ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Friday, November 20, 2009 6:43 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 310 (3709), FSARCh. 6
Attachments: RAI 310 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 310 Response US EPR DC.PDF" provides technically correct and complete responses to 3 of the 3 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 310 Question 06.03-12.

The following table indicates the respective pages in the response document, "RAI 310 Response US EPR DC.PDF," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 310 — 06.03-12	2	3
RAI 310 — 06.03-13	4	4
RAI 310 — 06.03-14	5	7

This concludes the formal AREVA NP response to RAI 310, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Ronda Pederson
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Sent: Wednesday, October 21, 2009 6:11 PM
To: ZZ-DL-A-USEPR-DL
Cc: Budzynski, John; VanWert, Christopher; Donoghue, Joseph; Carneal, Jason; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 310 (3709), FSARCh. 6

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on October 9, 2009, and on October 21, 2009, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
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Response to

Request for Additional Information No. 310 (3709), Revision 0

10/21/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.03 - Emergency Core Cooling System
Application Section: 6.3

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

Question 06.03-12:

Gas Accumulation

Section 6.3 of the US EPR FSAR refers to certain design features of the ECCS piping systems as “continuously vented” to prevent the accumulation of gases without any descriptions of such feature. Section 5.4.7 also refers to “self venting” as a piping system design feature to preclude “water hammer” events by assuring the safety injection system is always full of water. Again there is not a description of the feature. These features suggest possible protection against ECCS pump suction cavitation ECCS and voiding conditions during shutdown cooling operations to meet regulatory requirements such as GDC 4 and GL 2008-01. During the staff’s audit at the AREVA offices in Rockville, MD on June 23, 2009 of the isometric drawings of the ECCS the staff noted with concern the absence of venting and draining capability, protection against the development of loop seals and areas for gas accumulation. Gas accumulation can cause water hammer, gas binding in pumps, and inadvertent relief valve actuation that may damage pumps, valves, piping, and supports and may lead to loss of system operability. Most recently this has been addressed by GL 2008-01.

AREVA personnel in attendance at the audit stated that the design of the ECCS has not been completed and that additional design provisions would be added to the ECCS system in the final design stage to address the staff’s concerns expressed above to assure compliance with GDC 4 and GL 2008-01. In addition, the applicant should address the following questions:

Have potential pathways for gas intrusion in the ECCS (CS/RHR) system been evaluated? If so, identify the pathways. What design features are present in the EPR which prevents or controls gas accumulation to acceptable levels to ensure CS/RHR system operability? Does the design include any means of detecting unacceptable levels of gas accumulation? Describe the ITAAC test conditions for the CS/RHR pumps, NPSH (Tier 1, Table 2.4.5-5, 8f) test. Explain why these test conditions are conservative especially with regard to gas entrainment and its effect on NPSH.

Response to Question 06.03-12:

The following are potential pathways for gas intrusion in the U.S. EPR safety injection system and residual heat removal system (SIS/RHRS):

- Open connections to the in-containment refueling water storage tank (IRWST) via safety injection suction lines during system standby.
- Open connections to the IRWST via both the low head safety injection (LHSI) and medium head safety injection (MHSI) miniflow lines (i.e., discharge piping located above the IRWST level) during system standby. The open connections are susceptible to possible drainage to the IRWST (i.e., siphoning) via leakages from piping or equipment (e.g., valves, flow restrictors, flow and pressure measurements).
- Open connections to the containment atmosphere via residual heat removal system (RHRS) suction lines during reactor coolant system (RCS) mid-loop operation (i.e., refueling).
- Possible gas leakages from SIS accumulators to SIS discharge lines.

- Possible steam pockets produced via thermal conduction from the RCS, between the first two reactor coolant pressure boundary (RCPB) isolation valves in the SIS discharge lines, and in the RHRS suction lines from the RCS.

The following design features of the U.S. EPR SIS/RHRS prevent or control gas accumulation to acceptable levels in order to confirm system operability:

- Continuous venting of the safety injection suction lines (for both LHSI and MHSI) via continuous sloping of pipes.
- Vortex suppression grids arranged inside the SIS sumps to prevent vortex formation when the SIS pumps are taking suction from the IRWST.
- No flange on piping or equipment located above the minimum IRWST operating level to prevent gas intrusion.
- Continuous venting of the RHRS suction lines via continuous sloping of pipes.
- Numerous safety-related pressure and level sensors (wide and narrow ranges) available on SIS accumulators to inform the operator of potential gas leakage from the accumulators.
- An elevation difference of more than 10 ft between each SIS accumulator nozzle and the corresponding SIS accumulator check valve to minimize potential gas leakage from the nitrogen blanket of the accumulator to the SIS cold leg discharge line.
- Continuous pressurization of the RCPB lines by the SIS accumulators during system standby to prevent steam pockets from developing as a result of heat transfer from the RCS.
- Vent lines located at piping high points.

Vent lines placed at piping high points precludes the accumulation of unacceptable levels of gas in the U.S. EPR SIS/RHRS. Periodic surveillance of emergency core cooling system (ECCS) piping (e.g., Technical Specification, Surveillance Requirement, Section 3.5.2.2) is performed to prevent water hammer and gas accumulation to unacceptable levels.

The LHSI and MHSI pumps are tested for conditions with suction from a minimum IRWST level under maximum flow, and discharge into a minimum reactor vessel level. The LHSI pumps are also tested with suction from an RCS mid-loop level under maximum flow conditions. U.S. EPR FSAR Tier 2, Section 14.2.12.2.2, Section 14.2.12.2.4, and Section 14.2.12.2.5 describe the initial plant test program. U.S. EPR FSAR Tier 2, Section 14.2.12.2.4 will be revised to describe the NPSH test for the LPSI pumps at minimum suction level. The ITAAC test shall prescribe to the aforementioned initial test program.

The initial plant test conditions for the LHSI and MHSI pumps provide the most conservative result with regards to the available NPSH due to the maximum pump flow and minimum suction levels, which also induce the largest potential for gas entrainment.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 14.2.12.2.4 will be revised as described in the response and indicated on the enclosed markup.

Question 06.03-13:

Surveillance Requirement

Surveillance Requirement (SR) of FSAR Chapter 16 – SR 3.5.2.2 requires verification every 31 days that the ECCS is full of water, an NPSH and water hammer issue. During the staff's audit on June 10, 2009 of AREVA's engineering evaluation of the NPSHA versus NPSHR for the ECCS pumps the staff asked about the design features of the ECCS that accommodate the verification process of SR 3.5.2.2 related to GDC 4. Please confirm the current features of the ECCS that allow the verification of SR 3.5.2.2 during all modes of plant operations to assist in compliance with GDC 4.

Response to Question 06.03-13:

The U.S. EPR safety injection system and residual heat removal system (SIS/RHRS) will have vent lines located appropriately at piping high points to perform Technical Specification, Surveillance Requirement, SR 3.5.2.2 during all modes of plant operations.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.03-14:

NPSH

During the staff's audit on June 10, 2009 of AREVA's engineering evaluation of the NPSHA versus NPSHR for the ECCS pumps AREVA NP, Inc. AREVA Document No. 32-9017755-004 Calculation Summary Sheet: "US EPR Safety Injection System Analysis for Design Certification" was used by the staff to reach certain conclusions and understandings related to AREVA's methodology for NPSH calculations. Information contained in this document partial supports the bases of the staff's regulatory decisions on the determination of adequate NPSHA for the pumps of the ECCS. This document is "Proprietary" to AREVA and the staff requests that it be submitted on the US EPR™ Design Certification Application Docket No. 05200020 as a potential reference in the staff's Final Safety Evaluation Report.

In addition, please confirm that the bases of the NPSH calculational results reported in the above AREVA document are unique to the US EPRTM (and were not developed for similar, but different designs such as the Finish design at OL-3) as presented in other information already on Docket No. 05200020.

In the NPSH analysis, NPSH values were calculated assuming 212°F; however, in Figure 6.3-7, "IRWST LOCA Temperature Response," the maximum temperature is approximately 230°F about 3 hours into the event. Provide a discussion to support your assumption of 212°F instead of the maximum temperature. Include all assumptions made to support your NPSH analysis.

Response to Question 06.03-14:

The bases of NPSH calculational results reported in AREVA Document No. 32-9017755-004 (Reference 1) are unique to the U.S. EPR design and were not developed for similar, but different designs (e.g., European OL3 design). The analysis in Reference 1 was specific to the U.S. EPR design.

In the NPSH analysis, no credit was taken for containment pressurization; therefore, saturation conditions were used at 1.0 atmosphere. The NPSH margin at 212ºF (saturated) is less than higher temperatures because of the increased pressure loss due to debris. Therefore, 212ºF was conservatively used instead of the calculated maximum IRWST temperature of 230ºF.

To determine the worst case of low head safety injection (LHSI) net positive suction head (NPSH) margin, the large break loss-of-coolant accident (LBLOCA) scenario was rerun using four different combinations of pump performance and system resistance. For these cases, the pump performance and system resistance are varied. "Enhanced" system performance results from decreased system resistance and no debris loss; "Degraded" system performance results from increased system resistance. Pump performance was adjusted. The in-containment refueling water storage tank (IRWST) level elevation was set at -10.2 ft in each case.

Alignment for LHSI injection into the cold-legs was chosen because it would be used immediately, whereas simultaneous injection into cold and hot legs would not be used for at least one-half hour post-LOCA. The cases were run at 212ºF saturated liquid in the IRWST and 1.0 atmosphere pressure, both in containment and at the break. Pressure loss due to debris accumulation was modeled (debris K = 3.14 at 212ºF). The NPSH margin at 212ºF (saturated) is less than at higher temperatures because of the increased pressure loss due to debris. As shown in Table 06.03-14-1, the worst combination (i.e., enhanced pump, degraded pipes) NPSH margin is 0.42’ wg.

The pump performance drives the flow whereas the system resistance drives the NPSH. LHSI NPSH margin is maintained in each case. The worst case combination is enhanced pumps and degraded pipes. In these NPSH calculations, the liquid in the IRWST is saturated so that the atmospheric pressure (h_{atm}) is equal to the vapor pressure (h_{vp}). These two terms are equal, and thus cancel, and the equation reduces to hydrostatic head (h_{static}) minus friction loss (h_f). No credit is taken for containment pressurization, above the saturation vapor pressure, at the specified IRWST temperature.

$$NPSHA = h_{atm} + h\ static - h_{vp} - h_f$$

Vortex air ingestion will not be an issue for either the LHSI or medium head safety injection (MHSI) pumps for the U.S. EPR because of their design. The methodology used comes from ANSI standard 9.8-1998, Sections 9.8.6 and 9.8.7 (Reference 2).

The MHSI and LHSI pumps share a common inlet sump, one sump per train. The greatest combined flow for one sump is for an LBLOCA, with design margin applied:

2361 gpm (LHSI) + 1086 (MHSI) = 3447 gpm (T = 150°F)

The inlet bell diameter is larger than the connected pipe ID of nominal 16 in (actual 15.25 in). This yields a minimum flow area of 1.268 ft^2.

The flow of 3447 gpm = 7.68 ft^3/s which yields an inlet velocity of:

7.68/1.268 = 6.05 ft/s

This is within the recommended range of 2.0 to 9.0 ft/s from Section 9.8.6 of Reference 2, and is near the optimum velocity of 5.5 ft/s.

The minimum IRWST elevation is -10.2 ft, and the sump inlet elevation is -22.474 ft. Subtracting these two elevations yields a sump submergence of:

-10.2 - (-22.474) = 12.27 ft. = 147.3 in.

Figure 9.8.26B of Reference 2 shows that the minimum submergence is about 50 in. This is much less than the 147.3 in submergence in the U.S. EPR design; therefore the design of the U.S. EPR is more than adequate.

For conservatism, an IRWST temperature of 150°F was assumed in the calculation, rather than a lower, normal IRWST temperature. The Reference 2 methodology does not use LOCA conditions.

AREVA NP calculation 32-9017755-004 (Reference 1) is available for NRC inspection.

Table 06.03-14-1—LHSI NPSH in LBLOCA

Combination at 212ºF	flow into RCS Cold Leg	LHSI Pump flow @ added head	LHSI Pump NPSHA & NPSHR	LHSI Pump NPSH margin
	gpm & lbm/s	gpm @ psid	feet wg	feet wg
best estimate	3458 & 461	2610 @ 152	7.79 & 6.37	+ 1.42
degraded pump, degraded pipes (-P -S)	3151 & 420	2407 @ 139	8.37 & 6.54	+ 1.83
enhanced pump, degraded pipes (+P -S)	3515 & 469	2643 @ 165	6.64 & 6.22	+ 0.42
enhanced pump, enhanced pipes (+P +S)	3625 & 483	2739 @ 154	10.19 & 6.44	+ 3.75
degraded pump, enhanced pipes (-P +S)	3241 & 432	2485 @ 128	11.29 & 6.76	+ 4.53

References for Question 06.03-14:

1. 32-9017755-004 “U.S. EPR Safety Injection System Analysis for Design Certification,” AREVA NP Inc., March 2009.
2. ANSI/HI 9.8-1998, “American National Standard for Pump Intake Design,” American National Standard Institute, 1998.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

U.S. EPR Final Safety Analysis Report Markups

14.2.12.2.4 Residual Heat Removal System (Test #016)

1.0 OBJECTIVE

1.1 To perform the test described in this abstract on the RHRS in conditions that are representative of actual plant conditions or close enough to allow the data to be extrapolated to actual conditions.

1.2 To demonstrate that the RHRS including the residual heat removal (RHR) pumps is properly installed and is functional prior to fuel loading.

1.3 To record data that is used to validate design basis assumptions or provide a baseline record of system performance for non-safety-related attributes.

1.4 To demonstrate electrical independence and redundancy of power supplies.

2.0 PREREQUISITES

2.1 Construction activities on the RHR/low head safety injection (LHSI) system have either been completed or exceptions have been recorded and the impact on system performance has been determined.

2.2 Plant systems required to support testing are functional and temporary systems are installed and functional.

2.3 Permanently installed instrumentation is functional and calibrated and is operating satisfactorily prior to performing the following test.

2.4 Test instrumentation is available and calibrated. A record of calibrated test instrumentation used with individual tracking number and calibration due date shall be recorded in the official test record.

2.5 All lines in the RHR/LHSI system have been filled and vented.

3.0 TEST METHOD

3.1 Observe the minimum flow rate of each LHSI pump with minimum flow established.

3.2 Measure LHSI pump performance including head and flow characteristics for design flow paths which include the normal decay heat removal flow path and:

3.2.1 RHRS flow to the CVCS for purification during shutdown.

3.2.2 RHRS transfer of refueling water from the refueling cavity to the IRWST.

3.2.3 RHRS capability to cool the IRWST.

3.3 Perform a full flow test of the LHSI system when aligned to take suction from the IRWST and discharging to the reactor vessel, with vessel level below the hot and cold leg nozzles.

3.4 Observe operation of the protective devices, controls, interlocks, indications, and alarms using actual or simulated signals.

3.5 Observe operation, stroking speed, position indication, and response to interlock of control and isolation valves.

3.6 Determine if motor operated valve (MOV) isolation valves can be opened against design differential pressure.

3.7 Measure NPSH to the LHSI pumps from suction sources at maximum design flow rates and minimum suction levels.

06.03-12

3.7.1 $NPSH_a \geq NPSH_R$.

3.7.2 Discharge head.

3.7.3 Flow corresponding to head at each point.

3.7.4 Starting time (motor start time and time to reach rated flow).

3.8 Measure flow capability of the RHR heat exchangers.

3.9 Measure flow through the flow limiting device, if applicable, in the LHSI discharge lines prevents runout flow when the LHSI system is at full flow.

3.10 Determine if each RHR train is capable of being powered by the electrically independent and redundant emergency power supplies.

3.11 Operate each LHSI pump available for hot and cold leg safety injection (SI) through the associated SI line and collect pump operating data.

3.12 Observe response of RHR and LHSI power-operated valves upon loss of motive power (refer to Section 6.3 for anticipated response).

3.13 Verify that the LHSI system meets full flow and shutoff head (by extrapolation) design requirements.

4.0 DATA REQUIRED

4.1 Valve position indications.

4.2 LHSI pump head versus flow.

4.3 Valve performance data, where required.

4.4 Setpoints of alarms and interlocks.

4.5 Position response of valves to loss of motive power.

5.0 ACCEPTANCE CRITERIA

5.1 The RHR/LHSI systems meets design requirements (refer to Section 6.3):

5.1.1 Verify that LHSI pump miniflow is within minimum/ maximum flow limits.

5.1.2 Verify adequate LHSI pump NPSH from all available pump suction paths.