PRA EVALUATION:

PROPOSED CHANGES IN SERVICE WATER TECH SPEC 3.7.4

Engineering Evaluation 93- 53

December 1993

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1.0 Introduction

This evaluation documents the change in operational risk, at the system level (system availability) and at the plant level (core damage frequency), for a proposed change in the Allowed Outage Times (AOTs) for the Service Water (SW) System.

This is a follow-on evaluation from Engineering Evaluation 92-09[1], based on the actual submitted Tech Spec change[2], the most current Seabrook Station Probabilistic Safety Study (SSPSS-1993)[3], and more detailed documentation suitable for peer review.

2.0 Background

The current Service Water Tech Spec (TS 3.7.4) applies AOTs to all six SW pumps - four ocean water pumps and two cooling tower pumps. These pumps are each 100% capacity and provide triple redundancy per train. In addition, the Tech Spec 3.7.5, Ultimate Heat Sink, addresses the ocean SW pumphouse and the CT basin separate from the pumps. In the licensing design basis, the cooling tower is the seismically qualified ultimate heat sink while the ocean SW is the tornado qualified ultimate heat sink. Thus, to define operability, one train of SW must contain one SW pump from the ocean, one CT pump from the cooling tower basin, and the associated flow paths to the PCC and DG heat exchangers.

A new Tech Spec 3.7.4 has been proposed that:

- Combines the present TS 3.7.4 and 3.7.5. Because of the relationship between the ultimate heat sinks and the SW system, a single Tech Spec is clearer and removes ambiguities.
- Brings consistency among the various AOTs. For example, the current TS 3.7.5 allows the SW pumphouse to be unavailable for 24 hours, but TS 3.7.4 does not address the equivalent condition of having both ocean SW pump trains unavailable.
- Brings this Tech Spec in line with the standard Tech Specs. The standard Tech Spec for SW has a 72-hour AOT for a single train.

To account for the combinations of components that could be out of service, four pump loops have been defined:

SWA - ocean SW pump train A (2 pumps), SWB - ocean SW pump train B (2 pumps), CTA - cooling tower pump train A (one pump), and CTB - cooling tower pump train B (one pump).

The new proposed Tech Spec is summarized below, with a comparison of the current Tech Specs.

	Allowed Outage Time	
Components / Loops [a] Inoperable	<u>Current</u> TSs 3.7.4, 3.7.5	<u>Proposed</u> TS 3.7.4
1 SW pump	7 d	N/A [c]
1 SW train A pump <u>and</u> 1 SW train B pump	72 hr	N/A
SWA <u>or</u> SWB	24 hr	72 hr
CTA <u>or</u> CTB	72 hr	7 d
CTA <u>and</u> CTB	not explicit [b]	72 hr
CT Basin	72 hr	72 hr
SW Pumphouse	24 hr	24 hr
SWA <u>and</u> SWB	not explicit	24 hr
(SWA <u>or</u> SWB) <u>and</u> (CTA <u>or</u> CTB)	not explicit	24 hr

<u>Table Notes:</u>

[a] SW loops (SWA, SWB, CTA, CTB) are defined above.

[b] Some combinations of loops unavailable are not covered in the current Tech Spec 3.7.4. These combinations are generally equivalent to conditions addressed in Tech Spec 3.7.5 for the ultimate heat sinks.

[c] N/A = not applicable. These conditions would not be restricted by the proposed Tech Specs.

3.0 Discussion

This Tech Spec change impacts risk by increasing the likelihood that a SW pump would be unavailable due to planned or unplanned maintenance. This change is evaluated by considering the impact on system unavailability (Section 3.1) and on the frequency of shutdown due to loss of one train of SW (Section 3.2). These impacts are combined in the plant model to produce a delta core damage frequency (Section 3.3).

In addition, a sensitivity case is evaluated to examine the risk importance of the standby SW pump. This case assumes the two standby SW pumps are permanently removed, so that the system consists of two ocean pumps and two CT pumps. This is *not* the best estimate calculation since the station is committed to maintaining the standby SW pumps but is presented to examine the bounding case.

3.1 SW System Model

The SW system is included in the current Seabrook PRA - SSPSS-1993 (the base case). This model includes the ocean SW pumps, the Cooling Tower and pumps (manual actuation only), the flow path through the PCC and DG heat exchangers, and the associated area ventilation. Attachment A is a summary of the SW system model.

This evaluation considers only changes in maintenance unavailability due to the proposed change in Tech Specs. The following table describes how the changes from current to proposed Tech Specs have been modeled.

Component / Loop Inoperable	Current TSs AOT	Proposed TS AOT	Changes Modeled ?	Comments
1 SW pump (standby pump)	7 d	N/A	yes	Modeled as increased unplanned maintenance duration and new planned maintenance contribution, for each standby pump.
1 SWA pump <u>and</u> 1 SWB pump (standby pumps)	72 hr	N/A	no	This combination is not modeled because of the low frequency of entering this condition, i.e., having one pump fail and the standby pump in the opposite train fail while the first one is being repaired.
SWA <u>or</u> SWB (loop)	24 hr	72 hr	yes	The failure of either SW loop is assumed to cause or require a plant shutdown due to loss of RCP motor cooling. This is modeled in the loss of one train SW initiators.
CTA <u>or</u> CTB (loop)	72 hr	7 d	yes	Modeled as increased unplanned maintenance duration.
CTA <u>and</u> CTB (loops)	not explicit	72 hr	no	While this combination is not covered explicitly by the current TSs, it is equivalent to the CT basin allowed outage, which has not changed.
CT Basin	72 hr	72 hr	no	No change.
SW Pmphouse	24 hr	24 hr	no	No change.
SWA <u>and</u> SWB (loops)	not explicit	24 hr	no	While this combination is not covered explicitly by the current TSs, it is equivalent to the SW pumphouse allowed outage, which has not changed.
[SWA <u>or</u> SWB] <u>and</u> [CTA <u>or</u> CTB] (loops)	not explicit	24 hr	no	These combinations are not modeled because of the low frequency of entering such a condition.

The maintenance contribution to the SW system model is described below (the Base Case model); then the model with the change in Tech Spec is presented (the "New" model).

(1) Base Case (Current) Maintenance Model

This model includes contributions from *unplanned maintenance*, based on the number of pumps, the maintenance frequency, and the maintenance duration, as follows:

- Standby ocean SW pump, for each loop, 7-day LCO:

  AMNT1 = BMNT1 (train A , train B)

  = 2 x ZMPSWF x ZMPLSD = 0.0192 (2 SW pumps per loop)

- Standby cooling tower pump, 72-hr LCO:

  AMNT2 = BMNT2 (train A , train B)

  = ZMPMSF x ZMPMSD = 0.00130 (1 CT pump per loop)

- Cooling tower fans, based on TS 3.7.5, 72-hr LCO:

  AMNT3 = ZMPMSF x ZMPMSD = 0.00130 (train A - 1 CT fan per loop)

  BMNT3 = 2 x ZMPMSF x ZMPMSD = 0.00260 (train B - 2 CT fans per loop)

where the frequency and duration variables are based on generic data from PLG-0500, as follows:

ZMPSWF = 3.35E-4 (mean) - Maint. Freq. - operating SW pumps

ZMPMSF = 1.17E-4 (mean) - Maint. Freq. - standby pumps (CT pump/fan)

ZMPLSD = 28.7 hr (mean) - Maint. Duration - pumps, 7-day LCO

ZMPMSD = 11.1 hr (mean) - Maint Duration - pump/fan, 72-hr LCO

These values are means of distributions developed from generic maintenance data, taken from PLG-0500[4]. Attachment B provides the generic data that was the basis for the distributions.

Maintenance assumptions in the current model:

- Maintenance frequencies and durations are based on generic industry data and not on Seabrook specific data due to the limited operational data. This data was collected by PLG from a number of nuclear plants for similar equipment and is judged to be reasonably representative of expected Seabrook experience. (Note that the mean maintenance duration is considerably less than the AOT based on actual experience, but increases with longer AOT.)

- No planned maintenance is done on the SW system during power operation that makes a pump inoperable.

- No contribution is given to 2 SW pumps in unplanned maintenance at the same time because of the low likelihood of dual pump failure or failure of the second pump while the first was being repaired.

- No explicit maintenance contribution is modeled for valves, instrumentation, etc., that would make a loop inoperable. The pump (and CT fans) contribution is assumed to dominate maintenance unavailability.

- No contribution is given to having the SW pumphouse or the CT basin out for maintenance because of the low likelihood. During a storm in the fall of 1992, the SW suction was switched to the Cooling Tower because of the presence of large amounts of seaweed in the circulating water traveling screens. This was taken as a precaution and did not reflect the true unavailability of the ocean SW pumphouse. (Also, the proposed Tech Spec does not change the AOT for the SW pumphouse or the CT basin.)

- Maintenance contribution from failures of SW or CT ventilation is not included because it is assumed that remedial action would be taken to keep the SW system operational.

- Maintenance is unrecoverable. This assumption may be very conservative for some maintenance activities where the system can be made operable quickly.

(2) New Maintenance Model

A "New" SW model was developed to account for the proposed changes in Tech Specs. These changes impact the modeling of unplanned maintenance and planned maintenance, as follows:

Unplanned Maintenance:

- Standby SW pump in each loop, no LCO:

  AMNT1' = BMNT1' (train A, train B)

  = 2 x ZMPSWF x ZMPSWD = 0.0652 (2 SW pumps per loop)

- Standby cooling tower pump, 7-day LCO:

  AMNT2' = BMNT2' (train A, train B)

  = ZMPMSF x ZMPLSD = 0.00335 (one CT pump per loop)

- Cooling tower fans, based on TS 3.7.5, unchanged:

  AMNT3 (train A - same as current model)

  BMNT3 (train B - same as current model)

where the variables are based on generic data from PLG-0500, as follows:

ZMPSWD = 97.4 hr (mean)	- Maint. Duration - SW pumps, no LCO
Other variables	- see current model

Maintenance assumptions:

- The standby SW pump is repaired in unplanned maintenance with no special priority - consistent with other pumps with no LCO. This is believed to be conservative; a SW pump failure would still receive high priority. The variable ZMPSWD was developed from the data variable ZMPNSD in PLG-0500, using generic data for SW and CC pumps, judged to be more representative of the SW and CC pumps at Seabrook. (See Attachment B for details.)

Planned Maintenance for the standby SW pump in each loop:

= PLMNTA = PLMNTB

= 2 x (1/4 yr) x (1 yr/ 8760 hr) x (336 hr) = 0.0192 (2 pumps per loop)

Assumptions:

- Each SW pump is unavailable due to planned maintenance once every four years for 14 days (336 hrs).
- Planned maintenance is done on one pump at a time - no PLMNTA x PLMNTB terms.

The quantification for the "new" SW model is in general as follows

SW Unavail. = [SWpumps(hardware failure + **unplanned maint.** + **planned maint.**)
x CTpumps (hardware failure + **unplanned maint**)]
+ common components failure

where the terms in bold are the ones affected by the proposed Tech Spec change.

3) <u>Sensitivity Case</u>

The sensitivity case assumes the standby ocean SW pumps, one in each train, are permanently unavailable. Unplanned maintenance on the operating SW pumps is assumed to require a plant trip, and thus is reflected in the initiating event, loss of one SW train. The CT maintenance is modeled the same as the "New" Tech Specs, above.

4) Quantitative Results - Systems Analysis

The SW system configuration is quantified for a number of different boundary conditions. Boundary conditions are the signals and support systems, external to the SW system, that impact the system configuration. For example, with loss of offsite power (LOSP), the SW pumps must restart, presenting a different failure mode - pump fails to start - that is not present when offsite power is available. The important boundary conditions for the SW system are the number of support systems (e.g. AC power) available, LOSP, SI signal, and whether the Cooling Tower is included. The combination of two-train boundary conditions that are of interest is given below. Similar single-train configurations have also been quantified.

System Configuration	Number of Trains	LOSP Initiator	SI Signal Present	CT Included *	Comment
SW1	2			x	Normal configuration, with CT: 4 ocean SW pumps and 2 CT pumps.
SW2	2				Normal configuration, no CT: 4 ocean SW pumps.
SW3	2	x			Loss of offsite power, no CT: 2 ocean SW pumps.
SW4	2		x	x	SI alignment, with CT: 4 ocean SW pumps and 2 CT pumps.
SW5	2		x		SI alignment, no CT: 4 ocean SW pumps.
SW6	2			x	CT only: 2 CT pumps.

* Cooling Tower is included in the SW system assuming manual actuation. This action is not credited for offsite power (LOSP) due to the short time available to restore DG cooling, and for other severe hazards (e.g., seismic events) due to the confusion that might result in the control room.

With the maintenance contribution changes above, the SW system unavailability changes as follows:

System Unavailability			Maintenance Contribution (Percent of TOTAL)	
System Configuration	TOTAL: Current TS / New TS / Sensitivity Case	(Percent Change from Base Case)	Unplanned Maint.	Planned Maint.
SW1	3.91E-7		6.3 %	-
Normal configuration, with CT.	3.97E-7	(1.5 %)	16.8 %	3.8 %
	4.18E-7	(6.9 %)	3.7 %	-
SW2	3.96E-5		4.6 %	-
Normal configuration, no CT.	3.98E-5	(0.3 %)	14.5 %	4.0 %
	4.25E-5	(7.3 %)	1.1 %	-
SW3	7.64E-4		4.5 %	-
Loss of offsite power.	7.64E-4	(<0.1 %)	14.1 %	3.8 %
	7.64E-4	(<0.1 %)	1.1 %	
SW4	3.17E-4		4.5 %	-
SI alignment, with CT.	3.17E-4	(<0.1 %)	14.2 %	3.8 %
	3.17E-4	(<0.1 %)	1.1 %	-
SW5	3.58E-4		4.5 %	-
SI alignment, no CT.	3.59E-4	(0.3 %)	14.2 %	3.9 %
	3.63E-4	(1.4 %)	1.1 %	-
SW6	9.89E-3		6.2 %	-
CT alone.	1.00E-2	(1.1 %)	16.5 %	3.8 %
	1.00E-2	(1.1 %)	3.9 %	-

See Attachment C for details of the maintenance quantification.

These results, both for the current and the new TS, are based on point estimate quantifications of the system. The current SW system analysis in the SSPSS-1993 is quantified using Monte Carlo uncertainty methods. However, in comparing the small changes in system quantification that the change in Tech Specs produces, the effects of the Monte Carlo uncertainty overwhelm the results. Thus, to isolate the impact of the Tech Spec change alone, the system quantification for SW is presented using point estimate.

The results at the system level indicate that the change in system unavailability is extremely small for all cases, with a maximum change of less than 2%. This change is insignificant in comparison to the uncertainty of the results. The change in system unavailability is small even though the relative importance of maintenance increased from ~5% to ~15% of the system total. This is due to the multiple redundancy in the system and also the way it is modeled, as follows:

- SW1 - Normal configuration: 4 ocean SW pumps and 2 CT pumps. Because of the high level of pump redundancy and the modeling of common mode failure, the standby pump tends to contribute little to the overall system availability. Also, the less redundant ventilation system, which dominates this configuration, is not affected by maintenance. Thus, when maintenance is increased, it has little impact.

- SW2 - Normal configuration without the CT: 4 ocean SW pumps. Because of the redundancy with the ocean SW pumps, the standby pumps tend to contribute little to the overall system availability. Because CT is not included in this configuration, Tech Spec changes affecting the CT do not impact SW2.

- SW3 - LOSP configuration: 2 ocean SW pumps. The operating SW pumps will automatically load onto the diesel generators. The standby SW pumps and CT pumps do not auto-start on loss of the operating pumps. Because of the need for SW cooling of the diesel generators, no credit is given for manual actions to start the standby pumps. Thus, the standby pumps which are impacted by the Tech Spec change are not included in SW3.

- SW4 - SI configuration: 4 ocean SW pumps and 2 CT pumps. This is similar to the normal configuration (SW1) except the isolation of non-essential loads is also required. Common cause failure of the isolation MOVs to close is the dominant failure cutset. This cutset is not impacted by the Tech Spec changes.

- SW5 - SI configuration without the CT: 4 ocean SW pumps. This has the same basis as SW4 for the minimal impact of maintenance.

- SW6 - Cooling tower only: 2 CT pumps. This is impacted only by the change in CT pump AOTs. Because of common cause failure modeled between these pumps and the operator action to initiate CT, the increased maintenance contribution is not significant.

Thus, the impact of the Tech Spec change on SW system unavailability is insignificant, and it could be concluded that the impact on the plant model (i.e., core damage frequency) would be negligible. These changes are included in the plant model evaluation in Section 3.3.

The sensitivity case resulted in a maximum change of about 7 %, for the system configurations where all 4 ocean SW pumps are modeled in the base case. This change is also insignificant in light of the associated uncertainty.

3.2 Initiating Event - Loss of One Train SW

Loss of either train of SW would affect the plant power generation through PCC cooling to the RCP motors (SW cools PCC heat exchangers). This impact is modeled as two initiators, L1SWA and L1SWB. The frequency of loss of one SW train is given by the frequency of loss of one ocean SW pump over one year of operation and failure of the other ocean SW pump while the first is being repaired. This also includes failure of the operating pump while the standby pump is out for maintenance - either planned or unplanned.

There are also other combinations of valves, heat exchangers, etc. that could fail and contribute to loss of the train; however, they are not affected by this Tech Spec change. In addition, no credit is given for operator action to start the Cooling Tower in time to prevent the shutdown.

The simplified equation for loss of one SW train can be written as follows:

$$
\begin{aligned}
L1SW = & [FR(PmpA)*T(yr)] * [FS(PmpC) + FR(PmpC)*T(repair)] + \\
& [FR(PmpA)*T(yr) * MNT(PmpC)] + \\
& [FF(Common\ Valves)]
\end{aligned}
$$

where:

FR(Pmp) = failure rate for operating SW pump to continue to run
= 9.95E-6 / hr (SISWPR)

FS(Pmp) = failure rate for standby SW pump to start
= 1.61E-3 / demand (SIPMOS)

T(yr) = duration the operating SW pump must run
= 8760 hr per yr * 0.70 , plant availability factor,

T(repair) = duration of unplanned maintenance on failed pump A,

MNT(Pmp) = pump unavailability due to planned and unplanned maintenance,

FF(Common Valves) = failure frequency of common valves transferring open or closed over the operating year = 1.65E-3 (see Table D.1).

The two terms T(repair) and MNT(Pmp) are the ones that change due to the new Tech Spec AOT, as follows:

	Current TS Model	New TS Model
T(repair)	ZMPLSD = 28.7 hr	ZMPSWD = 97.4 hr
MN[illegible]mp) = [illegible] + UM		
PM Planned Maint.	none	2*(1/4)*(1/8760)*336 = 0.0192
UM Unplanned Maint.	ZMPSWF*ZMPLSD = 0.0096	ZMPSWF*ZMPSWD = 0.0326

where the variables are defined earlier.

The results from the RISKMAN system initiator model are given below. Similar results can be calculated with the simplified model above.

L1SW	Initiator Frequency		Maintenance Contribution (Percent of TOTAL)	
	TOTAL	(Percent Change from Base Case)	Unplanned Maint.	Planned Maint.
Current TS Model (w/ point est. calc)	2.63E-3 per yr		22.3 %	-
New TS Model	5.25E-3 per yr	(100 %)	38.9 %	22.7 %
Sensitivity Case	6.33E-2 per yr	(1400 %)	-	-

As explained in Section 3.1, these results were obtained using point estimate quantification, rather than Monte Carlo uncertainty calculations. This allows the change due strictly to change in the Tech Spec to be isolated. The detailed results for loss of one train of SW are given in Attachment D.

Thus, the initiator frequency increases by about a factor of 2. This large increase is due to the significance of maintenance in the current model.

For the sensitivity case, the increase is about a factor of 25. This impact is more dramatic, since the assumption is that failure of either operating SW pump would force a plant shutdown; no credit is given for manually starting the CT and remaining at power.

3.3 Plant Model

Service Water has two general safety functions, cooling PCC and cooling DGs. Thus, failure of SW effects the plant model in those two ways:

- For transients and LOCAs, loss of SW fails PCC which results in loss of cooling to RCP seals and to ECCS pumps, and
- For loss of offsite power, loss of SW fails the DGs (assumed unrecoverable) which results in station blackout.

Attachment E, Table E.1 contains the dominant CD sequences (top 25) for the base case, with the sequences that do not involve direct failure of SW shaded. From this table, it can be seen that the dominant SW sequence is LOSP with failure of both trains of SW and no recovery of offsite power. The next internal event sequences failing SW are loss of one train of SW initiating a plant shutdown followed by failure of the CT and the opposite train SW and CT. The next sequences involve transients (e.g. RT) with failure of both trains of SW.

Table E.2 presents the top 25 CD sequences with the new SW Tech Spec modeled. By comparing the dominant sequences, the most important change is clearly the change in initiating event frequency for loss of one train of SW.

The plant model results are as follows:

Plant Model Results	Core Damage Frequency (per year)	Percent Change from Base Case
SSPSS-1993 CDF (Monte Carlo)	8.02E-5	
➧Base Case CDF (with SW point estimate)	8.06E-5	
➧New SW Tech Spec	8.25E-5	2.4 %
Sensitivity Case	1.18E-4	46.4 %

This change is dominated by the initiating event frequency for loss of one train of SW.

The total CDF change due to changes in the SW Tech Spec is about 1.9E-6 per year, or 2.4 %, compared to the range of the CDF distribution which is approximately one order of magnitude (from 5th to 95th percentile). Thus, this is an insignificant change within the uncertainty bounds on the CDF distribution.

The change in CDF in the sensitivity case is more significant because of the importance of the loss of one SW train initiator. This change is still within the upper bound CDF estimate. Using this sensitivity case, the Risk Achievement (RA) importance factor for this change can be calculated:

RA = 1.18E-4 / 8.06E-5 = 1.46

4.0 Conclusion

As a result of the quantitative evaluation above, the effect of the changes proposed for TS 3.7.4 is generally small for the SW system unavailability and is significant for the SW initiating event frequency. However, with these changes in the plant model, the overall result is insignificant to the core damage frequency. This evaluation is based on a best estimate of planned and unplanned SW pump maintenance.

The evaluation does *not* include the positive contributions due to removing the major SW pump maintenance activities from outages. These contributions include reducing the unavailability of SW pumps during outages and permitting more flexibility in outage planning. The outage effects are very sensitive to the configuration of the primary system, time after shutdown, other systems unavailable, etc. and thus are difficult to estimate. As a result, the proposed Tech Spec change does not increase the core damage risk within the bounds of the uncertainty.

5.0 References

1. North Atlantic Energy Service Corp., "PRA Evaluation: Change in Service Water Tech Spec 3.7.4," Engineering Evaluation 92-09, Rev. 2, Dec. 1992.

2. NAESCo letter, T. Feigenbaum to USNRC, "License Amendment Request 93-02:'Service Water System / Ultimate Heat Sink OPERABILITY Requirement' (TAC No. M85750)," April 7, 1993.

3. North Atlantic Energy Service Corp., "Seabrook Station Probabilistic Safety Study - 1993 Update, (SSPSS-1993)," July 1993.

4. Pickard, Lowe and Garrick, Inc, "Data Base for Probabilistic Risk Assessment of Light Water Nuclear Power Plants - Maintenance Data," PLG-0500, Volume 3, Revision 1, August 1989.

Attachment A - SW System Model Summary

This section contains a copy of the SSPSS-1993 Tier 1 system documentation for Service Water. This is intended to give a summary description of the system, how it is modeled, and the base case results (Monte Carlo calculations).

DOCUMENTATION NOTEBOOK

SECTION 3.4

SERVICE WATER

SUMMARY: SERVICE WATER SYSTEM

1.0 SYSTEM DESCRIPTION

Function - The Service Water System (SWS) provides cooling water to transfer the heat from primary (safety-related) and secondary (nonsafety-related) loads to the ultimate heat sink, either the Atlantic Ocean or the atmosphere. During a loss of off-site power, the SWS also provides cooling to the diesel generator jacket water coolers.

Configuration - The SWS (see Figure 3.4-1) consists of a normally operating, seawater service water system, a cooling tower system, and their associated ventilation systems (see Figures 3.4-2 and 3). The seawater service water system includes two independent and redundant trains which take suction from a common bay in the service water pumphouse. Each train contains two parallel service water pumps, one normally operating and the other in standby. The Cooling Tower System also includes two independent trains, with one cooling tower pump per train. Fans are provided to remove heat from the cooling tower.

Dependencies - Support for the normal SWS is provided by the Service Water Pumphouse Heating and Ventilation System and by the Electric Power System. Support for the Cooling Tower System is provided by its associated Heating and Ventilation System and by the Electric Power System.

Operation - The SWS is operable during all modes of operation with one pump per train in standby mode. If the operating service water pump trips, the standby pump automatically starts. If the discharge pressure in a service water train falls below its low-low pressure setpoint, a train-associated tower actuation (TA) signal is generated which starts the associated cooling tower pump and stops that train's service water pumps. Given a TA signal, an S signal, or a loss of off-site power, the secondary heat loads are isolated to conserve cooling water to safeguards equipment.

Potential for Event Initiation - Loss of service water is a potential initiating event because the system is required to supply cooling water to the plant PCC system and SCC system heat exchangers at all times during operation. Loss of either train of the SWS would affect the plant power generation through PCC cooling to the RCPs.

2.0 SYSTEM MODEL

The SWS analysis includes several system models:

- Availability of "normal" service water, i.e., using the service water pumphouse,
- Availability of cooling towers, assumed to start only on manual actuation, and
- Initiating event - loss of one train of service water

Top Event Definition - The SWS System is analyzed for Top Event WA (loss of SWS Train A) and Top Event WB (loss of SWS Train B) in the support systems event tree under three boundary conditions:

Case 1 - SI signal with off-site power available

Case 2 - No SI signal and off-site power available (i.e., general transient)

Case 3 - Loss of off-site power

For all three cases, the SWS must continue to supply service water to the PCC heat loads after an initiating event occurs. Case 2 is applied to initiating events which require isolation of the nonsafety-related heat loads (i.e., secondary component cooling). Case 3 is applied to initiating events which also require isolation of the secondary heat loads. In addition, for Case 3, the SWS pumps must restart and operate throughout the mission time. The mission time for all three cases is 24 hours.

Success Criteria - System success criteria is one of two trains continuing to operate for 24 hours after event initiation.

The model also assumes loss of pumphouse switchgear ventilation and cooling tower ventilation systems result in failure of SW and CT pumps, respectively. Loss of pumphouse ventilation is assumed to have no effect for the 24-hour mission time.

The model assumes that isolation of the secondary heat loads is required for a loss of off-site power concurrent with an S signal or for a TA signal. For small LOCA, steam generator tube rupture, and steam line break outside containment initiating events with off-site power available, it is assumed that isolation of secondary heat loads is not required. Thus, for these three initiators, Service Water is quantified for Case 2 (no SI signal with off-site power available).

Analysis Conditions

- Operator actions to initiate cooling tower operation are modeled. No credit has been taken for the automatic generation of a TA signal.
- Failure of the operators to close the spray bypass MOVs SW-V139 and

SW-V140 is assumed to have no effect on system performance for the mission time. Closure of these valves controls cooling tower water temperature by redirecting all cooling tower return flow to the spray headers (instead of the tower basin).

- The SWS is analyzed for various combinations of support states, including loss of off-site power, S signal, TA signal, and single AC power train availability.
- No credit is given for manually initiating the cooling tower for LOSP-initiated sequences because of the time dependence between diesel cooling and recovery from SW failure.

3.0 RESULTS

The SW System quantification results are shown in Table 3.4-1. The definition of cutset basic events is given in Table 3.4-2.

4.0 UPDATE HISTORY

The system analysis has evolved in the model updates as follows:

- SSPSA(1983) - The original system analysis.
- SSPSS-1986 - Several changes were made:

  The Tech Spec AOTs and test frequencies for SW pumps were changed.

  Recovery of SW by manually starting the Cooling Towers or isolating non-essential loads was integrated into the systems analysis in order to correctly credit recovery.

  Common cause modeling was expanded to include groups of more than two components, including a SW pump group and a CT valve group.

- SSPSS-1989 - No significant changes.
- SSPSS-1990 - Several changes were made:

  The recovery action to manually isolate the non-essential loads was removed from the model, since there is no explicit procedural instructions. Instead, a more realistic success criteria was used so that isolation is required only for coincident LOSP and LOCA.

  SW pumphouse ventilation was removed from the model based on engineering judgment.

A detailed fault tree was developed using RISKMAN Release 2.0.

- SSPSS-1993 - Several changes were made:

  The fault tree was revised using RISKMAN Release 4.0.

  Plant specific data was used for pump start and run and for maintenance unavailability.

Table 3.4-1(a) Service Water Quantitative Results

Two Train Service Water System (with Cooling Tower): SW1 = 3.3117E-07

No.	Cutset Basic Events [a]	Value	Percent Importnce	Cumulatve Importnce	Alignment
1	OPTA * [FN.SWFN40A.FS, FN.SWFN40B.FS]	2.124E-07	64.1362	64.1362	NORMAL
2	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV4.FO, MO.SWV5.FO]	1.530E-08	4.6200	68.7562	NORMAL
3	MO.SWV44.CL * OPTA	1.379E-08	4.1640	72.9202	NORMAL
4	OPTA * FN.SWFN40A.FR, FN.SWFN40B.FR]	1.095E-08	3.3065	76.2266	NORMAL
5	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [PP.SWP110A.FS, PP.SWP110B.FS]	5.911E-09	1.7849	78.0115	NORMAL
6	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV25.FC, MO.SWV34.FC]	4.531E-09	1.3682	79.3797	NORMAL
7	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV25.FC, MO.SWV54.FC]	4.531E-09	1.3682	80.7479	NORMAL
8	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV19.FO, MO.SWV20.FO]	4.531E-09	1.3682	82.1161	NORMAL
9	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV19.FO, MO.SWV56.FO]	4.531E-09	1.3682	83.4842	NORMAL
10	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV20.FO, MO.SWV27.FO]	4.531E-09	1.3682	84.8524	NORMAL
11	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV56.FO, MO.SWV27.FO]	4.531E-09	1.3682	86.2206	NORMAL
12	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV23.FC, MO.SWV34.FC]	4.531E-09	1.3682	87.5888	NORMAL
13	[FN.SWFN40A.FS, FN.SWFN40B.FS] * [MO.SWV23.FC, MO.SWV54.FC]	4.531E-09	1.3682	88.9570	NORMAL

Table 3.4-1(b) Service Water Quantitative Results

Two Train Service Water System (given LOSP): SW3 = 7.2257E-04

No.	Cutset Basic Events	Value	Percent Importnce	Cumulatve Importnce	Alignment
1	[MO.SWV2.FC, MO.SWV29.FC]	2.505E-04	34.6682	34.6682	NORMAL
2	[MO.SWV4.FO, MO.SWV5.FO]	2.505E-04	34.6682	69.3363	NORMAL
3	[FN.SWFN40A.FS, FN.SWFN40B.FS]	2.706E-05	3.7450	73.0813	NORMAL
4	[MO.SWV2.FC] * [MO.SWV5.FO]	2.512E-05	3.4765	76.5578	NORMAL
5	[MO.SWV29.FC] * [MO.SWV4.FO]	2.512E-05	3.4765	80.0343	NORMAL
6	[MO.SWV2.FC] * [MO.SWV29.FC]	2.512E-05	3.4765	83.5108	NORMAL
7	[MO.SWV4.FO] * [MO.SWV5.FO]	2.512E-05	3.4765	86.9873	NORMAL
8	[PP.SWP41A.FS, PP.SWP41B.FS]	1.209E-05	1.6732	88.6605	NORMAL
9	[PP.SWP41B.FS] * [MO.SWV4.FO]	6.006E-06	.8312	89.4917	NORMAL

Table 3.4-1(c) Service Water Quantitative Results

Single Train (A) Service Water System (w/ Cooling Twr): WA1 = 5.1968E-05

No.	Cutset Basic Events	Value	Percent Importnce	Cumulatve Importnce	Alignment
1	OPTA * [FN.SWFN40A.FS]	2.781E-06	5.3514	5.3514	NORMAL
2	MO.SWV20.CL	2.087E-06	4.0159	9.3673	NORMAL
3	[FN.SWFN40A.FS] * [MO.SWV4.FO]	1.797E-06	3.4579	12.8252	NORMAL
4	[FN.SWFN40A.FS] * [MO.SWV34.FC]	1.797E-06	3.4579	16.2831	NORMAL
5	[FN.SWFN40A.FS] * [MO.SWV20.FO]	1.797E-06	3.4579	19.7411	NORMAL
6	[FN.SWFN40A.FS] * [MO.SWV56.FO]	1.797E-06	3.4579	23.1990	NORMAL
7	[FN.SWFN40A.FS] * [MO.SWV54.FC]	1.797E-06	3.4579	26.6569	NORMAL
8	OPTA * DP.DP60A.FC	1.780E-06	3.4252	30.0821	NORMAL
9	OPTA * DP.SWDP932A.FC	1.780E-06	3.4252	33.5073	NORMAL
10	OPTA * [FN.SWFN40A.FR]	1.353E-06	2.6035	36.1108	NORMAL
11	DP.DP60A.FC * [MO.SWV20.FO]	1.035E-06	1.9916	38.1024	NORMAL
12	DP.SWDP932A.FC * [MO.SWV20.FO]	1.035E-06	1.9916	40.0940	NORMAL
13	DP.SWDP932A.FC * [MO.SWV56.FO]	1.035E-06	1.9916	42.0856	NORMAL
14	DP.SWDP932A.FC * [MO.SWV34.FC]	1.035E-06	1.9916	44.0773	NORMAL
15	DP.SWDP932A.FC * [MO.SWV54.FC]	1.035E-06	1.9916	46.0689	NORMAL
16	DP.SWDP932A.FC * [MO.SWV4.FO]	1.035E-06	1.9916	48.0605	NORMAL
17	DP.DP60A.FC * [MO.SWV54.FC]	1.035E-06	1.9916	50.0521	NORMAL
18	DP.DP60A.FC * [MO.SWV56.FO]	1.035E-06	1.9916	52.0437	NORMAL
19	DP.DP60A.FC * [MO.SWV34.FC]	1.035E-06	1.9916	54.0353	NORMAL
20	DP.DP60A.FC * [MO.SWV4.FO]	1.035E-06	1.9916	56.0270	NORMAL
21	[FN.SWFN40A.FS] * [FN.SWFN51A.FS]	9.823E-07	1.8902	57.9172	NORMAL
22	VL.SWV68.CL	8.762E-07	1.6860	59.6032	NORMAL
23	VL.SWV70.CL	8.762E-07	1.6860	61.2892	NORMAL
24	[FN.SWFN40A.FS] * [PP.SWP110A.FS]	8.446E-07	1.6252	62.9145	NORMAL
25	[FN.SWFN40A.FR] * [MO.SWV20.FO]	7.627E-07	1.4676	64.3821	NORMAL

Table 3.4-[illegible] Service Water Quantitative Results

Single Train (A) Service Water System (given LOSP): WA3 = 1.1116E-02

No.	Cutset Basic Events	Value	Percent Importnce	Cumulatve Importnce	Alignment
1	[MO.SWV2.FC]	3.549E-03	31.9269	31.9269	NORMAL
2	[MO.SWV4.FO]	3.549E-03	31.9269	63.8538	NORMAL
3	[PP.SWP41A.FS]	1.609E-03	14.4746	78.3284	NORMAL
4	[FN.SWFN40A.FS]	4.181E-04	3.7612	82.0896	NORMAL
5	[MO.SWV2.FC, MO.SWV29.FC]	2.744E-04	2.4685	84.5581	NORMAL
6	[MO.SWV4.FO, MO.SWV5.FO]	2.744E-04	2.4685	87.0266	NORMAL
7	DP.DP60A.FC	2.519E-04	2.2661	89.2927	NORMAL

Table 3.4-2 Service Water Basic Event Definitions

Basic Event	Description
CV.SWV1.CL	P.41A DISCHARGE CHECK VALVE SW.V1 TRANSFERS CLOSED
CV.SWV1.FC	P.41A DISCHARGE CHECK VALVE SW.V1 FAILS TO RE.OPEN
CV.SWV24.CL	P.110B DISCHARGE CHECK VALVE SW.V24 TRANSFERS CLOSED
CV.SWV24.FC	P.110B DISCHARGE CHECK VALVE SW.V24 FAILS TO OPEN
CV.SWV28.CL	P.41B DISCHARGE CHECK VALVE SW.V28 TRANSFERS CLOSED
CV.SWV28.FC	P.41B DISCHARGE CHECK VALVE SW.V28 FAILS TO RE.OPEN
CV.SWV3.CL	P.41C DISCHARGE CHECK VALVE SW.V3 TRANSFERS CLOSED
CV.SWV3.FC	P.41C DISCHARGE CHECK VALVE SW.V3 FAILS TO OPEN
CV.SWV30.CL	P.41D DISCHARGE CHECK VALVE SW.V30 TRANSFERS CLOSED
CV.SWV30.FC	P.41D DISCHARGE CHECK VALVE SW.V30 FAILS TO OPEN
CV.SWV53.CL	P.110A DISCHARGE CHECK VALVE SW.V53 TRANSFERS CLOSED
CV.SWV53.FC	P.110A DISCHARGE CHECK VALVE SW.V53 FAILS TO OPEN
DP.DP191.IO	FIRE DAMPER DP.191 INADVERTENT ACTUATION
DP.DP192.IO	FIRE DAMPER DP.192 INADVERTENT ACTUATION
DP.DP369.CL	TORNADO CHECK DAMPER DP.369 TRANSFERS CLOSED
DP.DP370.CL	TORNADO CHECK DAMPER DP.370 TRANSFERS CLOSED
DP.DP60A.CL	SW SWGR RM RELIEF DAMPER DP.60A TRANSFERS CLOSED
DP.DP60A.FC	SW SWGR RM RELIEF DAMPER DP.60A FAILS TO OPEN
DP.DP60B.CL	SW SWGR RM RELIEF DAMPER DP.60B TRANSFERS CLOSED
DP.DP60B.FC	SW SWGR RM RELIEF DAMPER DP.60B FAILS TO OPEN
DP.SWDP189.IO	FIRE DAMPER DP.189 INADVERTENT ACTUATION
DP.SWDP190.IO	FIRE DAMPER DP.190 INADVERTENT ACTUATION
DP.SWDP64A.CL	RELIEF DAMPER DP.64A TRANSFERS CLOSED
DP.SWDP64A.FC	RELIEF DAMPER DP.64A FAILS TO OPEN
DP.SWDP64B.CL	RELIEF DAMPER DP.64B TRANSFERS CLOSED
DP.SWDP64B.FC	RELIEF DAMPER DP.64B FAILS TO OPEN
DP.SWDP65.CL	CT SWGR RM FAN DAMPER DP.65 TRANSFERS CLOSED
DP.SWDP65.FC	CT SWGR RM FAN DAMPER DP.65 FAILS TO TRANSFER OPEN
DP.SWDP66.CL	CT SWGR RM FAN DAMPER DP.66 TRANSFERS CLOSED
DP.SWDP66.FC	CT SWGR RM FAN DAMPER DP.66 FAILS TO TRANSFER OPEN
DP.SWDP67.CL	CT PUMP ROOM EXHAUST FAN DAMPER DP.67 TRANSFERS OPEN
DP.SWDP67.FC	CT PUMP ROOM EXHAUST FAN DAMPER DP.67 FAILS TO OPEN
DP.SWDP68.CL	CT PUMP ROOM EXHAUST FAN DAMPER DP.68 TRANSFERS OPEN
DP.SWDP68.FC	CT PUMP ROOM EXHAUST FAN DAMPER DP.68 FAILS TO OPEN

Table 3.4-2 Service Water Basic Event Definitions (Continued)

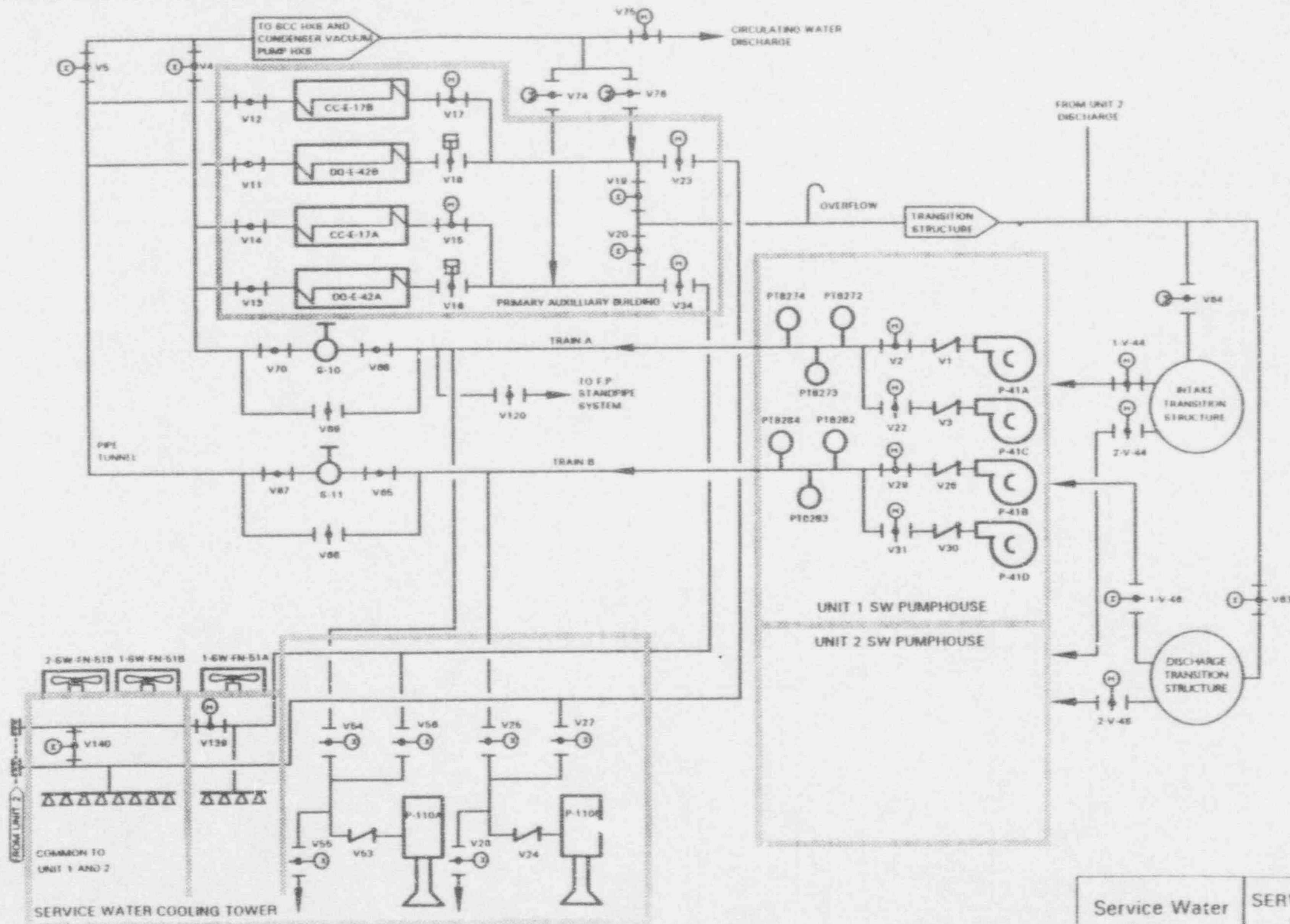
Basic Event	*Description*
DP.SWDP932A.CL	DISCHARGE DAMPER DP.932A TRANSFERS CLOSED
DP.SWDP932A.FC	DISCHARGE DAMPER DP.932A FAILS TO OPEN
DP.SWDP932B.CL	DISCHARGE DAMPER DP.932B TRANSFERS CLOSED
DP.SWDP932B.FC	DISCHARGE DAMPER DP.932B FAILS TO OPEN
DP.SWDR367.CL	TORNADO CHECK DAMPER DR.367 TRANSFERS CLOSED
FI.SWF192.PL	CT PUMP ROOM INTAKE FILTER F.192 PLUGGED
FI.SWF57.PL	FILTER F.57 PLUGGED
FI.SWF58.PL	FILTER F.58 PLUGGED
FN.2SWFN51B.FR	CT FAN 2.FN.51B FAILS TO RUN
FN.2SWFN51B.FS	CT FAN 2.FN.51B FAILS TO START
FN.SWFN40A.FR	SW SWGR VENT SUPPLY FAN FN.40A FAILS TO RUN
FN.SWFN40A.FS	SW SWGR VENT SUPPLY FAN FN.40A FAILS TO START
FN.SWFN40B.FR	SW SWGR VENT SUPPLY FAN FN.40B FAILS TO RUN
FN.SWFN40B.FS	SW SWGR VENT SUPPLY FAN FN.40B FAILS TO START
FN.SWFN51A.FR	CT FAN FN.51A FAILS TO RUN
FN.SWFN51A.FS	CT FAN FN.51A FAILS TO START
FN.SWFN51B.FR	CT FAN FN.51B FAILS TO RUN
FN.SWFN51B.FS	CT FAN FN.51B FAILS TO START
FN.SWFN63.FR	CT SWGR ROOM SUPPLY FAN FN.63 FAILS TO RUN
FN.SWFN63.FS	CT SWGR ROOM SUPPLY FAN FN.63 FAILS TO START
FN.SWFN64.FR	CT SWGR ROOM SUPPLY FAN FN.64 FAILS TO RUN
FN.SWFN64.FS	CT SWGR ROOM SUPPLY FAN FN.64 FAILS TO START
FN.SWFN70.FR	CT ROOF EXHAUST FAN FN.70 FAILS TO RUN
FN.SWFN70.FS	CT ROOF EXHAUST FAN FN.70 FAILS TO START
FN.SWFN71.FR	CT ROOF EXHAUST FAN FN.71 FAILS TO RUN
FN.SWFN71.FS	CT ROOF EXHAUST FAN FN.71 FAILS TO START
LV.SWL26.PL	CT PUMP ROOM INTAKE LOUVRE L.26 PLUGGED
LV.SWL27.PL	EXHAUST LOUVRE L.27 PLUGGED
LV.SWL28.PL	EXHAUST LOUVRE L.28 PLUGGED
MO.SWV19.CL	SW RETURN MOV SW.V19 TRANSFERS CLOSED
MO.SWV19.FO	SW RETURN MOV SW.V19 FAILS TO CLOSE
MO.SWV20.CL	SW RETURN MOV SW.V20 TRANSFERS CLOSED

Table 3.4-2 Service Water Basic Event Definitions (Continued)

Basic Event	*Description*
MO.SWV20.FO	SW RETURN MOV SW.V20 FAILS TO CLOSE
MO.SWV2.CL	P.41A DISCHARGE MOV SW.V2 TRANSFERS CLOSED
MO.SWV2.FC	P.41A DISCHARGE MOV SW.V2 FAILS TO RE.OPEN
MO.SWV29.CL	P.41B DISCHARGE MOV SW.V29 TRANSFERS CLOSED
MO.SWV29.FC	P.41B DISCHARGE MOV SW.V29 FAILS TO RE.OPEN
MO.SWV22.CL	P.41C DISCHARGE MOV SW.V22 TRANSFERS CLOSED
MO.SWV22.FC	P.41C DISCHARGE MOV SW.V22 FAILS TO OPEN
MO.SWV31.CL	P.41D DISCHARGE MOV SW.V31 TRANSFERS CLOSED
MO.SWV31.FC	P.41D DISCHARGE MOV SW.V31 FAILS TO OPEN
MO.SWV23.CL	CT RETURN MOV SW.V23 TRANSFERS CLOSED
MO.SWV23.FC	CT RETURN MOV SW.V23 FAILS TO OPEN
MO.SWV34.CL	CT RETURN MOV SW.V34 TRANSFERS CLOSED
MO.SWV34.FC	CT RETURN MOV SW.V34 FAILS TO OPEN
MO.SWV25.CL	P.110B DISCHARGE MOV SW.V25 TRANSFERS CLOSED
MO.SWV25.FC	P.110B DISCHARGE MOV SW.V25 FAILS TO OPEN
MO.SWV54.CL	P.110A DISCHARGE MOV SW.V54 TRANSFERS CLOSED
MO.SWV54.FC	P.110A DISCHARGE MOV SW.V54 FAILS TO OPEN
MO.SWV26.OP	P.110B BYPASS MOV SW.V26 TRANSFERS OPEN
MO.SWV27.FO	P.110B TEST RECIRC MOV SW.V27 FAILS TO CLOSE
MO.SWV27.OP	P.110B TEST RECIRC MOV SW.V27 TRANSFERS OPEN
MO.SWV55.OP	P.110A BYPASS MOV SW.V55 TRANSFERS OPEN
MO.SWV56.FO	P.110A TEST RECIRC MOV SW.V56 FAILS TO CLOSE
MO.SWV56.OP	P.110A TEST RECIRC MOV SW.V56 TRANSFERS OPEN
MO.SWV4.FO	TRAIN A SCC ISOLATION MOV SW.V4 FAILS TO CLOSE
MO.SWV5.FO	TRAIN B SCC ISOLATION MOV SW.V5 FAILS TO CLOSE
MO.SWV44.CL	UNIT 1 INTAKE TUNNEL MOV SW.V44 TRANSFERS CLOSED
MO.SWV74.OP	SCC ISOLATION TO CT MOV SW.V74 TRANSFERS OPEN
MO.SWV76.OP	SCC ISOLATION TO CT MOV SW.V76 TRANSFERS OPEN
OPTA	OPERATOR FAILS TO INITIATE COOLING TOWER OPERATION
PP.SWP110A.FR	CT PUMP P.110A FAILS TO RUN
PP.SWP110A.FS	CT PUMP P.110A FAILS TO START
PP.SWP110B.FR	CT PUMP P.110B FAILS TO RUN

Table 3.4-2 Service Water Basic Event Definitions (Continued)

Basic Event	*Description*
PP.SWP110B.FS	CT PUMP P.110B FAILS TO START
PP.SWP41A.FR	SW PUMP P.41A FAILS TO RUN
PP.SWP41A.FS	SW PUMP P.41A FAILS TO START
PP.SWP41B.FR	SW PUMP P.41B FAILS TO RUN
PP.SWP41B.FS	SW PUMP P.41B FAILS TO START
PP.SWP41C.FR	SW PUMP P.41C FAILS TO RUN
PP.SWP41C.FS	SW PUMP P.41C FAILS TO START
PP.SWP41D.FR	SW PUMP P.41D FAILS TO RUN
PP.SWP41D.FS	SW PUMP P.41D FAILS TO START
VL.SWV65.CL	SW DISCHARGE GATE VALVE SW.V65 TRANSFERS CLOSED
VL.SWV67.CL	SW DISCHARGE GATE VALVE SW.V67 TRANSFERS CLOSED
VL.SWV68.CL	SW DISCHARGE GATE VALVE SW.V68 TRANSFERS CLOSED
VL.SWV70.CL	SW DISCHARGE GATE VALVE SW.V70 TRANSFERS CLOSED
XX.OSP.XX	OFFSITE POWER UNAVAILABLE
XX.SSIGNAL.XX	SI SIGNAL PRESENT
XX.TRAINA.XX	TRAIN A SUPPORT SYSTEMS UNAVAILABLE
XX.TRAINB.XX	TRAIN B SUPPORT SYSTEMS UNAVAILABLE

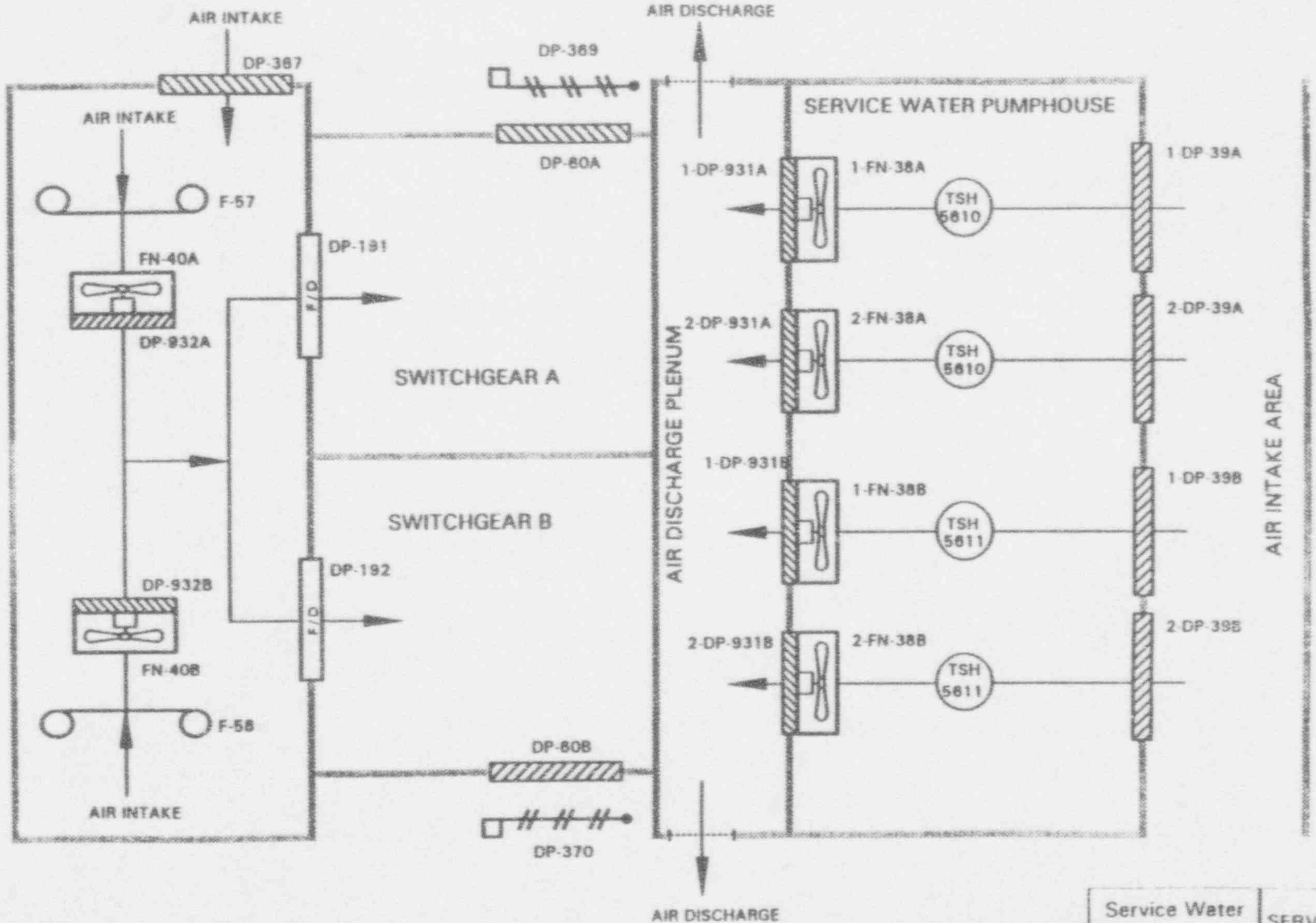


Service Water System Schematic

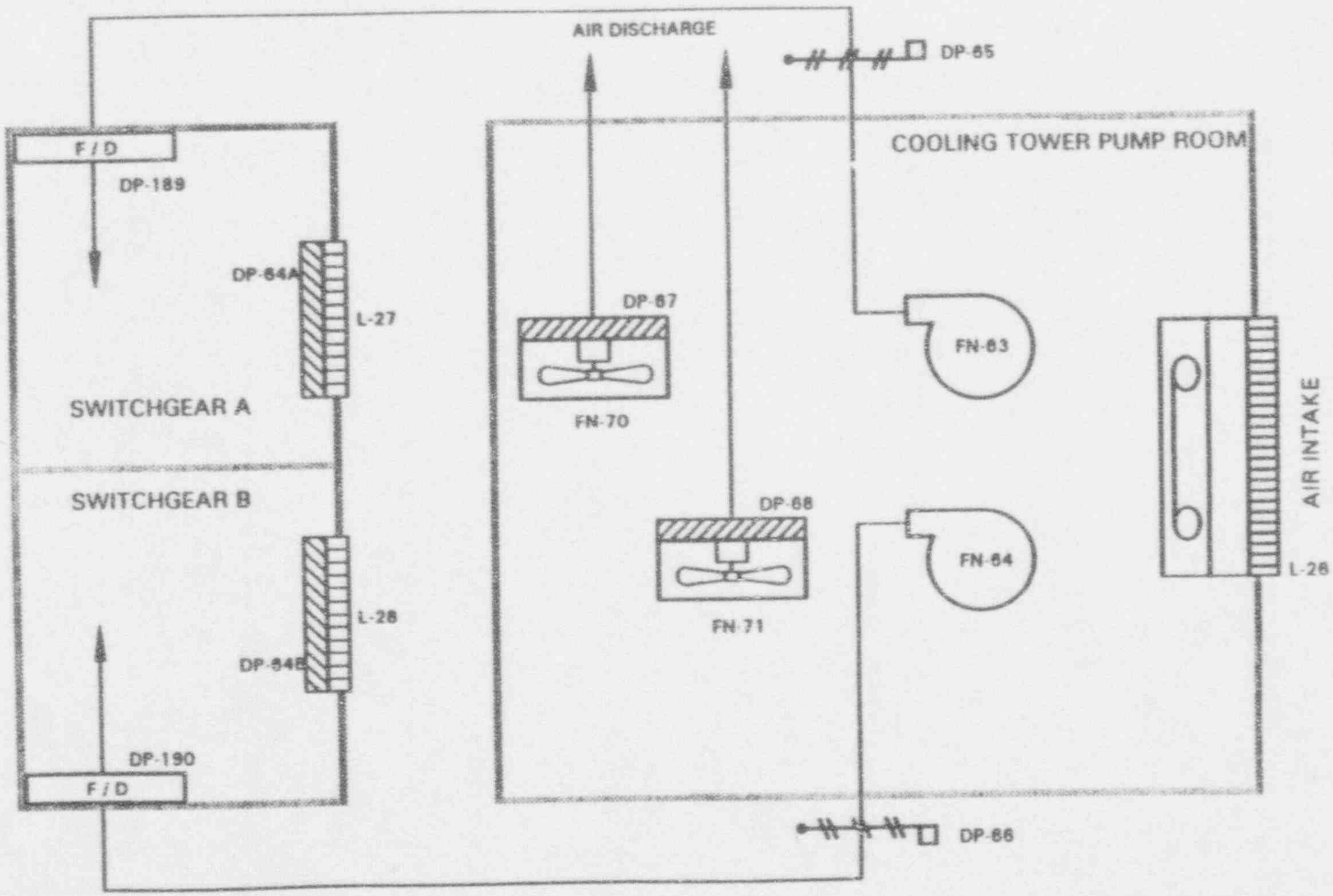
SSPSS-1993

SERVICE WATER SYSTEM

Figure 3.4-1



Service Water Pump House Ventilation	SERVICE WATER SYSTEM
SSPSS-1993	Figure 3.4-2



Cooling Tower Ventilation System	SERVICE WATER SYSTEM
SSPSS-1993	Figure 3.4-3

Attachment B - SW Maintenance Data Details

This section contains the basis of three generic data distributions used for SW maintenance duration. These are included for illustration purposes, to show the type of generic industry data that is used in this analysis. All the generic data distributions are taken from Reference 4.

• ZMPMSD	Maint. Duration	Pumps - 72 hour Tech Spec
• ZMPLSD	Maint. Duration	Pumps - 168 hour Tech Spec
• ZMPSWD	Maint. Duration	PCC / SW pumps with no LCO (modified from ZMPNSD for pumps with no LCO to account for the high priority SW and PCC pump maintenance is expected to be treated even with no LCO).