ArevaEPRDCPEm Resource

From:	Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent:	Wednesday, May 13, 2009 5:19 PM
To:	Getachew Tesfaye
Cc:	BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); BEELMAN Ronald J (AREVA NP INC)
Subject:	Response to U.S. EPR Design Certification Application RAI No. 212, FSAR Ch. 6
Attachments:	RAI 212 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 212 Response US EPR DC.pdf" provides technically correct and complete responses to 6 of the 13 questions.

The following table indicates the respective pages in the response document, "RAI 212 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

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A complete answer is not provided for 7 of the 13 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 212 — 06.02.02-23	July 17, 2009
RAI 212 — 06.02.02-24	July 17, 2009
RAI 212 — 06.02.02-25	July 17, 2009
RAI 212 — 06.02.02-26	July 17, 2009
RAI 212 — 06.02.02-27	July 17, 2009
RAI 212 — 06.02.02-28	July 17, 2009
RAI 212 — 06.03-9	July 17, 2009

Sincerely,

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Cc: Clinton Ashley; Christopher Jackson; Thomas Scarbrough; David Terao; John Budzynski; Shanlai Lu; Joseph Donoghue; Jason Carneal; Michael Miernicki; Joseph Colaccino; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 212 (2452, 2461,2421), FSAR Ch. 6

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on April 7, 2009, and on April 14, 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 with the exception of referenced RAI numbering clarification. 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
Email Number: 473

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Response to

Request for Additional Information No. 212 (2452, 2461, 2421), Revision 0

4/14/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 - Containment Heat Removal Systems
SRP Section: 06.03 - Emergency Core Cooling System

Application FSAR Ch 6

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)
QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)
QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

Question 06.02.02-23:

Information provided in response to RAI 111, Question No. 06.02.02-8.K.15 requires follow-up. Additional information is needed to determine how the IRWST safety function is assured when applying single failure criteria per §52.47 and §50 Appendix A, General Design Criteria. Based upon RAI 111, Question No. 06.02.02-8.K.15 and RAI 6, Question No. 19-103 (Figure 19-103-1) responses, it appears that it may be necessary to isolate the flow path connecting the IRWST to the core spreading area upon inadvertent (spurious) opening of the 'passive flooding device' in order to ensure the IRWST can perform its safety function (core cooling).

Therefore, describe the design of the passive flooding lines (two) that connect the IRWST to the Core Spreading Area and how the IRWST core cooling function is accomplished assuming a single failure – active and/or passive - of the components in the passive flooding line. Discuss the basis for assuming component failure (spurious opening) associated with the normally closed 'passive flooding valve' and when this is postulated to occur. Discuss if inadvertent (spurious) opening of a "passive flooding valve(s)" is consequential to the IRWST safety function and describe the analysis inputs and assumptions that support the conclusion. Discuss what, if any, automatic or manual actions are necessary to ensure the IRWST can perform its core cooling safety function assuming an inadvertent (spurious) opening of a "passive flooding valve(s)"

Response to Question 06.02.02-23:

A response to this question will be provided by July 17, 2009.

Question 06.02.02-24:

Define the IRWST water level (elevation) if the passive flooding device inadvertently opened and no action was taken to stop water flow. [Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-24:

A response to this question will be provided by July 17, 2009.

Question 06.02.02-25:

Define the lowest IRWST water level (elevation) necessary to support the worst case design basis accident. Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-25:

A response to this question will be provided by July 17, 2009.

Question 06.02.02-26:

In accordance with RG 1.206 C.I.6.3.2.1, provide a simplified drawing depicting all components in the flow path from the IRWST to the spreading area using the passive flooding line. This simplified drawing should be depicted in the FSAR. [Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-26:

A response to this question will be provided by July 17, 2009.

Question 06.02.02-27:

In response to an RAI on EPR FSAR Section 6.3.2.2, Areva stated that there are two connections from the In-Containment Refueling Water Storage Tank (IRWST) to the core spreading area for the EPR design. Each connection has two motor-operated valves (MOVs) and one passive flooding valve between the IRWST and the core spreading area. The normal position for the passive flooding valves is closed and the normal position for the MOVs is open. Areva stated that the MOVs can be closed if a passive flooding valve fails open. The NRC staff requests that Areva provide the following information regarding the MOVs in the IRWST system that are used to isolate the passive flooding valves: (1) provide their identification numbers; (2) specify their safety classification; (3) discuss their normal and safety functions; (4) discuss their functional design, qualification, and inservice testing; and (5) discuss their automatic and manual operation, and the justification for any manual reactor operator action associated with these MOVs.

Response to Question 06.02.02-27:

A response to this question will be provided by July 17, 2009.

Question 06.02.02-28:

The NRC staff requests the following additional information regarding the passive flooding valves in the IRWST system for the EPR design: (1) provide their identification numbers; (2) specify their safety classification; (3) describe their design and operating mechanism; (4) discuss their normal and safety functions; (5) discuss their functional design, qualification and inservice testing; and (6) discuss their position indication system, and the provisions to alert the reactor operators to an incorrect valve position.

Response to Question 06.02.02-28:

A response to this question will be provided by July 17, 2009.

Question 06.03-5:

Accumulator Over-Pressure Protection

The accumulators are part of the ECCS, a safety-related system, which must perform its intended function when called upon to satisfy GDC 35. EPR FSAR Tier 2 Figure 6.3-1 does not show relief valves for protection of the accumulators. Also, EPR FSAR Tier 1, Figure 2.2.3-1, Sheets 5 through 8 did not show relief valves either. Furthermore, FSAR Section 6.3.2.2.2, in the accumulator design description, does not address the issue of relief valves. However, FSAR Tier 2 Figure 6.3-2 (Sheet 2) indicates relief valves on the accumulators.

a. Correct the figures or provide justification for the differences in the drawings.

b. Provide a reference or a discussion to address the overpressure protection of the accumulators.

c. Could the MHSI pumps overpressurize the accumulators and relieve nitrogen gas through the relief valves? Provide a discussion or reference to support your answer.

Response to Question 06.03-5:

a. The U.S. EPR FSAR, Tier 2, Figure 6.3-1 is an overview of the safety injection system / residual heat removal system (SIS/RHRS) and only includes the main system piping.

   Safety relief valves 30JNG*3 AA197 (where * = Divisions 1 through 4) protect the accumulators. As described in U.S. EPR FSAR, Tier 2, Section 14.3.2, “features provided solely for protection are not included in Tier 1 material.” Therefore, these safety relief valves are not included in the U.S. EPR FSAR Tier 1.

b. Safety relief valves 30JNG*3 AA197 (where * = Divisions 1 through 4) provide overpressure protection for the accumulators. Each safety relief valve is designed to prevent a rise of more than 10% above the accumulator design pressure of 800 psig, per ASME Section III, NC-7311(b).

c. Safety relief valves 30JNG*3 AA197 (where * = Divisions 1 through 4) prevent the medium head safety injection (MHSI) pumps from overpressurizing the accumulators. However, nitrogen gas will be relieved via the safety relief valves if the MHSI pumps fail to trip during filling or refilling of the accumulators.

   Flow restrictors in the assigned accumulator filling lines restrict the MHSI pump flow. A large pressure drop is expected across the flow restrictors, while the MHSI pumps discharge primarily into the in-containment refueling water storage tank (IRWST) via the miniflow lines during filling or refilling of the accumulators.

FSAR Impact:

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

Question 06.03-6:

Net Positive Suction Head Calculations

GDC 35 requires that the ECCS pumps perform their intended functions during postulated accidents. Further guidance is provided in RG 1.82. One of the requirements is to demonstrate that the MHSI pumps and the LHSI pumps have sufficient net positive suction head (NPSH) available during postulated DBAs. Section 6.3 of the U.S. EPR FSAR and Topical Report ANP-10293 address this issue, but fail to provide all details needed for a regulatory review.

Please provide a description of the NPSH calculations performed for the MHSI and LHSI pumps. What IRWST liquid level was used? How was liquid hold up in the containment calculated? How were system resistances determined? What sump screen resistance was used? How was the sump screen resistance established? How is it justified? What other assumptions and data were used? When appropriate, please justify use of the selected data. Indicate how the results ensure pump performance under accident conditions.

It appears from Section 6.3.3.3 of the U.S. EPR FSAR and from ANP-10293 that the applicant elected to deviate from the recommendations of RG 1.82 on two points: (1) saturation pressure corresponding to the peak calculated IRWST temperature was used instead of the containment pressure present prior to the postulated accident, and (2) a bounding combination of pressure drop data and fluid temperature was used instead of NPSH calculations as a function of time. Is this correct? What assumptions were used for the bounding calculations? Please describe the bounding calculations. How are the deviations justified?

Response to Question 06.03-6:

Please provide a description of the NPSH calculations performed for the MHSI and LHSI pumps. What IRWST liquid level was used? How was liquid hold up in the containment calculated?

The available NPSH (NPSHA) for the medium head safety injection (MHSI) and low head safety injection (LHSI) pumps is part of the computer program *AFT Fathom*™ output and is based on the difference between the pump suction total pressure (static and dynamic) and the saturation pressure corresponding to the local fluid temperature. The suction static pressure accounts for the static head between the in-containment refueling water storage tank (IRWST) and the pump suction, and the applicable frictional loss along the flow path. This is consistent with the standard NPSHA formulation.

The IRWST liquid level elevation used was -10.2 ft., while the normal liquid level elevation is -8.497 ft. The lower level elevation of -10.2 ft conservatively allows for emergency core cooling system (ECCS) return flow hold-up. Refer to the responses for RAI-111 questions 06.02.02-8(1)9 and 06.02.02-8(J)1 for further information.

How were system resistances determined?

The entire system was modeled using the computer program *AFT Fathom™.* The hydraulic resistances for each component were calculated using standard industrial formulations, including those of Crane and Idel'chik. The pipe resistances were calculated using the Darcy formula and the Moody friction chart.

What sump screen resistance was used? How was the sump screen resistance established? How is it justified? What other assumptions and data were used? When appropriate, please justify use of the selected data.

AFT Fathom™ models the sump screen resistance as that of a clean sump screen. It is calculated based on the pressure losses across a clean screen and the ratio of free cross-sectional area of the strainers to the total sump cross-sectional area.

During a large break loss of coolant accident (LBLOCA), debris could accumulate on the IRWST safety injection system (SIS) inlet strainer. Therefore, conservative pressure loss values due to debris clogging the sump screen are used. No additional uncertainties are applied to this loss in the NPSH and margin calculations.

The degraded sump pressure loss data are based on correlations from experiments performed by AREVA and are similar to NUREG/CR-6224 methods. Pressure loss coefficients (K) are developed as a function of fluid temperature, and these values were applied to the LBLOCA and to the degraded flow calculation.

Indicate how the results ensure pump performance under accident conditions.

The pump performance accounts for different uncertainties that minimize the injection flow and the NPSH margins:

- The *Fathom*™ modeling considers the uncertainties on the system resistance and on the pumps' heads and flows. The debris loss is also included in the best estimate and the degraded LBLOCA calculations. Based on the combination of these uncertainties on the LHSI and MHSI pump performance, the calculated injection flow meets the stated minimum requirements under accident conditions.
- The evaluation also includes several conservatisms that minimize the NPSH margin. For instance, the IRWST level is conservatively low and does not credit emptying the accumulators or water flowing out of the break. By considering these conservatisms that minimize NPSH margin, the results demonstrate that sufficient NPSH margins for the MHSI and LHSI pumps are maintained under accident conditions.

Therefore, the results characterize pump performance under accident conditions.

It appears from Section 6.3.3.3 of the U.S. EPR FSAR and from ANP-1 0293 that the applicant elected to deviate from the recommendations of RG 1.82 on two points: (1) saturation pressure corresponding to the peak calculated IRWST temperature was used instead of the containment pressure present prior to the postulated accident, and (2) a bounding combination of pressure drop data and fluid temperature was used instead of NPSH calculations as a function of time. Is this correct? What assumptions were used for the bounding calculations? Please describe the bounding calculations. How are the deviations justified?

It is correct that AREVA NP elected to use the saturation pressure corresponding to the peak calculated IRWST temperature, instead of the containment pressure prior to the postulated accident as recommended by RG 1.82. This is justified since the containment pressure prior to the postulated accident (atmospheric) is not realistic for the peak calculated IRWST temperature of 230ºF. The realistic pressure above the IRWST is the saturation pressure corresponding to the peak IRWST temperature.

It is also correct that a bounding minimum NPSH is calculated instead of a time-varying NPSH calculation. Since the bounding case is based on the most penalizing conditions during the post-LBLOCA transient (the description of the bounding calculation follows later), it will bound the time history of the NPSH. Thus, this alternate approach is justified.

The bounding calculation takes into account the peak IRWST temperature, increased system resistance, additional pressure loss due to debris, and the worst pump performance (pump operating at the minimum curve). The outcome of this bounding case is a minimum NPSH during the post-accident transient.

The minimum pressure available to pressurize the IRWST is either atmospheric, or saturation pressure if the IRWST temperature is greater than 212°F. Because of the additional pressure loss due to debris in the IRWST sump following a LBLOCA—and the fact that NPSHA decreases with a decrease in reactor coolant system (RCS) break pressure (used as back pressure for the injection flow) because of the higher flow rate—the LHSI NPSH in a small break LOCA is bounded by the results for an LBLOCA.

To capture the worst case of LHSI NPSH margin following a postulated LBLOCA, the following assumptions and modeling simplifications are made:

- Direct injection alignment is used because it would be employed immediately, whereas simultaneous injection alignment is not employed for at least 30 minutes.
- All cases are run at 212°F saturated liquid in the IRWST and 1.0 atmosphere pressure, both in containment and at the break. The NPSH margin at 212°F is less than that at the peak calculated IRWST temperature of 230°F. This is attributed to two factors: (1) the additional pressure loss due to debris decreases as fluid temperature increases, and (2) the saturation pressure (hence the containment pressure, see alternate approach described above) at the peak IRWST temperature is higher than atmospheric pressure. This modeling assumption adds conservatism to the bounding calculation.
- Pressure loss due to debris accumulation is modeled.
- The IRWST level is conservatively set at -10.2 ft.

FSAR Impact:

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

Question 06.03-7:

Safety Injection Flow Calculations

GDC 35 requires that the ECCS perform its intended functions under all postulated design-basis accidents conditions. Some limiting safety analyses are performed with minimum safety injection, others with maximum safety injection. See, for example, the maximum safeguards LOCA mass and energy release calculations in Section 6.2.1.3.

Upon actuation of the ECCS, the MHSI pumps, LHSI pumps, and the accumulators inject borated water through a common injection line segment and a common injection nozzle into the RCS.

a. Provide a reference or discussion of the evaluation on the relationship of the merging flows to the introduction of uncertainties in the calculations.
b. How was the safety injection flow calculated for the minimum safety injection case and for the maximum safety injection case?
c. How were the mixing effects of the common pipe and nozzle taken into account?
d. Provide sample injection flow calculations for both cases.

Response to Question 06.03-7:

a. The combined mixing of merging LHSI and MHSI flows is evaluated in the *FATHOM*™ modeling. The accumulator flow is also treated in the *FATHOM*™ modeling as a separate flow. Appropriate loss coefficients are calculated internally by *FATHOM*™ using standard industrial correlations. The corresponding uncertainties are treated the same way as other loss coefficients in the piping system.
b. For the minimum safety injection case, the safety injection flow is calculated using the maximum system flow resistance and minimum pump curves. For the maximum safety injection case, the safety injection flow is calculated using the minimum system flow resistance and maximum pump curves. More details are provided in the response to Question 06.03-6 above.
c. The analysis did not specifically account for mixing effects in the common pipe and nozzle. The entire system was modeled using *FATHOM*™, and mixing effects were internally calculated by the code and are accounted for in the flow rates at the nozzles and common pipe.
d. All calculations are made by *FATHOM*™. These calculations are available for NRC inspection.

FSAR Impact:

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

Question 06.03-8:

Control of IRWST Level, Boron Concentration and Temperature

The ECCS must provide abundant core cooling in the event of design-basis accidents to meet the requirements of GDC 35. If the IRWST's water temperature and boron concentration is outside of the specified range, the technical specifications require correction within 8 hours. While surveillance of the tank's water level is required, there is no completion time assigned for restoration.

a. How are the water level, boron concentration and water temperature restored?

b. What systems and procedures are used?

c. Provide an explanation of why the completion time for the water level is not specified in the technical specifications.

Response to Question 06.03-8:

a. Make-up from the reactor boron water makeup system restores the in-containment refueling water storage tank (IRWST) water level and boron concentration. The IRWST water temperature is restored by recirculating the IRWST on the low head safety injection (LHSI) miniflow line and adjusting tank temperature via the LHSI heat exchanger.

b. Operating procedures provide for the control and restoration of IRWST water parameters.

c. An FSAR change provided with the response to Question 16-95 of RAI 101 provides the restoration time for the IRWST water level.

FSAR Impact:

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

Question 06.03-9:

Spurious Actuation of a SAHRS Flooding Valve

GDC 35 requires that the ECCS accomplish its safety functions assuming a single failure. During design basis accidents, opening of a valve could potentially deplete the IRWST level below the level required for NPSH for the safety injection pumps.

The failure mode and effect analysis of the ECCS did not address opening of a flooding valve. A mechanical failure of either the initiator or the actuator of one of the flooding valves would be a single passive failure. Opening of the valve could deplete the water level in the IRWST, which could affect all four LHSI pumps in the long term cooling mode.

a. What would be the consequence of inadvertent opening of a flooding valve during a design-basis accident?
b. Why was this failure mode not addressed in the single passive failure evaluation?

Response to Question 06.03-9:

A response to this question will be provided by July 17, 2009.

Question 06.03-10:

<u>Failure to Start a Diesel Generator in Alternate Feed Mode</u>

The ECCS must perform its intended function assuming a single failure to meet GDC 35 requirement. The failure mode and effect analysis of the FSAR ECCS Table 6.3-7 evaluates several failure modes including two failure modes of the emergency diesel generator: (1) failure to start and (2) failure to run on alternate feed mode. For both cases, the stated consequence is loss of interruptible power to two SIS/RHRS trains. The consequence of either of these failures is judged satisfactory because even with one train feeding the broken loop, another will provide core cooling function. However, the safety evaluation of the ECCS assumes that one train is valved out for maintenance. Are the consequences of these failures acceptable if one train is not available because of maintenance?

Response to Question 06.03-10:

The U.S. EPR FSAR, Tier 2, Table 6.3-7—Safety Injection System Failure Modes and Effects Analysis assumes one safety injection system / residual heat removal system (SIS/RHRS) train is unavailable due to preventive maintenance.

In the event of a loss of offsite power, the emergency diesel generator (EDG) on alternate feed mode provides power to one SIS/RHRS train and to selected equipment of the train undergoing preventive maintenance. Therefore, a single failure of the EDG on alternate feed mode (either failure to start or failure to run) will result in the loss of interruptible power to two SIS/RHRS trains, where one of the trains is already assumed unavailable for preventive maintenance. Mission success criteria are satisfied with the remaining two SIS/RHRS trains.

FSAR Impact:

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

Question 06.03-11:

Hot Leg Injection

Switching safety injection to the hot legs 90 minutes after the break, has a significant effect on the containment pressure in case of large break LOCAs. The rising containment pressure turns over and starts to decrease when cold safety injection water is delivered to the hot legs.

It is the staff's understanding that when hot leg injection is initiated the cold leg injection lines are not closed. Consequently, the safety injection flow will split three ways. Part of the flow will go to the hot legs, part to the cold legs, and part through the minimum flow lines will return to IRWST. Provide the following information:

a. What is the split among the three flow lines?

b. How is it ensured that at least a certain fraction of the flow will reach the hot legs?

c. Will the flow distribution be tested during startup testing?

d. Is there an ITAAC ascertaining conformance with a minimum hot leg injection acceptance criterion?

Response to Question 06.03-11:

a. Using best-estimate calculations, at a reactor coolant system (RCS) pressure of 58 psia, 78% of the total low head safety injection (LHSI) flow enters the hot leg, 11% enters the cold leg, and 11% is recirculated to the in-containment refueling water storage tank.

b. The hot leg injection flow is governed by the relative resistances in the hot and cold legs. During a large break loss of coolant accident the path to cold leg injection is through a smaller bypass line with a flow restrictor. This results in a relatively higher flow fraction to the hot leg.

c. The flow distribution will be tested during startup testing. Refer to U.S. EPR FSAR, Tier 2, Section 14.2 (Test #016) for specific test details.

d. The U.S. EPR FSAR does not provide an ITAAC ascertaining conformance with a minimum hot leg injection acceptance criterion. The strategy of hot leg injection is not credited in the containment analyses of record.

FSAR Impact:

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