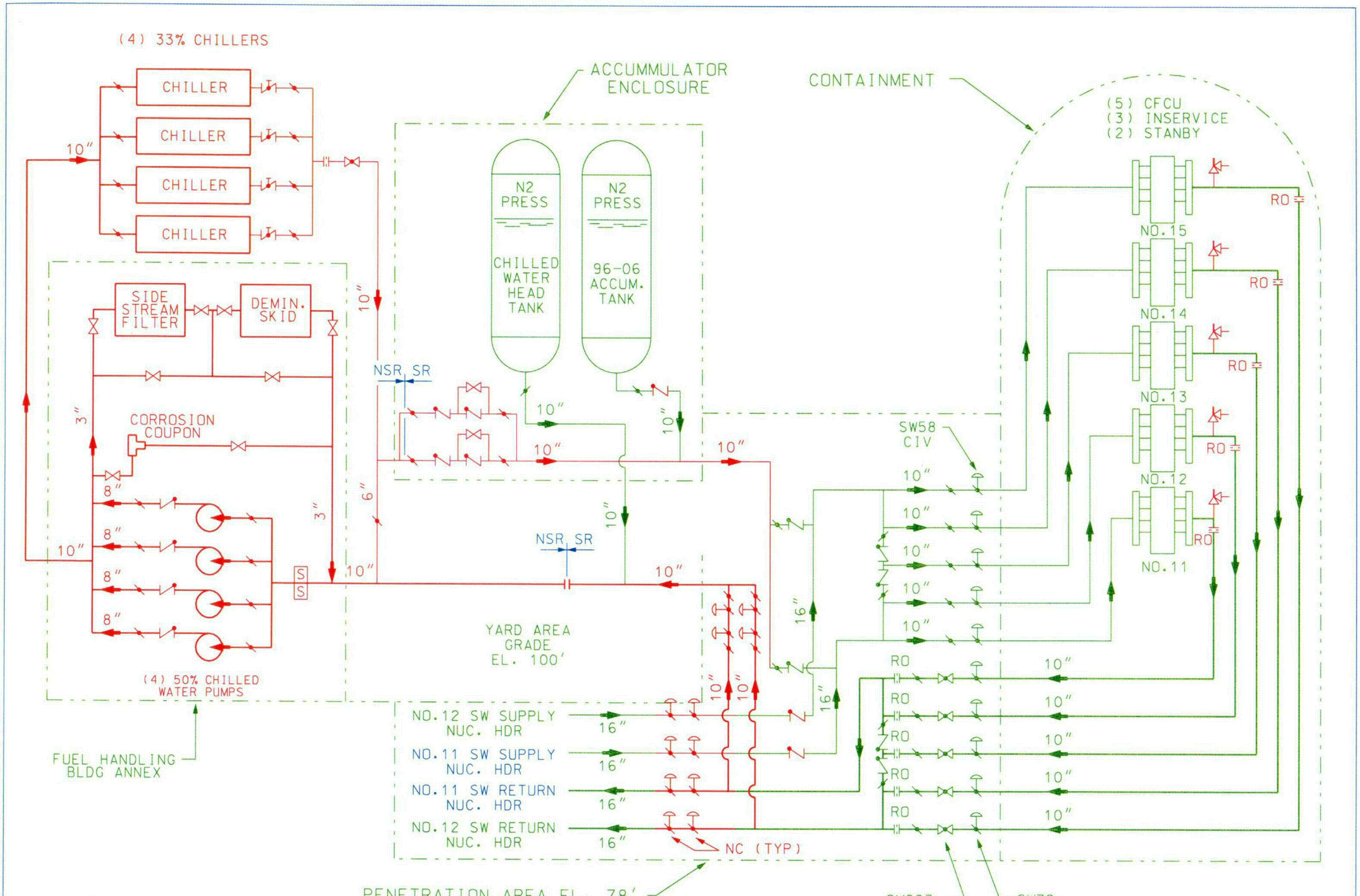
Ted Delgaizo, Conceptual & Analytical Support

Approved by:

Ashok K. Moudgill

Ashok Moudgill, PM

Table of Contents



NOTE:
RED INDICATES NEW PIPING & EQUIUPMENT.

SALEM UNIT 1 & UNIT 2
CFCU CHILLED WATER (CH) SYSTEM

C01

Revision 1 to revision 2 changes:

(1) Revised sections on chiller failures and CH bus to include the cross-tie between 480 V buses. This tie allows one 480 bus to power up to 3 chillers and two pumps (provided that no more than one chiller and one pump are on the opposite bus). Also, the limitation is that the failure on the opposite bus is on the power to the 480 V bus and not a failure of the 480 bus itself.

(2) Revised information on the GL 96-06 design basis to reflect that the accumulator is not critical when the transient commences with the CFCU Chilled Water System in operation. However, it is critical when SW is providing cooling with the unit at power.

(3) Clarified that the chillers will be elevated a nominal 3 feet to clear snow, improve access to key components, improve air-flow, and reduce potential for any localized flooding from severe weather.

System Description Limitations

The purpose of this System Description is to serve as a communication tool to consolidate the decisions made by the Project Team on the design of the CFCU CH System and to communicate this information for review, comment, and use by others.

It is anticipated that the System Description be updated on a continuous basis as the decisions evolve.

Although specific values are included for key parameters, these numerical values are not to be considered final nor is this System Description to be used as the reference source/input for these values. Rather, the source documents listed in Section 7 should be cited.

Any text highlighted indicates a preliminary decision and/or that effort is still underway.

Definitions

Anticipated Operations	Power operation, shutdown, refueling, and start-up. Excludes DBA accidents which are postulated, but not anticipated.
AOV	Air Operated Valve
AST	Alternate Source Term
CH	Chilled Water (as used herein, refers only to new, non-SR system)
CFCU	Containment Fan Coil Unit
condenser	The heat exchanger on the chiller that cools the refrigerant coils (air cooled chillers use fans on the chillers and outside air as the UHS)
DBA	Design Basis Accident
DM	Demineralized Water
EDG	Emergency Diesel Generator (On-site backup to vital buses)
EO	Equipment Operator
evaporator	The heat exchanger on the chiller that cools the chilled water
FHB	Fuel Handling Building
FHB Annex	Non-RCA portion of the FHB truck bay; also called "storage area".
Group Bus	Non-vital, 4160 VAC (without on-site diesel backup power)
GL	Generic Letter
IST	In-Service Testing
LCWT	Leaving Chilled Water Temperature (outlet of chiller)
LOCA	Loss of Coolant Accident
LOP	Loss-of-offsite-Power (but no loss of vital power from diesels)
MSLB	Main Steam Line Break
Non-SR, NSR	Non-Safety Related
"Operable"	Available as defined by Salem Technical Specifications
RCA	Radiologically Controlled Area

RCFC	Reactor Containment Fan Cooler, same as CFCU
SACF	Single Active Component Failure
SEC	Safeguards Equipment Controller
SGFP	Steam Generator Feed Pump
SI	Safety Injection
SIS	Safety Injection Signal
SR	Safety Related
SSE	Safe Shutdown Earthquake (lose non-SR equipment)
SW	Service Water
TB	Turbine Building
TDH	(pump) Total Driving Head
Ton	Cooling ton = 12000 BTU/hr
UHS	Ultimate Heat Sink (the final heat sink for the containment air). For anticipated operations this is the outside air; for DBA it is the Delaware River
UV	Under-voltage (as used herein, refers to UV on two or more vital buses which causes the vital power to transfer from normal to EDG. It is also called "SEC Black-out" is some documents).
Vital Bus	Powers SR Equipment for Safe-Shutdown

Key Design Parameters

Containment Heat Load at 86°F	12.6 MBTUH
Chilled Water Pump Heat Load (total 2 pumps)	0.3 MBTUH
Total CFCU CH System Heat Load	12.9 MBTUH (1074 tons)
Nominal CFCU CH System Flow, total	2400 gpm
Nominal CH System flow/CFCU air cooler	780 gpm
Nominal CH System flow/CFCU motor cooler	20 gpm
Nominal CH System Flow/pump	1200 gpm
LCWT, Chilled-water temperature to CFCU's, normal [1]	46°F
LCWT operating range	40-60°F
Chilled-water temperature rise across CFCU's	~11°F
Normal CFCU air flow/CFCU (unchanged from present)	110,000 cfm
Normal containment ambient temperature (3 CFCU's)[2]	~86°F
Abnormal containment ambient temperature (2 CFCU's)[3]	~104°F
Containment TS Limit maximum temperature for normal Ops	120°F
SW and CFCU CH System Piping Design Pressure	200 psig
CFCU, Accumulator, and Head Tank Design Pressure	150 psig
Head Tank N_2 Pressure	65 psig,+0, -5
Head Tank Static Head (125' – 102')	~10 psid
Head Tank Total Pressure at tank outlet line	75 psig,+0, -5
CFCU Chilled Water Pump TDH	65 psid
CFCU CH System Supply Pressure at Accum. Connection	~105 psig, + 0, -5

[1] The system description assumes 46°F setpoint, which will result in a containment temperature of 86°F. The actual setpoint will be determined in the detailed design. Operation at lower LCWT setpoints will increase power consumption and decrease chiller capacity. The converse is true.

[2] The containment temperature will be ~ 40°F higher than the LCWT.

[3] This value conservatively assumes that the chilled water to the inoperative CFCU is not isolated; therefore the chilled water flow to the two operating CFCU's remains at 800 gpm. The containment temperature will be ~ 58°F higher than the LCWT setpoint.

CFCU CH System Supply Pressure at SW Valve Interface	~110 psig, + 0, -5
Accumulator Nominal N_2 Pressure	~ 80 psig
Accumulator Total Pressure at tank outlet line	~ 90 psig
CFCU Supply Header Low Pressure Isolation Setpoint	$\leq$ 80 psig
Head Water Volume	8000 – 12000 gallons
Head Tank Water Height (Above bottom of tank)	17' – 25'
Accumulator Water Volume	8000 – 12000 gallons
Accumulator Water Height (Above bottom of tank)	17' – 25'
Number of CFCU's required "Operable"	5
Number of CFCU's credited for DBA after SACF	3
Start of DBA Containment CFCU Cooling[4]	<60 seconds
SWS flow rate/CFCU credited for DBA heat removal	1,200 gpm
Estimated SWS flow rate/CFCU in DBA[5]	>1,500 gpm
Accident CFCU air flow/CFCU[6] (unchanged)	39,000 cfm
Maximum outside air ambient temperature assumed	105°F
Design maximum SWS inlet temperature	90°F[7]
SW pump design flow	No change
SW system strainer backwash (normal and accident)	Constant[8]
2 Stage SW pump head (relative to 3 stage, Preliminary)	~ 66%
SW pump motor loading (3 Stage pump)	1000 Hp (746 KWe)
SW pump motor loading (2 Stage pump) Estimated	666 Hp (496 KWe)

[4] The design is based on meeting the technical specifications of 60 seconds for full CFCU SW flow. The Containment analysis conservatively assumes 100 seconds.

[5] This higher flow rate will be used to mitigate the SW outlet temperature and flashing when the SW flow enters the low pressure SW return header.

[6] No airside CFCU hardware changes. 39,000 cfm assumed with 5 CFCU's running. 40,000 cfm assumed when there are 3 or fewer CFCU's running.

[7] The DBA containment analysis assumes a 93°F SW temperature. This provides for added margin and contingency.

[8] The CFCU Chilled Water System Project will not perform this modification; it will only evaluate the SW System performance with this added load since it is a bounding assumption.

EDG allowable for continuous operation (no time restriction)	2600 KWe
EDG max allowable 2-hour (110% of continuous)	2860 KWe
KVA Rating for CFCU CH Substation feed (each of two)	2500 KVA
Amps rating for CFCU CH Substation (each of two)	3200 amps

Figure 1 Chiller Cooling Capacity versus Cooling Demand

Cooling Demand:

If 4 chillers available and 44°F LCWT (containment at 86°F): 270 tons/chiller

If 3 chillers available and 44°F LCWT (containment at 86°F): 360 tons/chiller

If 2 chillers available and 60°F LCWT (containment at 102°F): 530 tons/chiller

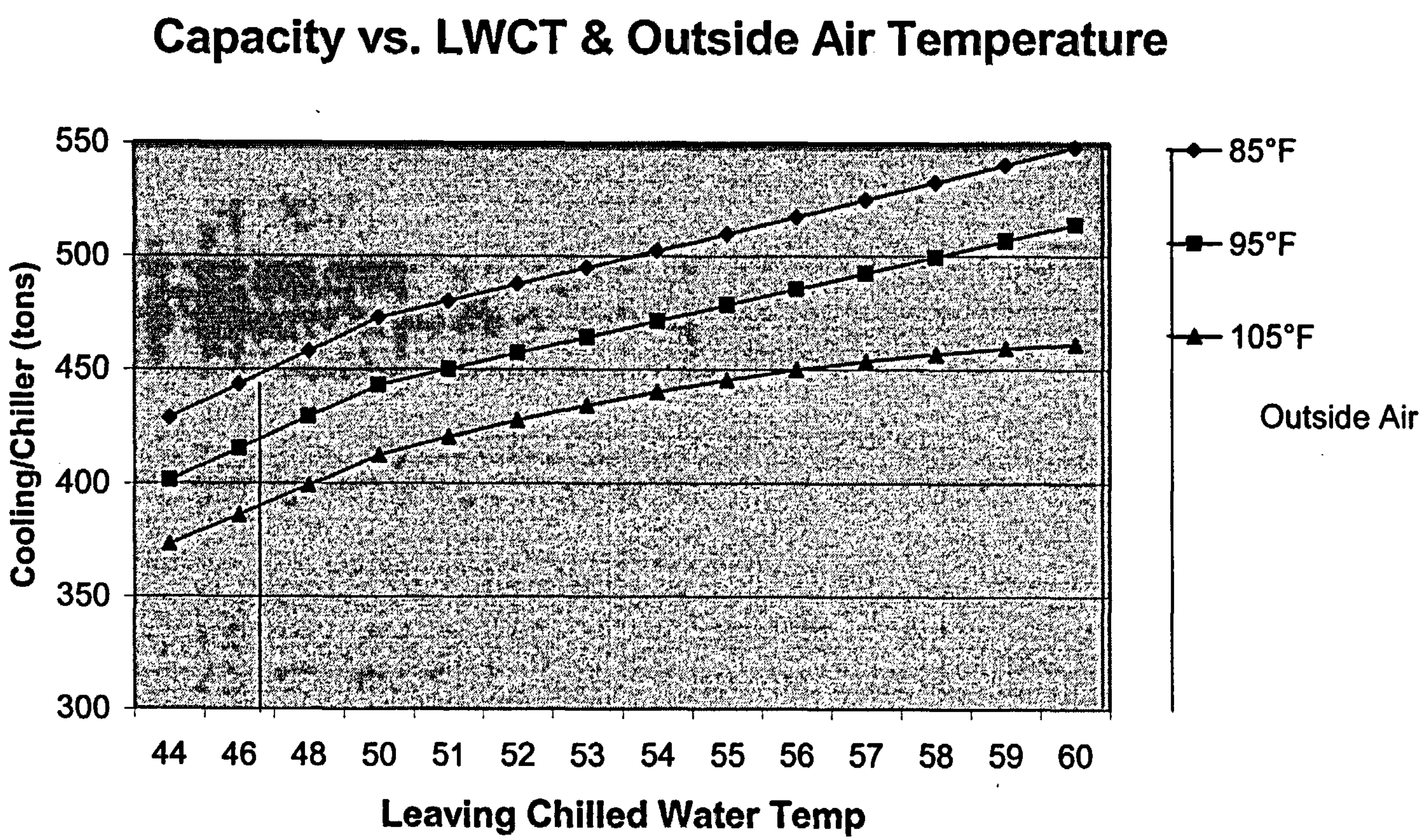


Figure 2 CFCU CH System Simplified P&ID

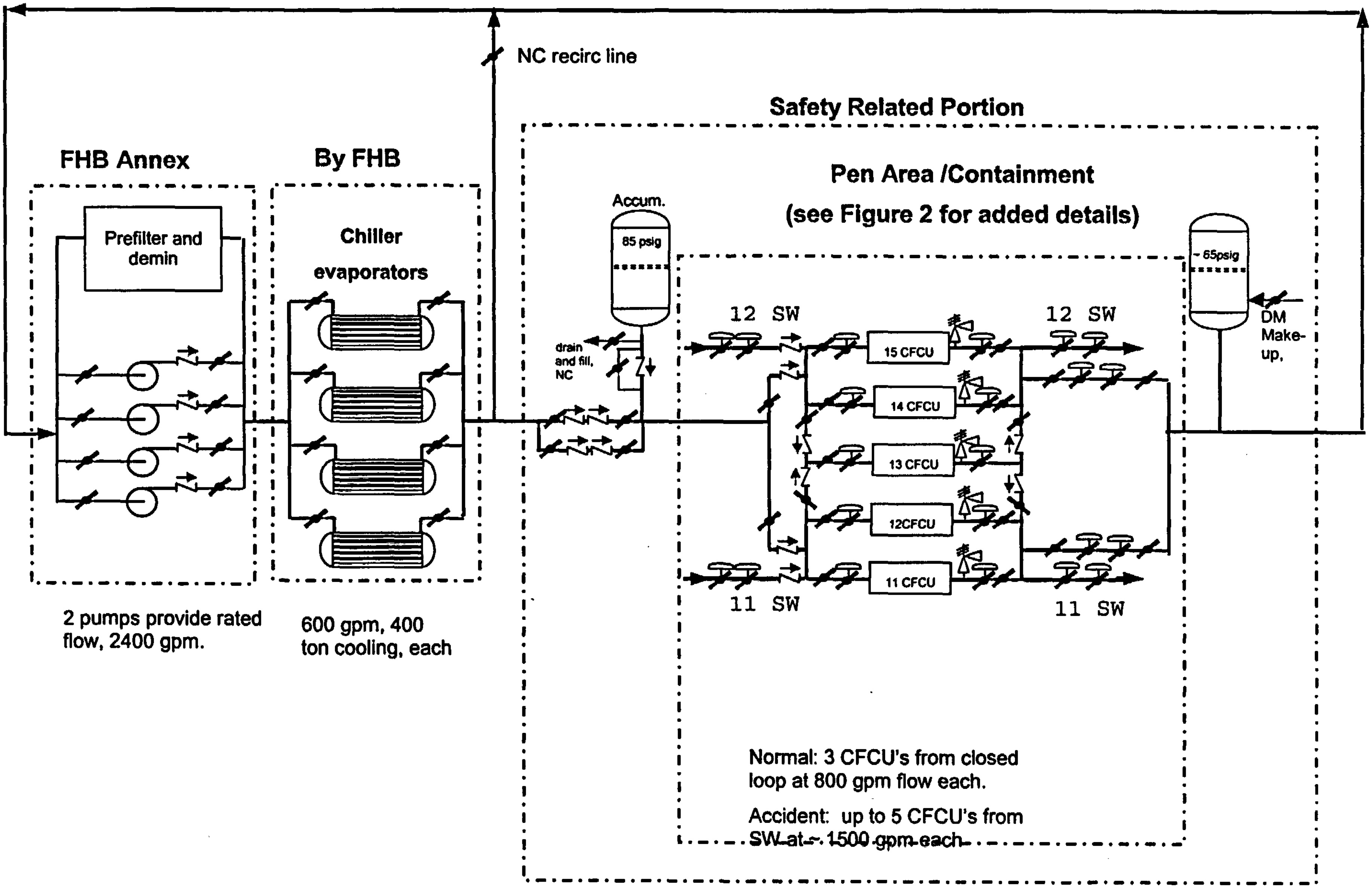
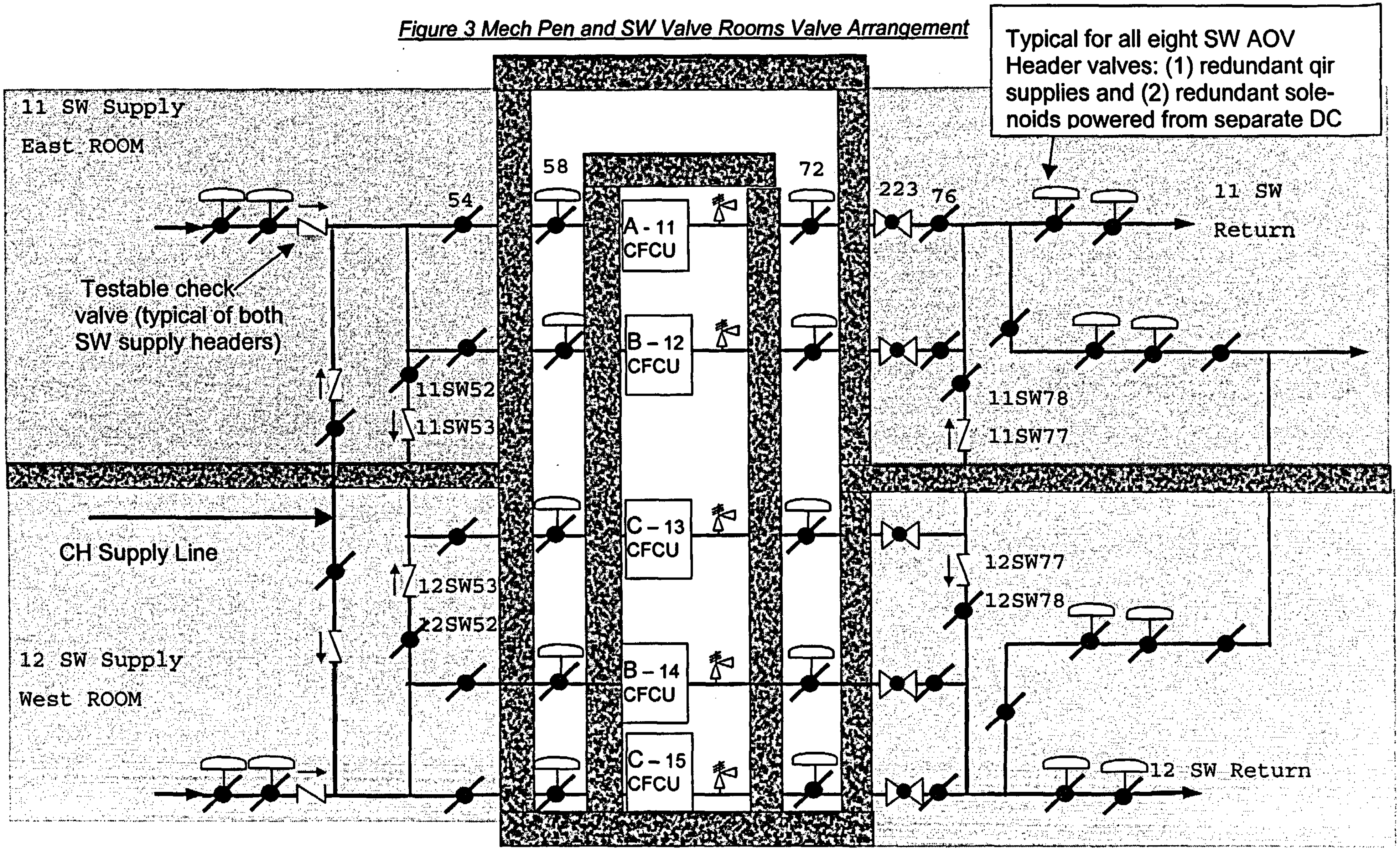
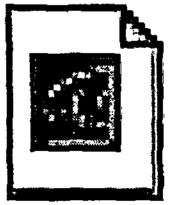


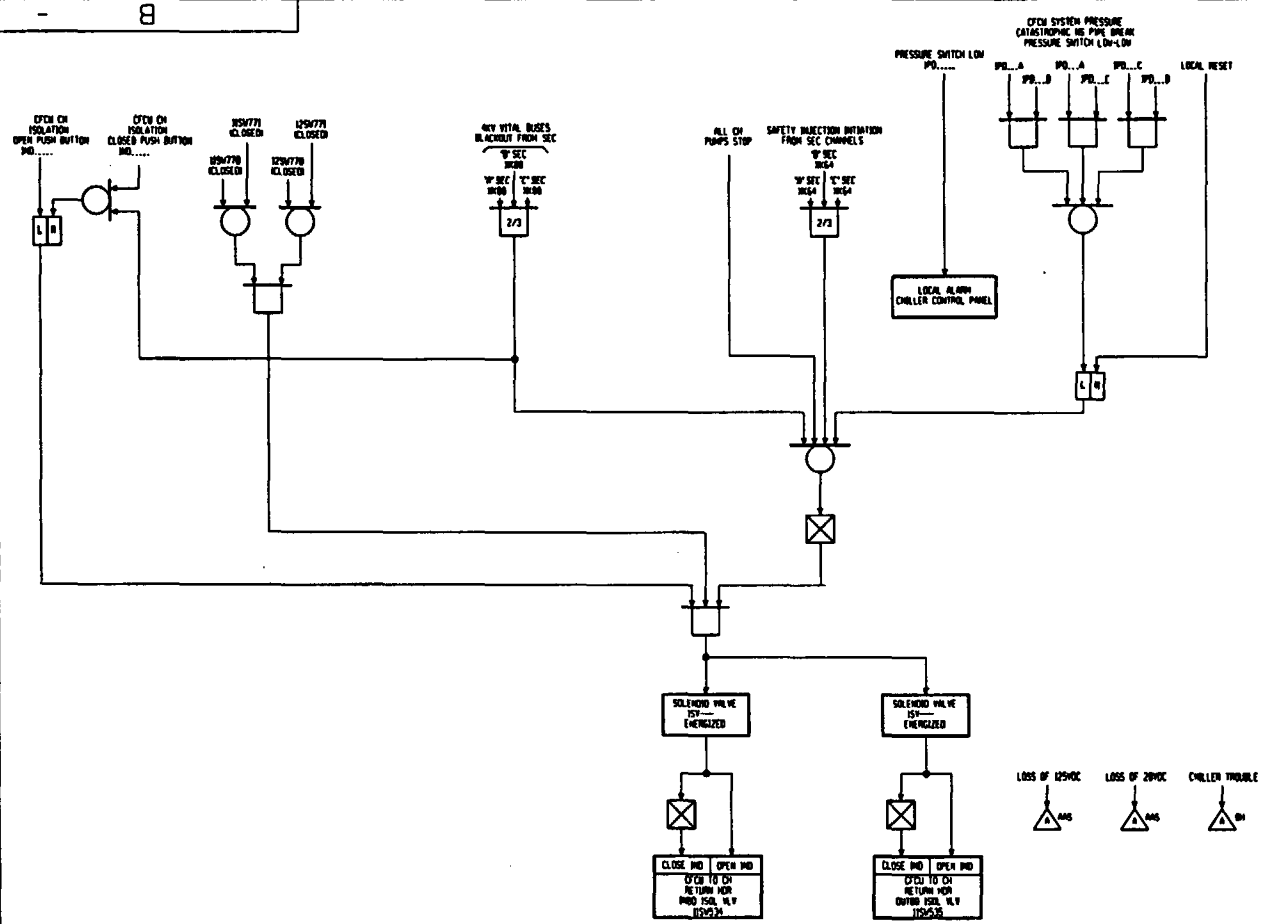
Figure 3 Mech Pen and SW Valve Rooms Valve Arrangement





B train CH Outlet.tif

Figure 4 Typical CH AOV Control Logic



REFERENCE DRAWINGS:

NO. 1 UNIT-CONTROL CONSOLE STATION FRONT VIEW ________ DWG. NO. ________

DESIGN FREEZE ISSUE - 3/8/04

- CHANGED LOP INPUT SOURCE FROM UV RELAYS TO SEC OUTPUT.
- ADDED 2/3 LOGIC FOR PRESSURE AND LEVEL ISOLATION AND ADDED ALARMS.

REV B NOTE: - 4/1/04

- DELETED LEVEL TRIPS THIS WILL BE ALARM ONLY

ATTENTION: ANY REVISION TO THIS DRAWING SHALL BE MADE ONLY BY CAED

SALEM NUCLEAR GENERATING STATION
CFCU NON-SAFETY RELATED CHILLED WATER SYSTEM
LOGIC DIAGRAM — CONTROLS

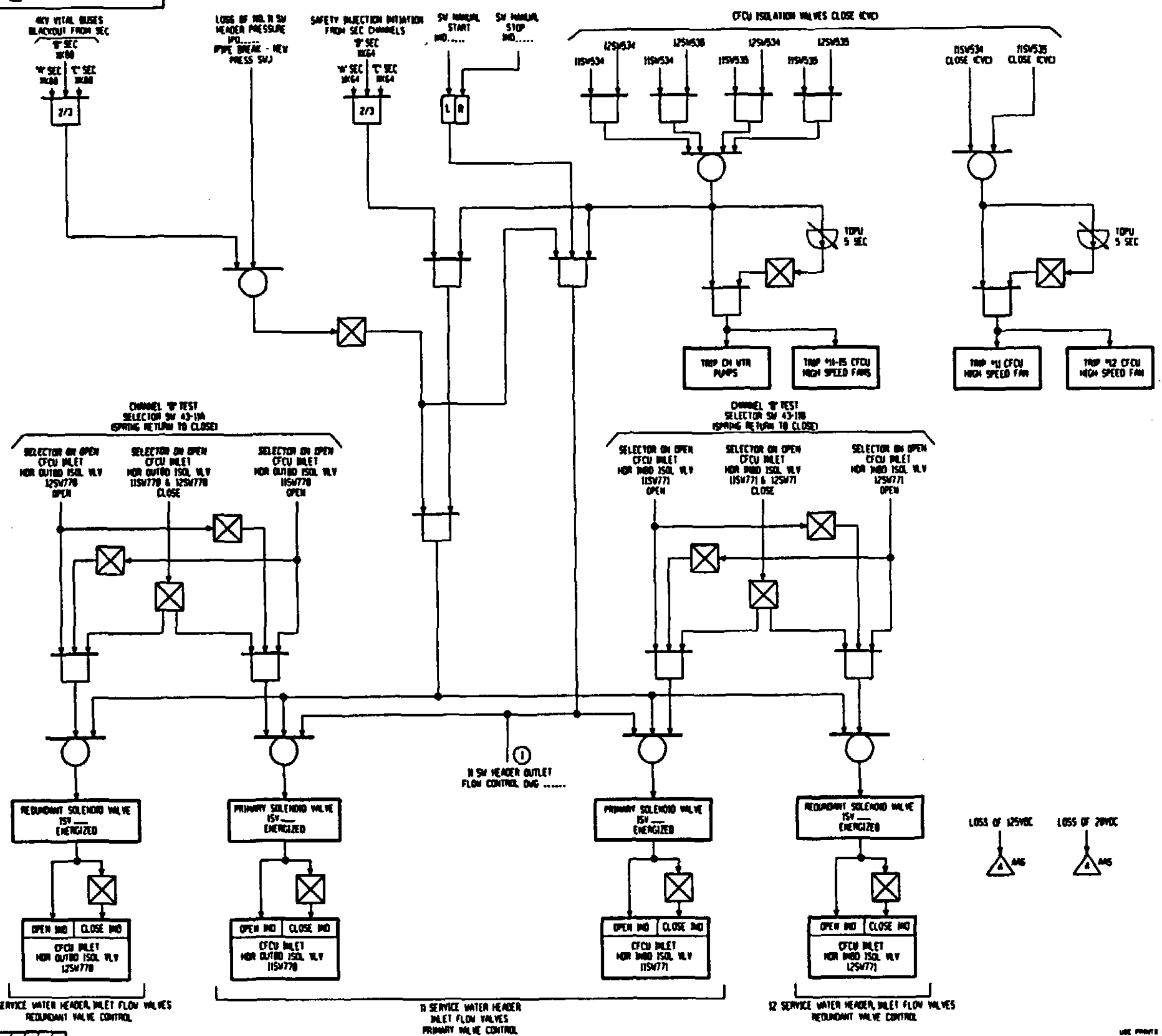
REVISION

B TRAIN OF CFCU CH WATER OUTLET ISOLATION VALVES

B -

11sw inlet.tif

Figure 5 Typical SW Supply Header AOV's Control Logic



- B

REFERENCE DRAWINGS:

NO. 1 UNIT-CONTROL CONSOLE STATION FRONT VIEW .... DWG. NO. ....

DESIGN FREEZE ISSUE - 3/8/04

- CHANGED LOP INPUT SOURCE FROM UV RELAYS TO SEC OUTPUT

REV B NOTE: 3-21-04

SPLIT "MANUAL" START FROM "AUTO" START (TO "B" CHANNEL SOV'S ONLY)

GENERAL NOTES

USE PRINTS OF LATEST REVISION ONLY. DO NOT SCALE - USE DIMENSIONS ONLY. FOR LIST OF REFERENCE DRAWINGS SEE DRAWING NO. THIS DRAWING. THIS DRAWING SUPERSEDES NONE.

ATTENTION: ANY REVISION TO THIS DRAWING SHALL BE MADE ONLY BY CACD

SALEM NUCLEAR GENERATING STATION
CFCU NON-SAFETY RELATED
CHILLED WATER SYSTEM

LOGIC DIAGRAM — CONTROLS

B -

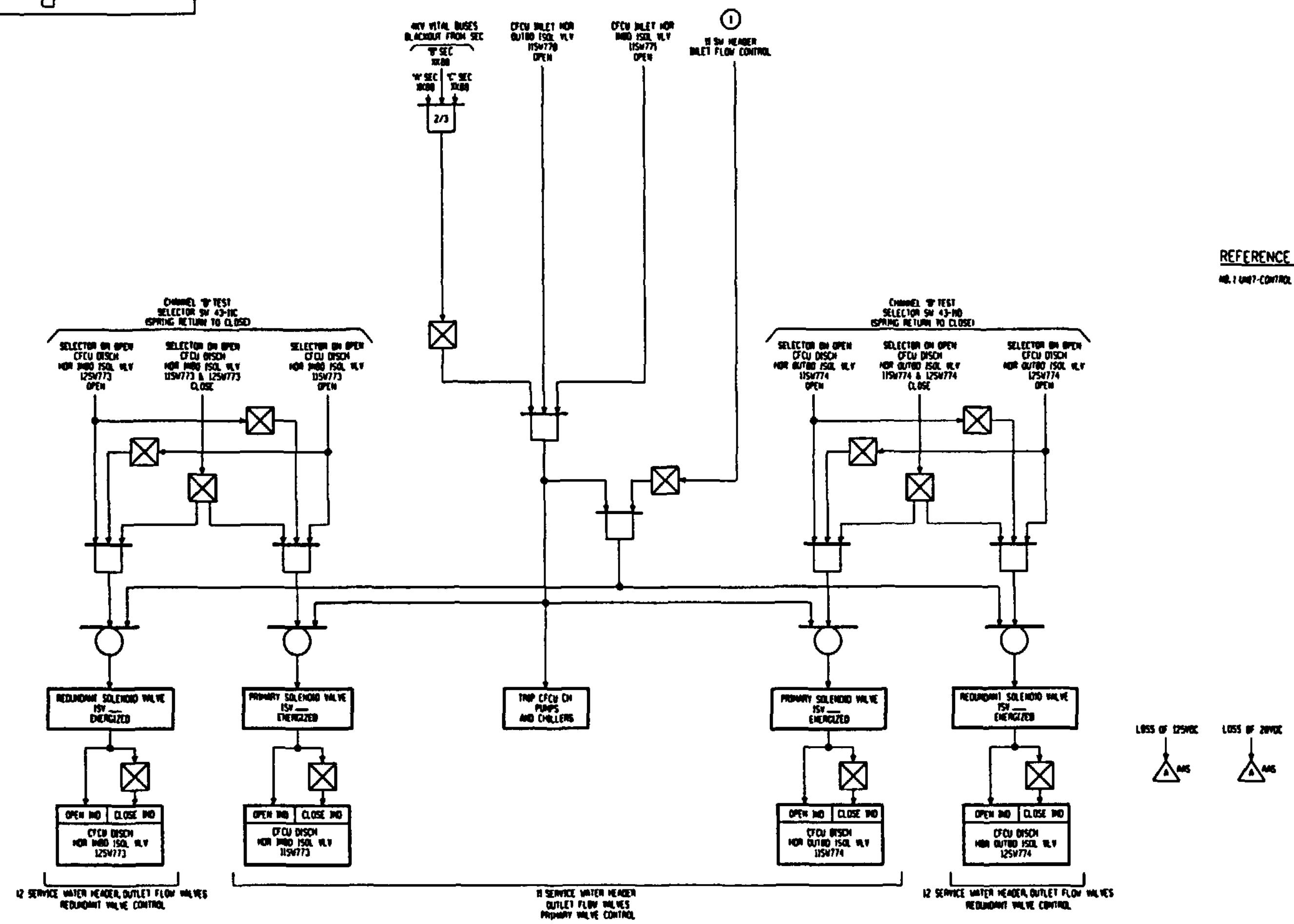
REVISION

11 SW HEADER INLET WATER FLOW VALVES ("B" CHANNEL)

11sw outlet.tif

Figure 6 Typical SW Return Header AOV's Control Logic

B -



REFERENCE DRAWINGS:

NO. 1 UNIT-CONTROL CONSOLE STATION FRONT VIEW __________ DWG. NO. ______

DESIGN FREEZE ISSUE - 3/8/04

- CHANGED LOP INPUT SOURCE FROM UV RELAYS TO SEC OUTPUT

REV B NOTE: 3-21-04

ADDED INTERLOCK TO ONLY OPEN ASSOCIATED (11) HEADER ON "MANUAL" INLET OPEN COMMAND

ATTENTION: ANY REVISION TO THIS DRAWING SHALL BE MADE ONLY BY CAED

SALEM NUCLEAR GENERATING STATION
CFCU NON-SAFETY RELATED
CHILLED WATER SYSTEM
LOGIC DIAGRAM CONTROLS

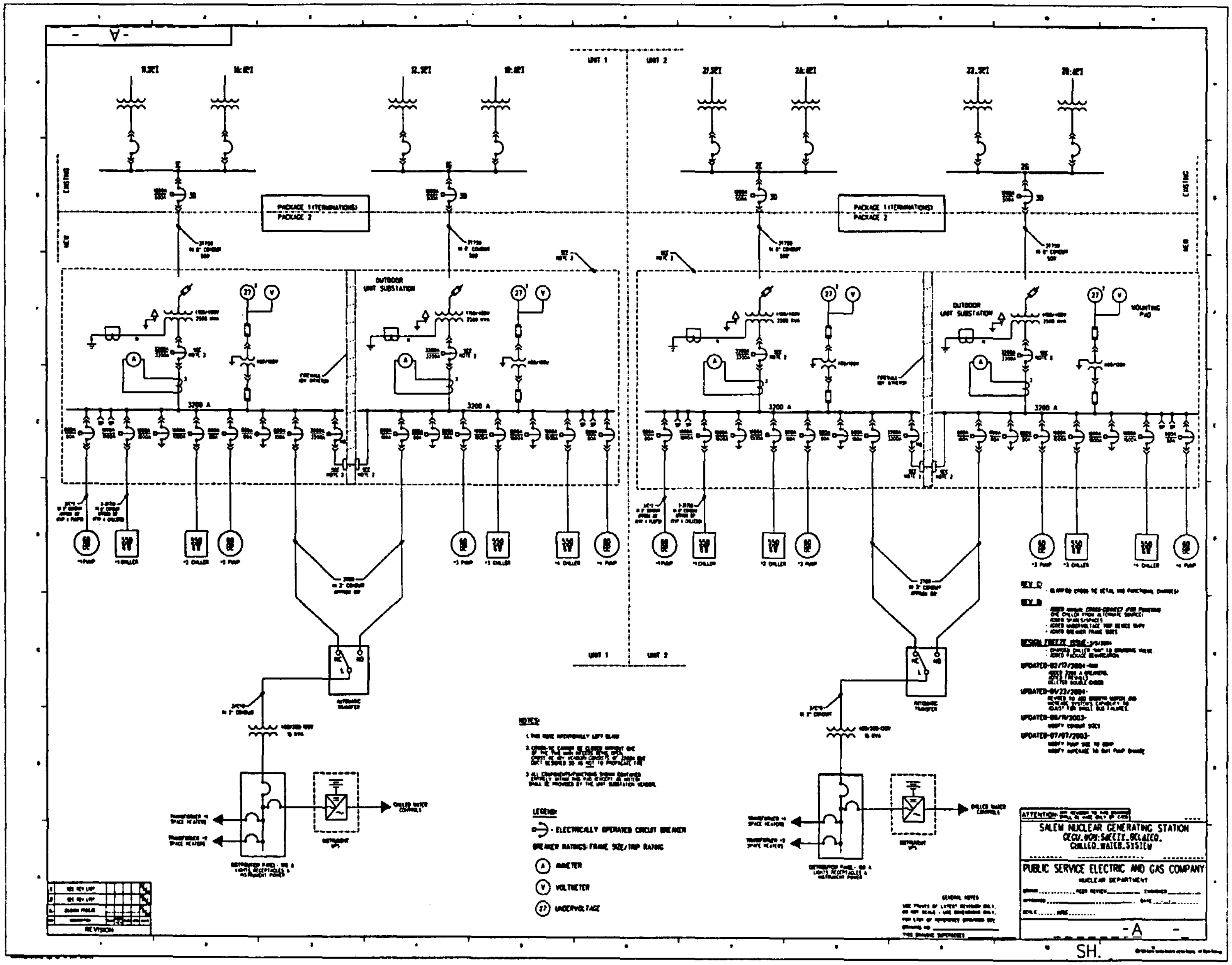
REVISION

11 SW HEADER OUTLET WATER FLOW VALVES ("B" CHANNEL)

B -

One Line - Design Freeze Issue - Draft.tif

Figure 7 CFCU CH System One Line Electrical


UNIT 1
UNIT 2
PACKAGE 2
OUTDOOR UNIT SUBSTATION
3200 A
NOTES:
LEGEND:
ELECTRICALLY OPERATED CIRCUIT BREAKER
AMMETER
VOLTMETER
UNDERVOLTAGE
ATTENTION:
SALEM NUCLEAR GENERATING STATION
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
NUCLEAR DEPARTMENT
-A -
SH.
REVISION

1. SYSTEM OPERATION

1.1. *Overview of Modification*

An independent Containment Fan Coil Units (CFCU's) Chilled Water (CH) System with redundant components is supplied for each Salem Unit. The CFCU CH System provides chilled water for containment cooling during normal power operation, normal shutdown, and refueling. It is not relied upon for design basis accident (DBA) cooling.

The CFCU CH System circulates a total of 2400 gpm of demineralized water in a closed loop between three CFCU's and four air-cooled chillers, mounted outside, to transfer the containment heat to the outside air. Three CFCU's and three chillers are sufficient to maintain the containment less than 90°F providing over 30°F margin to the maximum allowable temperature during normal operation, 120°F.

Service Water (SW) cooling is required during any DBA that releases mass/energy into the containment, even if the CFCU CH System remains available, since the DBA heat load would trip out the chillers on overload. A revised Westinghouse analyses, that credits improved CFCU fouling factor and improvements in accident modeling, shows that only two CFCU's, each with a minimum of 1200 gpm[9] SW flow, are adequate for DBA containment cooling. However, since the present dose calculation credits 3 CFCU's for DBA containment air mixing and iodine scrubbing, and a single active component failure (SACF) may disable two CFCU's, the CFCU Technical Specifications will retain the requirements to maintain five CFCU's "Operable". When Alternate Source Term (AST) is implemented, the analyses will support a licensing change to reduce the number of "Operable" CFCU's from 5 to 4.

On a SI signal, the CFCU flow is automatically realigned from CH to SW. The CFCU CH System is immediately isolated and SWS flow is then aligned by first opening the CFCU SW supply header isolation valves and then opening the SW return header isolation valves. However, if a LOP occurs at the same time, the SW valve opening is delayed until after the SW pumps are restarted.

Since the CFCU CH System shares some common piping and components with the SW system (e.g., CFCU's, and CFCU supply and return headers in the mechanical penetration area and containment), SW leakage into the demineralized water system has to be prevented during normal operation. This is done by using two in-series, SW isolation valves in each SW header and by maintaining the cleaner system at a slightly higher pressure than the SWS. All CFCU CH System components that are part of the DBA pressure boundary are designed to the higher standards imposed on the SW system. This includes the valves that isolate the non-safety related portion of the CFCU CH System.

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[9] However, approximately 1500 gpm will be provided to ensure no flashing of the SW outlet water when it is discharged into the common, low pressure SW return headers.

One of the two SWS accumulators is retained as an accumulator. It keeps the CFCU piping full and pressurized to prevent two-phase flow and water hammer during the post-DBA switch from chilled water to SW (Thermal relief valves, located immediately downstream of the CFCUs, protect the CFCU from thermal expansion when isolated). The other accumulator is used by the CFCU CH System as a head tank. It maintains NPSH and provides surge volume to accommodate thermal expansion, flow transients, and system leaks.

Since SW is not required for anticipated operations and the accident SW flow is significantly reduced, the complex flow control valve scheme previously required to establish different CFCU SW flows is eliminated. CFCU flow rates are fixed and hydraulically balanced by orifice plates and throttled valves. The resistance is set to assure (1) the nominal flow CH System flow of 800 gpm/CFCU to three CFCUs and (2) a minimum accident SW flow rate of ~ 1300 gpm/CFCU. With fixed resistance, the flow is determined by the pump head.

Overall, there is a significant gain in CFCU reliability and a significant reduction in maintenance[10] by using clean water to reduce the corrosion, erosion, and fouling of the CFCU's and by eliminating the flow control valves.

The reduced accident flow/CFCU allows the SW pumps to be destaged from 3 to 2 stages since it eliminates the CFCU as the dominant pressure loop. All normal and accident flows can be met with a 2 stage SW pump. Each destaged pump reduces vital power consumption by ~250 KW. Presently the EDG's operate during the ECCS injection phase close to the maximum allowed by the 2 hour short term limit, 2860 KWe. The 2 hour limit is 110% of the continuous allowable limit of 2600 KWe. The SW pump destaging decreases the peak EDG loading below the continuous loading, 2600 KWe, even during the ECCS injection phase.

The new chillers and pumps will be powered from the non-vital (group) buses. The 4160 VAC "G" and "E" buses will each power a 480 VAC CFCU CH substation. In turn, each of these substations powers two chillers, two pumps, and all common power (through an auto transfer). A limited cross-tie between the 480 VAC buses allows one bus to power up to three chillers in case the power feed to the other 480 VAC bus has failed. These 4160 VAC non-vital buses have the spare capability and breakers as a result of removing the Circ Water Pumps from these buses.

The power required to operate the Salem Units during peak (summer) demand is not increased. This is due to the savings from operating with 4 destaged SW pumps (1000 KW savings) and one less CFCU (224 KW savings) being greater than the added load of four chillers (<800 KW) and two CH pumps (<100 KW).

[10] This is achieved by significantly reducing, if not eliminating, the numerous water side problems, CFCU Reliability White Paper 7 22 03, Reference 7.11.

1.2. Normal Mode of Operation

1.2.1. CFCU CH System Pump and Chiller Operation

During normal plant operation, plant shutdown, and refueling activities, the CFCU CH System operates with 2 (of 4) chilled water pumps and 3 or 4 (of 4) 400 ton rated chillers to supply 3 CFCU's with 2400 gpm (total for all three CFCU's) of 46°F cooling water. This flow rate and supply temperature will remove 12.6 MBTUH from the containment and maintain containment ambient temperature less than 90°F.

Two of four 50% chilled water pumps are required for 2400 gpm flow. The other two are installed spares. A fixed CH flow of 2400 gpm will be maintained. Flow control to the CFCU's is set solely by fixed resistances and by hydraulically balancing system resistance to provide a simpler and more reliable design (All flow control valves including those in the CFCU branch lines are eliminated). Fixed resistances include orifices and manual throttle valves. Flow modulation is not required since the chiller loading automatically compensates for changes in the containment heat load.

The single fixed resistance is set for each of the two CFCU headers to establish CFCU flow rates for normal and accident conditions. Each CFCU header provides cooling water to three CFCU's (see Figures 1 and 2). The fixed resistance will provide a normal, chilled water flow of 800 gpm/CFCU to three CFCUs and a minimum SW, accident flow of 1300 gpm/CFCU. The post-implementation testing will confirm the CFCU's flows for both the chilled water system and the SW system. Once set, no flow adjustment should be required. The flow balance is checked periodically, using the chilled water system, to confirm that the fixed resistance is adequate for postulated accident conditions. The flow balance procedure would be repeated in the future only if the testing shows that the flows have degraded or if the throttle valves are repositioned for maintenance or repairs, etc. Flow indication for each CFCU will be maintained.

CH pump controls from the control room will be minimized. The chiller control panel will control pump operation. Since check valves are provided in each pump's individual discharge path, the suction and discharge valves can be kept open for the standby pump. All manual butterfly valves shall have clear "open" and "close" indication. Pump stops/starts are anticipated no more frequent than monthly to balance the service hours between pumps. On a low flow or indication of a pump failure, a back-up is automatically started. A signal from the high-low flow switch located in the common discharge header of the pumps indicates that the system flow is abnormal. This signal alarms locally and causes a general trouble alarm in the main control room.

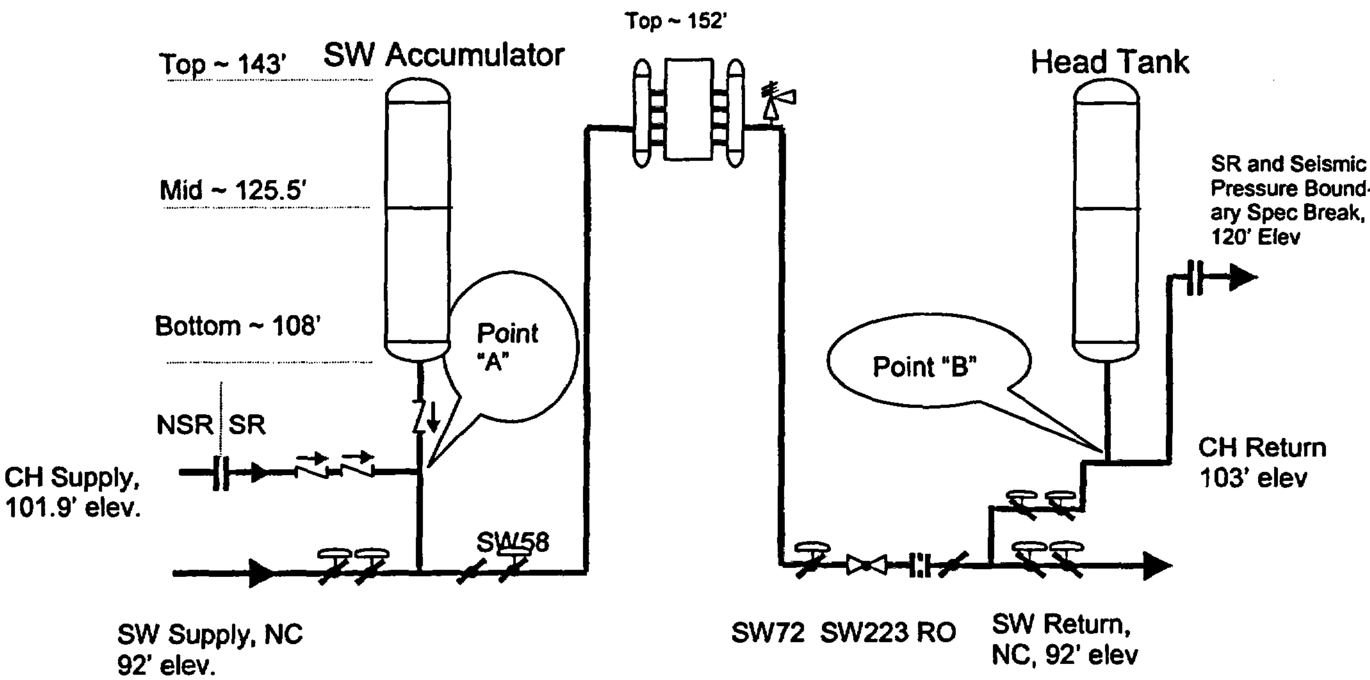
Normally all 4 chillers are in operation to maintain maximum chiller efficiency and minimize power requirements. However, one chiller can be removed from service for maintenance without impacting containment temperature since 3 chillers can meet a containment-cooling load of 1074 tons even with an outside air temperature of 105°F (each chiller can provide 380 tons at 105°F ambient air). The chillers automatically adjust their loading to maintain a constant chilled water supply temperature, selected as 46°F. A vendor supplied, central control unit coordinates all four chillers.

During normal shutdown and refueling, the chilled-water system continues to operate to maintain containment cooling to significantly reduce worker heat stress. However, the number of in-service CFCU's may be reduced due to the much lower containment heat load. All major CFCU CH System equipment is located in the yard or in the FHB Annex and is easily accessible.

1.2.2. Head Tank and Accumulator Operation

The sketch below is a simplified pictogram that omits 4 of the 5 CFCU's and redundant flow paths. The sketch is to illustrate the functions of the two tanks. Tank elevations are taken from PSEG Drawing 605395, Rev 0.

The parameters for both the accumulator and head tank, and the rationale for selecting them, is addressed in section 2.2, Key Design Parameters and in section 2.3, GL 96-06 Design Requirements.



SW Accumulator:

The SW accumulator, on the supply header side, is required to satisfy GL96-06 concerns. It operates in conjunction with the CH supply header check valves and return side AOV's to maintain the CFCU's full and the fluid subcooled (as discussed in Sections 1.4 and 2.3). The accumulator is always aligned to the CFCUs during anticipated operation (CH cooling) and during abnormal line up (SWS cooling due to the CFCU CH System being out of service).

The CH supply header pressure at the connection to the SW Supply headers will be a nominal 110 psig to meet the objective of maintaining the CH supply header pressure at ~10 psid above the anticipated SW supply header pressure with de-staged SW pumps.The accumulator is pressurized with N_2 gas to ~ 80 psig. Hydrostatic pressure between normal level and the outlet line from the tank (point A) adds another 10 psid. Therefore, except for some postulated CFCU flow transients, the accumulator will remain isolated from the discharge flow path by the accumulator outlet check valve due to the higher pressure on the CFCU supply header.

The accumulator water volume is kept between 8,000 to 12,000 gallons. Maximum discharge in a transient, based on Reference 7.4, is ~ 1000 gallons.

Head Tank:

A head tank is provided on the CH pump suction side. This tank allows for volume changes due to thermal expansion, and it provides a significant make-up volume in case of system leakage. The tank was originally safety related, and the pressure boundary will be retained as safety related.

In addition, the N_2 pressure above the head tank is used to establish the CFCU Chilled Water System operating pressure. This gas pressure plus the pump TDH is sufficient to maintain the CFCU CH System pressure above SW pressure at the SW valve rooms. This scheme (as opposed to relying solely on pump TDH) allows lower head pumps to be used. Lower head pumps lower the required Hp, throttling, and heat input to the system. The nitrogen blanket also serves to keep air out and minimize the corrosion of the carbon steel piping.

The head tank water volume is 8,000 to 12,000 gallons. This provides a volume for system leaks and feed and bleed. Each CFCU branch line has an approximate volume of 2200 gallons. The head tank contains sufficient volume to refill a CFCU even without make-up to the tank.

The head tank has a 2" nominal diameter make-up line from the DM system rated for > 50 gpm. This line has a normally shut manual isolation valve located in the 78' Mechanical Pen Area, near and above the abandoned-in-place SGBD HX's. A hard-piped line with normally shut valve allows for quick alignment of make-up water without requiring any temporary hoses. Reliance on Operator action should allow early detection of even small leaks.

Recirculation Line:

In case the CH System isolation valves are shut, a manually operated recirculation path is provided around the pumps and chillers. This allows for system start-up and it allows for the head tank and CH pumps to provide a source of pressurized clean water for flushing the CFCU's. The head tank will provide NPSH to the pumps. In order to protect the pump from damage, this tank is not isolated from the CH pump suction except by manual valves.

Anticipated Tank Fluctuations:

During normal operation, level changes are expected to be very small. Volumetric expansion/contraction corresponding to a 45°F change in CH water temperature will result in ~ 2" level change in the head tank.

Levels and pressures on the head tank should be monitored. Drops in water level (and consequently small pressure drops in operating pressure) pressure will alert the Operators of system out-leakage. The converse is true in case of SW leakage into the CH system. A 0.1 gpm leakage will cause a tank level change of 4"/day. Thus, during normal operation, even small leakages should be detectable[11].

The accumulator has a 10" check valve on the outlet that allows for outlet flow from the 10" line. Make-up to this tank is through a normally shut bypass valve around the check valve. A drain line, that is connected to the lower pressure head tank, allows for draining the tank in case there is leakage through the shut check valve. Since the accumulator is normally isolated from the flow path, there should be no level oscillations in this tank.

The CH AOV closure signals are designed to automatically isolate the CH return header AOV's if the CH pumps are tripped (as discussed in section 1.3.2) or there is a supply header depressurization. The in-series isolation valves should prevent the accumulator from draining into the head tank. The preferred pump alignment, as discussed in section 1.3.5, is to operate with one pump from the "E" bus and one from the "G" bus to minimize the possibility of simultaneously losing both operating CH water pumps.

Tank Sequencing/Alignment During System Start-up and Shutdown:

The following sequence is suggested during system start-up.

1) With the pumps off, fill both tanks to the desired water level (see section 2.2).
2) Pressurize both tanks more or less simultaneously with N_2 to the nominal gas pressure recommended for the head tank.

[11] This assumes that the Operator logs record this reading for at least daily comparison.

3) Start the CH pumps and verify that the tank levels do not change to confirm that the accumulator check valve has shut. Increase the accumulator gas pressure to the desired set-point.

The chilled water system can remain in service throughout a refueling outage. However, if it is to be taken out of service, the accumulator should be isolated prior to all the pumps being tripped.

1.2.3. Control Room SW and CFCU CH System I&C

A near term effort is required to provide a more detailed assessment and review against human factors, commitments, and to obtain Ops concurrence.

Although the system is not SR, the CFCU Chilled Water System is critical to power operation. As such, the Operators should be capable of monitoring the following key parameters in the CR that indicate if the cooling water to the CFCU's is operating as designed. These are:

1) Rated water flow to the operating CFCU's (The existing flow instrumentation on the CFCU lines should be reviewed to confirm that they are adequate for this purpose).
2) CH temperature on the supply and return headers (In addition, there is the temperature on the outlet of each CFCU).
3) Water level and N_2 pressure on the head tank and accumulator (confirmation of system integrity).
4) Adequate number of components operating (rely on the trouble alarms described below).

The first two (temperature and flow) are the minimum indication to allow the Operators to assess if the cooling water is performing its design functions, and therefore, to determine if a containment temperature excursion should be anticipated, or alternatively, if that temperature excursion can be attributed to a cooling water malfunction. The last two items are key to alert the Operators of a system degradation that may shortly cause system degradation or failure.

A high or low water temperature signal or chiller safety circuit trouble will alarm locally and cause a general trouble alarm in the main control room. Chiller protection is provided to automatically shut down chillers if supply or discharge temperatures are abnormally high or low. Local control panels will indicate chiller trouble before automatic trip setpoints are reached and a general CFCU CH System trouble alarm will signal in the control room. Automatic chiller trip actuation is locked in and must be manually reset. Loss of a single chiller will not cause a loss of flow and CFCU CH System pumps remain in-service.

Control Room changes are required to reflect removal of the individual CFCU flow control valves (i.e. SW57, SW223, SW65) and installation of new AOV's on the CFCU headers. This includes but is not limited to providing controls for the power operated valves and indication of valve position.

1.2.4. CFCU Operation

The preferred alignment for normal cooling is three CFCU's each with 800 gpm CH flow to keep the containment ambient temperature less than 90°F.

Closure of the CH return path AOV's from either the east or west SW valve room limits the CH flow to 3 CFCU's but maintains all 5 CFCU's "operable". For example, closure of the CH AOV's in the west room prevents CH flow to the 14 and 15 CFCU, allows CH cooling to the 11, 12, and 13 CFCU, but in case SW is initiated, all CFCU's can be cooled by SW.

If the fan on 1 of the 3 operating CFCU is tripped and the flow path is not isolated, the two other CFCU's each with a nominal flow of 800 gpm will maintain containment temperature ~ 102°F, ~ 18°F below containment maximum allowable.

Four (4) CFCU's for normal cooling with 600 gpm each is an acceptable alignment but it will only provide a marginal improvement in cooling over 3 CFCU's.

The Technical specifications will require all five CFCU's to be "Operable" to ensure 3 CFCU's operate post DBA and SACF for containment cooling and iodine scrubbing. Any 4 "Operable" CFCU's ensures that two CFCU's remain after a SACF which is adequate for containment cooling as discussed in section 1.4. Any 4 "Operable" CFCU's will also satisfy the design basis for iodine scrubbing after AST is implemented.

1.2.5. SW Operation

SW flows will remain the same except for the changes below.

1) No CFCU SW flow during normal operations
2) Reduced CFCU SW flow in a postulated DBA
3) SW strainer will be kept in constant backflush[12]

Reducing the CFCU required accident flow from 2500 gpm to 1200 gpm/CFCU significantly reduces the required SW pump TDH. The SW pump will be destaged from 3 to 2 stages. A 2-stage pump retains the same flow capacity, but the pump power and head will be reduced to 2/3 of its original value. The hydraulic model will verify that the 2-stage pump can provide all revised normal and accident SW flow rate. The modification will make any required changes to the SW control valves/orifices in all branch lines.

With the exception of the added AOV's to isolate SW from the CFCU's during anticipated operation, the CFCU SW accident flow path remains the same. Specifically, because of check valves SW53 and SW77, the 11 SW header can only

[12] The CFCU Chilled Water System Project will not be doing this modification, but it will factor this into the SW hydraulic modeling since it is anticipated that it will be implemented by the SW upgrade project.

cool the 11, 12, and 13 CFCU's. The 12 SW header can only cool the 13, 14, and 15 CFCU's.

The SW system will operate at lower pressure and with less throttling. Specifically, The pump shutoff head will be reduced from 180 psig to 120 psig. The supply header normal operating pressure will be reduced from ~ 150 psig to ~100 psig. This provides a far greater margin to the piping design pressure, 200 psig and to the design pressure for a number of the SW components, 150 psig.

Winter operation will be reviewed to determine if bypass flow has to be added to compensate for no flow thru the CFCU's. This is required maintain minimum SW pump flow. One option is to increase the bypass flow around the TAC HX.

Note that section 1.3.7, contrary to the above statement, does address SW flow in use in a non-DBA scenario for containment cooling. The basis for providing section 1.3.7 is to answer, proactively, if using SW for non-DBA containment cooling poses an unanalyzed condition to the unit.

1.2.6. Electrical Plant Operation

The primary electrical plant change for normal operation is to shift loading from the vital buses to the group buses. Specifically, the normal and accident loading on the vital buses are decreased by destaging the SW pumps. The SW pumps are the single largest loads on the vital buses. The normal load on the group bus is increased by the addition of the new CH pumps and chillers. The total plant electrical load to operate the unit will not significantly change. There will be a small reduction except in the winter time, when there will be a slight increase.

Vital Buses

The number of SW pumps in normal operation varies between 2 in the winter and 4 in the summer. This number is not expected to change, but destaging the SW pumps will reduce the vital bus loading by approximately 250 KW per operating SW pump. Since one SW pump is loaded on each diesel on a LOP, this also reduces the EDG loading by ~ 250 KW / diesel.

The number of CFCU's in operation varies from 2 in the winter to 4 in the summer. With the chilled water system, 3 CFCU's will be kept operating year-round. This reduces the summer load by 300 Hp (224 KWe), but increases the winter load by the same amount.

For DBA conditions, the CFCU fans are shifted to low speed operation (100 Hp). The A diesel is loaded with the 11 CFCU, the B diesel with 12 and 14 CFCU, and the C diesel with 13 and 15 CFCU(This is not a change from the present design).

Non-Vital (Group Buses)

The four chillers and four pumps will be normally split between the "G" and "E" buses. In addition, an auctioneered circuit will power the common control panel. Common I&C, local lighting, and maintenance outlets. Refer to Figure 7 CFCU CH System One Line Electrical on page 17. These non-vital buses have the spare capability and breakers as a result of removing the Circ Water Pumps from these buses.

Each of the two 480 VAC CFCU Chilled Water System substations will be able to provide full containment cooling under the bounding conditions discussed in section 1.3.1 and 1.3.5. These are loss of one or both chillers on the opposite bus.

Each 50% CFCU CH System pump motor is rated at 60 Hp and this load is year-round. Although each 400 ton chiller rated nameplate will be approximately 500 to 550 KW, the normal load, assuming all 4 chillers are in operation, is less than 200 KW/chiller as per the table below.

Chiller Capacity Versus Monthly Ambient Temp and 46°F LCWT			**3 Chiller Operation (each chiller at ~350 ton)**			**4 Chiller Operation (each chiller at ~262 ton)**		
Month	Mean Dry Bulb, °F	Capacity tons / chiller	% Loaded	KW / chiller	Total kW	% Loaded	KW / chiller	Total KW
May	82.2	451	77%	307	922	58%	190	757
Jun	86.6	439	80%	330	991	60%	192	766
Jul	89.3	431	81%	345	1038	61%	193	772
Aug	86.8	438	80%	331	994	60%	192	767
Sep	85.0	443	79%	321	965	59%	191	763

1.3. *Abnormal/Emergency Modes of Operation*

1.3.1. Failure of a CFCU CH System Chiller or Pump

Electrical failures are addressed in sections 1.3.5 and 1.3.6.

Since the CFCU CH System is required for power operation, it is provided with four 50% pumps and four chillers.

Although the CFCU CH System will not have Technical Specifications mandating a specific number of "Operable" CFCU Chilled Water System components, there is a containment technical specification on containment peak temperature, which in essence, mandates adequate CFCU CH System performance. Any chiller or pump failure should be addressed in reasonable time to minimize the possibility of cumulative failures that would then impact the system's ability to maintain containment temperature. The project will provide during the implementation phase an analysis showing the consequences of any failure including the impact on the cooling margin. The objective of this analysis is to identify the priority that the repair should have.

To mitigate the duration of any major failure, the chillers and pumps are located in an accessible, ground level location. All chiller and pump piping connections are flanged and valved to allow for quick replacement of the defective pump or an entire chiller without impacting the pressure boundary for the rest of the components. All chillers are provided with single point, lugged electrical lines.

Chillers

The cooling requirements and cooling capacity per individual chiller is shown in Figure 1. The cooling requirement/chiller is summarized for three conditions: all chillers available, one chiller lost, and 2 chillers lost. The actual capacity of a chiller is dependent on (1) outside air temperature and (2) LCWT setpoints. The chiller sizing is based on:

1) Assuming 4 chillers are normally on-line, a complete failure of any one chiller will only result in the other three automatically going from ~68% to 90% capacity. The remaining three are capable of cooling the containment assuming 105°F outside air and 44°F LCWT (keeping containment at less than 90°F).
2) On a loss of two chillers, the remaining two are capable of cooling the containment assuming $\leq$ 90°F outside air and 60°F LCWT (keeping containment at ~100°F). Under these conditions, the chillers will have zero margin (refer to section 1.3.5).

The chillers include self-diagnostics including screens with problem reports in plain English. In addition, the Vendors offer a maintenance agreement that includes periodical site inspections and repairs.

A complete loss of a chiller due to a chiller component failure is not likely. Each 400-ton chiller has four separate 100-ton refrigerant circuits[13]. Each 100-ton refrigerant circuit consists of one compressor and multiple condenser fans powered from a separate circuit breaker. Similarly, the refrigerant pressure boundary for each of these circuits has its independent refrigerant piping and condenser cooling coils such that a loss of refrigerant will not affect more than one circuit. Thus, the more probable consequence a single refrigerant component failure is loss of 1/16th of the total capacity of 4 chillers, and at least 5 refrigerant circuit failures can be tolerated before chiller capacity becomes limiting.

The above design allows for repairs or routine maintenance to one circuit while keeping the other three circuits available. Furthermore, the compressors are flanged and the physical lay-out specifies that piping shall be run so that it does not interfere with removal of a compressor or prevent fork-lift access to the compressor.

An obvious advantage of air-cooled chillers (as opposed to water-cooled) is the simplicity of the refrigerant cooling. As opposed to water cooled chillers, air cooled chillers are immersed in their cooling medium and only require power to the fans to provide adequate cooling even with 105°F outside air. The control scheme is simple. As outside air temperature or chiller loading change, automatic changes in the number of operating fans allow small step changes in the cooling flow rate to maintain optimal refrigerant cooling. Each chiller has 18 or more fans (depending on Vendor). The fan motors are approximately 2 Hp, direct drive, with double sealed, permanently lubricated ball bearings. A fan failure will only affect one circuit and even then a fan failure only results in a proportional reduction in capacity; therefore, in excess of 18 fans would have to fail before containment cooling is impacted.

In addition to the controls on each chiller, a central control panel coordinates the chillers and the pumps. This central control panel provides the following key functions:

- It allows for changing any input, e.g. LCWT setpoint, at one location versus individually at each chiller. Similarly, it simplifies obtaining operating data/history from the machines.
- It coordinates the chillers to rotate operating time.
- It coordinates the chillers when chilled water conditions change. This is more important when cooling loads vary. The central control panel will sequence the chillers to minimize "over-reaction" to a change in parameter.
- It will start a standby chilled water pump if it senses a pump trip.

[13] this is a standard design for York. It would require a customized design from the other vendors. For example, Trane's standard design has two 200 ton circuits with two 50% compressors/circuit.

The potential vendors have verbally stated (with verification to be done during the bid selection process) that a failure of the central panel will not disable any equipment. The pumps will remain as before. The running pumps will not be tripped and the standby pumps will not be started. The chillers will operate satisfactorily without the central control panel.

Pumps

The chilled water system relies on operation of 2 of 4 fifty (50) % capacity pumps to maintain the containment at less than 90°F. A failure of one operating pump will result in a reduced system flow (2400 gpm → approximately 2000 gpm) and an upward trend in containment temperature until a standby pump is placed into operation. One pump, however, will keep the containment temperature below 110°F. To mitigate this concern, the chiller central control panel will auto start a back-up pump when it senses a pump trip (via current transformers on the pump motors).

These pumps will be located inside the 100' level of FHB annex. This is outside of the RCA. This location was provided since it is adjacent to the chillers and it provides ample space, inside an existing concrete building, for optimal layout and access.

1.3.2. Tripping of all CFCU CH System Pumps

Refer to section 1.3.6 for a prolonged loss of pumps.

If all on-line chilled water pumps are tripped, the CH AOV's will be automatically shut due to the low CH discharge header signal to these valves[14]. The single accumulator then maintains the CFCU's and all SR piping pressurized at nearly normal pressure. If the CFCU CH System pumps are not quickly restarted, the Operators should confirm that these valves are shut (in a DBA, the CH system is also automatically isolated by a SI signal).

CH pumps are not credited for addressing GL96-06 concerns.

1.3.3. Failure of a CFCU

Containment Normal Temperature Impact:

If operating with CH water to only two CFCU's, the containment temperature will slowly rise due to the thermal inertia inherent in the mass inside containment, but the containment will remain below 110°F. The higher temperature differential between CFCU CH chill water and containment temperature then allows the remaining two CFCU's to remove the required heat load.

Technical Specification Requirements:

The design is based on the more limiting of the following:

[14] The design needs to ensure that the source of this signal is upstream of the CH System supply header check valves. Otherwise, the accumulator pressure will negate this function.

1) Any 4 "Operable" CFCU's ensure that two CFCU's operate in a DBA for required containment cooling, including worst postulated SACF, but
2) All 5 CFCU's must be "Operable" to satisfy the present design basis for iodine scrubbing which requires that 3 CFCU operate in a DBA.

Refer to added discussion in section 1.4:

1.3.4. Failure of a CFCU CH System or CFCU SW Isolation Valve

A failure of an isolation valve during testing has been considered. The design provisions are discussed in detail in Section 3.1.

In summary, SW double, in-series isolation is provided only to minimize potential of leakage into chilled water and to allow testing during normal operation; it is not a DBA requirement. One valve per line can be jacked-open and then the stem locked open if the valve testing determines that the valve would not open in case of an accident.

The chilled water system is provided with dual, parallel flow paths on the isolation valve portions. This allows one of the two parallel paths to be isolated for testing or maintenance without interrupting normal cooling.

The time limitation is imposed only by the need to test the redundant valve or flow path.

A failure in an accident condition has also been considered. The valves required to isolate the non-SR CFCU CH system are redundant, in-series, fail shut valves. Any single valve failure will not prevent isolation of the CFCU CH System. The SW flow paths consist of two redundant flow paths. A failure of either flow path to unisolate will not prevent the other flow path from providing adequate cooling to three CFCU's.

1.3.5. Partial Loss of Power to CFCU CH System

A loss of all power to the system is addresses in Section 1.3.6.

The CFCU CH System pumps and chillers are supplied with non-vital power. However, the power to the chillers is from two group buses. Each group feeds two chillers and two pumps.

Operating instructions will specify that the preferred mode of operation is to split the operating pumps between the two group buses (assuming both buses are available). This limits a loss of either group bus to (1) a loss of two chillers and (2) a reduction in CFCU CH System flow until the chiller central control panel starts the back-up pump.

If the loss of one circuit is due to a loss of the group bus, the reactor will also be tripped because each group bus supplies one RCP motor. The remaining two chillers should easily suffice due to the reduced heat load.

If the failure is due to the power feed from the 4160 VAC (including the 4160/480 VAC transformer) to one of the two 480 VAC buses, a limited cross-tie can be manually operated. This allows the single remaining 4160 VAC to 480 VAC power feed to operate three chillers and two pumps provided that no more than one chiller and one pump are powered through the cross-tie.

If the failure is one of the two 480 VAC buses themselves, the two chillers on the opposite bus can provide the required cooling under the following conditions (a) the two chillers can operate at 100% of their capacity, (b) the ambient air is below ~ 90°F, and (c) the LCWT setpoint is increased to ~60°F. A LCWT of 60°F will result in a containment temperature of ~ 105°F which is still well below the maximum allowable of 120°F.

1.3.6. Total Loss of CFCU CH System

Without CH System chillers and/or pumps, containment temperature will rise and will force a shutdown if the chilled water system is not restored reasonably fast. Provided the CFCU CH System integrity is maintained, there is no immediate safety concern. The CFCU branch lines will remain full since the CFCU CH System is a closed loop system and the single accumulator will maintain the CFCU's pressurized. The Operators should verify that the AOV's on the CH return path have isolated (see section 1.3.2).

A loss of both "E" and "G" will cause all CFCU CH System chillers and pumps to stop and is bounded by a total loss of group buses (loss-of-off-site power, LOP). A LOP by itself will not unisolate the SW isolation valves and initiate SW cooling. On a loss of the chilled water system following a LOP, it is anticipated that the Operators will initiate SW to the CFCU to prevent a containment transient. In a safe-shutdown earthquake (SSE), chilled-water cooling to CFCU's will remain in service only if off-site power remains available and if pressure boundary integrity is maintained. Any significant loss of pressure boundary integrity will cause the system to fail, but even thought the CFCU Chilled Water System is not designed to Seismic I standards, the design has minimized the risks of seismic failure. The NSR piping is designed to B.31.1 and for the most part, it is supported from Seismic 1 buildings.

1.3.7. Using SW for non-DBA Short Term "Abnormal" Containment Cooling

Although highly undesirable, the Project evaluated using SW for non-DBA short term cooling so that if it is ever required, it can be done safely. Assuming an initial containment temperature of 90°F and moisture at 20%, it is estimated[15] that the Operators will have ~ 14 minutes before containment temperature reaches 120°F, the Tech Spec limit. The following was performed to support this contingency:

1) Physical Modifications:

To address a LOP with SW already in operation, the CFCU SW isolation valves are shut on an undervoltage (UV) signal to the vital buses in order to prevent any

[15] This is based on a preliminary Gothic run, by Nuclear Fuels, that has not been formally reviewed.

water column separation or two phase flow during the SW pump transient. Redundant valves provide assurances that all the SW flow path will isolate. In addition, each CFCU SW supply header has a check valve to prevent loss of SW thru the supply side header during SW valve closure. This check valve will be "testable"; this allows quarterly IST verification that it will open and shut. SW flow will be reestablished after the SW pumps are started as described in Section 1.4, DBA Operation.

2) Analytical Work

GL 96-06 evaluation (reference 7.4):

The GL 96-06 evaluation confirms that a 61 psig gas pressure in the accumulator is adequate to keep the CFCU headers full of water and pressurized in the event of a LOP (with or without a simultaneous DBA) The GL 96-06 evaluation credits that (a) the SW return paths are isolated by redundant isolation valves and (b) the SW supply path is initially isolated by the single check valve and then by redundant AOV's. AOV closure time is assumed as 10 seconds; however, the valves are anticipated to shut well before 10 seconds since the closure time is only dependent on the sizing of the air operator's exhaust port. These assumptions are key in justifying the adequacy of one accumulator for keeping the water column on all 5 CFCU's solid. This analysis accounts for two SW outlet paths being initially open.

Fouling:

The revised containment analysis requires two CFCU's post SACF with a 0.0015 CFCU fouling factor. Reference 7.4 estimates that operation with SW cooling to the CFCU's can be maintained for ~ 4 weeks prior to invalidating the assumption on 0.0015 CFCU HX fouling.

Alternatively, if 5 CFCU's are kept "Operable" so that 3 operate post DBA and SACF, addenda 1 to reference 7.4 documents that 3 CFCU's with a 0.0032 fouling factor still provide greater containment heat removal than two CFCU's with lower fouling. A 0.0032 fouling factor assumes long-term SW cooling.

Added Normal Flow:

The final SW hydraulic calculations will determine if the SW System has the capability to provide continuous SW strainer backwash <u>and</u> CFCU flow during normal power operation. SW strainers may have to be restored to "cycling" mode rather than constant backflush.

3) Station Impact

The consequences are fouling of the CFCU HX's and river water contamination of the piping in the penetration and containment (This assumes that the non-SR carbon steel portion of the CFCU Chilled Water System is isolated beforehand).

A review of GL 89-13 program must be done to determine if cleaning, inspection and/or testing have to be performed on the CFCU HX's that had SW flow. It is anticipated that some testing of the CFCU HX will need to be done, but assuming the testing is acceptable, opening and cleaning would not be required.

1.3.8. CFCU CH System Leaks/Partial Isolation

With the revised design, the CFCU piping and headers are isolated from the SW during all anticipated modes of operation. Thus,

- Isolating the CFCU CH System will not impact SW System cooling to other components
- Isolating a SW System header will not impact CFCU cooling by the CH System

The safety related portion of the CFCU CH System is classified as a moderate energy system since it will operate at ~ 110 psig and low temperatures. Leaks, but not breaks, need to be considered.

Since the CFCU CH System is a closed system, any small leak can be easily detected by a drop in the head tank level (0.1 gpm leak will drop the tank 4"/day). Earlier detection allows Operator action while the leak size is manageable. Although there is no assurance that the leak will start as a small leak, this is typically the case. On the other hand, the system will have a large volume head tank that will provide a significant make-up volume, and Operator reaction time, to address leaks before system operation is impacted. This is addressed in Section 1.2.2.

Of particular concern is flooding in the SW valve rooms. A failure in either SW valve room should not affect the components in the opposite SW valve room. The design will maintain the water tight integrity between the two SW valve rooms and will maintain the same SW header separation.

Preventative Steps

Piping failures are considered improbable. All the original carbon SW piping has been replaced in the last ~ 10 years with AL6N, or other corrosion resistant materials.

As a clean water system with moderate flow velocities and minimal throttling, corrosion and erosion are minimized. The system will operate at a lower pressure, approximately 100 psig or about 50 psig below the present operating pressure, and half of the design pressure.

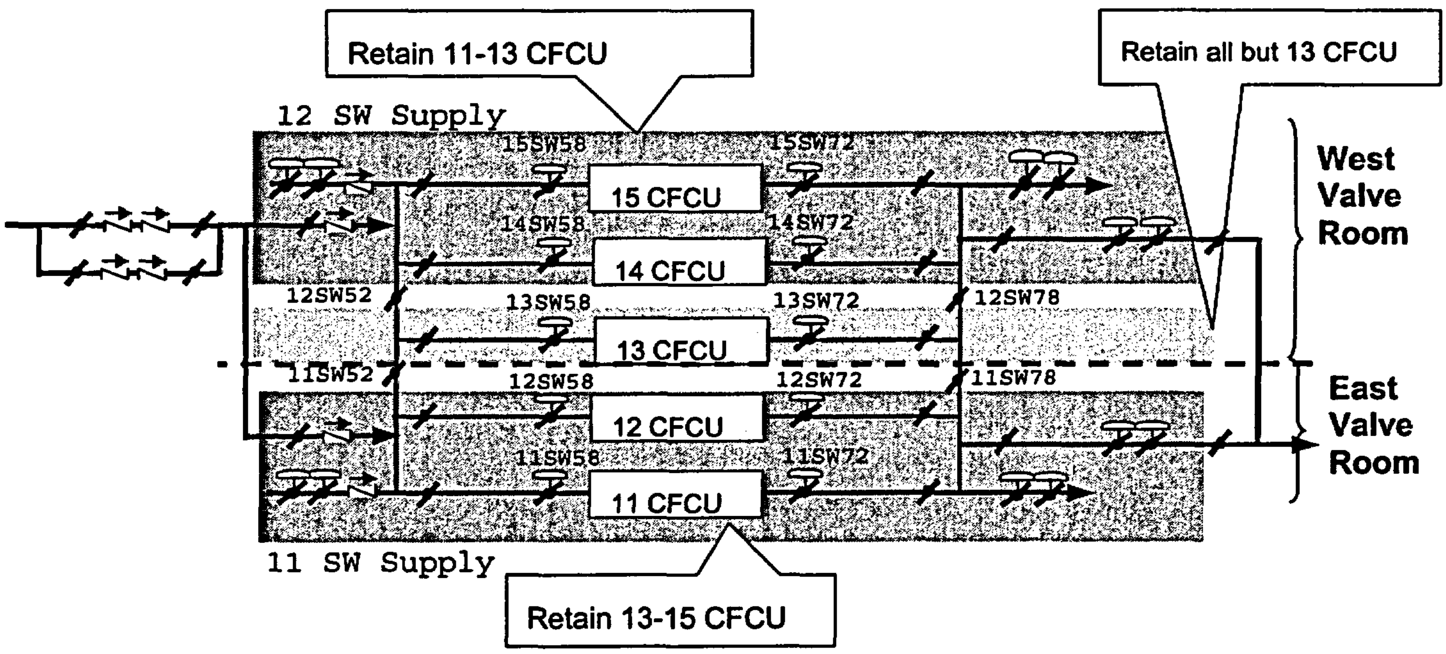
Care was taken to minimize the possibility of damage to the equipment outside the SR buildings. The majority of the CFCU Chilled Water System piping is routed on the outside walls of SR building at ~ 120' (20' above ground level). The pumps and demineralizer are located inside the FHB annex, a concrete building. The air-cooled chillers are fenced in.

More recently, the major sources of leaks have been at the CFCU's gasket for the CFCU air cooling HX channel head. Cooling with clean water eliminates the need for GL89-13 inspections that require periodical removal of the HX heads. Refer to section 2.10 for discussions on improved sealing.

Another problem has been failures of the motor cooling tubesheet due to corrosion at the tube to tubesheet crevice. During anticipated modes of operation, the motor cooler HX's will also see less corrosion and erosion.

On-Line SR Piping Repair Capability:

The design only assumes 3 CFCU's for normal cooling, but it will maintain containment temperature < 110°F even with 2 CFCU's. Although the CFCU CH System design is a single loop system, the single loop branches into two supply and return lines in the SW valve rooms. This allows continued operation of the CFCU Chilled Water System even after isolating any CFCU branch line or many portions of the common safety related CFCU supply and return headers to effect repairs. In most cases, operation of three CFCU's can be maintained. Removal of a SW52 or SW78 valve would require limiting operations to 2 CFCU's.



The CFCU CH supply and return flow paths are not redundant with the exception of the active components. The valves are discussed in Section 1.3.4. A failure of piping in a clean, low pressure (100 psig), close loop system is considered highly unlikely. The portions that are safety related, and may see SW in an abnormal or DBA condition, are fabricated from AL6N that has proven highly resistant to SW corrosion.

1.3.9. CFCU CH System Operation at Extreme Cold Weather

The chillers and some piping are located outside of buildings; however, to minimize exposed piping, piping will be run through the FHB truck bay rather than around the FHB. The pumps and the filter/demineralizer are located in the FHB annex. This area is heated, and in addition, the pump motors will add heat to the space.

Insulation is required to minimize heat gain in the summer. This insulation will be credited for minimizing heat loss in the winter. The design must determine the optimal insulation thickness to minimize heat gain/heat losses.

The CFCU CH System will operate year-round since the containment heat load is not significantly impacted by outside temperature. Normal operation will keep the recirculated fluid above freezing in the wintertime, but the following will be addressed:

1) The isolation valves for the individual chiller evaporators will be placed at the main headers. If an evaporator has to be isolated in the wintertime, the isolated portion can be drained and the stagnant portion will be negligible length (and remain at main header temperature).
2) Freeze protection of any dead legs and instrument lines exposed to freezing weather. External dead legs and external fluid filled instrumentation should be minimized.
3) The evaporators (water side HX) on the chillers include Vendor insulation and heat trace and vent and drain valves.

To address the possibility of a forced, winter outage, with no heat load from the containment, the detailed design will verify that one pump will add sufficient heat/pump work into the main headers to prevent freezing. Refer to section **Error! Reference source not found.** for a preliminary assessment. In case the flow path to the containment must be isolated in the wintertime, the recirculation path must be opened to allow the pumps to be operated.

The chillers are able to continue to operate in cold weather. Vendors have stated that the cold weather limitation is on "cold start" of the chiller rather than on continuous operation in cold weather. If the chiller is off and the refrigerant cools down to during the low ambient, e.g., 0°F, it may not restart. To address this, an option should be included to provide a heater for the refrigerant.

The Vendor/DCP must also document "freezing rain", defined as rain which freezes on contact and causes ice coating. One potential vendor has stated that freezing rain is not a concern since the condenser coils are well above freezing temperature.

1.3.10. SW Inadvertent Initiation During Normal Operation

Cooling water to the CFCU's has been designed to minimized inadvertent initiation of SWS into the clean CH system by:

1) The normally-closed, fail-closed isolation valves will not inadvertently open as a result of either power failures or pneumatic supply failures.
2) The SW isolation is provided by in series valves. This reduces the probability of an error during testing and/or maintenance from opening a flow path.

3) Summarized below are the SI's since 1984. Although SI signal initiation has been reduced in the last 10 years to once per 10 reactor-years, the probability of SW contamination of the CFCU's can be further reduced by blocking the SI signal to these SW valves in modes 5, 6 and undefined. Mode 6 accounts for 3 of the 9 SI's since 1984 and 2 of the 3 since 1990.

Date	**Mode**	**Unit**	**Cause (as documented in LER's)**
7/13/84	6	1	Personnel error (omitted testing step).
7/25/84	1	2	POP's (PR47) failed open during testing (Valve since removed).
10/7/85	1	2	Vital bus spike, during testing (vital bus receptacle polarity wired wrong).
8/26/86	1	2	Technician inadvertently shorted the vital bus.
6/22/88	1	2	2C Vital Inverter failure caused RCP breaker to indicate "open"; unit tripped (this trip since removed).
6/09/89	3	1	Inadequate draining of MS lines causing MSV Lifting during plant start-up.
5/01/90	6	2	Personnel error performing DCP wiring changes.
4/15/93	6	2	SI during testing due to SSPS switch design defect.
4/07/94	1	1	Circ water rack debris blockage followed by failure to maintain command and control, communications, and priorities at Control Room.

1.3.11. System Flush Following SW Actuation

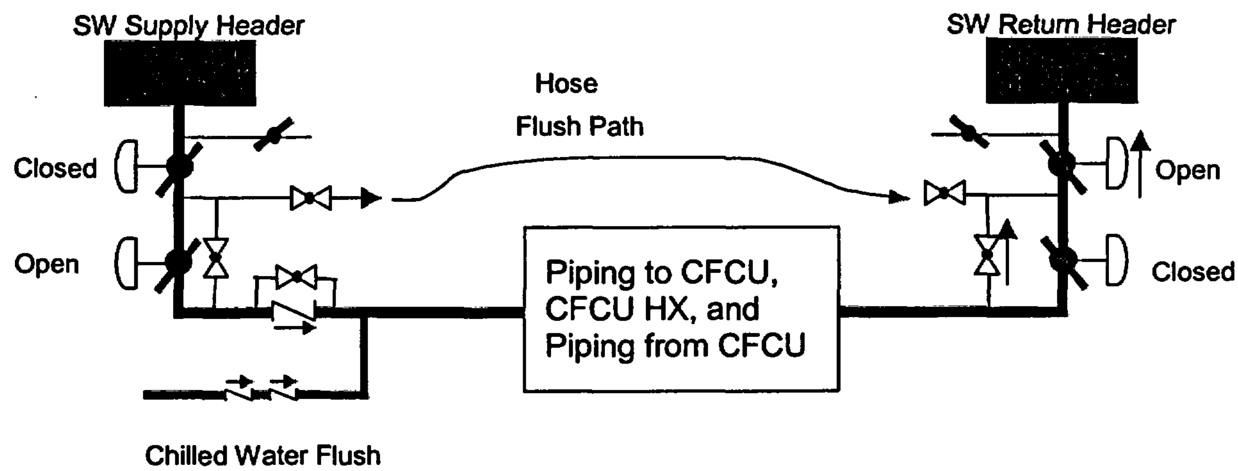
The assumptions herein are the CH side was automatically or remote-manually isolated prior to the SW initiation and that it remains isolated and clean while SW is used for containment cooling.

The purpose of flushing the CFCU side of the system is to minimize the introduction of river water impurities into the carbon steel CH piping and chiller copper tubing.

After the CFCU SW valves can be isolated but before the CH AOV's are opened, the CH side will provide the "feed" water to rinse out the CFCU piping by placing the CH pump in recirc flow and providing DM make-up to the head tank. The 2-inch flush lines in each SW supply and return header are opened to provide a "bleed" path until a reasonable water quality is reached. The supply header side will require much less flush water than the return header because of relative lengths. To minimize the amount of water that has to be drained into the SW valve rooms, the "bleed" path can be to the SW return headers as illustrated below. The return header is at very low pressure.

It is estimated that the water volume in the CFCU side of the piping (that is, the volume that needs to be flushed out) is ~ 10,000 gallons including 5 CFCU's. Assuming a 50 gpm feed/bleed rate, it would take just under seven hours to do a two volume (20,000 gallons) flush.

Once the majority of the river water contamination has been purged out of the CFCU HX and piping, the CH system can be returned to service. The small amount of remaining impurities will not result in a significant level of impurities on the CH side. In addition, they will be removed over time by the resin in the permanent CH side stream demineralizer.



1.4. *DBA Operation*

On a DBA, a SI signal will automatically isolate the normally open CH air-operated isolation valves to "bottle-up" the CFCU flow path and then will automatically unisolate the normally shut valves on the SW CFCU flow path (section 2.3.1).The sequencing and permissives ensure that the CFCU's remain full of water and pressurized during the transfer from CH System cooling to SWS cooling. This sequence, the safety related accumulator, and elimination of SW57 all minimize the pressure fluctuations on the CFCU. The CFCU CH system operates at 110 psig, the accumulator prevents any significant pressure transient, and the SW system pressure will be ~ 10 psig lower than the chilled water pressure.

If SW was initially in service for cooling the CFCU's, a DBA without a LOP will not cause any flow interruption. Protection on a concurrent LOP against water hammer and two phase flow is provided as discussed in Section 2.3.2.

The design ensures that full CFCU SW flow is established within 60 seconds of a DBA. This delay allows initiating the SW flow only after the SW pumps have restarted and the SW flow to non-essential services, e.g. Turbine Building loads, is fully isolated. The accumulator will ensure that the fluid within the CFCU's remains pressurized and sub-cooled during the CFCU CH System isolation, SW pump restart, and SW valve flow path opening[16].

The CFCU CH System cannot be used for containment DBA cooling even if it remains available post-DBA since the initial containment heat load will cause the chillers to trip out. On a SI Signal the CFCU CH System isolation valves will shut and the CH pumps and chillers will be tripped.

SW flow to the individual CFCU's can be verified by flow indication on the outlet of each CFCU. No flow control valves or modulating valves are used. SW flow is set by fixed resistances. Although the DBA analyses only credits 1200 gpm to each of two CFCU's for heat removal, a significantly higher SW flow is expected. No credit is taken for any heat removal by the CFCU branch without an operable fan, even though SWS flow is provided.

The system design allows (1) one SW header to fail (i.e. only the 11(21) or the 12(22) headers are assumed to open and initiate SW flow), (2) one CFCU CH System AOV valve fails to shut, and (3) one CFCU CH System check valve fails to shut.

The design incorporates the following licensing basis:

1) Per GDC 17, the a failure of the DC battery is considered a SACF
2) A LOP is considered simultaneously with a DBA (Although a LOP need not be considered after a DBA, the <u>physical</u> design for the new system will

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[16] Check valves on the supply side are credited with immediate closure. In series AOV's on the return side are credited with closure in ~ 10 seconds. There should be not water loss during the isolation if the non-SR portion remains intact.

tolerate a LOP anytime the SW system is in use for the reasons discussed in section 2.3.2.

The SW hydraulic model assumes the most limiting conditions. The cases considered are one header providing cooling water to 3 CFCU's and both headers providing cooling water to all 5 CFCU's. Note that check valves SW52 and SW77 prevent the flow from either header from exceeding the flow for 3 CFCU's.

The CFCU containment isolation valves meet GDC 57, closed system inside containment that is required post-DBA. They are shut only if the Operator detects a breach of the piping integrity inside containment. The present containment isolation valves and controls for each CFCU can remain as presently designed.

The capability of the operators on these containment isolation valves (SW58 and SW72) to operate under the new system maximum postulated ΔP is under review.

1.4.1. Active Component Failures

The two tables below are a simple FMEA to address the key SACF. It shows that 3 CFCU's remain available for containment cooling and iodine scrubbing after any postulated power failure or any header isolation valve failing to open, assuming 5 CFCU's were initially "Operable".

Equipment Remaining Available after Electrical Failure	
Train A, AC or DC, Fails	12,13,14,15 CFCU B & C SW pumps 11 & 12 SW flow path
Train B, AC or DC, Fails	11,13,15 CFCU A & C SW Pumps 11 & 12 SW Flow path
Train C, AC or DC, Fails	11,12, 14 CFCU A & B SW Pumps 11 & 12 SW Flow path

Based on the existing design, a loss of DC will prevent the corresponding diesel from providing back-up power in case of a LOP. A loss of a diesel on a LOP will result in a loss of one SW pump and the one or two CFCU's powered from that vital bus. Since the SW CFCU header AOV's have redundant solenoids, each powered from a different DC source, no single AC or DC failure prevents opening and then keeping open both headers (See section 3.3 paragraph 1).

Equipment Remaining after SW Header Fails to Open (Due to Valve Failure) Or Is Later Isolated	
11 SW Fails	13,14,15 CFCU A, B & C SW Pumps 12 SW flow path
12 SW Fails	11,12,13 CFCU A, B, & C SW Pumps 11 SW Flow path

Since the revised Westinghouse containment evaluation and the AST design basis both only credit two CFCU's post DBA, the tables also demonstrate that only 4 CFCU's will need be "Operable" at any one time once the AST is approved. In essence, the fifth CFCU will become an installed, redundant CFCU.

1.4.2. Passive (SW Piping) Failure

UFSAR SW section 9.2.1 states:

> "Failure of one of the nuclear supply headers downstream of the tie valves in the Auxiliary Building will not interrupt the supply of service water to the equipment required to operate following a LOCA. Each of the two service water loops provides service water to one component cooling heat exchanger, one charging pump lube oil cooler, one safety injection pump lube oil cooler, and three containment fan cooler units."

A similar statement also appears in section 6.3 as well as the original SER for Salem provided by the NRC. PSEG licensing has compiled clarifications on this statement. These clarifications are that a SW passive failure is limited to leaks, as opposed to pipe breaks, and furthermore these leaks need not be postulated any earlier than 24 hours into the DBA, and this passive failure is in lieu of postulating a SACF.

The design and licensing basis for SW leaks in a DBA will not be changed. Isolation of either header will not prevent the opposite header from providing cooling to three CFCU's. Isolating a SW header is the same as a SW not unisolating, refer to the table for section 1.4.1. Even with only 4 CFCU's initially "operable", a minimum of two will continue to provide cooling. Sensitivity analysis performed by Westinghouse demonstrated that only one CFCU is required 24 hours into a DBA (however, this sensitivity analysis is not being used to modify the licensing basis).

2. DESIGN REQUIREMENTS

2.1. *Major CFCU CH System Components per Salem Unit*

1) Four packaged nominal rating of 400 cooling tons capacity, electrically-driven, air-cooled water chillers complete with controls and logic. Each provides ~37% of required cooling. This allows 3 chillers to meet 100% load with an added 10% margin.
2) Four 50% capacity centrifugal pumps, design flow of 1200 gpm each.
3) Power from the "G" and "E" non-vital 4160 VAC buses to two 480 VAC CH System substation. Each substation supply is rated for 2500 KVA and each switchgear is rated for 3200 amps.
4) Local control panels with control room indication, controls and trouble alarms
5) One Accumulator (formerly the 12(22) SW Accumulator)
6) One Head Tank (formerly the 11(21) SW accumulator)
7) A 50 gpm cleanup system consisting of filters and mixed-bed demineralizers,
8) Automatic valves to isolate the CFCU CH System and unisolate the SWS during a DBA.
9) Associated piping, valves, orifices, instruments and controls.

2.2. *Key Design Parameters*

Key parameters derived in separate documents are summarized in the Table on page 8. These parameters are from References 7.1, 7.2, 7.3, 7.4 and 7.5.

The key parameters for accumulator and head tanks are summarized below.

2.2.1. Accumulator Design Parameters

The basis/logic for the key accumulator tank parameters is outlined below. The adequacy of these parameters for accident conditions will be discussed in section 2.3.

1) Normal CFCU Chilled Water System operating pressure immediately downstream of the SW Supply headers (point "A" on the pictogram in section 1.2.2) is to be controlled between approximately 105 psig and 110 psig. This allows operating the clean water system at 5 to 10 psid higher than the SW supply pressure to reduce the potential SW leakage into the clean system (Across the normally shut SW AOV's to the CFCU branch lines).

   Note: 110 psig was selected using the best estimates from SW pump destaging and hydraulic runs. These values may be adjusted after further calculations and testing is done to reflect actual values. If destaged SW pump performance is better than anticipated, the accumulator gas pressure will be adjusted upward to maintain the desired range at point "A".

2) Due to redundant, reasonably fast isolation valves in every flow path, the maximum anticipated outflow from the accumulator is ~ 1000 gallons

3) Since the normal water volume will be between 8,000 and 12,000 gallons, the final water volume will be ~ 7000 gallons. This provides assurance that no significant amount of N_2 will not be introduced into the CFCU headers.

4) The nominal gas pressure will be ~ 80 psig.

2.2.2. <u>CH Head Tank Design Parameters</u>

The head tank N_2 gas pressure required to support the nominal 110 psig chilled water system supply pressure is ~ 65 psig assuming the water level is at its minimum recommended level, 8000 gallons.

Note: these values are selected assuming friction losses from Reference 7.3. These values may be adjusted after further calculations and testing is done to reflect actual friction losses. If friction losses are less than calculated, the head tank gas pressure will be adjusted downward to maintain the desired range at point "A".

Operation at head tank pressures in excess of the above values will only result in a higher CFCU Chilled Water System operating pressure and higher accumulator pressures. The limiting components are (1) the CFCU waterbox with a design pressure of 150 psig and (2) the accumulator head tank with a design pressure of 150 psig. The piping is designed for 200 psig. Since the accumulator is at a lower elevation and closer to the CH pump discharge, it is the limiting component.

An objective is to keep the accumulator pressure ≤ 135 psig (10% below the relief valve setpoint of 150 psig) to prevent the relief valve from lifting. To do so, the head tank gas pressure must be maintained at 135 psig minus the pressure rise between the two tanks. The pressure rise is the CH pump head minus friction losses between the two tanks, 134.7' – (15.6' + 35.1') = 84', or 36 psid. Rounding off, the head tank relief valve should be set at no greater than 100 psig.

2.3. *<u>GL 96-06 Design Requirements</u>*

During the period that the CFCU's are isolated, relief valves vent any thermal expansion to prevent over-pressurization of the isolated piping. A relief valve is physically on located on each CFCU branch line between the CFCU and the CFCU downstream containment isolation valve. These valves are described in Section 3.1, paragraph 18.

Concerns identified in GL 96-06 (reduced heat transfer due to boiling water and hammer loads due to water column separation) are prevented by maintaining the CFCU lines completely full and sufficiently pressurized during any flow interruption including (1) stopping and restarting CH cooling (2) transfer from CH to SW flow (3) stopping and restarting SW cooling. Reference 7.4 demonstrates that the revised design satisfies the GL 96-06 concerns.

2.3.1. Postulated Transients - CH System Initially in Operation

The CFCU CH System normally has the only open flow paths to the CFCU's. All SW flow paths are normally isolated. Maintaining the CFCU piping water solid during normal operation is achieved by the CFCU CH closed loop system including the accumulator, head tank, and demineralized water make up. Closed loop cooling with clean water reduces the probability of small leaks, and it allows quicker identification of small leaks. Stopping and then restarting CH flow during normal operation should not pose any GL 96-06 concerns.

CH System Piping Failure due to Natural Phenomena:

Switching from CH water to SW does not require any accumulator outflow unless there is a CH system pressure boundary failure.

Since a portion of this closed loop system is non-SR and located outside the reinforced SR buildings, a loss of CFCU CH system integrity is postulated due to a seismic event or other natural phenomena. To mitigate the consequences of such a failure, the non-SR portion is isolated:

1) On the supply header by in-series, check valves that shut on reverse flow.
2) On the return header by in-series, automatic AOV's. The automatic closure signals for the CH AOV's are discussed in Section 2.7.2. These valves are designed "fail-shut".

Loss of fluid is postulated only during the time delay to initiate closure and then complete AOV closure on the single 10" diameter line CH return header. As shown on the pictogram in section 1.2.2, the SR, seismic 1 criteria for the return line is extended outside of the buildings upwards to elevation 120'. This location is immediately adjacent to and protected by the same missile barriers that were erected for the accumulators. The head tank is likewise protected against external missiles. The pressurized head tank located downstream of the return header AOV's provides a backpressure that minimizes the flow out of the AOV's during the transient.

The design still requires one accumulator to make-up for any water losses while the CH System isolates after a pressure boundary failure. However, the required accumulator outflow volume is significantly reduced in comparison with the original design.

SW unisolation requires that (1) there be no vital bus UV signal present and (2) that the SW supply header is pressurized. Then, the SW supply header valves are opened first to pressurize the CFCU headers with the SW pumps before the SW return header valves are opened. This sequence, along with one accumulator tank, ensures the CFCU piping remains pressurized throughout the transition to SW flow.

DBA:

The CH System is automatically isolated on a SI signal since it is not a SR system. Since a seismic event and a DBA are not postulated simultaneously, there is no loss of water from the CFCU during the isolation phase. The SW sequence, described above, ensures that the SW supply header is open before the corresponding return header begins to open.

After the CFCU headers are isolated, the fans continue to add heat to the stagnant fluid in the CFCU tubes. The final temperature of this "hot slug" will be above 212°F but below the peak containment temperature. Boiling is not anticipated because the CFCU piping is isolated, water solid, and the heating transient should maintain the water solid piping pressurized. The opposite, overpressurization, is the concern. The relief valves should limit the pressurization to the relief valve setpoint. The relief valves will reseat well above the saturation pressure of the fluid. The single accumulator is not critical for keeping the CFCU pressurized and subcooled, but it adds another level of defense.

The release of the "hot-slug" into the low pressure SW outlet header when SW is initiated is addressed analytically. The hot-slug is significantly mitigated by the lower CH operating temperatures.

2.3.2. Postulated Transients - SW System Operation

A GL 96-06 evaluation was performed to address the possibility of SW being in operation prior to a postulated DBA. The transients of concern are a LOP by itself and a DBA with a concurrent LOP. The accumulator is required (1) to maintain the piping water solid following a LOP and (2) to maintain the fluid in the CFCU pressurized for a DBA concurrent with a LOP.

A DBA without a concurrent LOP will not interrupt SW flow and therefore there is no water column or two phase flow concern.

To provide protection from a LOP, the SW system flow paths to and from the CFCU's are automatically isolated by vital bus UV signal or by a loss of pressure in the corresponding supply header.

The principal changes to the GL 96-06 evaluations are:

1) Reliance on a single accumulator (but no AOV's that must open)
2) Crediting of in-series fail-shut AOV's so that the required make-up from the accumulator is limited to the water losses before full closure. In addition, the SW supply header has a check valve to prevent backflow.

The CFCU SW valves are "fail-shut" to prevent a DC bus failure from opening the SW headers (see section 2.6).

The Salem DBA licensing basis only requires that the LOP be assumed concurrent with the DBA. Nevertheless, the control logic isolates the SW flow paths to the CFCU's, if open, any time power to the vital buses are lost. This design feature, along with the check valve on the SW CFCU supply header, provides a greater degree of reliability for the CFCU's in the longer term, post DBA cooling.

However, it is strictly a system design enhancement, and there is no intent or commitment to revise the Salem licensing basis to postulate LOP following a DBA event.

The potential for flashing of the "hot-slug" at the SW return header is addressed analytically.

2.4. GL 89-13 Requirements

Normal CFCU CH System operation with demineralized water ensures minimal fouling and improved CFCU thermal performance. Refer to section 2.5 paragraph 2) for credited fouling.

Routine CFCU cleaning and performance monitoring in accordance with Generic Letter 89-13 will no longer be required. This change needs to be reflected in the appropriate program and revised NRC commitments.

The design allows for periodical flushing of the dead legs above the normally shut SW AOV's, and during a SW header outage, inspection to ascertain and remove any build-up of marine growth that may not flush out (section 3.1, paragraph 13).

2.5. Containment Accident Analysis Requirements

The revised Westinghouse analyses made several key assumptions. Key assumptions include:

1) A cumulative heat transfer rate of 112.8 x 10E6 Btu/hr from the containment atmosphere at the post-accident design conditions, i.e., a saturated air-steam mixture at 47 psig and 271°F.
2) The required cumulative heat transfer is based on 2 CFCU's assuming a fouling factor of 0.0015 (Addenda 1 to reference 7.2 demonstrates that 3 CFCU with maximum fouling from long term SW operation will provide greater cooling than 2 CFCU's with 0.0015 fouling).
3) Rated CFCU SW flow is achieved by t=100 seconds (the design is however based on meeting the present Tech Spec requirements of 60 seconds).
4) SW cooling is initiated by the SI signal.
5) Initial containment temperature ≤ 120°F
6) MSLB will credit SGFP trip to reduce feedwater flow if the single failure is a stuck open feedwater regulating valve (this is not a design change; it is only incorporating a Salem design feature that was previously not credited).
7) A passive failure in a CFCU header during the long term phase of a DBA (> 24 hours) may require isolation of one SW header.

2.6. *SW and CFCU CH System Valves Fail Position*

The failure position for all the CH AOV's and the new CFCU SW header isolation valves is "shut" to support the GL 96-06 evaluation (section 2.3).

The fail shut mode for the CH valves ensures that these valves isolate and remain shut on a DBA when the SI signal is received. Since the AOV's have a redundant flow path, a spurious failure should not cause inadvertent loss of CH cooling.

The fail mode for the SW valves was selected to ensure that a failure of the DC bus coincident with a SI signal (required by GDC 17) would not cause premature opening of the return lines before the SW pumps restart. This is required to ensure that the CFCU piping is not partially drained and then subject to water hammer when the SW pumps restart.

The design of the SW valves prevents having to postulate both headers failing to open. Refer to Sections 3.3 paragraphs 1) and 2) for additional information on the I&C design features for these valves to minimize failures.

2.7. *SW & CFCU CH Valves, CH Pump, and Chiller Control Signals*

2.7.1. SW CFCU Valves

See Figure 5 Typical SW Supply Header AOV's Control Logic and Figure 6 Typical SW Return Header AOV's.

The following automatic SW CFCU valve signals are required:

1) On a vital bus undervoltage (UV), shut and/or prevent opening the CFCU SW inlet and outlet header isolation valves. This is required to satisfy GL 96-06 for a LOP that occurs:
   - If SW is used for CFCU cooling after a total CH System failure (section 1.3.7).
   - During a DBA alignment.
   - After SW is aligned for DBA cooling (section 2.3 paragraph 0).
2) On a loss of SW header pressure, shut and/or prevent opening of the corresponding CFCU SW supply header isolation valves. The primary purpose is to prevent opening of the SW supply header valves after a SI concurrent with a LOP until the SW pumps have restarted and restored header pressure. It also addresses the header being tagged out.
3) When the above conditions are met and the CH valves are shut, sequentially open the CFCU SW valves on a SI Signal. The SW inlet valve is opened first. When the SW inlet valve is ~90% open, the SW outlet valve then opens.

The design automatically initiates SW cooling on any SI except that the signal may be blocked in modes 5, 6 and undefined to avoid inadvertent and undesired SW initiation when not required for plant safety as discussed in section 1.3.10.

The design allows opening and closing any CFCU SW valve from the control room. This allows for testing one valve at a time for quarterly valve IST.

The signal to manually initiate SW system flow is in parallel with the SI signal. This is done to ensure that a manual SW initiation meets the same requirements as automatic SW initiation. The primary difference is that the SI signal automatically shuts CH whereas a manual SW is blocked until the Operators shuts the CH isolation valves.

The design needs to ensure that the proper SW isolation sequence can be done to prevent inadvertent accumulator discharge. Specifically, the SW return header should be isolated first. Then the SW supply header is isolated.

Caution: If SW system is providing cooling to the CFCU's during normal power operation, only a LOP will automatically isolate the CFCU SW flow path, but a LOP will also trip the high speed fans. For non-automatic transients, e.g. Operator controlled shutdown of SW flow, Station procedures/training should clearly alert the Operators to trip the fans before securing SW flow to that fan since motor cooling is lost.

2.7.2. CH System Valves

Refer to Figure 4 Typical CH AOV, page 14.

The CH valves must automatically shut on any of the following conditions:

1) On a SI signal
2) UV on the vital buses (preventative since it is highly likely that the group buses are also affected).
3) The CH discharge header pressure dropping significantly below the anticipated operating pressure. This is indicative of a pressure boundary failure, pump failure, excess make-up to the SR portion of the design (e.g., leak in the CFCU gasket), or loss of power to all operating CH pumps.

Isolation on low pressure provides protection against a catastrophic pipe break. If the suction is on the suction side of the pumps, the pumps will trip from loss of NPSH or water. If the break is on the supply header, the supply header will depressurize. Either way, there will be a significant pressure drop on the supply header. The more likely scenario is a failure that leads to a leak. A tank low water level alarm and/or low supply header pressure will then alert the Operators. A single CH pump trip will cause the supply header to drop by approximately 10 psig. The resulting pressure remains well above the automatic isolation setpoint.

The CH valves can only be opened if none of the above signals are present, and in addition, the SW supply header isolation valves are shut.

The CH valves will fail shut on a loss of control power or control air since they are fails shut design.

There are two CH open/shut push buttons in the control room. One operates the two in-series valves from the 11/12/13 CFCU return. The other operates the 13/14/15 return path. Normally, only one path is open to limit CH flow to three CFCU's. However, both flow paths may be open to establish and confirm the flow in the second flow path before isolating the first flow path. Once containment cooling is confirmed on the second flow path, the first flow path should be shut. Operating with both flow paths open will not result in an unsafe or unacceptable condition. However, the CH flow to the three operating CFCU's will be reduced from 800 gpm to approximately 550 gpm (estimated) and containment temperature will be approximately 7°F (estimated) higher. Containment temperature will remain well below the allowable value.

Closure of a CH return path automatically trips the CFCU high-speed breakers for the two CFCU's cooled exclusively by that circuit. The 13 CFCU high-speed breaker is not tripped unless both CH cooling paths are isolated. The tripped signal is not locked-in. This allows the CFCU's to be restarted on SW flow.

An existing SI signal will also trip the high-speed breakers.

Caution: Station procedures/training should clearly alert the Operators to trip a CFCU that has no cooling flow since motor cooling is lost.

2.7.3. CH System Pumps

The CH water pumps will automatically trip following a CH valve automatic closure. This signal need not be safety related since its sole function is to prevent the pump from running in a deadhead condition. A trip signal shall not be locked-in. This is to allow restarting the CH pump with the recirculation flow path open.

The chiller control panel will control pump operation. Since check valves are provided in each pump's individual discharge path, the suction and discharge valves can be kept open for the standby pump. All manual butterfly valves shall have clear "open" and "close" indication. On a low flow or indication of a pump failure, a back-up is automatically started. A signal from the high-low flow switch located in the common discharge header of the pumps indicates that the system flow is abnormal. This signal alarms locally and causes a general trouble alarm in the main control room.

2.7.4. CH Chillers

The Vendor will provide all controls for maintaining the chiller outlet temperature at the desired LCWT setpoint (40°F to 60°F range). The chillers require a flow switch in each chiller branch line. This trips the chiller if there is no-flow in that branch line. This need not be safety related.

2.8. *In-Service Testing Requirements*

All safety related valves that must change position in an accident have redundancy to allow for testing without impacting the normal operation of the system.

The CH AOV's and check valves have redundant flow paths as described in section 3.1 paragraphs 14) and 15). This allows the valves in one flow path to be tested for closure. If a valve fails to shut, it can be isolated and removed for repairs. The redundant flow path allows the CFCU CH system to remain in service.

Each SW CFCU supply and return header has redundant, in-series AOV's as described in section 3.1 paragraph 13). This allows the valve to be tested for opening without initialing SW flow to the CFCU. This, of course, is predicated on testing each valve separately.

2.9. SW Pump Destaging Requirements

The present requirements for SW pump head is due to the CFCU flow requirements of 2500 gpm in a DBA coupled with having up to 5 CFCU's post-accident. The reduction in accident flow/CFCU allows the SW pumps to be destaged from 3 to 2 stages since it eliminates the CFCU as the dominant pressure loop. All normal and accident flows can be met with a 2 stage SW pump.

Destaging the SW pumps is desirable in order to reduce the SW pump electrical power consumption during normal and postulated accident conditions and to lower the SW supply header operating pressure from approximately 150 psig to 100 psig. Since the SW system piping design pressure is 200 psig but a number of SW components have a design pressure of 150 psig, this will provide a significant safety margin. Destaging will require:

1) Physical modification of the SW pump. The simplest method is to remove the last (third) stage and replace it with a spoolpiece with bearing at the same location as third stage bowl bearing.
2) Pump destaging will require destaging all SW pumps for that unit within the same outage. Refer to Section **Error! Reference source not found.** for Outage Planning concerns.
3) Upgrading the SW hydraulic model to include a model of the non-nuclear header and then changing the configuration to reflect:
   - Reduced pump head (~66% of previous TDH)
   - Revised CFCU flows (0 during normal operation and ~ 7500 gpm total to 5 CFCU's in DBA)
   - Revised constant 700 gpm SW strainer backwash
4) Reviewing and revising, as necessary, fixed and variable resistances in all the individual branch lines to determine any changes due to the lower pump head.
5) Reviewing and revising, as necessary, all I&C setpoints that use SW pressure as an input.
6) Updating the EDG/vital bus loadings to credit the reduced SW pump Hp requirements.
7) Verifying that the peak diesel loading remains below the continuous allowable diesel loading (2600 KW), allowing elimination of testing for the 2

hour and 2000 hour maximum allowable, 2860 KW and 2750 KW, respectively.

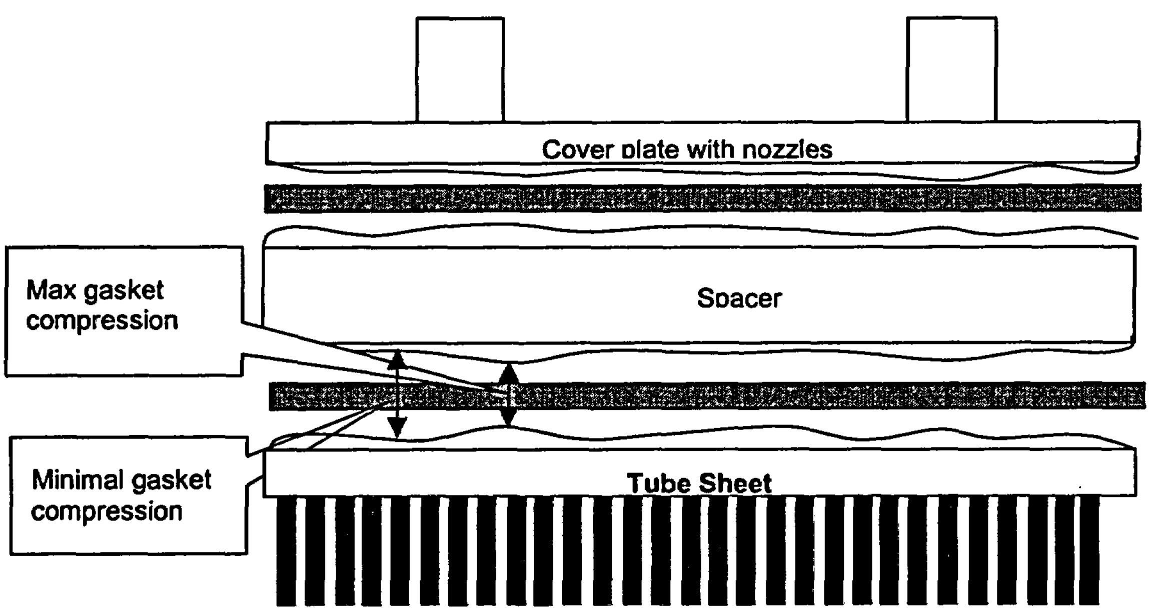
8) Updating any diesel testing procedures to reflect that the largest single load, the SW pump, has been reduced from 1000 Hp to ~ 666 Hp and is comparable to the second and third largest loads, the C/SI pump and MD AFW pump. This should be reflected in a quicker frequency and voltage recovery during diesel loading and unloading.

2.10. *CFCU Water Box Coating, Sealing, and Minimization of Leaks*

The CFCU project scope does not include any modifications to the CFCU water box coating and sealing since these are O&M items. However, it is discussed herein since this a Station concern.

The preliminary assessment is that the tubesheet should continue to be coated as a precautionary measure since crevices tend to accumulate any impurities. This decision should be finalized by Station and Engineering Design personnel. However, the coating in the rest of waterbox is unnecessary, and explained below, undesirable.

Since the coating is not even, it causes uneven compression of the gasket as illustration of the top view showing the components prior to assembly shows. It may be a key contributor to the waterbox leakage problems. Removing the coating on the cover plate and spacer (at least in the mating surfaces) will provide more uniform gasket compression. Removing the coating on the spacer, but not the tubesheet, will provide an even surface on one side of that gasket which nevertheless should provide greater sealing reliability.



In addition to allowing the above improvements in sealing, the design minimize the probability of leaks across the gaskets since it (1) will lower the differential pressure across the sealing surfaces to 2/3 of the present value, and perhaps more importantly, (2) it will greatly reduce the pressure surges. During normal operation, no pressure surges are anticipated since it will operate at constant pressure constant flow. Even if the pumps are all tripped, the accumulator will maintain the pressure essentially unchanged.

Pressure fluctuations during transition to SW flow are also reduced since the flow control valves are eliminated. The CFCU's will first be bottled up by closure of the CFCU CH AOV's and the accumulator will maintain the CFCU's at essentially the same pressure. The SW supply header valves are sequenced to open only after the SW pumps are restarted and SW pressure has stabilized. The SW pressure will be about the same as the CH pressure.

3. DISCIPLINE DESIGN REQUIREMENTS

This section is primarily a repetition of information from other sections broken down by engineering discipline but with added details.

3.1. *Mechanical*

1) A constant nominal flow of 2400 gpm chilled water at 40°F to 60°F supply temperature is to be provided by the CFCU CH System to three CFCU's. Each CFCU cooling coil will have approximately 780 gpm and each CFCU motor cooling coil will have about 20 gpm.
2) Cooling is provided by four (4) 400 ton nominal capacity, air-cooled chillers. Since the required containment cooling load is 1074 tons, and each chiller can provide 380 tons even with 105°F ambient outside air, each chiller is rated slightly in excess of 1/3 of the required load. Once the chillers are selected, curves should be provided to show chiller capacity (in cooling tons) versus LCWT and outside ambient air. This will be used to determine any limitations when operating with two or three chillers.
3) Chilled water is to be circulated by four (4) 50% capacity centrifugal pumps rated at 1200 gpm each powered from non-vital buses. Automatic pump controls will be kept to an absolute minimum due to the simplicity of the design.
4) The majority of the CFCU CH System, which includes the chillers and CH pumps, shall be non-safety related. Piping will be carbon steel. This piping need not be seismic, but since this non-SR CFCU CH System piping, except the piping on the pad will be supported from SR buildings, the detailed design should determine if the piping will resist a seismic event based on SQUG criteria, and/or if the break can be limited as opposed to having to assume a full guillotine break.
5) All other portions of the CFCU CH System, which includes all portions that will be part of the SW pressure boundary following a DBA, will be designed to the same criteria as the present SW piping (Seismic Category I, Safety Class 3). This includes the isolation valves which isolate the non-safety related CFCU CH System. All safety related portions will comply with existing SW piping material requirements.
6) All safety related piping and components will be designated as "SW" and shown as part of the SW system P&ID. This includes the CFCU CH System isolation valves. All non-safety related portions will be designated as "CH" and shown on the CH system P&ID, but on a separate sheet.
7) Corrosion control will be maintained by keeping a N_2 blanket on the CFCU CH System head tank and by maintaining water quality through intermittent use of a mixed bed demineralizer, or for significant SW intrusion events, through feed and bleed followed by use of the demineralizer. To reduce the need to backwash the demineralizer due to non-soluble loading, the demineralizer flow should first pass thru a mechanical strainer/filter. Joint between carbon steel and AL6N will be a flanged joint and include "Maloney" kits.

8) Under normal operating conditions, the CFCU CH System pressure will be maintained a nominal value (about 10 psid) higher than the normal SW supply header pressure. As discussed later, the normal SW system pressure will be approximately 66% of present pressure since the SW pumps will be converted from a 3 to a 2 stage pump. This requirement is to minimize the possibility of SW to CFCU CH System "nuisance" leakages. Short-term operation with higher SW pressure due to unusual line-ups is acceptable.

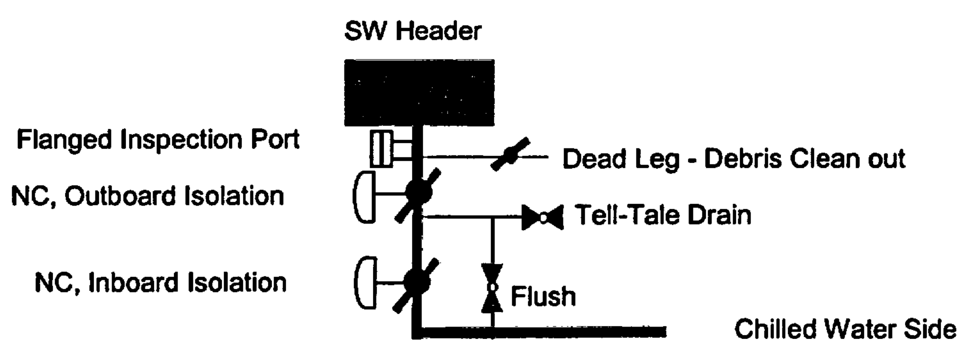
9) Two new 12" SWS AOV butterfly isolation valves in-series on each SWS supply header in addition to retaining one testable check valves. These new valves are seismic category I, safety related class 3, normally closed, fail shut valves that are automatically opened upon SI initiation or manually opened from the control room to supply SWS to CFCU's during accident conditions.

10) Two new 12" SWS AOV globe valves in-series on each SWS discharge header are seismic category I, safety related class 3, normally closed, fail shut valves that are automatically opened upon SI initiation or manually sequenced opened from the control room after SWS supply header valves are fully opened under accident conditions.

11) Since the SWS isolation valves are normally shut and fail shut, the hydraulic analysis must account for one of the flow paths failing to open.

12) All new AOV's will be butterfly valves. The valve body will use the same design concept as the existing SW accumulator isolation valves, SW534 and 535 valves. The valve body will be carbon steel but is entirely rubber lined. This provides excellent leak tightness and it also protects the valve body. The disc will be selected from corrosion resistance materials.

13) The two in-series isolation valves on each SW CFCU supply and return line, design features on the individual AOV's, and additional manual valves allow:



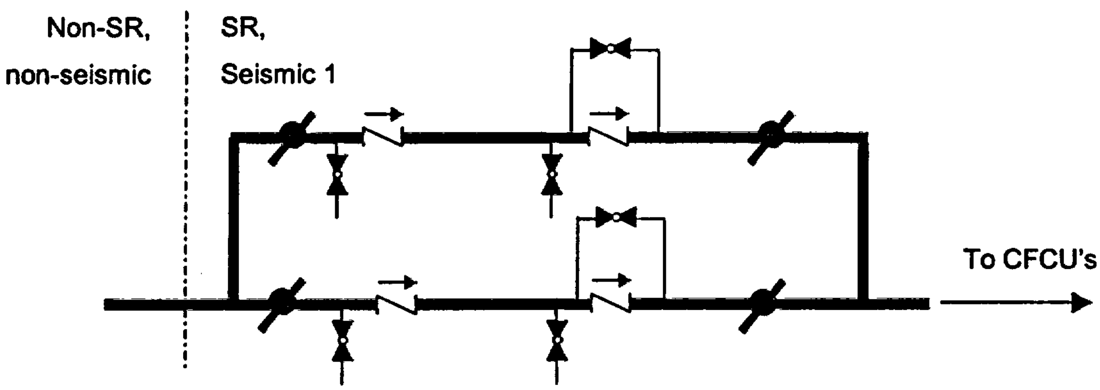
- A greater leakage barrier between the SW system and the CFCU CH System. The valves shall be rubber seated to provide greater leakage tightness. Metal seats are not required since these valves will not see SW flow except in a DBA, and leak tightness is not then required. In addition, metal seats would require larger operators that would be extremely difficult to install in the SW valve rooms.

- Cycling one valve at a time for quarterly IST without introducing SW flow to the CFCU flow path.
- In case an AOV fails to open during testing, the valve will be provided with features to allow it to be jacked-open, the stem locked in the open position, and the valve operator removed/replaced/repaired. Although this increases the risk of SW contamination of the CFCU CH System, it maintains the system in an "operable" status[17].
- A flush valve (labeled dead leg – debris clean out) allows blow down of the vertical, dead-headed piping between the main SW header and the first SW isolation valve before stroking the SW valves. Flushing this dead leg prevents long-term accumulation of silt and debris in the dead-headed portion of the line (and it avoids having that debris drop into the clean areas during AOV testing).
- An inspection port in the "dead leg" allows inspections and removal of any marine life, such as mussels, which would not flush out but which could over time cause flow reductions.
- When testing the outboard SW isolation valve (outboard refers to the AOV closest to the main SW header), a small, manual by-pass around the "inboard" SW isolation valve is opened. This "flush" valve keeps the volume between the two valves pressurized with the higher pressure, clean chilled water. Flow when testing the outboard isolation valve will then be into the SW header.
- A tell-tale valve between the two AOV's can be periodically opened to determine if either AOV is leaking. The water quality of the leak determines which valve is leaking. The object is to detect a single valve leaking, and repair it at a convenient time, and to minimize the probability of both valves leaking at the same time.
- Removal of the SW AOV is anticipated to be an infrequent outage activity. Manual valves allow for the SW AOV's in one header to be removed while maintaining CH to 3 CFCU's. For example, the 11 SW header valves can be removed and CH can be maintained to the 13, 14, and 15 CFCU's by shutting 11SW52, 11SW78, 11SW54 and SW76, 12SW54 and SW76, and the CH manual valves to the 11 SW header.

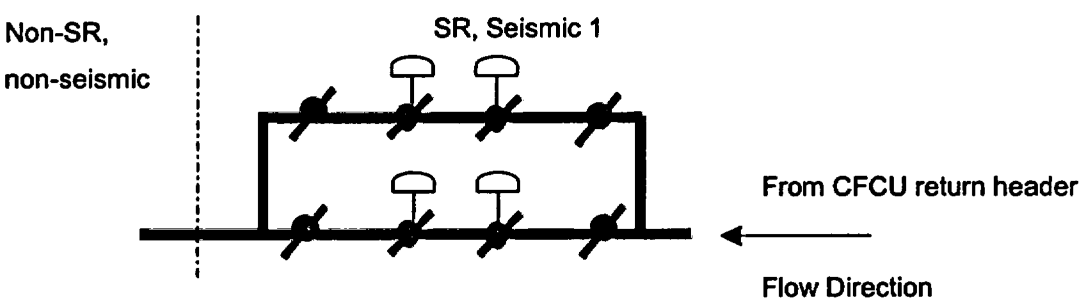
14)The CFCU CH System supply header is a single flow path. However, to allow for testing and to minimize the risk and consequences of an isolation check valve failure incapacitating the system, the isolation header portion will have two redundant parallel flow paths, each with redundant in-series check valves. One of the two paths can be removed from service to allow testing, and if the check

[17] The limitation is that this valve is required to be returned to service prior to testing the other isolation valve.

valve fails to shut on reverse flow, it can be kept out of service without entry into any Technical Specifications Action Statement[18].



15)Likewise, the CFCU CH System return header is a single flow path and it's isolation header portion will also have two redundant parallel flow paths each with in-series fast closure AOV's. These 10" nominal diameter AOV's will "recycle" the present SW accumulator isolation valves (SW534 and 535's) except that they will be modified from normally shut, fail open to normally open, fail shut.



16)The present CFCU control valves, SW57 and SW65 will be deleted. SW223, will be converted to a manual valve, locked in a specific throttle position[19]. This will entail determining the extent of demolition for all associated controls (including control switches, logics, wires, pneumatics, etc).

17)The SW53 and SW77 check valves will be retained. These valves prevent the 11(21) SW header from cooling the 14(24) and 15(25) CFCU and, similarly the

[18] The limitation is that this flow path is required to be returned to service prior to testing the other flow path valve.

[19] Refer to SH.OP-AP.ZZ-0103, Attachment 4 "Locked Valve Validation Criteria", Criterion 5, SR Throttle valves. Manual valves that are throttled to balance flow in a system or regulate flow to a component shall be locked in the required position. When incorrectly positioned these valves could affect system or component operability". Criterion 4 also applies.

12(22) SW header from cooling the 11(21) and 12(22) CFCU. These valves allow the SW headers to be separated to address the possibility of a passive failure, resulting in a leak, in a CFCU line during a DBA. This passive failure need only be postulated 24 hours after the start of a DBA. The CH supply line into each SW valve room will is provided with a check valve in each room branch line. These check valves are required for the same reason as SW53, maintain SW header separation.

18)Since the maximum anticipated operating pressure at the CFCU's will be approximately 95 psig (about 55 psid below the CFCU design pressure) and the system will be operating with clean water except on a DBA, a thermal relief valve will be added to each CFCU branch line to address isolation of the CFCU's. The existing bypasses to the SW223 valves will be eliminated. The setpoint will be 150 psig which provides a significant margin to prevent leakage and spurious opening. The design shall include a bellows so that the set pressure is not raised during a containment DBA.

19)The 12(22) SWS accumulator will be retained to ensure the CFCU's remain full and pressurized, as discussed earlier, during a transition from normal cooling to SW cooling. The N_2 pressure will be reduced from 150 psig to ~ 80 psig. The AOV's on its discharge path are removed (used elsewhere).

20)The 11(21) SWS accumulator be converted to a head/surge tank for the CFCU CH System. The N_2 blanket will be maintained but pressure will be significantly reduced. The pressure will be determined by how much pressure has to be added to the CFCU CH System pumps, during normal operation, to maintain the chilled water pressure slightly higher than the SW supply header pressure (measured at the point where the SW headers enter the Mechanical Pen Area).

21)A make-up line from the Demineralized Water (DM) System to the CFCU CH System is required. The detailed design will determine if the DM System can make up directly to the suction side of the CFCU CH System without requiring added pumps. If so, the present SW accumulator pumps will be deleted.

22)During anticipated operations, CH water is aligned to three CFCU's. To prevent CH flow to the other 2 CFCU's but maintain the SW flow path operable, the CH return line AOV's from either the east SW valve room or the west SW valve room are shut.

23)No changes are required to existing CFCU containment isolation valves, SW58 and SW72. However, their capability to isolate must be reviewed to ensure adequate closure assuming the following changes (1) lower SW pressure but (2) closure against full SW flow. Presently, valve closure credits prior SW223 closure.

24)The SW System hydraulic model will be revised to confirm satisfactory flow to all components during normal and accident conditions incorporating the changes in flow to the CFCU's and SW strainer backwash and the reduction in SW pump TDH. This may require a review of control valve Cv's and/or fixed orifices in the individual branch lines.

25)SW minimum flow must be reviewed during winter operation. Presently, SW flow to the major loads (TAC and CCHX) is significantly throttled with low river temperatures. Eliminating the CFCU flow may require increasing the flow on an existing bypass line to ensure that the minimum SW pump flow can be maintained.

26)Determine if added HVAC is required in the FHB annex due to normal operation of two, 60 Hp motors for the CFCU CH System pumps. This includes added ventilation during the summer and added heat during the winter. Note that the heater used in the wintertime is unreliable because the hot water line to it has tended to freeze.

27)Determine impact on Control Air System loads. This assessment should credit per Salem unit (a) deletion of fifteen valves AOV's (SW57, SW65, and SW223 in each CFCU) (b) addition of 8 SW header isolation valves (c) conversion of the 4 SW accumulator valves to 4 CH isolation valves and (d) changes in instrumentation.

3.2. Electrical

The electrical one line is Figure 7 CFCU CH System One Line Electrical.

1) Two chillers and 2 CH pumps will be powered from the "E" group bus and 2 chillers and 2 CH pump will be powered from the "G" group bus as shown on Figure 7 CFCU CH System One Line Electrical. This design allows for over full cooling with the limitations described in the next paragraph) and full flow on a single group bus (note that all four group buses are required to operate the unit since Salem is not licensed to operate with less than 4 RCP's).

2) If there is failure of one of the two CFCU Chilled Water System buses, which causes a loss of power to 2 pumps and 2 chillers, the remaining bus should be capable of providing the required power one chiller and one pump on the opposite bus through the cross-tie, as discussed in Section 1.3.5.

3) Miscellaneous power to the area including lights, receptacles for power tools, instrumentation, and heat tracing.

4) Run two (2) cables from the Turbine Building (TB) E and G buses to the outside of the FHB. The cable will be 4KV. Use the breaker location vacated by the CW pumps.

   The routing of the cable shall be determined by cost considerations.

   Each cable will feed one 4160V to 480V transformer mounted by the FHB.

5) No changes are required in the "fan" side of the CFCU's. Normal, high speed is required during normal operation, and low speed is required during DBA. The Project considered the option of a single speed fan speed, but determined that it was not desirable. Reducing the speed during normal operation would invalidate much of the temperature gains achievable by the use of CH water; increasing the speed during DBA would require a much higher SW flow and would negate the goal of replacing the control valves with fixed resistances.

3.3. I&C

The I&C control logic for the valves are shown on Figure 4 Typical CH AOV Control Logic, Figure 5 Typical SW Supply Header AOV's Control Logic, and Figure 6 Typical SW Return Header AOV's Control Logic. Refer to section 2.7, SW & CFCU CH Valves, CH Pump, and Chiller Control Signals. Additional information:

1) The new SW System CFCU air operated isolation valves are required to open for DBA's but they are normally shut, fail shut (see section 2.6). Therefore, all control air and electrical power will be from safety related sources and will require careful design (e.g., provide accumulators to ensure no common mode air failures and use DC solenoid valves, powered from a vital power supply to address a diesel SACF). Spurious opening of both in-series SW isolation valves due to a single component failure or testing error is highly undesirable. The design needs to consider to the extent reasonable how to minimize spurious simultaneous openings while at the same time providing reliable opening when an actuation signal is received.

   The SW AOV's require air to open and the solenoid valves that control air to these valves will be normally shut, fail shut. However, each SW AOV will be provided with redundant air thru redundant, parallel path solenoid valves powered from separate DC sources. Thus, any single DC failure will not prevent any SW AOV from automatically opening when required.

   Note: although automatic actuation energizes both redundant solenoids and both headers, remote-manual unisolation from the control allows the Operator to select one or both headers, but it only energizes the "primary" solenoid for a header.

2) The new CFCU CH System air operated isolation valves are normally open and must shut on a SI signal. Two in series valves are provided to ensure that no failure keeps both valves remaining open. The design should however minimize the inadvertent isolation of both return paths.

3) In addition to automatic signals, remote-manual controls for both the CFCU CH System and SWS isolation valves are to be located in the main control room. This is in keeping with FSAR commitments to provide controls in the control room for all key SW isolation valves.

4) Presently, the CFCU's have inlet and outlet flow measurements to detect significant leaks. Flow measurement is required to verify normal and accident flow. Flow deviation is not critical for normal operation, but must be retained for DBA.

5) The Project must delete the I&C for SW57, SW65 and SW223. These valves presently control flow in the CFCU branch lines. They are being removed or converted to manual valves.

6) Review, and as necessary, modify all the instrumentation and controls on the SW system that are affected by destaging the SW pump and operating the SW system at approximately 66% of present pressure.

7) The design should allow testing of the SI signal to the CH and SW valves; however, the design should allow this tests to be performed without actually opening the SW valves. Testing of the SI signal to these valves is anticipated as part of the safeguard test performed during a refueling outage.

8) To minimize SW initiation due to spurious SI signals, the design should allow blocking the SI initiation signal to the CFCU SW isolation valves when CFCU accident cooling is not required by Technical Specifications (during modes 4, 5, 6 and defueled).

9) Chillers

   Controls, indication, and alarms for the chillers are located on local vendor supplied chiller control panels. Any alarm actuation on the local panel will also cause a trouble alarm the main control room panel. Chiller controls will be programmed to add or drop compressor loading as necessary to maintain chilled water in the control band (around 46°F), as heat load in the containment increases or decreases.

   Controls and instrumentation for each chiller include:

   - Vendor-furnished, equipment-mounted control package and control panels that include chiller outlet water low flow switch, flow indicator, local pressure indicator, temperature indicator, temperature switch, and temperature high-low alarm,
   - Local chiller inlet water pressure indicator,
   - Computer input for compressor motor winding temperature,
   - Computer input for compressor motor bearing temperature.

10) Centrifugal Pumps

   The pumps shall trip following any CH System isolation signal.

   Controls and alarms for chilled-water pumps are located on the local vendor supplied control panel. Any alarm actuation on the local panel will also cause a trouble alarm the main control room.

   Controls and instrumentation for each chilled-water pump include:

   - A chilled-water flow transmitter and indicator, flow displayed on the local control panel.
   - A chilled-water flow high-low switch which alarms at the local control panel and cause a trouble alarm the main control room.
   - Pump suction and discharge pressure indicators.
   - Computer input for chilled water discharge pressure.

3.4. *Corrosion/Water Chemistry Control*

Due to the possibility of SW initiation and discharge of the CFCU CH System fluid into the river, no chemicals will be used.

Corrosion will be controlled by maintaining a N_2 blanket on the accumulator and head tank and using demineralized water as make-up.

To maintain water quality a fifty (50) gpm, or 2% of the total chilled-water flow, will be filtered through a filter and then treated thru a mixed bed demineralizer. The filter/mixed-bed demineralizer skid is a preassembled unit with the following instruments:

1. An in-line, turbine type flow element with digital indicator and totalizer for monitoring skid flow and total usage.
2. Several local pressure gauges for monitoring differential pressure across the media beds and across the outlet resin trap.
3. An outlet flow conductivity element with digital, local indication and high alarm for monitoring demineralizer performance.

The filter minimizes the insoluble loadings added to the resins and minimizes the need for backwashing resins.

Since this skid may not be in constant use, it will be located indoors to provide freeze protection.

3.5. *Civil/Structural*

Civil/Structural is required to support installation of the new equipment and activities as described elsewhere and briefly summarized below:

1. Provide a support pad for the chillers and switchgear located by the FHB. The supports shall raise the components above ground to minimize the risk from a nominal flood and/or from snow accumulation. The bottom of the chillers shall be a nominal 3' above grade.
2. Civil work for piping, conduits, etc including core bores
3. Relocation of fences and other commodities located in the yard
4. Any modifications required in the FHB "Annex" to support installation of the CFCU CH System pumps and demineralizer skid. This includes re-opening of the floor drain that was plugged during the re-rack work.

3.6. *Design Specialties*

1) Radiation Monitoring on the SW return lines will be addressed by a separate project. The present R13A monitors are located on a tubing bypass around the SW223 valves. There is one per CFCU branch line, and their design function is to detect for any containment leakage thru a failed CFCU tube that, if undetected, would result in releases to the river. These monitors are not adversely impacted by the CFCU CH System.

- During CFCU CH System operation, chilled water pressure will be at ~ 100 psig whereas containment pressure will be at ~ 0 psig. Any CFCU pressure boundary leakage will result in demineralized water leaking into the containment and be detectable by a decreasing level in the head tank. A 0.1 gpm leak will result in a 4"/day level drop. Even if the chilled water pumps were all lost, the accumulator tank would maintain chilled water pressure well above containment design pressure.
- In the event of a DBA, the CFCU CH System is isolated and SW is initiated. SW pressure on all lines inside containment will remain higher than containment pressure even with destaged SW pumps. Nevertheless, if one were to postulate a containment leak into the SW system water, the lower SW flow (reduced from ~ 2500 gpm to ~ 1500 gpm/CFCU) would reduce the dilution making detection easier.

2) The CFCU CH System is subject to moderate line break evaluations. Specific concerns are leaks/flooding of the SW valve rooms.
3) Pipe whip protection is not required for components located outside of containment.
4) No environmental qualification is required except for the added SW and CFCU CH System isolation valves and related controls or instrumentation.
5) No new tornado missile protection is required. Although much of the CFCU CH System equipment is outdoors, the only new safety-related components that are outside the present buildings are the portions that are in or immediately adjacent to the accumulator building. This piping should be protected by the same shields originally installed to protect the accumulator building.
6) EQ of components inside the containment needs to be reviewed against the new DBA temperature and pressure profiles. In addition, once the modification is implemented, the EQ program should credit a normal containment ambient temperature of ~90°F when computing EQ component replacements.

3.7. *Licensing*

1) Technical Specification changes to change number of CFCU's required to be "Operable" from 5 to 4 (depending on the source term/CR dose calculation, may have to require 5 CFCU's Operable until AST is approved), reduce required SW flow from 2500 gpm to ~1200 gpm, revised SW accumulator requirements, and as required to support the licensing change process.
2) Provide revised FSAR analysis and text changes.
3) Permits may be required for the chiller foundations and for discharging the heat to the atmosphere.
4) Coordinate above effort with Licensing for AST Project

4. KEY PROJECT DOCUMENTS

All calculations are retrievable thru DCRM. All memo's, position papers, evaluations, and studies are located in the CFCU Project S-Drive under the folder labeled "906 Reports_Studies_Evaluations".

7.1. Westinghouse WCAP, Containment Analysis for Revised CFCU Cooling

7.2. S-C-SWS-MDC-1968, Revision 1, Post-Modification CFCU Heat Removal Capacity

7.3. S-C-CH-MDC-1970, CFCU Chilled Water System Design Basis Parameters

7.4. S-C-SW-MDC-1969, SWS System Requirements for Post-Accident Containment Cooling (also called GL96-06 calculation)

7.5. S-C-SW-MEE-1821 SW System Hydraulic Performance with 2-Stage Pumps

7.6. Johnston Pump Preliminary Data (letter Dated 9/30/02)

7.7. Johnston Pump Test Data on Destaged Pump (After Testing)

7.8. Final Proto-Flow SW Hydraulic Analysis for Destaged Pumps and 5 CFCU's (includes Turbine Bldg Loads)

7.9. DBA Dose Calculation (Need document #)

7.10. Basis for Selection of Air Cooled Chillers Memo 08 08 03

7.11. CFCU Reliability White Paper 7 22 03

7.12. CLCWC Piping and Corrosion Control Options 07 10 03

7.13. Revised Plot Plan Showing Location of Major Equipment (Approved by Station Management) 7 14 03

7.14. Isolation Signals Requirements 08 11 03

7.15. Marked Up SW P&ID's Showing Changes

7.16. CFCU CH Simplified P&ID, SR

7.17. CFCU CH Simplified P&ID, non-SR

7.18. Conceptual Piping and Equipment Layout for Pumps and Chillers

7.19. Conceptual Layout of Piping in SW Valve Rooms

7.20. CFCU Chilled Water System Substation Electrical One-Line

7.21. Control Logic Drawings for All New Power Valves

7.22. Control Logic Drawings for CH Pumps

7.23. Chiller Specification

7.24. CFCU CH Pump Specification[20]
7.25. Filter/Demineralizer Specification
7.26. Switchgear Specification
7.27. SR Valve Specification
7.28. NSR Valve Specification
7.29. Chiller Vendor Data
7.30. CFCU Pump Vendor Data
7.31. Filter/Demineralizer Vendor Data
7.32. Switchgear Vendor Data
7.33. SR Valve Vendor Data
7.34. NSR Valve Vendor Data

[20] The conceptual layout was done assuming a Goulds Model 3410, 6x8-13