PRA EVALUATION:

CHANGE IN SERVICE WATER TECH SPEC 3.7.4

Engineering Evaluation 92-09 Rev. 2

December 1992

Prepared by Kenneth L. Kiper 12-10-92
K. L. Kiper

Reviewed by Paul J. O'Regan 12-10-92
P. J. O'Regan

Approved by J. M. Vargas 12/11/92
J. M. Vargas

PRA EVALUATION: CHANGE IN SERVICE WATER TECH SPEC 3.7.4

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.

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 the licensing design basis, the cooling tower is the seismically qualified ultimate heat sink. Thus, to define operability, one train of SW must contain one SW pump, one CT pump, and the associated flow paths to the PCC and DG heat exchangers. On that basis, a new TS has been proposed, summarized in the table below:

	Allowed Outage Time	
Components Inoperable	Current TS 3.7.4	Proposed TS 3.7.4
1 SW pump	7 d	N/A
2 SW pumps, opposite loop	72 hr	N/A
2 SW pumps, same loop	24 hr	72 hr
1 CT pump	72 hr	7 d
One loop (except for CT pump)	not explicit	72 hr

(See proposed Tech Spec 3.7.4, Attachment 1). The change for SW pumps brings this Tech Spec in line with the Standard Tech Specs, which have a 72-hour AOT for single SW train unavailability. The increase in the CT pump AOT is based on the lower risk importance of the standby CT subsystem compared to the normally operating ocean SW subsystem. Thus, a longer AOT for 1 CT pump (7 days Vs 72 hours for one SW loop) has been proposed.

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).

3.1 SW System Model

The SW system is included in the current Seabrook PRA - SSPSS-1990. 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. The maintenance contribution to the SW system model is described below (the "current" model); then the model with the change in Tech Spec is presented (the "new" model).

(1) 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:

- ocean SW pump, for each loop (7-day LCO)

  = MNT1 = MNT2

  = 2 x ZMPSWF x ZMPLSD = 0.0123
- cooling tower pump (72-hr LCO)

  = MNT3

  = 2 x ZMPMSF x ZMPMSD = 0.00260
- cooling tower fans (based on TS 3.7.5, 72-hr LCO)

  = MNT4

  = 3 x ZMPMSF x ZMPMSD = 0.00526

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

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 LCO based on actual experience, but increases with longer LCO.)

- 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.
- The maintenance contribution from pumps (and CT fans) covers unplanned maintenance from other components. Thus, no explicit maintenance contribution is modeled for valves, instrumentation, etc., that would make a loop inoperable. The pump contribution is assumed to dominate maintenance unavailability.
- 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) <u>New Maintenance Model</u>

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 train (no LCO)

  = MNT1' = MNT2'

  = 2 x ZMPSWF x <u>ZMPSWD</u> = 0.0653
- cooling tower pump (7-day LCO)

  = MNT3'

  = 2 x ZMPMSF x <u>ZMPLSD</u> = 0.00672
- cooling tower fans (based on TS 3.7.5, unchanged)

  = MNT4 (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

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.

Planned Maintenance for the standby SW pump in each train:

= MNT1(PLANNED) = MNT2(PLANNED)

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

Assumptions:

- Each SW pump is unavailable due to planned maintenance once every four years for 14 days.
- Planned maintenance is done on one pump at a time - no MNT1(PLANNED) X MNT2(PLANNED) terms.

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

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

where the terms in italic are the ones affected by the proposed TS change.

(3) 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 boundary conditions that are quantified is given below:

System Configuration	Number of Trains	LOSP Initiator	SI Signal Present	CT Included *
SW1	2		x	x
SW2	2			x
SW3	2	x		
SW4	1		x	x
SW5	1			x
SW6	1	x		
SW7	2		x	
SW8	2			
SW9	1		x	
SWA	1			

* Cooling Tower is included in the SW system assuming manual actuation. This action is credited for all initiators except loss of offsite power (LOSP), due to the short time available to restore DG cooling, and 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 (Current/New TS)			Maintenance Contribution (Percent of TOTAL)	
System Configuration	TOTAL	(Percent Change)	Unplanned Maint.	Planned Maint.
SW1	3.32E-4		<0.1 %	-
	3.32E-4	(<0.1 %)	<0.1 %	<0.1 %
SW2	3.95E-7		9.1 %	-
	4.67E-7	(18.1 %)	19.3 %	3.8 %
SW3	7.90E-4		2.2 %	-
	8.50E-4	(7.6 %)	7.1 %	2.1 %
SW4	4.34E-3		0.2 %	-
	4.35E-3	(0.2 %)	0.4 %	<0.1 %
SW5	6.01E-5		15.7 %	-
	7.02E-5	(16.8 %)	25.7 %	2.1 %
SW6	1.34E-2		1.3 %	-
	1.40E-2	(4.4 %)	4.2 %	1.2%
SW7	3.70E-4		0.5 %	-
	3.76E-4	(1.6 %)	1.6 %	0.5 %
SW8	4.09E-5		4.3 %	-
	4.69E-5	(14.6 %)	12.7 %	<0.1 %
SW9	5.57E-3		0.7 %	-
	5.70E-3	(2.3 %)	2.3 %	0.7 %
SWA	1.29E-3		3.0 %	-
	1.42E-3	(10.3%)	9.3 %	2.7 %

The results at the system level indicate that, for about half the cases, the change in Tech Specs generally has a insignificant impact on system unavailability. Of the others, the most significant changes are for SW2, SW5, SW8, and SWA which are all normal configuration cases, i.e. offsite power available and no SI signal present. For these cases, the pump failure terms are important and, consequently, increasing pump maintenance unavailability affects the total. For the other system

configurations, the system unavailability is dominated by failure of valves to close to isolate the non-safety loads given a LOSP or SI signal. For these cases, pump maintenance is a relatively small contribution to total system unavailability. Increasing this small contribution results in small changes in system unavailability.

Thus, the impact of the Tech Spec change on SW system unavailability is dependent on the boundary conditions. To evaluate how important the various boundary conditions are to risk, these results are integrated into the plant model below.

3.2 Initiating Event Frequency

Loss of either train of SW would affect the plant power generation through PCC cooling to the RCP motors. 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 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 TS change. In addition, no credit is given for operator action to start the Cooling Tower in time to prevent the shutdown.)

The equation for loss of one SW train can be written, in general, as follows:

L1SW = F(PA)*T(yr) * F(PC)*T(repair) + F(PA)*T(yr) * M(PC)

where:

F(PA) = failure rate for operating SW pump (A) to continue to run,

F(PC) = failure rate for standby SW pump (C) to start and run while pump A is being repaired,

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,

M(PC) = pump C unavailability due to planned and unplanned maintenance.

The last two term are the ones that change due to the new TS AOT, as follows:

	Current TS Model	New TS Model
T(repair)	ZMPLSD	ZMPSWD
M(PC)		
Planned Maint.	none	2*(1/4)*(1/8760)*336
Unplanned Maint.	ZMPSWF*ZMPLSD	ZMPSWF*ZMPSWD

where the variables are defined earlier.

The results are given below:

L1SW	Initiator Frequency	Maintenance Contribution (Percent of TOTAL)	
	TOTAL	Unplanned Maint.	Planned Maint.
Current TS Model	5.47E-3 per yr	44.2 %	-
New TS Model	1.83E-2 per yr	67.8 %	20.9 %

Thus, the initiator frequency increases by about a factor of 3. This large increase is due to the significance of maintenance in the current model.

3.3 Quantitative Results - Core Damage Frequency

As a result of the change in TS, the CDF (mean) changes by about 2.5E-6 per year, or 2.3 % increase in the total (1.12E-4/yr). This change is due about equally to the following impacts:

- System unavailability (1.0 %)
- Initiating event frequency (1.3 %)

This is a change in the mean value from 1.12E-4 to 1.14E-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.

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.