ArevaEPRDCPEm Resource

From: BRYAN Martin (EXTERNAL AREVA) [Martin.Bryan.ext@areva.com]
Sent: Thursday, September 23, 2010 6:20 PM
To: Tesfaye, Getachew
Cc: GARDNER Darrell (AREVA)
Subject: FW: RAI 351 Q 09.02.05-27 DRAFT response
Attachments: RAI 351 Supplement 2 Q 9.2.5-27 Response HEE 9-23-10.doc; RAI 351 Q 9.2.5-27 MU T1 tbl 2.7.11-3.pdf; RAI 351 Q9.2.5-27 MU 9-22-10.pdf; RAI 351 Q 9.2.5-27 MU T2 tbl 9.2.5-1.pdf; RAI 351 Q -27 resp MU Inserts 9-23-10.doc

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

From: EDWARDS Harold (EP/PE)
Sent: Thursday, September 23, 2010 5:12 PM
To: GARDNER Darrell (RS/NB); BRYAN Martin (External RS/NB)
Cc: HARTSELL Jody (EP/PE); HUDDLESTON Stephen (EP/PE); BRYANT Chad (EP/PE); BALLARD Bob (EP/PE); KOWALSKI David (RS/NB)
Subject: RAI 351 Q 09.02.05-27 DRAFT response

Darrell,

Attached are the DRAFT response to RAI 351 Question 09.02.05-27, markups and inserts. This is for first round review by NRC.

Harold E. Edwards (Gene), PE

Advisory Engineer

AREVA NP Inc.
7207 IBM Drive, CLT 3C

Charlotte, North Carolina 28262

Phone: 704-805-2340

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Created By: Martin.Bryan.ext@areva.com

Recipients:
"GARDNER Darrell (AREVA)" <Darrell.Gardner@areva.com>
Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

Post Office: AUSLYNCMX02.adom.ad.corp

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RAI 351 Supplement 2 Q 9.2.5-27 Response HEE 9-23-10.doc	67136	
RAI 351 Q 9.2.5-27 MU T1 tbl 2.7.11-3.pdf	111560	
RAI 351 Q9.2.5-27 MU 9-22-10.pdf	222616	
RAI 351 Q 9.2.5-27 MU T2 tbl 9.2.5-1.pdf	76053	
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Response to

Request for Additional Information No. 351, Supplement 2

01/15/2010

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 09.02.05 - Ultimate Heat Sink
SRP Section: 09.05.01 - Fire Protection Program

Application Section: FSAR Chapter 9

QUESTIONS for Balance of Plant Branch 1 (AP1000/EPR Projects) (SBPA)

Question 09.02.05-27:

Follow-up to RAI 175, Question 9.2.5-09:

In order to satisfy system flow requirements, the ultimate heat sink (UHS) design must assure that the minimum net positive suction head (NPSH) for the essential service water system (ESWS) pumps will be met for all postulated conditions, including consideration of vortex formation. Standard Review Plan (SRP) 9.2.5 Section III, paragraph 3.C specifies confirmation that the maximum design cooling water temperature is not exceeded under the worst combination of adverse environmental conditions, in conjunction with a design basis accident. Final Safety Analysis Report (FSAR) Tier 2 Table 9.2.5-1 indicates the maximum required ESWS design basis accident (DBA) temperature is 35˚C (95˚F) and FSAR Tier 2 Section 16 Technical Specification Surveillance Requirement (SR) 3.7.8.2 requires UHS basin temperature during plant operation to be maintained less than or equal to 32.2˚C (90˚F). This indicates that the maximum basin temperature increase during worst case design basis conditions is 2.8˚C (5˚F). However, there is no explanation of the relationship between these temperatures or the calculation basis used to determine the 2.8˚C (5˚F) temperature increase in FSAR Section 9.2.5. As such, the following questions are provided:

1. Provide key assumptions and inputs in FSAR Section 9.2.5 for calculations that establish the basis and define design margin for the minimum basin water level, maximum basin volume loss and maximum temperature increase during the first 72 hours when basin water makeup is assumed to be lost and after the minimum makeup water flow (300 gpm) is established; include consideration of vortex formation. These calculations should be made available for staff audit
2. Provide the heat load associated with ESWS pump mechanical work and ESWS pump room cooler in this analysis. The heat loads/flows should be listed in FSAR Tier 2 Table 9.2.5-1.
3. Provide an explanation in FSAR Tier 2 Section 9.2.5 for; (1) the relationship between 32.2˚C (90˚F) and 35˚C (95˚F), (2) the analysis used to determine the accident temperature increase and why it is conservative.
4. Provided in FSAR Tier 1 Section 2.7.11 the maximum temperature for the cooling tower water volume.

Based on the staff's review of the applicant's response to RAI 9.2.5-09 (ID1817/6804) AREVA #175, Supplement 2, the following were determined as unresolved and needed further clarification/resolution by the applicant.

The response to Item 1 referred to FSAR Tier 2 Section 9.2.1 (AREVA RAI No. 119, Question 9.2.1-08) for establishing the minimum cooling tower basin water level. However, this information needs to be included or referenced in FSAR Tier 2 Section 9.2.5. In addition to the meteorological conditions in FSAR Tier 2 Table 2.1-3 that are referred to, the methodology and key analytical assumptions and inputs (including excess margin and conservatisms) that were used in establishing the total water usage over the most limiting 72 hour period need to be described in FSAR Tier 2 Section 9.2.5. The FSAR description needs to specify what this water volume is. Also, the minimum required cooling tower basin water level needs to be established and specified in FSAR Tier 2 Section 9.2.5 by adding the minimum required water usage volume to the minimum water level that is needed to satisfy essential service water pump NPSH and vortexing considerations. Similarly, the methodology and key analytical assumptions and inputs (including excess margin and conservatisms, and information provided in FSAR Tier 2

Table 2.1-4) that were used in establishing the maximum increase in the basin water temperature, and what this maximum temperature is, needs to be described in FSAR Tier 2 Section 9.2.5.

With regard to Item 2, the response only addressed the heat rejected by the essential service water pump air cooled motor and did not address heat input due to pump mechanical work. As noted in guidance provided by SRP 9.2.5 Paragraph III.1A, pump mechanical work is one of the UHS heat inputs considered by the design. Since the ESWS pumps are relatively large, the energy imparted to the pumped fluid as heat should be included with the other UHS heat loads. In contrast, pump motor ambient heat should be included in the ESWS pump room cooler heat load. These heat load inputs need to be described and included in the FSAR along with the other heat loads that have been identified and addressed.

With regard to Item 3, in response to part (1) the applicant explained that the UHS basin temperature is maintained less than or equal to 32.2 °C (90 °F) during normal plant operation so that the maximum UHS basin temperature for the duration of a DBA of 35 °C (95 °F) is not exceeded. The associated markup of FSAR Tier 2 Section 9.2.5 needs to be expanded to make it clear what 35 °C (95 °F) represents (e.g. the maximum design basis UHS basin temperature for the duration of a DBA). Also, the basis for all ESWS temperatures that are listed in Table 9.2.5-1 needs to be included in the FSAR Tier 2 description.

In response to part (2) of Item 3, the applicant explained that the maximum basin temperature was based on an (81 °F) wet bulb temperature with 1 percent exceedance, and that it was highly unlikely that these climate conditions could occur simultaneously with a DBA. However, the staff considers the 1 percent exceedance wet bulb temperature to be nonconservative for this application because higher temperatures that are less than two hours in duration can cause UHS temperature limits to be exceeded. Additionally, the staff noted that use of this 1 percent exceedance value appears to be inconsistent with the information provided in FSAR Tier 2 Table 2.1-4. Therefore, additional explanation and justification is needed to ensure that temperature assumptions are conservative.

Response to Question 09.02.05-27:

Item 1

Analytical results confirm that the minimum submergence level for the essential service water pump to prevent vortex effects is the limiting condition for determining the minimum water level in the cooling tower basin.

The 72 hour basin water volume is the minimum water volume that must be present in the basin to accommodate system water inventory losses experienced due to UHS Cooling tower operation during a Design Basis Accident (DBA). The required volume is determined based on water losses under the worst case environmental conditions and with the essential service water (ESW) heat load during a DBA for a 72-hour period, without incurring pump vortexing during this period.

UHS Cooling tower blowdown is automatically secured during the initial 72-hour post-accident period through system instrumentation and control design features. As a result, the only significant system water inventory losses are due to evaporation, cooling tower drift, valve seat leakage, and seepage.

Meteorological conditions resulting in the maximum evaporative loss of water for the UHS over a 72-hour period are represented in U.S. EPR FSAR, Tier 2, Table 2.1-3, Design Values for Maximum Evaporation and Drift Losses of Water from the UHS (this table will be moved to Tier 2, Table 9.2.5-3 in Revision 2 of the U.S. EPR FSAR).

Response to RAI 119 Question 09.02.01-17 provides a figure that details the various UHS Tower basin water levels and respective margins. This figure was added to U.S. EPR FSAR Tier 2, Section 9.2.5 per RAI 345, Question 09.02.01-41. A margin of 6" was applied for the minimum pump submergence and a 10" margin for the 72-hour water volume. Drift loss from the UHS tower is 0.005%; however, a conservative 0.10% was used in the analysis. The valve leakage is calculated assuming all isolated valves leak simultaneously at a maintained rate of 0.5 D (inch) gpm. The 30 day seepage loss is 360,000 lbm and a 3-day seepage loss of 40,000 lbm was chosen for this analysis. This analysis also assumes that ESW pumps operate at design flow for the 72-hour duration. A water height of 21" is provided above the technical specification height required to account for the operating band and other instrument margins. Also 6" is provided for freeboard.

The maximum temperature increase during the first 72 hours assumes each ESW train consists of a two-cell cooling tower, where both cells share a common water storage basin. One ESW pump serves each ESW train, and the flow is assumed to be evenly split between the two cells of the cooling tower. Two of the four ESW trains are assumed to operate following the DBA. The fans in both cells of the cooling tower are assumed to operate at full speed for the 72-hour duration.

The cooling tower basin water volume required for the most limiting 72 hour period is currently provided in FSAR Tier 2, Table 9.2.5-2. Additionally, the minimum required cooling tower basin water level for pump operation is provided in Table 9.2.5-2.

Item 2

The mechanical work done by the UHS Cooling Tower Basin Pump during normal, cooldown, and DBA operations is 2.80 MBtu/hr (820 kW). This value will be added to FSAR Tier 2 Table 9.2.5-1. Table 9.2.5-1 heat load values are revised as indicated in the response to RAI 406 Question 09.02.02-110. U.S. EPR FSAR Tier 1, Table 2.7.11-3, Item 7.1 will be revised in accordance with the revised CCWS heat load value and include the ESW pump mechanical work. The corresponding insert supersedes the markup and acceptance criteria stated in the response to RAI 345, Question 09.02.01-45. The pump motor ambient heat is included in the ESWS pump room cooler heat load in FSAR Tier 2 Table 9.2.5-1. These numbers assume that the pump is operating at the maximum horsepower.

Item 3, Part 1

The RAI 175 Supplement 2, Question 09.02.05-9 markup of FSAR Tier 2 Section 9.2.5.4 will be expanded to indicate that 95 °F is the maximum design basis UHS basin temperature for the duration of a DBA. Also it will be expanded to indicate that normal UHS basin temperature of less than or equal to 90 °F and DBA UHS basin temperature of less than or equal to 95 °F are the bases for ESWS temperatures listed in FSAR Table 9.2.5-1. As indicated in the response to RAI 406 Question 09.02.02-110, a value of 92 °F normal ESWS temperature is used for sizing the CCWS heat exchanger.

Item 3, Part 2

The maximum basin temperature is based on an 81°F Wet Bulb temperature with a zero percent exceedance which is the most conservative design for this application and is consistent with FSAR Tier 2, Table 2.1-4, Design Values for Minimum Water Cooling of the UHS (this table will be moved to Tier 2, Table 9.2.5-4 in Revision 2 of the U.S. EPR FSAR). The previous response incorrectly listed the 81°F WBT is with a 1 percent exceedance.

FSAR Impact:

U.S. EPR FSAR Tier 1, Table 2.7.11-3 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Sections 9.2.5.3.3, 9.2.5.4 and Table 9.2.5-1 will be revised as described in the response and indicated on the enclosed markup.

Table 2.7.11-3—Essential Service Water System ITAAC (6 Sheets)

Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
5.1	The components designated as Class 1E in Table 2.7.11-2 are powered from the Class 1E division as listed in Table 2.7.11-2 in a normal or alternate feed condition.	a. Testing will be performed for components designated as Class 1E in Table 2.7.11-2 by providing a test signal in each normally aligned division. b. Testing will be performed for components designated as Class 1E in Table 2.7.11-2 by providing a test signal in each division with the alternate feed aligned to the divisional pair.	a. The test signal provided in the normally aligned division is present at the respective Class 1E component identified in Table 2.7.11-2. b. The test signal provided in each division with the alternate feed aligned to the divisional pair is present at the respective Class 1E component identified in Table 2.7.11-2.
5.2	Valves listed in Table 2.7.11-2 fail as-is on loss of power.	Testing will be performed for the valves listed in Table 2.7.11-2 to fail as-is on loss of power.	Following loss of power, the valves listed in Table 2.7.11-2 fail as-is.
5.3	Deleted.	Deleted.	Deleted.
5.4	Items identified in Table 2.7.11-2 as "Dedicated" ESWS motor-operated components are capable of being supplied by a SBODG.	Testing will be performed for motor-operated components designated as "Dedicated" in Table 2.7.11-2 by providing a test signal with the SBODG.	The test signal provided by the SBODG is present at the respective "Dedicated" component identified in Table 2.7.11-2.
6.1	Deleted.	Deleted.	Deleted.
7.1	The ESWS UHS as listed in Table 2.7.11-1 has the capacity to remove the design heat load from the CCWS and EDG heat exchangers, and the ESWPBVS room cooler.~~The ESW UHS as listed in Table 2.7.11-1 has the capacity to remove the design heat load from the CCWS.~~	Tests of the UHS and inspection of a heat exchanger/cooler data report ~~Tests and analyses~~ will be performed to demonstrate the capability of the ESWS UHS as listed in Table 2.7.11-1 to remove the design heat load from CCWS and EDG heat exchangers and the ESWPBVS room cooler.	A report exists and concludes that ~~The~~ the ESWS UHS has the capacity to remove ~~at least~~ the total design heat load of 3.139+08 BTU/hr from the CCWS and EDG heat exchangers and the ESWPBVS room cooler.~~of 2.913 E+08 BTU/hr.~~

UHS cooling tower fill is constructed of ceramic tile, supported on reinforced concrete beams. Spray piping and nozzles are fabricated of corrosion resistant materials (e.g., stainless steel, bronze). UHS cooling tower internals are seismically designed and supported to withstand a safe shutdown earthquake (SSE). Passive failures of the cooling tower spray or fill systems are considered extremely unlikely due to their materials of construction, supporting systems and Seismic Category I design.

To prevent the entrainment of debris from the UHS cooling tower, each cell of the UHS cooling tower includes a debris screen located between the cooling tower internals and the ESW pump.

To account for potential interference effects of the cooling towers, an inlet wet bulb correction factor is used. As part of addressing Item 2.0-1 of Table 1.8-2, the COL applicant that references the U.S. EPR design certification will evaluate their site-specific conditions of orientation (with respect to wind direction), location, wind velocity, and direction to determine a wet bulb correction factor to account for interference effects.

To account for potential recirculation effects of the cooling towers, an inlet wet bulb correction factor is used. As part of addressing Item 2.0-1 of Table 1.8-2, the COL applicant that references the U.S. EPR design certification will evaluate their site-specific location to determine a wet bulb correlation factor to account for recirculation effects.

Each cooling tower basin is sized to provide for a minimum 72-hour supply of cooling water to the associated ESW division under design basis accident (DBA) conditions assuming loss of normal makeup water capability.

9.2.5.3.2 Piping, Valves, and Fittings

System materials are selected that are suitable to the site location, UHS fluid properties and site installation. System materials that come into contact with one another are chosen to minimize galvanic corrosion. All safety-related piping, valves, and fittings are in accordance with ASME Code Section III, Class 3 (Reference 1).

Inservice testing of valves will be performed as described in Section 3.9.6.3. Leakage rates for boundary isolation valves that require testing are based on ASME OM Code, Subsection ISTC (Reference 2).

9.2.5.3.3 Cooling Tower Basin

The 72-hour basin water volume is the minimum water volume that must be present in a basin to accommodate system water inventory losses experienced in the basin due to ultimate heat sink (UHS) tower operation under the worst case environmental conditions, and with the highest essential service water (ESW) heat load for a 72-hour period, without incurring pump damage during operation.

UHS tower blowdown is automatically secured during the initial 72-hour post-accident period through system instrumentation and control design features, so the only significant system water inventory losses are due to evaporation, tower drift, and valve seat leakage and seepage.

Meteorological conditions resulting in the maximum evaporative and drift loss of water for the UHS over a 72-hour period are presented in Table 9.2.5-3—Design Values for Maximum Evaporation and Drift Loss of Water from the UHS.

Meteorological conditions for the U.S. EPR that result in minimum cooling tower cooling that are the worst combination of controlling parameters (wet bulb and dry bulb), including diurnal variations for the first 24 hours of a DBA LOCA, are presented in Table 9.2.5-4 and do not result in a maximum ESWS supply temperature from the UHS basin exceeding 95°F.

9.2.5.4 System Operation

The safety related ESWS pumps cooling water from the cooling tower basin to supply ESWS loads and back to the mechanical draft cooling tower. The four safety-related divisions of the UHS are powered by Class 1E electrical buses and are emergency powered by the emergency diesel generators (EDG).

The non-safety-related dedicated ESWS pumps cooling water from the division four cooling tower basin to the dedicated system heat load and back to the division four mechanical draft cooling tower during SA and beyond DBAs.

The cooling tower fans are driven with multi-speed drives that are capable of fan operation in the reverse direction. Consistent with vendor recommendations, the fan may be operated in the reverse direction for short periods to minimize ice buildup at the air inlets. Cooling tower fans operating in the reverse direction during normal operation are considered operable at the onset of a design basis accident (DBA). Upon receipt of a safety injection (SI) signal, any fans operating in the reverse direction are secured and brought to a complete stop before re-energizing to operate at full speed in the forward direction. Upon receipt of an SI signal, fans in the operating and standby trains are automatically set to full fan speed to dissipate the maximum heat load to the environment. The cooling tower bypass piping provides a means for diverting ESW return flow directly to the tower basin under low load/low ambient temperature conditions to maintain ESW cold water temperature within established limits and to protect against freezing.

Based on the increase in heat removal during a DBA, a temperature of less than or equal to 90°F is maintained in the UHS basin during normal operation, so that the cooling tower basin temperature does not exceed 95°F.

9.2.5.5 Safety Evaluation

The UHS pump buildings and cooling towers are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles and other natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7 and Section 3.8 provide the basis for the adequacy of the structural design of these structures. The aboveground piping and components are protected by the structures.

The UHS is designed to remain functional after a safe shutdown earthquake (SSE). Section 3.7 and Section 3.9 provide the design loading conditions that are considered. Section 3.5, Section 3.6 and Section 9.5.1 provide the hazards analyses to verify that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

The four division design of the UHS provides complete redundancy; therefore a single failure will not compromise the UHS system safety-related functions. Each division of UHS is independent of any other division and does not share components with other divisions or with other nuclear power plant units.

Considering preventative maintenance and a single failure, two UHS divisions may be lost, but the ability to achieve the safe shutdown state under DBA conditions can be reached by the remaining two UHS divisions. In case of LOOP the four UHS cooling towers have power supplied by their respective division EDGs. Isolation valves can isolate non-safety-related portions of the system if necessary without compromising the safety-related function of the system.

The cooling towers must operate for a nominal 30 days following a LOCA without requiring any makeup water to the source or it must be demonstrated that replenishment or use of an alternate or additional water supply can provide continuous capability of the heat sink to perform its safety-related functions. The tower basin contains a minimum 72-hour supply of water. After the initial 72 hours, the site--specific emergency makeup water system will provide sufficient flow rates of makeup water to compensate for system volume losses for the remaining 27 days. The normal and emergency blowdown isolation valves provide automatic isolation of the ESWS from downstream non-safety-related blowdown piping under DBA conditions to prevent loss of ESW inventory. The ESW emergency makeup water system also provides isolation of the normal makeup water system from the tower basins under DBA conditions to prevent loss of ESW inventory.

The heat load after 72 hours post-DBA is lower than the peak heat load due to a reduction in the decay heat from the reactor. Consequently, the makeup flow rate required after 72 hours is lower than the peak condition. Since the UHS basin contains

RAI 406; Q 9.2.2-110

Table 9.2.5-1—Ultimate Heat Sink System Interface

Component	Max Heat Load MBTU/hr	Total Required ESW Flow (10^6 lb_m/hr)	Required ESW Temperature	Comments
CCWS heat exchanger	128.1	7.540 min	≤92°F	Normal Operation
	120.1	7.540 min	≤90°F	Spring/Fall Outage Cooldown
	293.35 (1) ~~291.3~~	7.540 min	≤95°F	DBA
Dedicated CCWS heat exchanger	~~48.64~~ 51.2 (nominal)	~~1.205~~ min 1.102	≤95°F	Severe Accident
EDG heat exchanger	22.0	1.06	≤95°F	
ESW pump room cooler for 31/32/33/34 UQB	0.619	~~137.6 gpm~~0.0685	≤ 95°F	Normal Operations Shutdown/ Cooldown and DBA
ESW pump room cooler for 34 UQB	0.314	~~69.8 gpm~~0.0347	≤ 95°F	Severe Accident - ESW flow supplied by dedicated ESW pump

Notes:

1. The CCWS heat exchanger load on the UHS in DBA is equal to the LHSI DBA heat load of 241 x 10^6 Btu/hr in Table 9.2.2-2 plus the additional loads from the CCWS common users.

RAI 351, Q 09.02.05-27, response MU Inserts

9.2.5.3.3 Cooling Tower Basin

INSERT 1 FOR U.S EPR FSAR 9.2.5.3.3:

The 72 hour basin water volume is the minimum water volume that must be present in the basin to accommodate system water inventory losses experienced in that basin due to UHS Cooling tower operation during a Design Basis Accident. The required volume is determined based on water losses under worst case environmental conditions with the highest ESW heat load during a Design Basis Accident for a 72 hour period without incurring pump vortexting during operation. Inventory losses consist of evaporation losses, tower drift losses as well as valve seat leakage and seepage.

A margin of 6” was applied for the minimum pump submergence and a 10” margin for the 72-hour water volume. Drift loss from the UHS tower is 0.005%; however, a conservative 0.10% was used in the analysis. The valve leakage is calculated assuming all isolated valves leak simultaneously at a maintained rate of 0.5 D (inch) gpm. The 30 day seepage loss is 360,000 lbm and a 3-day seepage loss of 40,000 lbm was chosen for this analysis. This analysis also assumes that ESW pumps operate at design flow for the 72-hour duration. A water height of 21” is provided above the technical specification height required to account for the operating band and other instrument margins. Also 6” is provided for freeboard.

UHS Cooling tower blowdown is automatically secured during the initial 72 hour post-accident period through system instrumentation and control design features. As a result, the only significant system water inventory losses are due to evaporation, cooling tower drift, valve seat leakage, and seepage.

INSERT 2 FOR U.S EPR FSAR Section 9.2.5.4:

95 °F is the maximum design basis UHS basin temperature for the duration of a DBA. The normal UHS basin temperature of less than or equal to 90 °F and DBA UHS basin temperature of less than or equal to 95 °F are the bases for ESWS temperatures listed in FSAR Table 9.2.5-1. A value of 92 °F normal ESWS temperature is used for sizing the CCWS heat exchanger.

INSERT 3 FOR U.S EPR FSAR Table 9.2.5-1:

ESW Pump PEB 10/20/30/40 AP001	2.80	N/A	N/A	Normal Operations/Cooldown/ and DBA