HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NPF-57
DOCKET NO. 50-354
SUPPLEMENT TO REQUEST FOR LICENSE AMENDMENT
ULTIMATE HEAT SINK

Calculation No. EG-0047, Rev. 4
HCGS Ultimate Heat Sink Temperature Limits

USER RESPONSIBLE FOR VERIFYING REVISION, STATUS AND CHANGES
PRINTED 20060801

CALCULATION COVER SHEET Page 1 of 36

CALCULATION NUMBER: EG-0047 **REVISION:** 4

TITLE: HCGS Ultimate Heat Sink Temperature Limits - EPU

#SHTS (CALC): 36 **#ATT/#SHTS:** 9/~~307~~ 315 **#IDV/50.59 SHTS:** 9 / 9 **#TOTAL SHTS:** ~~381~~ 369

CHECK ONE:

☒ FINAL ☐ INTERIM (Proposed Plant Change) ☐ VOID

☐ FINAL (Future Confirmation Req'd, enter tracking Notification number:)

SALEM OR HOPE CREEK: ☒ Q – LIST ☐ IMPORTANT TO SAFETY ☐ NON-SAFETY RELATED

HOPE CREEK ONLY: ☒Q ☐Qs ☐Qsh ☐F ☐R

☒ ARE STATION PROCEDURES IMPACTED? YES ☒ NO ☐

IF "YES", INTERFACE WITH THE SYSTEM ENGINEER & PROCEDURE SPONSOR. ALL IMPACTED PROCEDURES SHOULD BE IDENTIFIED IN A SECTION IN THE CALCULATION BODY [CRCA 70038194-0280]. INCLUDE AN SAP OPERATION FOR UPDATE AND LIST THE SAP ORDERS HERE AND WITHIN THE BODY OF THIS CALCULATION.

80087020

☒ CP and ADs/CDs INCORPORATED (IF ANY):
This Revision Incorporates DCP 80076229, AD M-0004 ('A' Loop Weko Seals); and DCP 80057204, AD M-0011 and M-0012 (EG-V540/541 changeouts). In addition, for conservatism this calculation also incorporates the following pending changes; DCP 80083499, AD M-0003 ('B' Loop Weko Seals); and DCP 80045390, AD M-0023 and M-0026 (EA-V450/451 changeouts).

DESCRIPTION OF CALCULATION REVISION (If applicable.):
The calculation is revised to reflect heat loads associated with EPU conditions and is bounding up to and including a rated thermal power of 3840 MWt. In addition, the calculation is revised to reflect appropriate design basis SSWS flows for the limiting accident scenarios and evaluates short-term elevated UHS temperatures. An allowance for installed and future Weko seal applications is provided and the concerns of notification 20271880 are incorporated.

PURPOSE:
The purpose of this calculation is to determine the maximum allowable UHS temperature to maintain the SACS header temperature below its post-accident design basis temperature of 100°F. The maximum UHS temperature will be determined for the design basis Loss of Coolant Accident (LOCA) and Loss of Offsite Power (LOP). The effects of a coincident Safe Shutdown Earthquake (SSE) with the LOCA/LOP and normal operation are also evaluated.

CONCLUSIONS:
The limiting post-EPU design basis event is a LOP coincident with a SSE coupled with a single failure of the 'C' emergency diesel generator (EDG). The resulting continuous UHS temperature limit is 91.4°F. Short-duration peak UHS temperatures as high as 95°F have been evaluated. This meets the current Technical Specification limit of 89°F and is consistent with an outstanding license change request (LCR) on the subject. The UHS temperature limit for conditions resulting from design basis failures concurrent with equipment outages permitted by Technical Specifications is 88.3°F which meets the current limit of 88°F. Normal Operation is supported post-EPU at an 89°F UHS temperature.

	Printed Name / Signature	Date
ORIGINATOR/COMPANY NAME:	Paul Lindsay / MLEA	March 28, 2006
REVIEWER/COMPANY NAME:	N/A	
VERIFIER/COMPANY NAME:	Theodore DelGaizo / MLEA	March 28, 2006
CONTRACTOR SUPERVISOR (If applicable)	N/A	
PSEG SUPERVISOR APPROVAL:	Emin Ortalan / PSEG Nuclear	4/12/06

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PRINTED 20060801

PSEG	CALCULATION CONTINUATION SHEET	SHEET: 2 of 36 CONT'D ON SHEET:

CALC. NO.: EG-0047				REFERENCE: N/A			
ORIGINATOR, DATE	REV:	RED 3/12/2002	2	JBM 11/30/2005	3	PJL 3/28/2006	4
REVIEWER/VERIFIER, DATE		KCK 3/20/2002		RED 12/06/2005		TDG 3/28/2006	

REVISION HISTORY

Revision	Issue Date	Revision Description
0	1/17/2000	Initial Issue.
1	2/27/2000	The purpose of this calculation is to revise the SACS hydraulic model to account for by-pass leakage of the RHR heat exchanger SACS outlet valve 1EGHV-2512A (1EGV-023), and to analyze the effects of plugged tubes in the SACS heat exchanger. The calculation did not account for bypass leakage of the valve, which could have leakage upwards of 3000 gpm. In addition, the model assumed that the SACS heat exchanger did not have any tubes plugged. This revision also determines the impact of 50 plugged tubes in the SACS heat exchanger.
2	4/09/2002	The calculation is being revised to determine the impact to the Ultimate Heat Sink (UHS) temperature limit due to the Residual Heat Removal (RHR) heat load transferred to the Safety Auxiliaries Cooling System (SACS) during automatic Low Pressure Coolant Injection (LPCI) in the LOCA short-term.
3	12/07/2005	Incorporating 80075972 (AD M03R0). Revising the degraded pump curve from EG-0046, Revision 5. Simplifying the calculation complexity by making all non-bounding alignments history cases only to be used as a justification for limiting cases.
4	See Cover	The calculation is revised to reflect heat loads associated with EPU conditions and is bounding up to a rated thermal power of 3840 MWt. In addition, the calculation is revised to reflect appropriate design basis SSWS flows for each accident scenario and evaluates short-term elevated UHS temperatures. References were added and editorial changes were made throughout. An allowance for installed and future Weko seal applications is provided and the concerns of notification 20271880 are incorporated in Attachment 5.

PAGE REVISION INDEX

PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
1	4	16	4	32	4	Attachment 1	4
2	4	17	3 ↓	33	4	Attachment 2	DELETED
3	4	18	3 ↓	34	4	Attachment 3	3 ↓
4	4	19	3 ↓	35	4	Attachment 4	↓
5	4	20	↓	36	4	Attachment 5	4
6	4	21	4			Attachment 6	0
7	4	22	4			Attachment 7	0
8	4	23	4			Attachment 8	1
9	4	24	4			Attachment 9	1
10	4	25	4			Attachment 10	2
11	4	26	4			Attachment 11	2
12	4	27	4			Attachment 12	4
13	3 ↓	28	4				
14	3 ↓	29	4				
15	↓	30	4				
		31	4				

PSEG	CALCULATION CONTINUATION SHEET					SHEET: 3 of 36 CONT'D ON SHEET:	
CALC. NO.: EG-0047				REFERENCE: N/A			
ORIGINATOR,DATE	REV:	RED 3/12/2002	2	JBM 11/30/2005	3	PJL 3/28/2006	4
REVIEWER/VERIFIER,DATE		KCK 3/20/2002		RED 12/06/2005		TDG 3/28/2006	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this calculation is to determine the maximum allowable Ultimate Heat Sink (UHS) temperature to maintain the SACS header below its design basis temperature of 100°F. The maximum UHS temperature will be determined for the design basis Loss of Coolant Accident (LOCA) and Loss of Offsite Power (LOP). The effects of a coincident Safe Shutdown Earthquake (SSE) with the LOCA/LOP and normal operation are also evaluated. As discussed in Section 5.10, the calculation also determines the UHS temperature where a diesel generator must be declared inoperable when a room cooler is out of service for maintenance.

2.0 SCOPE

This calculation is being performed for the Safety Auxiliaries Cooling System (SACS) and Station Service Water System (SSWS), the ultimate heat sink for the Hope Creek Generating Station (HCGS). It includes heat loads associated with EPU conditions and is bounding up to and including a rated thermal power of 3840 MWt (with the exception of the normal operation case which is evaluated with the turbine-generator at 3673 MWt, see Section 6.0 for discussion). The scope is limited to the bounding cases determined in previous revisions to this calculation and cases involving operator action. In addition, an evaluation of short-term elevated UHS temperatures is included in support of H-1-EA-MEE-1926, Average Ultimate Heat Sink Temperature, and a related license change request (LCR) on the subject. This revision also includes provisions for future Weko seal installations in the SSW header, addresses pending valve changeouts, and corrective actions associated with Notification 20271880. Refer to Attachment 5 for a detailed discussion of these topics.

3.0 ASSUMPTIONS / INPUTS / CONDITIONS

3.1 <u>SACS Supply Temperature Limits</u>

3.1.1 The SACS heat exchanger outlet design temperature (or inlet to the RHR heat exchanger) shall be limited to 95°F during normal operations (Reference 4.4.2, Page 3-7).

3.1.2 The SACS system design allows for a SACS heat exchanger outlet temperature limit of 100°F during accident/transient conditions with the exception listed below (References 4.1.8; 4.4.2, Pages 3-9 and 3-10; and 4.4.3, Section 5.2.2.2, Item 6).

3.1.3 The SACS post-accident design temperature shall be limited to 95°F for a SACS AOT in which only one SACS pump in each loop is operable. In this configuration, insufficient SACS flow is supplied to the RHR Hx to support 100°F.

3.1.4 Due to limitations in maintaining the suppression pool temperature at a maximum temperature of 95°F, the SACS design temperature must remain less than or equal to 95°F during normal conditions. The scope of increasing the SACS temperature to 100°F was limited to the SACS portion of the Safety and Turbine Auxiliary Cooling System (STACS). The non-safety related TACS portion of the system is isolated following a LOP and/or LOCA scenario, and is not evaluated for 100°F SACS temperatures.

3.2 SACS Heat Loads

3.2.1 The heat loads used for this calculation were obtained from References 4.1.1, 4.1.8, 4.1.9, 4.1.10, 4.1.11 and 4.4.2.

3.2.2 For the LOP/SSE and the LOP accident scenarios, the suppression pool temperature could raise up to 212°F (213.6°F post-EPU) for one RHR heat exchanger operation with an RHR flow rate of 10,000 gpm (Reference 4.4.1, Table 5-4, and Reference 4.4.3, Section 5.3.1.3). For two RHR heat exchanger operation with an RHR flow rate of 10,000 gpm each, the suppression pool temperature could raise to 183°F (Reference 4.4.1, Table 5-5). For the LOCA accident scenarios, the suppression pool temperature could raise to 210°F (212.3°F post-EPU) for one RHR heat exchanger operation with an RHR flow rate of 10,000 gpm (Reference 4.4.1, Tables 5-2 and 5-3, and Reference 4.4.3, Section 5.3.1.3). For two RHR heat exchanger operation with an RHR flow rate of 10,000 gpm each, the suppression pool temperature could raise to 185°F (Reference 4.4.1, Table 5-1). See Section 5.10.3 for a discussion of the post-EPU 2 RHR HX accident response.

3.2.3 The process side controls for the Emergency Diesel Generator (EDG) heat exchangers are assumed to control the process side flow rates so that a fixed design heat load is removed through these heat exchangers. This will prevent over cooling of the EDG's.

3.2.4 Following the failure of an EDG, the heat load on the associated EDG room cooler is assumed to be zero. This is reasonable since the primary heat source for the EDG room coolers is the EDG itself.

3.2.5 The heat load removed (shown below) by SACS for any Emergency Auxiliaries Cooling System (EACS) pump room cooler is assumed to be the required heat load determined in Reference 4.1.11, regardless of the number of room coolers operating for the room.

VH210, RHR Pump Room = 360,000 Btu/hr
VH210, RHR Pump / HX Room = 346,000 Btu/hr
VH211, Core Spray Pump Room = 185,400 Btu/hr
VH209, HPCI Pump Room = 144,000 Btu/hr
VH208, RCIC Pump Room = 50,400 Btu/hr

3.2.6 For the Filtration Ventilation and Recirculation System (FRVS), during a LOCA the long-term heat load is 0.85 Mbtu/hr for both three and four operating FRVS units. During the short term, the heat load to each operating FRVS unit is 0.52 Mbtu/hr (Conservatively obtained from Reference 4.1.11).

3.2.7 For this analysis, the SFP heat exchangers are isolated if the SACS header temperature cannot be maintained below 95°F (normal conditions) or 100°F (LOCA and/or LOP). Following a LOP signal the fuel pool pumps trip and are not automatically loaded onto the EDGs; fuel pool heat exchangers would remain isolated if river temperatures were high. Following a LOCA scenario, the instrument air system is assumed to be lost (since the RACS and TACS systems that cool the air compressors would automatically be isolated). The Loss of Instrument Air (LIA) would cause the fuel pool heat exchanger outlet valves to fail closed preventing fuel pool cooling pump flow, and fuel pool heat exchangers would remain isolated if river temperatures were high. If a LOP or LIA did not occur, and SACS temperature reaches the design value (95°F or 100°F), operator action in accordance with Reference 4.3.6 would isolate the SFP heat exchangers.

3.2.8 EDG room cooler heat load is 1.9 MBtu/hr for one operating EDG room cooler, and 2.2 MBtu/hr (1.1 Mbtu/hr each) when two EDG room coolers are operating (see Reference 4.1.1). At 100°F SACS temperatures, two EDG room coolers are required to maintain EDG rooms below their design temperature of 120°F (Reference 4.1.10).

3.2.9 The RHR pump seal coolers' heat load depends on the source of water aligned to the RHR pump. For the RHR pump seal coolers, a post LOCA heat load of 0.09 MBtu/hr was used since it is assumed that the water is from the suppression pool at a maximum temperature of 212°F. The post-LOP heat load of 0.35 MBtu/hr (applied to the A & B coolers only) was used since it is assumed that the water is taken directly from the reactor vessel at a maximum shutdown cooling temperature of 350°F. These heat loads are taken directly from Reference 4.1.1. The change due to a 1.6°F post-EPU suppresson pool temperature is negligible.

3.2.10 The calculation includes heat loads associated with Extended Power Uprate (EPU) conditions corresponding to a rated thermal power level of 3840 MWt. The SACS PROTO-FLO model is updated to reflect the following post-EPU changes. Use of higher heat loads is conservative for operation at any power level less than 3840 MWt. Per Reference 4.4.2, Section 1.3, the SACS heat load is increased for the accident condition as a result of EPU "by increases in the...RHR heat exchanger and room coolers." Other SACS supplied loads were not affected or resulted in a negligible change.

1) RHR HX – Per Reference 4.4.2, Pages 3-4 & 3-5, the LOCA RHR heat exchanger heat load increases to 127.1 Mbtu/hr from the current 123.8 Mbtu/hr (and decreases to 127.1 Mbtu/hr from the currently assumed 132.5 Mbtu/hr for a LOP, due to excessive conservatism). Per Reference 4.4.3, Section 5.3.1.3, maximum predicted suppression pool temperatures analyzed at 102% of 3840 MWt are 212.3°F for a LOCA and 213.6°F for a LOP. The PROTO-FLO thermal/hydraulic cases (see Attachment 1) are adjusted to predict actual heat rejection rates corresponding to these peak temperatures. Note this is conservative because the peak occurs late in the accident (approximately 8-9 hours) after many near-term loads (ECCS pump/cooler) loads would have been secured.

2) The EACS room coolers experience a slight increase in heat load due to elevated ECCS pump suction piping temperatures due to higher peak suppression pool temperatures. The FRVS system experiences slightly higher heat loads due to changes in both the suppression pool and drywell post-accident temperature profiles. The analysis uses the heat loads stated in Sections 3.2.5 and 3.2.6 since they are based on a calculation already updated to reflect the post-EPU condition (Reference 4.1.11).

3) Spent fuel pool cooling heat loads increase due to EPU conditions (higher decay heat rates). Given the assumptions made in 3.2.7 above (that the SFP heat loads are not present during a LOCA or LOP), this has no impact on the results of this calculation.

4) Per References 4.4.4 and 4.4.5, there is no change (negligible) in RACS heat loads due to EPU conditions. During normal operation, TACS heat loads increase from 124.7 to 126.2 Mbtu/hr.

Specific EPU changes to equipment include the isophase bus duct coolers (0.515 to 0.682 Mbtu/hr); stator water cooling (16.10 to 17.16 Mbtu/hr); condenser compartment coolers (2.011 to 2.205 Mbtu/hr); and turbine building chillers (58.5 to 58.58 btu/hr). Note these are total increases and are divided by the number of units running in the Proto-flo model.

3.3 SACS/SSWS System Alignments

3.3.1 The heat load between the "A" and "B" SACS loop are assumed identical except for the RCIC and HPCI heat loads. Since the RCIC pump room cooler required heat load is significantly lower (by a factor of two) than the HPCI pump room cooler heat load the "A" SACS loop is assumed to produce the limiting UHS temperature.

3.3.2 The Emergency Overboard (EOB) valves are opened under administrative controls when the SSWS temperature reaches 85°F and the breakers (10B212 MCC No. 131 and 10B222 MCC No. 131) are racked out to prevent the spurious actuation of the valve (Reference 4.3.2).

3.3.3 The control room chiller and 1E panel chiller control valves were set to control the flow rate through these units to the required flow rate stated in the UFSAR, which bounds the minimum required flow rate from Reference 4.1.1, 1588 gpm and 408 gpm respectively. Higher SACS flow increases the heat load transferred to SACS, resulting in a lower UHS temperature (see Attachment 7 for a detailed explanation). The chiller water controls will continue to control following a loss of instrument air. These valves have their own separate compressed gas cylinders that are designed to maintain pressure and allow the control valves to remain functional after a loss of instrument air.

3.3.4 Following a LOCA, during a SSWS loop outage; it is assumed that the SSWS pumps within that loop are out of service. In addition, a SSWS loop outage due to a pump outage limits the SSWS loop outage due to a SACS heat exchanger outage (see Attachment 5 for results).

3.3.5 The EDG crosstie configuration provided in the UHS spreadsheet analysis (see Attachment 5) assumes that the configuration when three EDG's are crosstied is bounded by the configuration when four EDG's are crosstied. Only the limiting temperature for the four EDG's crosstied is provided.

3.3.6 For the crosstie configurations, the SACS flow to the EDG room coolers is throttled according to the SACS System Operation Procedure (Reference 4.3.1).

3.3.7 For the limiting case from the 95°F SACS LOP/SSE UHS spreadsheet of Attachment (5) (represented by the 212.2 – 212.2 configuration on line 1 of the "AOT - One SACS Pump Per Loop", and the A1&2 - B1&2 configuration in the PROTO-FLO™ model runs), a sensitivity study was performed for the Probabilistic Risk Assessment Group to determine the UHS temperature for two special alignments: The A1&2 - B1&1 PROTO-FLO™ model line-up (represented by the 212.2 – 211.2 configuration on line 2 of the "AOT - One SACS Pump Per Loop"), and the A1&1 - B1&1 PROTO-FLO™ model line-up (represented by the 211.2 – 211.2 configuration on line 3 of the "AOT - One SACS Pump Per Loop"). These sensitivity studies are not part of the design basis, and are not used to determine the limiting UHS temperature. However, the PSA group will use the results as a model for their success criteria for the Safety System requirements in their probabilistic risk assessment of the SACS/SSWS system. Note that in the actual model runs, all the heat loads and component alignments for the A1&2, A1&1, B1&2, B1&1 model runs were analyzed by the "A" loop in PROTO-FLO™.

a) The A1&2 – B1&1 alignment: Two SACS Hx's in one loop and one SACS Hx in the other loop. In the A1&2 configuration (1 SACS pump and 2 SACS heat exchangers), only the "A" loop is being analyzed. Flow is <u>directed</u> to the RHR heat exchanger and <u>isolated</u> to the control room chiller. The "B" loop is analyzed in the B1&1 configuration (1 SACS pump and 1 SACS heat exchanger), in which flow is <u>isolated</u> to the RHR heat exchanger and <u>directed</u> to the control room chiller.

b) The A1&1 – B1&1 alignment: One SACS Hx in one loop and one SACS Hx in the other loop. In the A1&1 configuration (1 SACS pump and 1 SACS heat exchanger), only the "A" loop is being analyzed. Flow is <u>directed</u> to the RHR heat exchanger and <u>isolated</u> to the control room chiller. The "B" loop is analyzed in the B1&1 configuration (1 SACS pump and 1 SACS heat exchanger), in which flow is <u>isolated</u> to the RHR heat exchanger and <u>directed</u> to the control room chiller.

3.3.8 SSWS flows provided to the SACS HXs for each accident are taken from Attachment 5. This attachment takes into account outstanding and near-term pending changes to the SSW system and addresses two deficiencies identified in notification 20271880. In addition, a review of the operating modes analyzed in Reference 4.1.5 has concluded that alignments associated with the LOP/SSE scenario are not credible in that selective non safety- related portions of the system are postulated to fail while other non safety-related portions do not fail. While extremely conservative, such a postulated scenario is not considered part of the cooling water systems' design basis. Specifically, as can be seen from Section 8.3 of Reference 4.1.5, in addition to a minimum tide level, degraded pumps, fouled strainers and heat exchangers, the LOP event coincident with the safe shutdown earthquake (SSE) is postulated such that the non safety-related cooling tower collapses forcing the SSW discharge through the safety-related emergency overboard lines (EOBs). However, no breach is postulated in the non-seismic Category I RACS system forcing SSW to supply the non-seismic portions of the system following an SSE. No credit is taken for auto-isolation of SSW to the RACs HXs via the room flooded auto-isolation logic (Reference 4.5.2).

For the purposes of this analysis, SSW modes are defines as follows:

LOCA	SSW discharge is to the cooling tower basin (CTB) SSW flow to RACS auto-isolates on a LOCA signal
LOP	SSW discharge is to the CTB SSW flow is provided to the SACS and RACS HXs
LOCA/SSE	SSW discharge is to the EOB flowpath SSW flow to RACS auto-isolates on a LOCA signal
LOP/SSE	SSW discharge is to the EOB flowpath SSW flow to RACS auto-isolates on a room flooded signal

As shown in Section 5.2.2, limiting alignments involve both the LOCA and LOP postulated coincident with a safe shutdown earthquake. Although regulations do not specifically require the simultaneous postulation of an SSE and a design basis accident (Reference 4.5.1), for conservatism during a LOCA complete blockage of the non-Q portions of the discharge piping is assumed to occur. This is postulated absent any credible coincident failure mechanism or regulation.

For the purposes of evaluating UHS performance during a short duration peak temperature of 95°F (see Reference 4.1.14 for additional discussion), the normal cooling tower basin discharge path is assumed to be available should a LOCA occur. See Section 5.10.3 for further discussion.

For the LOP/SSE scenario, non-seismic Category I loads and flow paths are assumed to fail. Since there is no direct isolation logic signal associated with an SSE, the effects of a delay in RACS isolation is considered. An earthquake of sufficient magnitude to collapse the non safety-related cooling tower and completely block the buried SSW discharge piping is assumed to breach the non-seismically designed RACS system. For the purposes of this analysis, a single critical crack is assumed to occur in a large diameter cooling water pipe. In accordance with References 4.1.13 and 4.1.15, a crack occurring in a 36" line in the RACS room results in a blowdown flowrate of 300 lbm/sec or approximately 2200 gpm (at 150°F). Taking credit for 8 floor drains in the room at 89 gpm capacity each (Reference 4.1.15, Sheet 33), the time to reach the one-inch room flooded logic is determined as follows:

Net Inflow to Room	2200 gpm – 8 drains (89 gpm/drain) = 1488 gpm or 199 ft^3/min
Volume at 1"	4137ft^2 (Room Area, Ref. 4.1.15, Sht. 34) x (1" setpoint) x 1ft/12" = 344.8 ft^3
Time to Reach 1"	344.8 ft^3 / 199 ft^3/min = 1.73 minutes

Taking no credit for room drains, Reference 4.1.15, Sheet 34, determines that given a crack in a 24" diameter pipe, the time for the flood level to reach one inch would be 2.4 minutes.

As shown above, isolation of the non-safety related portions of the SSW to RACS piping would be expected to occur in several minutes following a major SSE. However, should a breach occur in smaller piping or not occur at all, existing procedures have operators secure SSW to the non-Q RACS loads if SACS temperatures cannot be maintained below 95°F. Step H.8 of HC.OP-AB.COOL-0002 (Reference 4.3.2) has operators reduce SSW flow to the RACS heat exchangers to provide additional cooling for SACS if temperatures in either or both SACS loops cannot be maintained below 95°F.

Given the above, it is conservatively assumed that following a LOP/SSE with complete blockage of the SSW discharge path (cooling tower collapse), RACS will either auto-isolate or be procedurally isolated within one hour from the event. As discussed in Sections 5.2.2 and 5.4, the LOP/SSE scenario will be evaluated in two parts, for the first hour with SSW supplying the non-seismic Category I RACS HX, and with flow to the RACS HX isolated thereafter.

3.4 Assumptions

Common Assumptions

3.4.1 The uncertainty of the temperature instrumentation for the SSWS and SACS temperatures is assumed to be 0.79°F (Reference 4.1.6). For a listing of the overall uncertainty see Section 5.11.

3.4.2 The service fluid for the SACS heat exchanger models is "Brackish Water - 12 ppt" in the PROTO-FLO™ model (Reference 4.1.3).

3.4.3 The RHR heat exchanger SACS outlet valves are assumed to be in the full-open position for all cases, with the exception of the "one SACS pump per loop" configuration. For this case, the valve is assumed to be closed to isolate flow to one of the RHR heat exchangers (see the discussion in Section 5.2.1.5 for details). The vendor-provided calculation in Attachment (9) shows that the valve has the potential for leakage of 360 gpm with the valve seat removed (based on a disc clearance of 0.019 inches). Based on a visual inspection of the valve, the disc clearance could be up to 0.125 inches. Using this value, the possible leakage rate was re-calculated using the equation found in Attachment (9), resulting in a bypass leakage rate of approximately 2500 gpm. To account for leakage in this configuration, the valve (1EGV-026) has been flow balanced to allow 3000 gpm of flow through the RHR heat exchanger isolation valve.

Revision 2 Assumptions

3.4.4 For situations where both SACS heat exchangers in the same SACS loop received SACS and SSWS flow, the average SACS flow rate, heat load, and shell outlet temperature from the PROTO-FLO™ run were used in the PROTO-HX™ model.

3.4.5 For the LOCA short-term analysis (less than 10 minutes), the suppression pool temperature is assumed 170°F per Reference 4.4.1. Per Reference 4.4.3, Section B.2, this is conservative for the post-EPU condition.

3.4.6 During LPCI injection phase of the LOCA short-term, the "RHR HX shell bypass MOV (BC-HV-F048A(B))" opens, and cannot be closed for 3 minutes, after which the Operator is directed to close this bypass valve as soon as possible (Reference 4.3.5).

3.5 SOFTWARE QUALITY ASSURANCE

3.5.1 The PROTO-FLO™ thermal hydraulic model of SACS was developed and benchmarked by EG-0043 (Reference 4.1.3) and balanced by EG-0046 (Reference 4.1.2). The heat exchanger models used for this calculation were developed in EG-0044 (Reference 4.1.4).

3.5.2 The PROTO-FLO™ program is CRITICAL SOFTWARE as defined by ND.DE-AP.ZZ-0052(Q) designated Proto-Flo (A-0-ZZ-MCS-0149, Reference 4.2.1). This program was developed and validated in accordance with Proto-Power's Nuclear Software Quality Assurance Program (SQAP), documented in Reference 4.2.2. This program meets the requirements of 10CFR50 Appendix B, 10CFR21, and ANSI NQA-1, and was developed according to the guidelines and standards contained in ANSI/IEEE Standard 730/1984 and ANSI NQA-2b-1991. PROTO-FLO™ Version 4.51 is approved for use on safety-related applications as documented in Reference 4.2.2.

3.5.3 The PROTO-HX™ program is CRITICAL SOFTWARE as defined by ND.DE-AP.ZZ-0052(Q) designated Proto-Hx (A-0-ZZ-MCS-0169, Reference 4.2.3). This program was developed and validated in accordance with Proto-Power's Nuclear Software Quality Assurance Program (SQAP). This program meets the requirements of 10CFR50 Appendix B, 10CFR21, and ANSI NQA-1, and was developed according to the guidelines and standards contained in ANSI/IEEE Standard 730/1984 and ANSI NQA-2b-1991. PROTO-HX™ Version 4.01 was verified and approved for use as documented in Reference 4.2.4.

3.5.4 The PIPE-FLO™ program is CRITICAL SOFTWARE as defined by ND.DE-AP.ZZ-0052(Q) designated Pipe-Flo (A-0-ZZ-MCS-0023) - Steady State Hydraulic Analysis (Reference 4.2.5). This program is used to calculate the SSWS flow rates to each SACS heat exchanger under the various conditions that are input into the analysis spreadsheet lookup tables. The SSWS flow rates are contained in EA-0003 (Reference 4.1.5).

4.0 REFERENCES

4.1 Design Calculations / Evaluations

4.1.1 EG-0020, "STACS - Required Flows and Heat Loads", Revision 8.
4.1.2 EG-0046, "Safety and Turbine Auxiliaries Cooling System (STACS) Operation" Revision 5.
4.1.3 EG-0043, "Safety and Turbine Auxiliaries Cooling System (STACS) PROTO-FLO™ Thermal Hydraulic Model", Revision 6IR0.
4.1.4 EG-0044, "Safety and Turbine Auxiliaries Cooling System (STACS) PROTO-HX™ Heat Exchanger Models" Revision 1.
4.1.5 EA-0003, "Station Service Water System Hydraulic Analysis" Revision 9.
4.1.6 H-1-EA-CEE-1126, "Evaluation of Service Water Pump Output Temperature Loop Accuracy", Revision 0.
4.1.7 EA-0001,"Station Service Water System Hydraulic Model", Revision 3.
4.1.8 H-1-EG-MEE-1301, "100°F SACS Design Temperature Limit Evaluation", Revision 1.
4.1.9 H-0-EA-MEE-1237, "Station Service Water System Failure Mode And Effects Analysis", Revision 1.
4.1.10 GM-0027, "Diesel Generator Area HVAC Analysis", Revision 1.
4.1.11 11-0066, HCGS FRVS Drawdown And Long-Term Post-Loca Reactor Building Temperature, Revision 7.
4.1.12 BC-0056, "RHR Hydraulic Analysis (Torus Cooling, Shutdown Cooling, LPCI)", Revision 4.
4.1.13 ED-0006, RACS Room Break Flow Rate, Revision 0, dated 3/27/80.
4.1.14 H-1-EA-MEE-1926, Average Ultimate Heat Sink Temperature, Revision 0, dated August 2, 2005.
4.1.15 11-92(Q), RX Bldg Flooding El 54' and 77', Revision 5, dated 8/8/97.

4.2 Critical Software

4.2.1 A-0-ZZ-MCS-0149, "Critical Software Document for PROTO-FLO™" Version 4.51, Revision 8.
4.2.2 Thermal Hydraulic Modeling Software Program PROTO-FLO™ Version 4.5 Software Validation and Verification Report (SVVR) SQA No. 93948-01, Revision M, dated 9/10/99
4.2.3 A-0-ZZ-MCS-0169, "Critical Software Document for PROTO-HX™" Version 4.01, Revision 6.
4.2.4 Heat Exchanger Thermal Performance Modeling Software Program PROTO-HX™ Version 4.01 Software Validation and Verification Report (SVVR) SQA No. SVVR-93948-02, Revision G, dated 5/28/99
4.2.5 A-0-ZZ-MCS-0023, "Pipe-Flo – Steady State Hydraulic Analysis", Ver. 4.06, Revision 0.

4.3 Procedures

4.3.1 HC.OP-SO.EG-0001, Safety and Turbine Auxiliaries Cooling Water System Operation, Revision 35
4.3.2 HC.OP-AB.COOL-0001, Station Service Water, Revision 7.
4.3.3 HC.OP-AB.ZZ-0135, Station Blackout//Loss of Offsite Power/Diesel Generator Malfunction, Revision 23.
4.3.4 ND.DE-AP.ZZ-0052, Software Control, Revision 1.
4.3.5 HC.OP-SO.BC-0001, Residual Heat Removal System Operation, Revision 41.
4.3.6 HC.OP-AB.COOL-0002, Safety/Turbine Auxiliaries Cooling System, Revision 0.

4.4 Vendor Documents

4.4.1 323835, Sheet 2, Containment Analysis with 100°F SACS Temperature, Revision 1.

4.4.2 DRF-000-0004-6923, HCGS Extended Power Uprate, Task T0606, Safety Auxiliaries Cooling System, Revision 2, dated April 2004 ((VTD 430044(002)).

4.4.3 GE-NE-0000-0005-4298-R6, HCGS Extended Power Uprate, Task T0400, Containment System Response, dated August 2004 ((VTD 430024(002)).

4.4.4 GE-NE-0000-0004-6923, HCGS Extended Power Uprate, Task T0608, Ultimate Heat Sink, Revision 1, May 2004 ((VTD 430046(002)).

4.4.5 GE-NE-0000-0004-6923, HCGS Extended Power Uprate, Task T0604, Station Service Water System, Revision 1, May 2004 ((VTD 430042(002)).

4.4.6 DRF-0000-0004-6923, HCGS Extended Power Uprate, Task T0607, Turbine Auxiliaries Cooling System, Revision 1, April 2004 (VTD 430045(002)).

4.5 Other Documents

4.5.1 NRC Denial of Amendment Request Regarding HCGS SSW and UHS, letter J. Stolz to L. Eliason, dated December 24, 1996.

4.5.2 P&ID M-10-1, Service Water, Sheet 2, Revision 36.

5.0 ANALYSIS

5.1 Methodology

5.1.1 Revision 2 Methodology

For the accident scenario and failure alignments discussed below, the following method was used to determine the UHS temperature. Using the PROTO-FLO™ thermal hydraulic model of SACS, the temperature at the tube-side (SSWS side) of the SACS heat exchangers was iteratively reduced until a temperature of 95°F (or 100°F) was achieved at the SACS inlet to the Residual Heat Removal (RHR) heat exchanger. This process was performed using a SSWS flow of 10,000 gpm on the tube-side of the SACS heat exchangers. The PROTO-HX™ model of the SACS heat exchangers was then used with the SACS flow rate, SACS heat load, and SACS heat exchanger shell-side outlet temperature from the PROTO-FLO™ run. The required UHS temperature was determined for SSWS flow of 5,000 gpm, 7,500 gpm, 10,000 gpm, 12,500 gpm, and 15,000 gpm on the tube side of the heat exchanger for each case. The resulting UHS temperature versus SSWS flow rate data was then plotted and curve fit. The coefficients for the curve-fits were then incorporated into the EXCEL spreadsheet along with SSWS system flowrates to determine the limiting UHS temperature for each scenario. This process was performed for each failure alignment (discussed in Section 5.3.1) during the three accident modes at SACS temperatures of either 95°F or 100°F.

Six different case alignments were then created in the default database (STACS99.DBD) to represent the three accident conditions, under both crosstied and non-crosstied configurations, at SACS temperatures of 95°F and 100°F. These case alignments were used to evaluate the UHS temperature limit for the following conditions: LOCA/LIA, LOP-EOB, LOP-CTB, LOP/SSE, and Normal (where LIA is a Loss of Instrument Air, CTB is the Cooling Tower Basin, EOB is the Emergency Over Board valve and SSE is a Safe Shutdown Earthquake). An uncertainty analysis was performed, and the calculated value was used to determine the final UHS temperature.

APPROACH

Step 1: Determine the failure modes

Step 2: Run the SACS thermal/hydraulic model using a SSWS flowrate of 10,000 gpm.

Step 3: Iterate the tube-side temperature of the SACS heat exchanger until the desired SACS temperature is achieved at the inlet to RHR Heat exchangers.

Step 4: Repeat for each failure mode.

Step 5: Using PROTO-HX, determine the corresponding SSWS (UHS) temperature based on SSWS flowrates of 5000 - 15000 gpm (2500 gpm increments) using SACS flowrate, heat load, and heat exchanger shell-side temperature results from PROTO-FLO in steps 2-4

Step 6: Tabulate, plot and curve-fit the UHS temperature vs SSWS flow using the results of step 5

Step 7: Determine the required UHS temperature for various SSWS flowrates (through SACS heat exchangers)

Step 8: Perform a curve fit verification

Step 9: Operability determination

Step 10: Input the curve-fit coefficients from step 6 and flowrates from Reference 4.1.5 into the UHS spreadsheet analysis to determine the required UHS temperature for various SSWS flowrates (through SACS heat exchangers)

Step 11: Calculate uncertainty for the limiting UHS temperature limits

Step 12: Select the limiting UHS temperature limits

5.1.2 Methodology Using Limiting Alignment / Accident Conditions

The methodology from previous revisions has changed. Revision 2 to this calculation went through a thorough process of identifying all case alignments (i.e., single failures and AOT's) for each accident scenario (i.e., LOCA, LOP, LOP/SSE). The resulting limiting alignments are used for future UHS analyses to determine the UHS temperatures required for accident mitigation. In addition, any alignment / accident condition that is used to justify operator action will be included in future analyses.

For historical and justification purposes, the process of finding the limiting alignment / accident conditions will not be deleted from future revisions, but are identified as "Revision 2" in all appropriate sections of this calculation.

APPROACH

Step 1: Determine the limiting failure modes.

Step 2: Run the SACS thermal/hydraulic model using SSWS flowrates identified in Attachment (5) (rows are highlighted in bold borders).

Step 3: Iterate the tube side temperature of the SACS heat exchanger until the desired SACS temperature is achieved at the inlet to the RHR Heat exchangers.

Step 4: Repeat for each failure mode.

Step 5: Calculate uncertainty for the limiting UHS temperature limits.

Step 6: Select the limiting UHS temperature.

5.2 Failure Modes

5.2.1 Revision 2 Determination of Failure Modes

Scenarios

This calculation investigates accident conditions and normal operation. The three accident conditions considered for this analysis are a LOCA, a LOP/SSE, and a LOP. Heat loads (obtained from Reference 4.1.1) and system configurations vary between failure modes, and are discussed in greater detail below.

LOCA

Following a LOCA, the station instrument air system fails, resulting in a Loss of Instrument Air (LIA). In SACS, the instrument air system provides the motive force for the Air Operated Valves (AOV's) that isolate the redundant pump room coolers and the pressure control valves associated with the control room and the 1E panel room chiller units. As a result of the LIA, the AOV's that isolate the redundant room coolers all fail wide open. With all the isolation valves failing open, SACS flow is provided to all components with the exception of the Post Accident Sampling System (PASS) coolers. For this analysis, the PASS coolers are assumed to be aligned to the SACS loop being analyzed since this will produce the highest heat load on SACS. Note that the heat loads and valve alignments are slightly different for the LOCA short-term (t < 10 minutes) due to system configuration and Operator action response times.

- For the RHR heat exchanger, the required heat load (in Revision 3) following a LOCA is 121.7 and 123.8 MBtu/hr with 10,000 gpm of RHR flow at 212°F and a SACS temperature of 95°F and 100°F, respectively (see Section 3.2.10 for a discussion of post-EPU RHR heat loads).
- For the RHR pump seal coolers, the post LOCA heat load of 0.09 MBtu/hr was used.
- Each SACS loop is assumed to have three FRVS cooling coils operating in the non cross-tied configuration.
- For the cross-tied configuration, four FRVS cooling coils operate.
- The full-required heat load was applied to the operating room coolers for the non cross-tied failure alignments; no heat load was applied to the redundant coolers.
- The full-required heat load was applied to the operating room cooler in the cross-tied failure alignments, with the exception of the EDG room coolers (equal heat load to the operating and redundant EDG room coolers).
- Half the design heat load was applied to each of the PASS coolers.

LOCA Short-term

During a Quality Assurance In-Service Test (IST) Audit no. 97-012, it was identified that during normal operations, the RHR system is aligned for Low Pressure Coolant Injection (LPCI) with both the RHR heat exchanger and bypass valves open (AR#970815134). Previous analyses state that there is no RHR heat load during the short-term. However, following a large break LOCA scenario, a portion of the RHR flow would be directed from the suppression pool through the RHR heat exchanger to the reactor vessel. The flow to the vessel by one RHR pump would be split through the RHR heat exchanger and the bypass line. The RHR hydraulic analysis (Reference 4.1.12) shows that RHR flow is 1945 gpm through the "A" RHR heat exchanger and 2340 gpm for the "B" heat exchanger during LPCI injection using a degraded pump (Reference 4.1.12, Attachments E and F respectively). To maximize flow (and maximize the heat load transferred to SACS), a sensitivity case was performed using the design pump curve. The results show that flow through the "B" RHR heat exchanger is 2479 gpm (see Attachment 10). This flow has been increased to 2504 gpm to account for 1% model error in accordance with Reference 4.1.12. An RHR flow of 2504 gpm will conservatively be used for both RHR heat exchangers, since the higher flow yields a higher heat input into SACS.

As stated in Assumption 3.4.6, the RHR heat exchanger bypass valve can be closed through operator action after three minutes. The assumed RHR temperature of 170°F is based on the heat-up of the suppression pool after a period of ten minutes prior to establishing shutdown cooling. If the bypass valve is closed prior to ten minutes and shutdown-cooling mode is initiated, the resulting SACS temperature is bounded by the pre-analyzed long-term LOCA, since the long-term LOCA case assumes a higher suppression pool temperature (212°F vs. 170°F). Therefore, for the purpose of this analysis the bypass valve is assumed to remain open for the duration of the short-term LOCA.

In the long-term accident analyses, all failure alignments assume RHR flow to the RHR heat exchangers. The RHR heat exchanger SACS outlet valves are assumed to be in the full-open position for all cases, with the exception of the "one SACS pump per loop" configuration. For this alignment, the valve is assumed "closed" to isolate flow to one of the RHR heat exchangers (see Section 3.4.3). For all alignments (with the exception of the "one SACS pump per loop" configuration), the long-term analyses bound the LOCA short-term since the RHR flow rate and heat load of the long-term LOCA (10000 gpm at 212°F or as high as 212.3°F post EPU) exceed the flow rate and heat load of the short-term LOCA (2504 gpm at 170°F).

To verify that the SACS temperature limits are not exceeded during the short-term LOCA, a model run using the LOCA short-term RHR flow rate and heat load in the "one SACS pump per loop" configuration was performed. The UHS temperature is conservatively assumed at its bounding limit of 89°F. Upon receiving the LOCA signal, the assumptions stated in Sections 3.2.7 and 5.2.1 for a LOCA apply with the exception of (or in addition to) the following:

- The RHR flow through the RHR heat exchangers is 2504 gpm at 170°F
- The SACS flow through the aligned RHR heat exchanger is 7524 gpm, determined by the system configuration in the model run (see Attachment 11). The SACS flow through the isolated RHR heat exchanger is 3000 gpm per Section 3.4.3.
- All RHR pumps auto-start (unless tagged out-of-service)
- All SACS pumps auto start (unless tagged out-of-service)
- TACS is auto-isolated
- The SFP and PCIG cross-connect valves auto-close
- All six FRVS fans auto-start

For the purpose of this model run (Case 25), it is assumed that one SACS pump is tagged out-of-service on the standby loop, and one pump on the opposite loop supplying TACS is lost. Both SACS heat exchangers in each loop are available and in service.

The results of Case 25 show that SACS reaches a temperature of 93.1°F in the "A" Loop, and 92.9°F in the "B" Loop. For this system configuration, the RHR heat exchanger transfers a heat load of 48.965 Mbtu/hr to SACS in the "A" Loop, and 39.822 Mbtu/hr to SACS in the "B" Loop. For all configurations, the LOCA short-term analysis is bounded by the LOCA long-term analysis. See Attachment (11) for additional details.

LOP/SSE

- Following a LOP/SSE, the instrument air system also fails, resulting in nearly the same SACS operational alignment as following a LOCA. However, for this scenario, the PASS coolers are not placed on line.
- The RHR heat exchanger inlet temperature is 212°F at 10,000 gpm when removing the required heat from the Suppression Pool (or as high as 213.6°F post EPU). This assumes that the RHR conditions will be modified so that the required heat load is removed while maintaining the SACS header temperature at or below its design temperature. The SACS operating procedure directs the operator to throttle SACS flow.
- The FRVS cooling coils and the Core Spray pump room coolers have no heat load but still receive flow due to the failure of the instrument air system.
- The RHR pump seal cooler heat load is 0.35 MBtu/hr when the cooler is aligned to the RHR heat exchanger. All other RHR pump seal coolers have a 0.09 Mbtu/hr heat load applied.
- The full-required heat load was applied to the operating room coolers for the non cross-tied failure alignments; no heat load was applied to the redundant coolers.
- The full-required heat load was applied to the operating room cooler in the cross-tied failure alignments, with the exception of the EDG room coolers (equal heat load to the operating and redundant EDG room coolers).

LOP

The post LOP SACS operating configuration is the same as the post LOP/SSE SACS operating configuration, except for the following.

- Following a LOP only, it is assumed that the instrument air system does not fail.
- The FRVS cooling coils and the core spray pump room coolers (which are not required following a LOP) do not receive flow.
- The PASS coolers are isolated.

Normal

Under normal operating conditions, all systems and components are assumed to be operating as designed. Heat loads include the Turbine Auxiliaries Cooling System (TACS) and are taken from Reference 4.1.1.

5.2.1.1 Failure Modes and Consequences

The failure modes considered encompass the plausible combinations of single failures and/or AOT conditions, and the consequences of the assumed failures and alignments. Table 5.2.1 lists the active failures that directly impact UHS temperatures and the consequences of each. The following is an example of a failure mode and its effect on other components from Reference 4.1.9.

Design Basis: SACS Heat Exchanger SSWS outlet valve: 1EAHV-2371A(B). Opens to allow SSWS flow through the SACS heat exchanger.

Controls: The valve is normally open when its associated SSWS pump is operating. The valve can be manually operated using 1EAHS-2371A,B. 1EAHV-2371B can be operated from the RSP. When the valve is in auto, it is signaled to open when its associated SSWS pump starts. The valve is signaled to close when its associated SSWS pump is not running (i.e., failure or out-of-service). 1EAHV-2371A and 1EAHV-2371B are powered by the class 1E channel A and B buses respectively.

For this failure mode, when a SSWS pump fails, the valve gets a signal to automatically close (unless a previously running pump fails due to a loss of an EDG following a LOP, then it is assumed the valve remains open).

Table 5.2.1 - Failure Modes and Consequences

System	Failure Mode	Consequences
SSWS	EOB valve fails shut	Reduction of SSWS flow (with SSE (Note 1)) (loss of 1/2 discharge path)
SSWS	SSWS pump failure	Reduced SSWS flow to both SACS heat exchangers in that loop (For AOT cases or cases where the pump fails to start, the associated SACS heat exchanger discharge isolation valve also fails to open)
SSWS	SACS heat exchanger valve fails to open	Loss of all SSWS flow to one SACS heat exchanger
SACS	SACS pump failure	Reduced SACS flow
SACS	SACS heat exchanger valve fails to open	Loss of all SACS flow to one SACS heat exchanger
EDG	"A" or "B" EDG failure	Loss of "A" or "B" SSWS and SACS pumps; Loss of power to EOB valve; Loss of power to "A1" or "B1" SACS heat exchanger valves (both sides); Loss of RHR pumps; Loss of ECCS heat loads (flow is still provided due to the LIA); etc.
EDG	"C" or "D" EDG failure	Loss of "C" or "D" SSWS and SACS pumps; Loss of power to "A2" or "B2" SACS heat exchanger valves (both sides); Loss of ECCS heat loads (flow is still provided due to the LIA); etc.
All	LIA	AOVs reposition to fail position (Note 2)

Notes: 1. SSE = Safe Shutdown Earthquake which bounds the Operating Basis Earthquake (OBE).
2. All SACS AOVs fail open except the SACS heat exchanger bypass valves (that fail shut), and the chiller water valves (that continue to control due to the back-up air supply).

5.2.1.2 AOT Case

The design basis cases were developed accounting for single failure conditions as well as consequences of these failures. The AOT cases are four (4) additional conditions; complete loss of one SACS loop, complete loss of one SSWS loop, one SACS pump in each loop, and one SSWS pump in each. These four special cases are addressed specifically in the Technical Specifications.

Loop Out of Service

When a loop of SSWS or SACS becomes unavailable, the operators cross-tie at least one EDG to the remaining operable loop. This EDG is typically the "C" or "D" EDG depending if the A or B loop is unavailable since the "C" or "D" EDG will power the required fourth FRVS unit which is cross-tied. The "A" and "B" EDG's power the EOB valves; so two additional cases are listed to simulate only one EOB available under these conditions. This temperature is the limit at which the EOB powered from the EDG that was not cross-tied in a loop outage must be opened.

One Pump Per Loop

Each case (one SACS pump/loop and one SSWS pump/loop) considers progressive operator action to determine the optimum condition for the least limiting UHS temperature limit.

5.2.1.3 Unique SACS Failure Conditions

A set of cases for each scenario, namely LOCA/LIA, LOP, and LOP/SSE, were developed. The different case scenarios were necessary because the heat loads differed for each scenario. The failure mode matrix was set up with a row representing one case. A separate column was included for each component potentially affected. For example, SSWS pump failures receive a separate column for each of the four pumps. The cases were developed by applying one of each type of failure for each combination of component and loop. Failures were marked in the appropriate column with an "X". Consequences of the specified failures were marked with a "C", and operator actions were marked with a "P". The specific AOT conditions considered were developed by marking the AOT failures with an "A". Table 5.2.3 shows an example of an abridged EXCEL UHS spreadsheet. The complete spreadsheets can be found in Attachment (5).

Table 5.2.3 – UHS temperature spreadsheet (abridged) – 100°F LOP/SSE

A LOOP	B LOOP	AOT	A SWPUMP	C SWPUMP	B SWPUMP	A1 SWHX	A2 SWHX	A EOB	B EOB	C SACS PUMP	B SACS PUMP	A2 SACS HX	C EDG	A+B LOOP	A1 SSWS FLOW	A2 SSWS FLOW	B1 SSWS FLOW	B2 SSWS FLOW	A LOOP UHS	B LOOP UHS	SSWS CONFIG
SSWS Pump Failures																					
122.2	222.2	30d		X			C								10797	0.0	10538	10625	67.48	92.95	18x2_c.plu
EDG Failures																					
112.1	222.2	14 d		C			C			C			X		10797	0.0	10538	10625	66.60	92.95	18x2_c.plu
212.1	222.2	14 d		C						C			X		9026	8990	8966	9031	93.49	91.22	14x2_c.plu
111.1	222.2	14 d		C			C			C		C	X		10797	0.0	10538	10625	84.07	92.95	18x2_c.plu
211.1	222.2	14 d		C						C		C	X		9026	8990	8966	9031	79.97	91.22	14x2_c.plu
AOT - SSWS Loop Failures																					
22.2	222.4	72 h	A	A		C	C								0	0	10514	10599	0.00	91.43	55x2_c.plu
22.2	222.4	72 h				A	A								0	0	13221	13343	0.00	93.66	11x2_c.plu
22.2	222.4	72 h	A	A		C	C								0	0	9353	9427	0.00	89.97	55x1b_c.plu

5.2.1.4 Worse-Case Representation

Cases representing similar SACS failure modes, such as an "A", "B", "C", or "D" SACS pump, were consolidated into one failure case since the UHS temperature curves assume the failure of given components are equivalent. The others were eliminated from this analysis since they are bounded by the worst-case pump failure (A, B, C, or D).

Considering the "A" and "B" SACS loops to be interchangeable, based on the assigned index number the cases distilled into 11 unique SACS failure conditions as indicated in Table 5.2.4. The specific "A" loop component lineups used for this evaluation are also provided next to each index number.

Table 5.2.4: Unique SACS Failure Conditions

Index Number	Active SACS HXs (SSWS Side)	Operating SACS Pumps	Active SACS HXs (SACS Side)	EDGs Receiving SACS Flow (See Note)	Operating EDGs (Generating Heat Load)
X11.1	A1	A	A1	A, (C)	A
X11.2	A1	A	A1	A, C	A, C
112.1	A1	A	A1, A2	A, (C)	A
112.2	A1	A	A1, A2	A, C	A, C
X21.2	A1	A, C	A1	A, C	A, C
122.2	A1	A, C	A1, A2	A, C	A, C
212.1	A1, A2	A	A1, A2	A, (C)	A
212.2	A1, A2	A	A1, A2	A, C	A, C
222.2	A1, A2	A, C	A1, A2	A, C	A, C
222.3	A1, A2	A, C	A1, A2	A, C, B	A, C, B
222.4	A1, A2	A, C	A1, A2	A, C, B, D	A, C, B, D

Note: EDGs shown in parentheses receive flow only with concurrent LIA.

5.2.1.5 Failure Alignments

Eleven different failure alignments were evaluated for each of the three accident scenarios. The failure scenarios are tabulated below in Table 5.2.5 and designated by the following code:

ABC.D

Where:
- A is the number of SACS heat exchangers receiving SSWS flow
- B is the number of SACS pumps operating
- C is the number of SACS heat exchangers receiving SACS flow
- D is the number of EDG's being cooled by SACS

The limiting failure alignment(s) for each failure mode is presented below.

EOB Failure – one EOB valve fails, resulting in less SSWS flow. The limiting alignment is the 222.2

SSWS failure – one SSWS pump fails, resulting in a SSWS heat exchanger valve closing. The limiting alignment is the 122.2.

SSWS heat exchanger failure – one SSWS heat exchanger valve fails closed. The limiting alignment is the 122.2.

EDG failure – one EDG fails to start, resulting in the possible loss of one or more of the following: SSWS pump, SSWS heat exchanger, SACS pump, and SACS heat exchanger. The possible limiting alignments are: 112.1, 212.1, 111.1, 211.1.

SACS pump failure – one SACS pump fails to start, resulting in reduced SACS flow. The limiting alignment is the 212.2.

SACS heat exchanger failure – one SACS heat exchanger valve fails to open, resulting in less heat removal capability. The limiting alignment is the 221.2.

Table 5.2.5 - Failure Alignments

222.2	X21.2	212.2	212.1	X11.2	X11.1
122.2	112.2	112.1	222.3	222.4	

An alignment with only one SACS heat exchanger on line will create the same SACS conditions regardless of whether the isolated SACS heat exchanger receives SSWS flow. Therefore, it is concluded that a 2X1.X and a 1X1.X failure alignment produce the same SACS conditions. The X21.2, X11.2, and the X11.1 alignments correspond to the alignments with both one and two SACS heat exchangers receiving SSWS flow. For example, the 221.2 and the 121.2 failure alignments are both represented by the X21.2 failure alignment.

The 222.3 and 222.4 alignments are alignments where one SACS loop has become inoperable and one or two EDG's have been cross-tied to the opposite SACS loop. These alignments are referred to as the cross-tied alignments. The cross tying of the EDG's is assumed to have been performed in accordance with Reference 4.3.1. When the EDG's are cross tied, the "D" FRVS cooling coil, the HPCI or RCIC room coolers, the RHR pump coolers, and the RHR pump room coolers are also cross tied to the operable SACS loop. In addition, the redundant room coolers are manually isolated when the EDG's are cross-tied. For the 222.3 alignment with only one EDG crosstied in the LOP scenario, the RHR pump powered by the non-cross tied EDG will not start. Since the instrument air system is not assumed to fail under the LOP scenario, the RHR pump seal and bearing coolers and the RHR pump room coolers associated with the non operating RHR pump will not come on line. The HCGS Technical Specification allows for operation with one SACS pump operating in each SACS loop. While evaluating this alignment, Reference 4.1.2 determined that the Control Room chiller, 1-A(B)K-400, must be isolated in one SACS loop to provide adequate cooling to the RHR heat exchanger. In addition, the RHR heat exchanger must remain isolated in one SACS loop to provide adequate cooling to the 1E and Control Room chillers. This alignment was evaluated for the single pump alignments that do not result from an EDG failure (alignments 212.2, X11.2 and 112.2). For the analysis of these alignments, both SACS loops are operating with the following configuration: One loop has the RHR heat exchanger aligned and the control room chiller isolated, the other loop has the RHR heat exchanger isolated and the control room chiller aligned. See Section 3.3.7 for more details.

5.2.2 Limiting Failure Modes for Current / Future UHS Analyses

5.2.2.1 Limiting with Compensatory Actions

The limiting alignment / accident conditions were identified from Attachment (5). The limiting accident conditions for the SACS system are as follows:

- LOCA/SSE
- LOP/SSE

The limiting case alignments (i.e., single failures and AOT's) are as follows:

- Failure of an EDG
- Failure of an EOB Valve (SSWS Failure)
- Failure of an EDG concurrent with a Failure of an EOB valve
- One SACS Pump per SACS Loop
- One SSWS Pump per SSWS Loop

Each case alignment is run for each accident condition to determine the UHS temperature. Note as discussed in Section 3.3.8, the LOP/SSE case is run in two parts; with SSW supplying the non-Q RACS HX for one hour, and with RACS isolated thereafter.

In addition to the above, cases involving a short-duration excursion UHS temperature of 95°F are evaluated. Engineering evaluation H-1-EA-MEE-1926 (Reference 4.1.14) has concluded that a reasonable degree of equipment degradation can still be assumed while demonstrating that affected safety-related components could continuously perform their design functions at UHS cooling water temperatures up to 95°F. Consistent with Technical Specification Task Force, TSTF-330, the UHS is not relied upon for immediate heat removal (such as to prevent containment overpressuriziation), but is relied upon for longer-term cooling such that a temperature averaging approach continues to satisfy the accident analysis assumptions for heat removal over time. Although based on historical data UHS temperatures as high as 95°F are expected to never occur, a conservative evaluation of a LOCA/LOP occurring at this temperature is provided. See Section 5.10.3 for additional discussion of the methodology used and results of the short-term UHS temperature evaluation.

5.2.2.2 Limiting without Compensatory Actions

Cases performed in Revision 2 determined that compensatory actions are required in the AOT case of one SSW pump per SSW loop. Refer to Section 5.8.1 for a discussion of compensatory actions assumed in the 1 SSWS Pump per loop failure mode.

5.2.2.3 Special Maintenance Alignments

When an EDG room cooler is taken out of service for maintenance, the remaining room cooler still must maintain its respective EDG room temperature within acceptable temperature limits. Reference 4.1.2 (Section 6.4.13) determined the required SACS temperature needed for a single room cooler to maintain design temperatures for two limiting alignments.

- Single Failure of an EDG
- AOT Configuration of One SACS Loop Operable / One SACS Loop Inoperable (i.e., Crosstied)

CALC. NO.: EG-0047		REFERENCE: N/A			
ORIGINATOR,DATE	REV: RED 3/12/2002	2	JBM 11/30/2005	3	PJL 3/28/2006	4
REVIEWER/VERIFIER,DATE	KCK 3/20/2002		RED 12/06/2005		TDG 3/28/2006

From Attachment (5), the LOP/SSE accident condition is limiting for these two alignments. Note that if one SACS pump and one SSWS pump are operating on the same SACS loop, Reference 4.3.6 has operators close the SACS heat exchanger's inlet SACS valve and outlet SW valve associated with the idle / failed SACS pump.

5.3 Case Alignments Baseline Database

5.3.1 Revision 2 Database

The default PROTO-FLO™ database, "STACS99.DBD" from Reference 4.1.3 was used to create the six baseline databases, representing the three different failure scenarios for both 95°F and 100°F SACS temperatures. The six case alignments of the default database are documented as electronic Attachments on CD-ROM, and are identified as follows: "LOCA-95", "LOP-95", "LOP/SE-95", "LOCA-100", "LOP-100", and "LOP/SSE-100".

5.3.2 Database for Current / Future UHS Analyses

The database from the most current version of Reference 4.1.2 (STACS06.DBD) was used to create two databases, "UHS-LOCA.PDB" and "UHS-LOPSSE.PDB", that represent the limiting failure alignments. A third database, "UHSNORM.PDB" was created to evaluate normal operation.

5.4 SACS Heat Exchanger Tube-side Temperature

Using the PROTO-FLO™ thermal hydraulic model of SACS, the temperature at the tube side (SSWS side) of the SACS heat exchangers was iterated until the desired temperature was achieved at the SACS inlet to the RHR heat exchanger. This process was performed with 10,000 gpm on the SSWS side of the SACS heat exchangers for Revision 2. For current / future analyses, the process was performed using the flows identified in Attachment (5) for the limiting alignments with the exceptions listed below:

- For the LOP/SSE scenarios in which RACS loads are supplied for the first hour, SSW flows are taken from Attachment 5 for a LOP/SSE. RHR heat load during this event is determined by PROTO-FLO by inputting the post-LOP predicted suppression pool temperature one hour into the event of 186°F based on a conservative post-EPU suppression pool temperature response evaluated at a rated thermal power level of 3952 MWt (Reference 4.4.3, Section B.2).

- For the LOP/SSE scenario where RACS loads are isolated (after one hour), SSW flows are taken from Attachment 5 for the corresponding LOCA/SSE case. SSW supplied flows during a LOP/SSE after RACS isolation are identical to those supplied during a LOCA/SSE.

PSEG	CALCULATION CONTINUATION SHEET					SHEET: 24 of 36 CONT'D ON SHEET:	
CALC. NO.: EG-0047				REFERENCE: N/A			
ORIGINATOR, DATE	REV:	RED 3/12/2002	2	JBM 11/30/2005	3	PJL 3/28/2006	4
REVIEWER/VERIFIER, DATE		KCK 3/20/2002		RED 12/06/2005		TDG 3/28/2006	

5.5 Generate Output Files

Using the baseline databases from above, PROTO-FLO™ models runs were performed for all failure alignments for the limiting accident conditions (LOCA/SSE and LOP/SSE) assuming a SACS temperature of 95°F or 100°F. A set of eight PROTO-FLO™ output reports (Calculation Summary, Flow Summary, Node Summary, Boundary Conditions, Pump Status, Control Valve Line-up, Manual Valve Line-up, and Heat Exchanger Data) for each model run were generated, and are included in Attachment (1) as an electronic file on CD. The files are named accordingly:

Loss of Coolant Accidents (LOCA/SSE/LIA):

NLOCA##: No failures during LOCA
1LOCA##: Failure of an EDG during LOCA
2LOCA##: Failure of an EOB Valve (SSWS Failure) during LOCA
3LOCA##: Failure of an EDG concurrent with a Failure of an EOB valve during LOCA
4LOCA##: One SACS Pump per SACS Loop during LOCA
5LOCA##: One SSWS Pump per SSWS Loop during LOCA
6LOCA##: One Operable SACS Loop with EDG room cooler maintenance during LOCA

Loss of Offsite Power (LOP/SSE) – Short Term 0-60 Minutes:

1LOPST##: Failure of an EDG during LOP/SSE
1aLOP##: Failure of an EDG with EDG room cooler maintenance during LOP/SSE
2LOPST##: Failure of an EOB Valve (SSWS Failure) during LOP/SSE
3LOPST##: Failure of an EDG concurrent with a Failure of an EOB valve during LOP/SSE
4LOPST##: One SACS Pump per SACS Loop during LOP/SSE
5LOPST##: One SSWS Pump per SSWS Loop during LOP/SSE
6LOPST##: One Operable SACS Loop with EDG room cooler maintenance during LOP/SSE

Loss of Offsite Power (LOP/SSE) – Long Term >60 Minutes:

1LOP##: Failure of an EDG during LOP/SSE
1bLOP##: Failure of an EDG with EDG room cooler maintenance during LOP/SSE
2LOP##: Failure of an EOB Valve (SSWS Failure) during LOP/SSE
3LOP##: Failure of an EDG concurrent with a Failure of an EOB valve during LOP/SSE
4LOP##: One SACS Pump per SACS Loop during LOP/SSE
4aLOP##: One SACS Pump per SACS Loop during LOP/SSE (PRA Analysis A1&2 – B1&1)
4bLOP##: One SACS Pump per SACS Loop during LOP/SSE (PRA Analysis A1&1 – B1&1)
5LOP##: One SSWS Pump per SSWS Loop during LOP/SSE
6LOP##: One Operable SACS Loop with EDG room cooler maintenance during LOP/SSE

Normal##: Normal Operation for Two Loops

In addition to the above, other alignments are included in Attachment 1 as discussed in Section 5.10.3.

95LOCA##: Failure of an EDG during a LOCA to the CTB at Elevated UHS Temperature
95#LOP##: Failure of an EDG during a LOP to the CTB at Elevated UHS Temperature

Note: The 95#LOP## case is actually four cases where the third digit represents the first four hours after the onset of the event (e.g., 951LOP##, 952LOP##, etc.). See Section 5.10.3 for a discussion.

5.6 Approximate SSWS Temperatures For Varying Flows (Revision 2 Only)

The PROTO-HX™ model of the SACS heat exchangers was used to determine the corresponding SSWS temperature at various flowrates. The SACS flowrate, heat load, and heat exchanger shell-side temperatures (taken from the heat exchanger data report for each run) were tabulated and the average values calculated. Based on these average values, the SACS heat exchanger model was analyzed for SSWS flows at 5000 gpm, 7500 gpm, 10000 gpm, 12500 gpm, and 15000 gpm.

5.7 Plot and Curve-fit the UHS Temperature vs SSWS (Revision 2 Only)

The resulting UHS temperature versus SSWS flow rate data from Section 5.6 was tabulated, plotted, and curve fit using the computer program TableCurve™. The UHS temperature and SSWS flow rate data were curve fit using the following expression.

$$T = a + \frac{b}{Q^{1.5}} + \frac{c}{Q^2}$$

Where: T is the maximum UHS temperature (°F)
Q is the SSWS flow rate (gpm)
a, b, and c are curve fit coefficients

The curve-fits coefficients were incorporated into the UHS EXCEL spreadsheet along with SSWS system flowrates (from Reference 4.1.5) to determine the limiting UHS temperature for each scenario. This process was performed for each failure alignment during the three accident modes at SACS temperatures for either 95°F or 100°F. The spreadsheets can be found in Attachment (5).

5.8 Limiting Conditions

5.8.1 Revision 2 Limiting Conditions

Attachment (5) contains the UHS analysis spreadsheets for LOCA/LIA, LOP/SSE, and LOP scenarios, respectively with the reduced scope alignments updated accordingly. The maximum UHS temperature limit between the "A" and "B" loops is the overall limit for the case represented by a row in the spreadsheet. If one of the loops is completely inoperable, a zero is shown as the temperature limit. The use of the maximum UHS temperature limit reflects the fact that only one loop must remove the RHR heat load to meet the design basis of the system because the loops are redundant. The loop with the lower UHS temperature limit will be rendered inoperable at the UHS temperature limit for the other loop due to excessive SACS supply header temperature if the operators continue to remove the design RHR heat loads on both loops. If the RHR heat exchanger were isolated on the degraded loop, the loop would remain operable; however, for conservatism it is assumed to fail. Only at UHS temperatures less than both loop limits will it be possible to remove the design RHR heat load with both loops.

Under the "1 SSWS Pump per Loop" failure mode, operator action is credited in accordance with Reference 4.3.2. The SACS heat exchanger SSWS isolation valves corresponding to the out-of-service SSWS pumps are shut as an automatic consequence when a SSWS pump is secured. Un-isolating 2 SSWS heat exchangers meets the intent of the stated procedure that actually applies if 4 SSWS pumps are available. In the analysis spreadsheet, Attachment (5), 1 and 2 SSWS heat exchangers were un-isolated to determine the impact.

5.8.2 Limiting Conditions for Current / Future UHS Analyses

The same method was used for determining the limiting UHS temperature for the LOCA/SSE and LOP/SSE.

5.9 Operability Determination (Revision 2 Only)

Reference 4.1.2 demonstrated that SACS is operable under all possible failure conditions, with respect to individual cooler flowrate. Because of this, the flow rates through the SACS components were not evaluated for this analysis. However, for the LOCA scenario, the heat removal across the RHR heat exchanger was compared to the required heat removal contained in Reference 4.1.1 to determine whether a lower SACS header temperature limit was required for that particular failure alignment. All the single SACS pump failure alignments did not remove the required heat load from the RHR system (121.7 Mbtu/hr for SACS at 95°F and 123.8 MBtu/hr for SACS at 100°F), but the SACS loop opposite a SACS pump failure alignment will be a fully operable SACS loop and will be capable of removing the required heat load.

For the "One SACS pump per loop" alignments, the SACS temperature is limited to 95°F, and only one RHR heat exchanger is aligned. The model run shows that in the limiting alignment (LOCA) with the RHR and Control Room Chiller on opposite loops (see the last paragraph of Section 5.2.1.5 for details), that SACS was able to remove 124.0 Mbtu/hr from the RHR system. This exceeds the requirement of 121.7 Mbtu/hr as listed above for SACS at 95°F.

5.10 Required UHS Temperature

5.10.1 Temperature Limits for Design Basis (Single Failure) Conditions

Table 5.10.1 provides the UHS temperature limits for the limiting failure modes considered, for the LOCA/SSE/LIA and LOP/SSE. The values are taken from the "Heat Exchanger Data" reports included in Attachment (1) (electronic files on CD). **Caution: The values do not take into consideration the uncertainty analysis (discussed in Section 5.11).**

The following methodology was used in analyzing the Attachment (5) spreadsheets:

a) No failures - the limiting loop temperature was used.

b) Failures – the degraded loop (A or B) was discarded because RHR would not be applied to the degraded loop, and the temperature was bounded by a SACS loop failure. Then the lowest temperature for each failure mode of the remaining loop was used as the limiting UHS temperature.

Table 5.10.1 summarizes the best achievable conditions for each failure mode considering the compensatory action required by current procedures.

Table 5.10.1: Design Basis Conditions
100°F SACS
Best Achievable UHS Temperature Limit (without uncertainty)

Failure Mode	LOCA/SSE/LIA UHS Temp. Limit (°F)	LOP/SSE UHS Temp. Limit 0 – 60 min (°F)	LOP/SSE UHS Temp. Limit > 60 min (°F)
None	93.30 ✓	93.95 ✓	93.35 ✓
EOB	90.60 ✓	91.50	90.65
EDG	93.30 ✓	92.90 ✓	93.35 ✓
EDG w/EOB failure	91.70	90.50	91.70

The overall UHS temperature limit for the Design Basis conditions is 90.5°F (without uncertainty) due to a failure of the EOB valve to open. The EOB valves and their breakers are procedurally opened at a temperature of 85°F, therefore, this failure mode would no longer be considered credible. After the removal of this failure mode, the UHS temperature limit without uncertainty is 92.9°F for a normal alignment assuming a limiting single active failure.

With an EDG room cooler out for maintenance, the UHS temperature limit, considering a single failure, is 81.9°F without uncertainty. This corresponds to a SACS temperature of 94°F (Reference 4.1.2, Section 6.4.13). This assumes two RHR heat exchangers in service at a suppression pool temperature of 183°F (see Section 3.2.2) at a rated thermal power level of 3359 MWt. Although the post-EPU DBA-LOCA Case A (two RHR heat exchanger) case was not included or required as part of Reference 4.4.3, it can be shown that the above limit is conservative post-EPU. For the short-term (0-60 min) LOP/SSE, Reference 4.4.3, Appendix B.2, supports that with a single RHR heat exchanger in operation, suppression pool temperatures peak at approximately 186°F at the end of one hour assumed at 3952 MWt. It is conservatively assumed that with two RHR heat exchangers in operation during this period, the suppression pool temperature reaches 183°F, although it would be considerably lower. Case 1aLOP is provided in Attachment 1 documenting the resulting 81.9°F limit without uncertainty. Consistent with the methodology discussed in Section 3.3.8, RACS is isolated on a LOP/SSE within one hour. Peak post-EPU LOP temperatures change from 212°F (Reference 4.4.1) to 213.6°F (Reference 4.4.3). Absent actual data, this calculation conservatively assumes a post-EPU two RHR heat exchanger temperature peak five times larger than the 1 RHR HX increase amount (1.6°F x 5) when evaluating the long-term LOP case. Case 1bLOP (Attachment 1) demonstrates that an UHS temperature of 81.9°F supports a two RHR heat exchanger in service configuration with a conservative peak pool temperature of 192°F, therefore, the short-term evaluation is considered limiting.

5.10.2 Temperature Limits for AOT Conditions:

Table 5.10.2 provides the UHS temperature limits for the multiple failure modes considered for the LOCA/SSE and LOP/SSE scenarios.

In both the LOCA/SSE and LOP/SSE scenarios, the one (1) SSWS pump per loop condition is limiting with and without operator action. Operator action is essential for the one (1) SSWS pump, one (1) SACS heat exchanger (two (2) SACS heat exchangers total) per loop case.

The limiting AOT condition for a SACS temperature of 100°F is the "1 and 1" SSWS pump AOT following a LOCA/SSE with a required UHS temperature of 89.9°F, without uncertainty. However, the heat loads being removed in this configuration are based on both RHR heat exchangers receiving 10,000 gpm of 212.3°F flow from the suppression pool. From Section 3.2.2 the actual suppression pool temperature with both RHR heat exchangers is 185°F or slightly higher post-EPU.

Using the same methodology and logic as Section 5.10.1, the "best achievable" UHS temperature limit for AOT conditions has been summarized in Table 5.10.2 below. Note that the temperatures listed below for the "one SSWS pump per loop" are the best achievable values taken from the UHS temperature spreadsheets, but are not limiting per the discussion in the previous paragraph.

Table 5.10.2: AOT Conditions
100°F SACS (95°F for 1 SACS pump/loop)
Best Achievable UHS Temperature Limit (without uncertainty)

Failure Mode	LOCA/SSE/LIA UHS Temp. Limit (°F)	LOP/SSE UHS Temp. Limit 0 – 60 min (°F)	LOP/SSE UHS Temp. Limit > 60 min (°F)
1 SSWS Pump Per Loop (Note 1)	89.90	92.60	89.95 (Note 6)
1 SACS Pump Per Loop (Note 2)	89.80 ✓	90.20 ✓	89.80 ✓
1 SACS Pump Per Loop (Notes 2, 3)	N/A	N/A	89.10 (Note 7)
1 SACS Pump Per Loop (Notes 2, 4)	N/A	N/A	77.55 (Note 7)
1 SACS Loop Operable (Note 5)	82.3 ✓	83.0 ✓	82.5 ✓

Note 1. One operator action (four SACS heat exchangers required) see Section 5.8.1.
Note 2. Based on 95°F SACS temperature.
Note 3. PRA case (A1&2-B1&1) defined in section 3.3.7 for the "B" loop
Note 4. PRA case (A1&1-B1&1) defined in section 3.3.7 for the "A" loop
Note 5. AOT case with an EDG room cooler out for maintenance
Note 6. SSW Flows to the RHR supplied loop actually go down after RACS isolation because loop to loop contribution through the RACs piping is cut off (see Reference 4.1.5, Att. 3, Page 544).
Note 7. Conservatively assumes RACS HX is supplied by SSW during long term and both heat loads associated with RHR HX and control room chiller are on same loop, consistent with previous revision.

The overall UHS temperature limit for the AOT conditions is 89.80°F (without uncertainty). With an EDG room cooler out for maintenance, the UHS temperature limit, considering an AOT configuration, is 82.30°F without uncertainty. This corresponds to a SACS temperature of 91°F (Reference 4.1.2, Section 6.4.13). Physically isolating the room cooler undergoing maintenance from the SACS system does not result in a higher UHS temperature.

5.10.3 Short-Term UHS Temperature Limits

H-1-EA-MEE-1926 (Reference 4.1.14) proposed an amendment to Technical Specification 3/4.7.1 to allow continued operation with short-term elevated UHS temperatures based on NRC approved TSTF-330, Revision 3, dated October 16, 2000. A temperature averaging approach forms the basis for acceptance since the UHS is not relied upon for immediate heat removal (such as to prevent containment overpressurization), but is relied upon for longer-term cooling such that the temperature averaging approach continues to satisfy accident analysis assumptions for heat removal over time. Reference 4.1.14 concludes that with a proposed maximum allowed value of 95°F, equipment that is relied upon for accident mitigation, anticipated operational occurrences, or for safe shutdown, will not be adversely affected.

Two non-design basis cases were run at the short-term elevated UHS temperature of 95°F to determine the likely affect on equipment performance should a LOCA or LOP occur. The limiting EDG failure case as described above was run as modified below. Note all SSW pumps were assumed at maximum degraded conditions, tide was at its Technical Specification minimum level and strainers were fouled.

LOCA: A loss-of-coolant accident is postulated at the peak UHS temperature of 95°F. No coincident SSE is assumed and SSW discharge flows through the normal flowpath (cooling tower basin at its normal operating level 102.5 ft). Tide is assumed at 82 feet as discussed in Attachment 5. Using the approved station service water hydraulic model in PipeFlow contained in References 4.1.5 and 4.1.7, a SSW LOCA case was run with Minimum Flow to the Cooling Tower Basin (degraded pumps, fouled strainers and heat exchangers). As contained in Attachment 5, linelist file ea80_5-5.pll was run using the limiting lineup file 14 x 2_c.plu modified to reflect SSW discharge flow to the CTB versus the EOBs (changed FG-CT to an active boundary and FG-0BA/OBB to inactive and lowered the CTB discharge grade to the normal level of 102.5 ft), re-run, and renamed as LOCA95.plu. As shown in Attachment 5 and 12, minimum predicted flows to the SACS HXs are as follows:

SACS HX	LOCA-EOB (Att. 5)	LOCA-CTB (Att. 5)
1A1E201	7756 gpm	9201 gpm
1A2E201	7725 gpm	9163 gpm
1B1E201	10763 gpm	13028 gpm
1B2E201	10856 gpm	13144 gpm

Similar to the methodology described in Section 5.2.2, the minimum SSW flows (for the operable loop) are input into the SACS PROTO-FLO model at EPU conditions with a SACS HX tube side temperature of 95°F. The LOCA case (contained in Attachment 1, titled 95LOCA) demonstrates that SACS temperatures remain approximately 100°F for this analysis (100.17°F). It should be noted that the 95°F limit does not consider uncertainty, however, provides assurance and collaborates conclusions of MEE-1926 that equipment performance will be unaffected. It should also be noted that this analysis is very conservative in that maximum heat loads are applied simultaneously at the onset of the LOCA with the UHS temperature at 95°F. This is unrealistic since maximum RHR heat loads do not occur until approximately 8 hours into the event after which many other loads are secured, and peak UHS temperatures would have returned closer to average temperature.

Loss of Offsite Power: Similar to the above, a loss of offsite power is assumed to occur at the peak UHS temperature of 95°F. No coincident SSE is assumed and discharge flow to the normal flowpath (cooling tower basin) is creditted. SSW flowrates are taken from Attachment 5 (Lop95.plu).

Similar to the methodology described in Section 5.2.2, the minimum SSW flows (for the operable loop) are input into the SACS PROTO-FLO model at EPU conditions with a SACS HX tube side temperature of 95°F. The LOP case (contained in Attachment 1, titled 95LOP) demonstrates that SACS temperatures above 100°F (101.7°F) result when assuming all heat loads are at their maximum at the LOP onset. Therefore, several runs were performed representing heat-load requirements for the first hours following the LOP. Actual RHR heat loads based on predicted suppression pool temperatures from Reference 4.4.3 were used in the following determination:

Time	Case	Torus Temp	RHR Heat Load	UHS Temp	SACS Temp
0-1hr	951lop	186°F	95.7 Mbtu/hr	95.0°F	100.5°F
1-2hr	952lop	197°F	108.6 Mbtu/hr	94.3°F	100.3°F
2-3hr	953lop	202°F	114.4 Mbtu/hr	94.1°F	100.3°F
3-4hr	954lop	206°F	119.0 Mbtu/hr	94.0°F	100.4°F

It is a reasonable expectation that the peak temperature excursion subsides 1°F within 4 hours and the slight excursion above 100°F would be negligible. Note that the above evaluation assumes no reduction in SSW supply to the non-safety related RACS heat exchangers. Procedurally as discussed in Section 3.3.8, SSW flow to the RACS heat exchangers would be reduced if SACS temperatures cannot be maintained below 95°F. Considering the above analyses, the conservative assumptions used in the SSW and SACS models, and the fact the historical UHS temperatures have never been sustained at (or ever reached) 95°F, assurance is provided that SACS temperatures will remain at or below design basis limits following a LOP. It should be noted that the above UHS temperatures do not consider uncertainty in collaborating the conclusions of MEE-1926 that equipment performance will be unaffected, nor consider a coincident SSE in the performance of the above sensitivity runs.

5.11 Uncertainty Analysis

Analysis uncertainty is applied to the final UHS temperature limit consistent with the method introduced in Engineering Evaluation H-0-EG-MEE-1205 (now voided). Since UHS temperature is the parameter of interest, the sensitivity of UHS temperature to variations in each uncertainty parameter is established using a PROTO-HX™ model of the SACS heat exchanger. The additional uncertainties introduced by the analysis technique introduced in this evaluation are considered. Then the impacts of variation of each uncertainty parameter are combined using the square-root-sum-of-the-squares (SRSS) method to arrive at the overall UHS temperature limit uncertainty.

For the uncertainty analysis, engineering judgment was used to select the appropriate bias to apply to each parameter considered since benchmark testing of the SACS heat exchangers has not been performed. These biases are listed below. The SSWS flow rate uncertainty is based on Reference 4.1.7.

Thermal-Hydraulic Model Uncertainty Parameters

Parameter	Uncertainty	Reference	Method
SACS Flow Rate	+5%	4.1.3 (assumed value)	SRSS
SSWS Flow Rate	-3.0%	4.1.7	SRSS
Total SACS Heat Load	+5%	assumed	SRSS
SACS and SSWS Header Temp.	-0.79°F	4.1.6	SRSS
Tube Pluggage (SACS HX)	50 Tubes Max.	assumed	Bias
Fouling (Design)	+0%	assumed	Bias

These are consistent with the uncertainties and biases assumed in H-0-EG-MEE-1205, except that tube pluggage was previously ignored. Bias will be discussed later in this section. Five additional uncertainty considerations are necessary to account for the technique for determining and using the equations for UHS temperature limit versus average SSWS flow rate per active SACS heat exchanger.

First, on the SSWS side of the SACS heat exchangers, the average SSWS flow rate is used with the equation to determine the limiting UHS temperature. When two heat exchangers receive SSWS flow, slight flow imbalances will be present, observed from Reference 4.1.5 data to be about ± 0.4 percent of the average flow rate for the "A" loop. In cases where only one heat exchanger receives SACS flow, the active heat exchanger could actually receive 0.4 percent less flow than the average SSWS flow rate. However, the flow rates contained in Reference 4.1.5 are the limiting flow rates for the SACS heat exchangers and the minimum SSWS flow rates are used to calculate the required UHS temperature.

Second, in cases where both SACS heat exchangers receive flow but only one heat exchanger receives SSWS flow (always assumed to be 1A1E201), the active heat exchanger could actually receive the other SACS heat exchanger flow rate based on the random occurrence of the failure. Referring to results of Reference 4.1.2, based on the benchmark flow balance, the 1A2E201 SACS heat exchanger typically receives about four to five percent more SACS flow than the 1A1E201 heat exchanger. The marginal impact of this different flow rate is difficult to assess due to competing factors. Therefore, the impact of this uncertainty will be determined by performing a model run with the 1A2E201 heat exchanger active vice the 1A1E201 heat exchanger for a limiting case, and this produces a negligible impact on the required UHS temperature.

Third, uncertainty is introduced due to potential SACS flow differences between the "A" and "B" loops. A similar consideration is unnecessary for SSWS flow because model predictions are generally available for both loops. Section 3.3.1 indicates that the conservative SACS loop has been used.

Fourth, this analysis is performed using degraded SACS pump curves as opposed to design curves. Although higher flow generally results in more total SACS heat load which more than offsets the marginally improved effectiveness of the SACS heat exchangers as it affects the UHS temperature limit, the heat loads are essentially fixed as inputs for the LOP/SSE and LOP scenarios (as long as the EDG heat loads truncate). Therefore the UHS temperature limit may be lower with a degraded pump curve due solely to the reduced effectiveness of the SACS heat exchanger. The impact of using a design pump curve will be determined for a limiting case in the LOP/SSE scenario, and the difference will be added to the overall uncertainty.

Fifth and finally, this analysis is performed for single SACS pump cases using the "A" pump only. Pump-to-pump variations in SACS flow rate due to piping arrangement differences may impact the results. The LOP-SSE 212.2 configuration was evaluated with a failure of the C SACS pump and this had no impact on the required UHS temperature.

The additional parameters from above (with the exception of the design SACS pump curve) are captured by the total uncertainty by using the most limiting values. The design SACS pump curve introduces an uncertainty of 0.2°F. This will be added to the overall uncertainty found by SRSS methodology.

The effects of bias have to be addressed separately to determine the overall uncertainty. For the parameters listed above, the results would fall somewhere in a given range of values, and the SRSS methodology could be applied to the overall uncertainty. In determining the result due to bias, the error is either present or it is not, and the bias uncertainty must be added to the total uncertainty. In the case of plugged tubes, the analysis assumes 50 plugged tubes.

A sensitivity study was performed on the effects of plugged tubes on the SACS heat exchanger. Using the limiting alignment determined in Sections 5.10.1 and 5.10.2 (LOP/SSE with 1 SACS pump per loop), the maximum UHS temperature was calculated for zero plugged tubes and for 50 plugged tubes. The results of the study show that the temperature limit for the UHS based on a SSWS flow of 10000 gpm are the same to the nearest tenth of a degree (see Attachment 8), therefore, the effects of plugged tubes produces a negligible impact on the required UHS temperature, and is not included for the calculation of overall uncertainty. The impact of greater-than-design fouling was previously calculated but ignored for the final computation of overall uncertainty. These biases are applied to the operating point conditions for a limiting case and the impact on SSWS inlet temperature is calculated using the PROTO-HX™ model of the SACS heat exchanger.

For the LOP/SSE scenario, the 212.2 failure alignment was considered for the uncertainty analysis. The output for this uncertainty analysis is contained as an Attachment on CD (see Table 5.11a).

Table 5.11a - Uncertainty Analysis for the 212.2 Failure Alignment of the LOP/SSE Scenario

Parameter	Nominal Value	Uncert. Bias	Input Value	Nom. UHS Temp. (°F)	Calc. UHS Temp. (°F)	UHS Temp. Diff. (°F)
SSWS Temp. (°F)	88.9	-0.79	N/A	88.9	88.1	-0.8
SACS Flow Rate (gpm)	7118.38	+5%	7474.30	88.9	88.7	-0.2
SSWS Flow Rate (gpm)	10,000	-3.0%	9700	88.9	88.7	-0.2
SACS Heat Load (MBtu/hr)	84.098	+5%	88.303	88.9	88.6	-0.3
SACS Temp. (°F)	94.98	-0.79	94.18	88.9	88.1	-0.8
Total Uncert. (SRSS)				88.9	87.7	-1.2

For the LOCA scenario, the 222.2 failure alignment was considered for the uncertainty analysis. The output for this uncertainty analysis is contained as an Attachment on CD (see Table 5.11b).

Table 5.11b - Uncertainty Analysis for the 222.2 Failure Alignment of the LOCA Scenario

Parameter	Nominal Value	Uncert. Bias	Input Value	Nom. UHS Temp. (°F)	Calc. UHS Temp. (°F)	UHS Temp. Diff. (°F)
SSWS Temp. (°F)	87.2	-0.79	N/A	87.2	86.4	-0.8
SACS Flow Rate (gpm)	9416.85	+5%	9887.74	87.2	86.9	-0.3
SSWS Flow Rate (gpm)	10,000	-3.0%	9700	87.2	86.9	-0.3
SACS Heat Load (MBtu/hr)	86.150	+5%	90.4575	87.2	86.8	-0.4
SACS Temp. (°F)	95.00	-0.79	94.21	87.2	86.4	-0.8
Total Uncert. (SRSS)				87.2	85.9	-1.3

To be conservative, the higher of the uncertainties should be used and an uncertainty of 1.3°F is the overall uncertainty. An additional uncertainty of 0.2°F is added to the overall uncertainty to account for the difference between the design and degraded pumps. The total uncertainty that should be applied to the UHS temperatures is 1.3°F + 0.2°F = **1.5°F**.

5.12 Limiting UHS Temperature

Table 5.12 provides the SACS UHS temperature limits compiled from Tables 5.10.1 and 5.10.2 for the limiting conditions. The values listed include the temperature uncertainty of 1.5°F (calculated in the previous section) and have been rounded down to the nearest tenth of a degree.

Table 5.12 - Best Achievable UHS Temperature Limit for Each Scenario (Limiting Conditions Shown in boldface - 1.5°F Uncertainty Applied)

Condition	Failure Mode	SACS Temperature (°F)	LOCA/SSE – UHS Temp. Limit (°F)	LOP/SSE - UHS Temp. Limit (°F)
Design Basis	None	100	91.8	91.8
Design Basis	EOB	100	89.1	89.1
Design Basis	EDG	100	91.8	91.4
Design Basis	EDG with EOB failure	100	90.2	89.0
AOT	1 SACS Pump Per Loop	95	88.3	88.3
AOT	1 SSWS Pump Per Loop (Note 1)	100	88.4	88.4

Notes 1. One (1) operator action, see Section 5.8.1.

The UHS temperature is limited to 80.4°F assuming a single failure and an EDG room cooler out for maintenance. The UHS temperature is limited to 80.8°F in an AOT condition when a SACS pump and an EDG room cooler are out for maintenance simultaneously.

6.0 CONCLUSIONS

Adequate cooling to all safety related loads can be provided for the design basis and limited multiple failure conditions considered with a SACS header temperature of 95°F and 100°F.

No Failures	91.8°F
EOB Valve Failure	89.1°F
EDG Failure	91.4 °F
EDG w/EOB Failure	89.0°F
1 SACS Pump/Loop	88.3°F
1 SSWS Pump/Loop	88.4°F
Normal	89.0°F (see discussion below)

The Ultimate Heat Sink (UHS) temperature limit for DBA scenarios assuming a single active failure is 89.0°F. This failure mode is dependent on an EOB valve, 1EA-HV2356A(B), failure. It can be eliminated by opening the EOB under administrative controls, and racking out the breakers (10B212 MCC No. 131 and 10B222 MCC No. 131) to prevent the spurious actuation of the valve. Reference 4.3.2 directs the operators to open the EOB valves at a river temperature of 85°F.

The UHS temperature limit for conditions resulting from combinations of design basis failures concurrent with equipment outages permitted by Technical Specification AOT Action Statements with only one (1) SACS pump per loop and two (2) SACS heat exchangers per loop is 88.3°F. This meets the Technical Specification limit of 88°F.

The SACS system design allows for a SACS heat exchanger outlet temperature limit of 100°F with the exceptions listed below. The Technical Specifications have been updated to reflect the UHS temperature limits using the higher SACS temperatures. For a SSWS/SACS loop outage, normal design basis alignments with all equipment operating, or a 30-day SSWS/SACS pump AOT, the Technical Specification UHS limit is 88.0°F. The calculated limit for this configuration is 88.3°F. Provided all SSWS/SACS/EDGs components are operable, the current Technical Specification limit is 89.0°F. This requirement is met since the analysis demonstrates that a limiting single failure (active short-term or passive long-term) can be accommodated up to 91.4°F (the limiting single failure is an EDG failure without a concurrent EOB failure).

The results of the post-EPU normal two-loop alignment model run performed assuming degraded pumps, fouled strainers and heat exchangers supports operation at an UHS temperature of 89 °F without uncertainty. This is based on the A-loop removing the full TACS load as specified in Reference 4.1.1 and the B-Loop removing the SFP, PCIG, Control Room Chiller and 1E Panel Chiller heat loads. However, the above value is non-limiting since the SACS abnormal operating procedure (Reference 4.3.6) states that the operators can reduce reactor power or remove components from service as needed to maintain SACS temperatures less than 95°F (see Attachment 1, runs NORMAL00 through 17). Note that the Generator Stator Coolers and Hydrogen Coolers are evaluated at 110% of current rated thermal power (3673 MWt) in accordance with reference 4.4.6.

7.0 DESIGN INPUT/OUTPUT DOCUMENTS

See Section 4.0 for design input documents used in this calculation. The following output documents are associated with this calculation:

SH.OP-AP.ZZ-0108, Exhibit 3
HC.OP-AB.COOL-0001 and 0002, Conditions H and I
Technical Specification 3/4.7.1.3, Ultimate Heat Sink
11-0066, HCGS FRVS Drawdown & Long-Term Temperatures, Revision 7, dated 6/28/05
ED-0012, RACS Required Flows and Heat Loads, Revision 4, dated 12/1/99

Procedure SH.OP-AP.ZZ-0108(Q), Exhibit 3, should be revised as follows for the EDG Room Recirc Units 1-A-V-412 through 1-H-V-412 (Reference Order 80087020, Activity 0010) to reflect the following required action when EDG room coolers are inoperable:

- When a SACS pump is out of service and when river water temperature is greater than 80°F, declare its respective EDG inoperable.
- In any other SACS configuration, when river water temperature is greater than 80°F, declare its respective EDG inoperable.
- With both EDG room coolers inoperable, declare its respective EDG inoperable.

8.0 DESIGN MARGIN

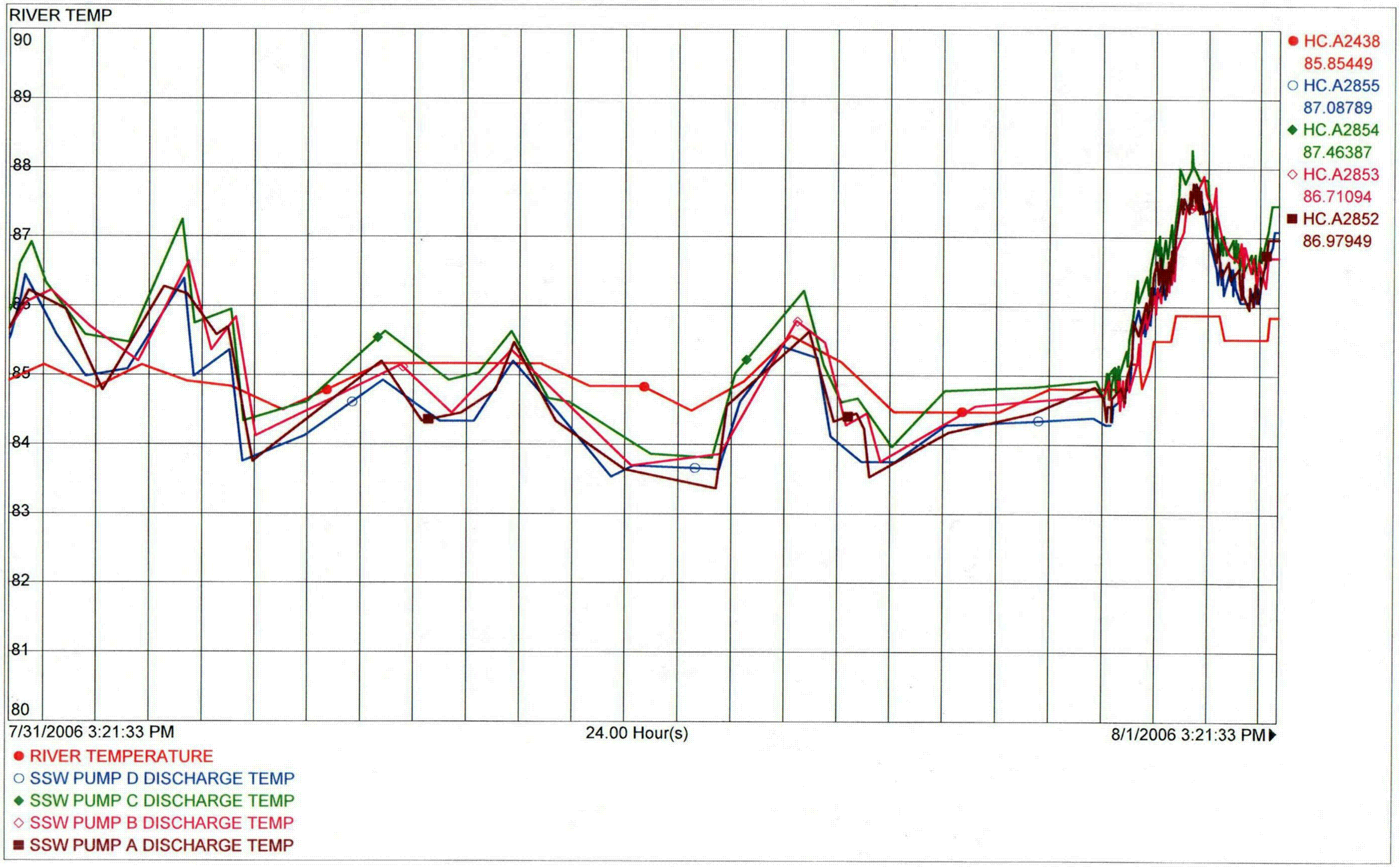
Condition	Tech Spec Requirement	Calculated Value	Margin
Fail Open EOBs	85°F	89.0°F	4.0°F
AOT Case Limit	88°F	88.3°F	0.3°F
Plant Shutdown	*89°F	91.4°F	2.4°F

**An outstanding license change request will change this limit to 89.5°F; therefore, the available margin will be 1.9°F.*

Note that two initiatives have been identified in Attachment 5 to increase margin should the need arise. The first has to do with the potential for a reduction in SSW flows delivered during the limiting events due to a line-break of the non-seismic Category I SSW chlorination lines. These are conservatively modeled as 856 gpm flow losses per loop. Procedures currently require isolation of the system above 85°F, however, the specific SSW to chlorination seismic interface valves are not closed per these documents. A procedure change to close the subject valves above 85°F would add flow margin to the UHS analyses.

Second, per Attachment 5 it was determined that the 85°F Technical Specification requirement to enter the LCO and fail open the EOBs may be able to be eliminated if procedurally Operator's isolate each loop using the Q/non-Q loop discharge interface valves following a loss of the cooling tower. By doing so, safety-related flows in the non-faulted loop always increase regardless of whether it is a LOCA or LOP scenario. Although not being pursued at this time (as a license change request), it is included here as a source for available margin should the need arise.

Note the above analyses include margins for Weko seals not yet installed. See Attachment 5 for a discussion.



RIVER TEMP
90
89
88
87
86
85
84
83
82
81
80
7/31/2006 3:21:33 PM
24.00 Hour(s)
8/1/2006 3:21:33 PM
HC.A2438
85.85449
HC.A2855
87.08789
HC.A2854
87.46387
HC.A2853
86.71094
HC.A2852
86.97949
RIVER TEMPERATURE
SSW PUMP D DISCHARGE TEMP
SSW PUMP C DISCHARGE TEMP
SSW PUMP B DISCHARGE TEMP
SSW PUMP A DISCHARGE TEMP