AREVA

September 29, 2010
NRC:10:088

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to U.S. EPR Design Certification Application RAI No. 368, Supplement 5

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Martin C. Bryan (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 368 (4344), FSAR Ch. 6," March 19, 2010.

Ref. 2: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 368, FSAR Ch. 6," April 19, 2010.

Ref. 3: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 368, Supplement 1, FSAR Ch. 6," June 9, 2010.

Ref. 4: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 368, Supplement 2, FSAR Ch. 6," July 8, 2010.

Ref. 5: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 368, Supplement 3, FSAR Ch. 6," August 5, 2010.

Ref. 6: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 368, Supplement 4, FSAR Ch. 6," September 9, 2010.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application. Reference 2 provided a technically correct and complete response to 3 of the 23 questions in RAI No. 368. Reference 3 provided a technically correct and complete response to 6 of the remaining 20 questions.

Reference 4 provided a revised schedule for questions 06.02.01-61, 63, 70, 71, 73, 76, 78, 80, and 81. Reference 5 provided a revised schedule for questions 06.02.01-62, 63, 66, 67, 68, 69, 73, 76, 78, and 81. Reference 6 provided a revised schedule for questions 06.02.01-66, 67, 68, 69, 73, 76, 78 and 81.

The attached file, "Proprietary RAI 368 Supplement 5 Response US EPR DC.pdf" provides technically correct and complete responses to 3 of the remaining 14 questions (06.02.01-61, 62 and 63). AREVA NP considers some of the material contained in the attached response to be proprietary. As required by 10 CFR 2.390(b), an affidavit is attached to support the withholding of the information from public disclosure.

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NRO

AREVA NP INC.
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The following table indicates the respective pages in the response document, "Proprietary RAI 368 Supplement 5 Response US EPR DC.pdf," that contain AREVA NP's response to the subject 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 368 Question 06.02.01-61.

Question #	Start Page	End Page
RAI 368 — 06.02.01-61	2	2
RAI 368 — 06.02.01-62	3	8
RAI 368 — 06.02.01-63	9	11

To provide an opportunity to interact with the NRC staff, a revised response schedule is provided for Questions 06.02.01-70, 71 and 80 as indicated below.

Question #	Response Date
RAI 368 — 06.02.01-66	October 13, 2010
RAI 368 — 06.02.01-67	October 13, 2010
RAI 368 — 06.02.01-68	October 13, 2010
RAI 368 — 06.02.01-69	October 13, 2010
RAI 368 — 06.02.01-70	**December 9, 2010**
RAI 368 — 06.02.01-71	**December 9, 2010**
RAI 368 — 06.02.01-73	October 13, 2010
RAI 368 — 06.02.01-76	October 13, 2010
RAI 368 — 06.02.01-78	October 13, 2010
RAI 368 — 06.02.01-80	**December 22, 2010**
RAI 368 — 06.02.01-81	October 13, 2010

If you have any questions related to this submittal, please contact me by telephone at 434-832-2369 or by e-mail to sandra.sloan@areva.com.

Sincerely,

R. Wells for

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA	)	
	)	ss.
COUNTY OF CAMPBELL	)	

1. My name is Gayle Elliott. I am Manager, Regulatory Affairs for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in letter NRC:10:088, "Response to U.S. EPR Design Certification RAI No. 368, FSAR Chapter 6, Supplement 5," and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(d) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 29th

day of September, 2010.

Kathleen A. Bennett

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2011
Reg. #110864

[illegible]
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2011

Response to

Request for Additional Information No. 368(4344), Revision 1, Supplement 5

3/19/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.01 - Containment Functional Design
Application Section: 06.02.01

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

Question 06.02.01-61:

The response to RAI 221, Question 06.02.01-46 states that the configuration for a cold leg pump discharge break limits the delivery of coolant to the loops seal piping because of a virtual weir in the U.S. EPR reactor coolant pump design that rises above the top of the cold leg piping. As a result of the weirs, the loop seals will not form as early in the CLPD scenario as for a CLPS break. For this reason the transition from RELAP5/MOD2-BW to GOTHIC for the discharge breaks can be as late as 3600 seconds coincident with the initiation of hot leg injection. Provide the supporting data and evaluation to justify the later formation of loop seals for postulated CLPD breaks given the chugging nature of the coolant flow in cold legs predicted by RELAP5-BW.

Response to Question 06.02.01-61:

The virtual weir is a result of the reactor coolant pump (RCP) diffuser vane configuration. The top of the impeller diffuser vane is 3.02" (46.61" + 15.35" – 58.94") below the top of the cold leg piping.

The orientation of the double-ended guillotine cold leg pump discharge (CLPD) break precludes complete filling of the cold legs. This orientation, combined with a RCP spill elevation above the mid-plane of the cold leg, makes the formation of the loop seals much more difficult than the case of the cold leg pump suction (CLPS) break. In a CLPD sensitivity case using a model not accounting for the virtual weir and having a 9,000 second duration, the loop seal on the broken loop does not refill. The loop seals on the other loops do not refill until after 4,800 seconds into the event due to a slug flow pattern in which the loop seal alternatively refills and empties.

U.S. EPR FSAR Tier 2, Section 6.2.1.3 will be revised to clarify the orientation of the weir in the RCP, and Table 6.2.1-1 will be revised due to a typographical error.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 6.2.1.3 and Table 6.2.1-1 will be revised as described in the response and indicated on the enclosed markups.

Question 06.02.01-62:

The response to RAI 221 06.02.01-46 states that as the break size decreases, the dynamics of the RCS changes and input considerations such as the partial cooldown of the steam generators, loop seal formation, and hot leg injection have a significant impact on the containment response. The response states that methods and inputs will be evaluated individually for each break to verify a conservative pressure and temperature response. Describe how these methods and inputs are evaluated as a function of break size and justify that the process yields conservative results. Describe how partial cooldown of the steam generators, loop seal formation and hot leg injection are evaluated for small breaks. Provide and justify the nodding used in the RELAP5-BW model for small break LOCA if different from that presented in ANP-10299P. Provide and justify the GOTHIC model used to calculate long term mass and energy release and describe and justify the criteria that are used in switching between the reactor system models.

Response to Question 06.02.01-62:

The Response to RAI 221, Question 06.02.01-46 delineates differences in the analysis methodology between large break loss of coolant accident (LBLOCA) and small break loss of coolant accident (SBLOCA) break sizes. The methodology for handling partial cooldown, loop seal formation, and hot leg injection differs for LBLOCA and SBLOCA cases.

The partial cooldown function is a safety-related feature designed to lower secondary pressure and lower reactor coolant system (RCS) pressure due to a SBLOCA or steam generator tube rupture (SGTR). Due to the rapid RCS pressure decrease, partial cooldown is not credited in the LBLOCA analyses. Partial cooldown, which is performed by the main steam relief trains (MSRT), is incorporated into the SBLOCA models via RELAP5-BW VALVE components, along with associated controllers and trips. Trips are used to initiate a partial cooldown based on a low pressurizer pressure or safety injection signal (SIS). Controllers are used to achieve an 180°F/hr cooldown rate. Trip setpoints and delays are based on nominal values biased by setpoint uncertainties, resulting in conservative estimates for the trip time.

[ ]

With the exception of the break noding, the RELAP-BW SBLOCA model uses the same noding as the LBLOCA model presented in Technical Report ANP-10299P. The SBLOCA model break noding for a hot leg break, cold leg pump suction break, and a cold leg pump discharge break are presented in Figure 06.02.01-62-1 through Figure 06.02.01-62-3. The break noding used for the RELAP5-BW SBLOCA model is consistent with NRC-approved methodology documented in Topical Report BAW-10168P-A, Volume II.

The criteria and justification for determining the time for switchover from the RELAP5-BW short-term mass and energy release model to the GOTHIC long-term mass and energy release model is provided in Technical Report ANP-10299P, Section 8.1.16, as follows:

"8.1.16 Transition Time between RELAP5 and GOTHIC

The short-term mass and energy releases calculated with RELAP5-BW code are input as boundary conditions to the GOTHIC containment pressure response calculation. A simplified analytical model is incorporated into the GOTHIC code to calculate the long-term mass and energy releases.

FSAR Impact:

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

Figure 06.02.01-62-1—SBLOCA Hot Leg Break Noding

[ ]

Figure 06.02.01-62-2—SBLOCA Cold Leg Pump Suction Break Noding

Figure 06.02.01-62-3—SBLOCA Cold Leg Pump Discharge Break Noding

Question 06.02.01-63:

Section 9 of ANP-10299P Rev 2 describes the application of the LOCA mass and energy release methodology described in Section 8 to a double-ended guillotine break in the cold leg pump suction piping. Descriptions of the RELAP5-BW nodding and the 1200 second time for switching between the RELAP5-BW model and the GOTHIC mass and energy model are described in Section 9. FSAR Table 6.2.1.1 lists LOCA break sizes and locations that were analyzed for US-EPR. Identify which of these analyses were done using assumptions consistent with those of ANP-10299P Sections 8 and 9. For those which were not, describe what assumptions that were used. Justify that sufficient break sizes have been analyzed using the ANP-10299P methodology including the multi-nodded GOTHIC containment model, that the limiting break size at each location has been identified.

Response to Question 06.02.01-63:

U.S. EPR FSAR Tier 2, Table 6.2.1.1, cases one through 41 (large break loss of coolant accident (LBLOCA) cases) were performed using assumptions consistent with Technical Report ANP-10299P, Sections 8 and 9. The assumptions for U.S. EPR FSAR Tier 2, Table 6.2.1.1, cases 42 through 46 (small break loss of coolant accident (SBLOCA) cases) are described in the Response to Question 0.6.02.01-62.

The approved SBLOCA methodology documented in Technical Report BAW-10168P-A, Volume II sets an upper bound of 0.5 ft^2 for a SBLOCA. The lower bound break size of 3-inches is smaller than the smallest vent/instrument/non-drain line that connects to the reactor coolant system (RCS). An intermediate break size sensitivity case of 6-inches was performed to confirm the limiting SBLOCA break size of 0.5 ft^2.

Using a single lumped parameter GOTHIC containment model, 0.5 ft^2, 6-inch, and 3-inch SBLOCA cases were performed for the hot leg, pump suction leg, and pump discharge leg breaks. Additional cases with and without loss of offsite power (LOOP), and with minimum and maximum emergency core cooling system (ECCS) flow were performed (giving a total of 16 SBLOCA cases, see Table 06.02.01-63-1).

The peak pressure and temperature results for the cases listed in Table 06.02.01-63-1 consistently decreased with decreasing break size for the three break locations (with the same ECCS and LOOP assumptions). Based on the results for the single lumped parameter GOTHIC containment model, the following cases were rerun with the multi-node GOTHIC model (see Table 06.02.01-63-2):

- Case 7 (bounding pressure and temperature case).
- Case 8 (containment temperature response close to Case 7)
- Case 9 (short term containment temperature response close to Case 7, and long term temperature response higher than Case 7).
- Case 2 (peak pressure and temperature response close to Case 7, and long term pressure and temperature response higher than Case 7).
- Case 2b (short term pressure and temperature response close to Case 7).

- Case 6 (lowest containment pressure response, rerun with and without credit for containment dP foils to evaluate the performance of dP foils in response to smallest SBLOCA).

The volumes that correspond to available break locations in the multi-node GOTHIC model differ in size (volume) and available relief area (via connected flow paths). With the exception of Cases 6a and 6b, the limiting break locations in the multi-node GOTHIC model were chosen based on minimizing the available relief area (via connected flow paths) to maximize the challenge to the pressure relief systems. For Cases 6a and 6b, it is conservative to minimize the break room pressure. For these two cases, the room with the maximum relief area was used for the break.

FSAR Impact:

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

Table 06.02.01-63-1—Single Node GOTHIC SBLOCA Cases

Case	Break Size	Location	ECCS	LOOP Condition	Other
1	0.5 ft^2	Pump Suction	Minimum ECCS	LOOP	
2	0.1963 ft^2	Pump Suction	Minimum ECCS	LOOP	
2a	0.1963 ft^2	Pump Suction	Minimum ECCS	No LOOP	
2b	0.1963 ft^2	Pump Suction	Maximum ECCS	LOOP	
3	0.0491 ft^2	Pump Suction	Minimum ECCS	LOOP	
4	0.5 ft^2	Hot Leg	Minimum ECCS	LOOP	
4a	0.5 ft^2	Hot Leg	Minimum ECCS	No LOOP	
4b	0.5 ft^2	Hot Leg	Maximum ECCS	LOOP	
5	0.1963 ft^2	Hot Leg	Minimum ECCS	LOOP	
6	0.0491 ft^2	Hot Leg	Minimum ECCS	LOOP	
7	0.5 ft^2	Pump Discharge	Minimum ECCS	LOOP	
7a	0.5 ft^2	Pump Discharge	Minimum ECCS	No LOOP	
7b	0.5 ft^2	Pump Discharge	Maximum ECCS	LOOP	
8	0.1963 ft^2	Pump Discharge	Minimum ECCS	LOOP	
9	0.0491 ft^2	Pump Discharge	Minimum ECCS	LOOP	
9c	0.0491 ft^2	Pump Discharge	Minimum ECCS	LOOP	EFW Temp = 120°F

Table 06.02.01-63-2—Multi-node GOTHIC SBLOCA Cases

Case	Break Size	Location	ECCS	LOOP Condition	Other
7	0.5 ft^2	Pump Discharge	Minimum ECCS	LOOP	
8	0.1963 ft^2	Pump Discharge	Minimum ECCS	LOOP	
9	0.0491 ft^2	Pump Discharge	Minimum ECCS	LOOP	
2	0.1963 ft^2	Pump Suction	Minimum ECCS	LOOP	
2b	0.1963 ft^2	Pump Suction	Maximum ECCS	LOOP	
6a	0.0491 ft^2	Hot Leg	Minimum ECCS	LOOP	With dP foils
6b	0.0491 ft^2	Hot Leg	Minimum ECCS	LOOP	Without dP foils

U.S. EPR Final Safety Analysis Report Markups

absorb the energy in containment and reduce the pressure. During the reflood phase of the event, steam generated in the core superheats. It approaches saturated conditions as the core water level increases. Steam from the core traverses the SG, absorbing additional energy from the secondary system. As a result, the energy content of the break effluent increases beyond the capacity of the containment heat structures, and the containment pressure begins to rise again. A reduction in the steam flow from the decreasing decay heat allows the crossover legs to begin to fill and form loop seals. The most penalizing condition occurs when the three intact loops no longer provide a vent path to the break such that steam from the core flows to the containment by a path that circumvents cold ECCS injection water. This condition causes a further increase in the containment pressure until the manual switchover of at least 75 percent of the LHSI to the hot legs. The limiting break configuration for the cold leg pump suction break scenario is a double-ended guillotine break with minimum safety injection supplied to the two cross-connected intact loops with no LOOP. Figure 6.2.1-14 through Figure 6.2.1-17 provide the pressure and temperature results for the most limiting cold leg pump suction scenarios. The temperature profile corresponds to the temperature in the equipment room area where the break occurs. Figure 6.2.1-38 shows the temperature profiles in the dome region at various elevations. This figure demonstrates that thermal stratification does not occur in the long term. Figure 6.2.1-39 shows the temperature profiles in different rooms below the dome area.

A blowdown peak of 66.44 psia occurs at 28.0 seconds. The containment pressure begins rise following refill until ECCS injecting in the hot legs can suppress core steam production. The post-reflood peak of 69.27 psia occurs at 3600 seconds when at least 1720 gpm of each of the available LHSI trains is aligned to the hot legs. The containment pressure continues to decrease, reaching 32.0 psia by the end of the analysis at 24 hours.

06.02.01-61

A break in the cold leg pump discharge piping produces the lowest peak containment pressure. The blowdown phase is similar in duration to the cold leg pump suction break and produces a similar containment pressure response. However, the reflood and post-reflood phases of the cold leg pump discharge event are less limiting than the pump suction break. Unlike the pump suction break, coolant delivery to the loop seal piping segment is significantly reduced because of a weir in the U.S. EPR reactor coolant pump design ~~rising above the top of the cold leg piping~~. As a result, the formation of loop seals is not likely until after re-alignment of the LHSI to the hot legs. The steam that goes through the intact loop must pass pumped injection locations on the way to the reactor vessel (RV) downcomer and through the break. As a result of the condensation on the safety injection fluid, the effluent through the RV side of the break has a lower enthalpy.

The limiting break configuration for the cold leg pump discharge break scenario is a double-ended guillotine break with minimum available SIS and no postulated LOOP.

Table 6.2.1-1—Loss of Coolant Accidents
Sheet 3 of 3

Case	Break Location	Break Type[7]	Cd	Single Failure	ECCS	Offsite Power Configuration	Back Pressure
37	Pump Suction	DEG	1.0	1 Train ECCS[10, 12]	Min	No LOOP	Note 8
38	Pump Suction	DEG	1.0	1 Train ECCS [10]	Min	LOOP	Note 8
39	Pump Suction	DEG	1.0	1 Train ECCS [10, 11]	Min	No LOOP	Note 8
40	Pump Suction	DEG	1.0	1 Train ECCS [10, 11, 13]	Min	No LOOP	Note 8
41	Pump Discharge	DEG	1.0	1 Train ECCS [9, 11, 13]	Min	No LOOP	Note 8
42	Pump Discharge	0.5 ft^2 (9 in)	1.0	1 Train ECCS	Min	LOOP	Note 8
43	Pump Discharge	0.1963 ft^2 (6 in)	1.0 06.02.01-61	1 Train ECCS	Min	LOOP	Note 8
44	Pump Discharge	0.0491 ft^2 (3 in)	1.0	1 Train ECCS	Min	LOOP	Note 8
45	Hot Leg	0.0491 ft^2 (3 in)	1.0	1 Train ECCS	Min	LOOP	Note 8
46	Hot Leg	0.0491 ft^2 (3 in)	1.0	1 Train ECCS [14]	Min	LOOP	Note 8

Notes:

1. Increased IRWST Temperature to 248°F.
2. Based on Case 17 with the percentage of LHSI to the intact loop to be 0%.
3. Based on Case 17 with the percentage of LHSI to the intact loop to be 25%.
4. Based on Case 25 with instantaneous feedwater isolation.
5. Long-Term LOCA Run Based on Case 25.