ArevaEPRDCPEm Resource

From: Snyder, Amy
Sent: Friday, July 19, 2013 7:36 AM
To: ArevaEPRDCPEm Resource
Subject: PUBLIC- cover letter and affavidit only -FW: PROPRIETARY Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 11
Attachments: NRC-13-059.pdf; RAI 403 Supplement 11 Response US EPR DC Non-Proprietary.pdf

Amy

Amy Snyder, U.S. EPR Design Certification Lead Project Manager
Licensing Branch 1 (LB1)
Division of New Reactor Licensing
Office of New Reactors
U.S. Nuclear Regulatory Commission
Office: (301) 415-6822
Fax: (301) 415-6406
Mail Stop: T6-C20M
E-mail: Amy.Snyder@nrc.gov

From: WILLIFORD Dennis (AREVA) [mailto:Dennis.Williford@areva.com]
Sent: Thursday, July 18, 2013 4:49 PM
To: Snyder, Amy
Cc: Gleaves, Bill; ANDERSON Katherine (EXTERNAL AREVA); DELANO Karen (AREVA); LEIGHLITER John (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); HOLM Jerald (EXTERNAL AREVA)
Subject: PROPRIETARY Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 11

Amy,

Attached is AREVA NP Inc. letter NRC:13:059 with affidavit, and the proprietary and non-proprietary versions of the response to RAI No. 403, Supplement 11.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Thursday, July 18, 2013 4:44 PM
To: Amy.Snyder@nrc.gov
Cc: bill.gleaves@nrc.gov; ANDERSON Katherine (External AREVA NP INC.); DELANO Karen (RS/NB); LEIGHLITER John

(RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 11

Amy,

AREVA NP Inc. letter NRC 13:059 dated July 18, 2013 provides a technically correct and complete response to the remaining three questions in RAI 403. AREVA NP considers some of the material contained in the response to be Proprietary information. As required by 10 CFR 2.390(b), an affidavit is provided to support the withholding of the proprietary information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided separately.

The following table indicates the respective pages in the enclosure that contain AREVA NP's final response to the subject questions.

Question #	Start Page	End Page
RAI 403 — 15.06.05-61	2	11
RAI 403 — 15.06.05-62	12	19
RAI 403 — 15.06.05-63	20	27

This concludes the formal AREVA NP response to RAI 403, and there are no questions from this RAI for which AREVA NP has not provided a response.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, June 05, 2012 4:18 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 10

Getachew,

AREVA NP provided a schedule for responding to the 16 questions in RAI 403 in an email on June 30, 2010. A revised schedule was provided in Supplement 1 on November 24, 2010, Supplement 2 on February 24, 2011, and Supplement 3 on April 22, 2011. A final response to 10 questions (Questions 15.06.05-64, -65, -67, -69, -71, -72, -73, -75, -76 and -77) was provided in Supplement 4 on May 31, 2011. Supplement 5 sent on July 12, 2011, Supplement 6 sent on November 23, 2011, Supplement 7 sent on January 18, 2012, and Supplement 8 sent on February 26, 2012 provided a revised schedule for the remaining 6 questions. On March 9, 2012, AREVA NP sent a final response to 3 of the 6 remaining questions in RAI 403.

The schedule for providing a technically correct and complete final response to the remaining 3 questions in RAI 403 has been changed as provided below. This schedule was transmitted to the NRC in AREVA NP letter NRC:12:024 dated May 10, 2012.

Question #	Schedule

RAI 403 — 15.06.05-61	**July 30, 2013**
RAI 403 — 15.06.05-62	**July 30, 2013**
RAI 403 — 15.06.05-63	**July 30, 2013**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Friday, March 09, 2012 4:53 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 9

Getachew,

AREVA NP Inc. letter NRC:12:013 dated March 9, 2012 provides a technically correct and complete final response to 3 of the 6 remaining questions in RAI 403. AREVA NP considers some of the material contained in the response to be proprietary information. As required by 10 CFR 2.390(b), an affidavit is provided to support the withholding of the proprietary information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided separately.

The following table indicates the respective pages in the enclosed response that contain AREVA NP's final response to the subject questions.

Question #	Start Page	End Page
RAI 403 — 15.06.05-66	2	18
RAI 403 — 15.06.05-68	19	38
RAI 403 — 15.06.05-70	39	49

The schedule for technically correct and complete final responses to the remaining three questions is unchanged as shown below.

Question #	Schedule
RAI 403 — 15.06.05-61	August 30, 2013
RAI 403 — 15.06.05-62	August 30, 2013
RAI 403 — 15.06.05-63	August 30, 2013

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262

Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Sunday, February 26, 2012 6:59 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 8

Getachew,

AREVA NP provided a schedule for responding to the 16 questions in RAI 403 in an email on June 30, 2010. A revised schedule was provided in Supplement 1 on November 24, 2010, Supplement 2 on February 24, 2011, and Supplement 3 on April 22, 2011. A final response to 10 questions (Questions 15.06.05-64, -65, -67, -69, -71, -72, -73, -75, -76 and -77) was provided in Supplement 4 on May 31, 2011. Supplement 5 sent on July 12, 2011, Supplement 6 sent on November 23, 2011, and Supplement 7 sent on January 18, 2012 provided a revised schedule for the remaining 6 questions.

AREVA NP's schedule for providing a technically correct and complete response to the remaining 6 questions in RAI 403 has been changed as provided below. The schedule for the response to 3 of the 6 questions (Questions 15.06.05-66, 68 and 70) is unchanged.

Question #	Response Date
RAI 403 — 15.06.05-61	**August 30, 2013**
RAI 403 — 15.06.05-62	**August 30, 2013**
RAI 403 — 15.06.05-63	**August 30, 2013**
RAI 403 — 15.06.05-66	March 20, 2012
RAI 403 — 15.06.05-68	March 9, 2012
RAI 403 — 15.06.05-70	March 20, 2012

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, January 18, 2012 1:23 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 7

Getachew,

AREVA NP provided a schedule for responding to the 16 questions in RAI 403 in an email on June 30, 2010. A revised schedule was provided in Supplement 1 on November 24, 2010, Supplement 2 on February 24, 2011, and Supplement 3 on April 22, 2011. A final response to 10 questions (Questions 15.06.05-64, -65, -67, -69, -71, -72, -73, -75, -76 and -77) was provided in Supplement 4 on May 31, 2011. Supplement 5 sent on July 12, 2011 and Supplement 6 sent on November 23, 2011 provided a revised schedule for the remaining 6 questions.

AREVA NP's schedule for providing a technically correct and complete response to the remaining 6 questions in RAI 403 has been changed as provided below. A preliminary revised schedule for technically correct and complete responses to Questions 15.06.05-61, 62 and 63 is provided below. The preliminary schedule for providing a response to Questions 15.06.05-61, 62 and 63 is being reevaluated and a new supplement with a revised schedule for these 3 questions will be transmitted by February 21, 2012. The schedule for a technically correct and complete final response to Question 15.06.05-68 is unchanged as provided below.

Question #	**Response Date**
RAI 403 — 15.06.05-61	**February 21, 2012**
RAI 403 — 15.06.05-62	**February 21, 2012**
RAI 403 — 15.06.05-63	**February 21, 2012**
RAI 403 — 15.06.05-66	**March 20, 2012**
RAI 403 — 15.06.05-68	March 9, 2012
RAI 403 — 15.06.05-70	**March 20, 2012**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, November 23, 2011 1:22 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 6

Getachew,

AREVA NP provided a schedule for responding to the 16 questions in RAI 403 in an email on June 30, 2010. A revised schedule was provided in Supplement 1 on November 24, 2010, Supplement 2 on February 24, 2011, and Supplement 3 on April 22, 2011. A final response to 10 questions (Questions 15.06.05-64, -65, -67, -69, -71, -72, -73, -75, -76 and -77) was provided in Supplement 4 on May 31, 2011. Supplement 5 was sent on July 12, 2011 to provide a revised schedule for the remaining 6 questions.

AREVA NP's schedule for providing a technically correct and complete response to the remaining 6 questions in RAI 403 has been changed as provided below. This includes a preliminary revised schedule for the response to Questions 15.06.05-61, 15.06.05-62, and 15.06.05-63. The schedule for these 3 questions will be updated following further discussions with NRC staff prior to the date given below.

Question #	**Response Date**
RAI 403 — 15.06.05-61	**February 10, 2012**
RAI 403 — 15.06.05-62	**February 10, 2012**
RAI 403 — 15.06.05-63	**February 10, 2012**
RAI 403 — 15.06.05-66	**January 20, 2012**

RAI 403 — 15.06.05-68	**March 9, 2012**
RAI 403 — 15.06.05-70	**January 20, 2012**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, July 12, 2011 10:22 AM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 5

Getachew,

AREVA NP provided a schedule for responding to the 16 questions in RAI 403 in an email on June 30, 2010. A revised schedule was provided in Supplement 1 on November 24, 2010, Supplement 2 on February 24, 2011, and Supplement 3 on April 22, 2011. A final response to 10 questions (Questions 15.06.05-64, -65, -67, -69, -71, -72, -73, -75, -76 and -77) was provided in Supplement 4 on May 31, 2011.

AREVA NP's schedule for providing a technically correct and complete response to the remaining 6 questions in RAI 403 has been changed as provided below.

Question #	Response Date
RAI 403 — 15.06.05-61	**November 23, 2011**
RAI 403 — 15.06.05-62	**November 23, 2011**
RAI 403 — 15.06.05-63	**November 23, 2011**
RAI 403 — 15.06.05-66	**November 23, 2011**
RAI 403 — 15.06.05-68	**November 23, 2011**
RAI 403 — 15.06.05-70	**November 23, 2011**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, May 31, 2011 6:05 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); HOLM Jerald

(External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 4

Getachew,

AREVA NP Inc. letter NRC 11:052 dated May 31, 2011 provides a technically correct and complete response to 10 of the 16 remaining questions in RAI 403. AREVA NP considers some of the material contained in the response to be proprietary information. As required by 10 CFR 2.390(b), an affidavit is provided to support the withholding of the proprietary information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided separately.

The following table indicates the respective pages in the enclosure that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 403 — 15.06.05-64	2	12
RAI 403 — 15.06.05-65	13	16
RAI 403 — 15.06.05-67	17	25
RAI 403 — 15.06.05-69	26	29
RAI 403 — 15.06.05-71	30	31
RAI 403 — 15.06.05-72	32	33
RAI 403 — 15.06.05-73	34	40
RAI 403 — 15.06.05-75	41	42
RAI 403 — 15.06.05-76	43	44
RAI 403 — 15.06.05-77	45	54

A preliminary schedule for technically correct and complete responses to the remaining 6 questions is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted as soon as practicable but no later than July 12, 2011.

Question #	Schedule
RAI 403 — 15.06.05-61	July 12, 2011
RAI 403 — 15.06.05-62	July 12, 2011
RAI 403 — 15.06.05-63	July 12, 2011
RAI 403 — 15.06.05-66	July 12, 2011
RAI 403 — 15.06.05-68	July 12, 2011
RAI 403 — 15.06.05-70	July 12, 2011
RAI 403 — 15.06.05-74	Question Deleted By NRC
RAI 403 — 15.06.05-78	Question Deleted By NRC

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WELLS Russell (RS/NB)
Sent: Friday, April 22, 2011 4:07 PM
To: 'Tesfaye, Getachew'
Cc: HOLM Jerald (External RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 3

Getachew,

AREVA NP provided a schedule for responding to RAI 403 in an email on June 30, 2010. A revised schedule was provided on November 24, 2010 and February 24, 2011.

To allow time for interaction between AREVA and the NRC staff, a revised schedule for submittal of the final response is provided in this e-mail.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 403 is provided below.

Question #	Schedule
RAI 403 — 15.06.05-61	July 12, 2011
RAI 403 — 15.06.05-62	July 12, 2011
RAI 403 — 15.06.05-63	July 12, 2011
RAI 403 — 15.06.05-64	May 31, 2011
RAI 403 — 15.06.05-65	May 31, 2011
RAI 403 — 15.06.05-66	May 31, 2011
RAI 403 — 15.06.05-67	May 31, 2011
RAI 403 — 15.06.05-68	May 31, 2011
RAI 403 — 15.06.05-69	May 31, 2011
RAI 403 — 15.06.05-70	May 31, 2011
RAI 403 — 15.06.05-71	May 31, 2011
RAI 403 — 15.06.05-72	May 31, 2011
RAI 403 — 15.06.05-73	May 31, 2011
RAI 403 — 15.06.05-74	Question Deleted By NRC
RAI 403 — 15.06.05-75	May 31, 2011
RAI 403 — 15.06.05-76	May 31, 2011
RAI 403 — 15.06.05-77	May 31, 2011
RAI 403 — 15.06.05-78	Question Deleted By NRC

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884

Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Thursday, February 24, 2011 9:27 AM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BRYAN Martin (External RS/NB); BENNETT Kathy (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 2

Getachew,

AREVA NP provided a schedule for responding to RAI 403 in an email on June 30, 2010. A revised schedule was provided on November 24, 2010. A draft response to Questions 64 to 77 was provided on November 29, 2010.

To allow time for interaction between AREVA and the NRC staff, a revised schedule for submittal of the final response is provided in this e-mail.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 403 is provided below.

Question #	Schedule
RAI 403 — 15.06.05-61	July 12, 2011
RAI 403 — 15.06.05-62	July 12, 2011
RAI 403 — 15.06.05-63	July 12, 2011
RAI 403 — 15.06.05-64	April 29, 2011
RAI 403 — 15.06.05-65	April 29, 2011
RAI 403 — 15.06.05-66	April 29, 2011
RAI 403 — 15.06.05-67	April 29, 2011
RAI 403 — 15.06.05-68	April 29, 2011
RAI 403 — 15.06.05-69	April 29, 2011
RAI 403 — 15.06.05-70	April 29, 2011
RAI 403 — 15.06.05-71	April 29, 2011
RAI 403 — 15.06.05-72	April 29, 2011
RAI 403 — 15.06.05-73	April 29, 2011
RAI 403 — 15.06.05-74	Question Deleted By NRC
RAI 403 — 15.06.05-75	April 29, 2011
RAI 403 — 15.06.05-76	April 29, 2011
RAI 403 — 15.06.05-77	April 29, 2011
RAI 403 — 15.06.05-78	Question Deleted By NRC

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)

434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: BRYAN Martin (External RS/NB)
Sent: Wednesday, November 24, 2010 3:10 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); HOLM Jerald (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 1

Getachew,

AREVA NP provided a schedule for responding to RAI 403 in an email on June 30, 2010. A revised schedule is being provided to finalize the response and allow time to interact with the NRC.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 403 is provided below.

Question #	Schedule
RAI 403 — 15.06.05-61	February 28, 2011
RAI 403 — 15.06.05-62	February 28, 2011
RAI 403 — 15.06.05-63	February 28, 2011
RAI 403 — 15.06.05-64	February 28, 2011
RAI 403 — 15.06.05-65	February 28, 2011
RAI 403 — 15.06.05-66	February 28, 2011
RAI 403 — 15.06.05-67	February 28, 2011
RAI 403 — 15.06.05-68	February 28, 2011
RAI 403 — 15.06.05-69	February 28, 2011
RAI 403 — 15.06.05-70	February 28, 2011
RAI 403 — 15.06.05-71	February 28, 2011
RAI 403 — 15.06.05-72	February 28, 2011
RAI 403 — 15.06.05-73	February 28, 2011
RAI 403 — 15.06.05-74	Question Deleted By NRC
RAI 403 — 15.06.05-75	February 28, 2011
RAI 403 — 15.06.05-76	February 28, 2011
RAI 403 — 15.06.05-77	February 28, 2011
RAI 403 — 15.06.05-78	Question Deleted By NRC

Sincerely,

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: BRYAN Martin (EXT)
Sent: Wednesday, June 30, 2010 7:22 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); HOLM Jerald S (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 403 Response US EPR DC.pdf" provides a schedule for a response to all of the questions.

The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 403—15.06.05-61	November 30, 2010
RAI 403—15.06.05-62	November 30, 2010
RAI 403—15.06.05-63	November 30, 2010
RAI 403—15.06.05-64	November 30, 2010
RAI 403—15.06.05-65	November 30, 2010
RAI 403—15.06.05-66	November 30, 2010
RAI 403—15.06.05-67	November 30, 2010
RAI 403—15.06.05-68	November 30, 2010
RAI 403—15.06.05-69	November 30, 2010
RAI 403—15.06.05-70	November 30, 2010
RAI 403—15.06.05-71	November 30, 2010
RAI 403—15.06.05-72	November 30, 2010
RAI 403—15.06.05-73	November 30, 2010
RAI 403—15.06.05-74	Question Deleted by NRC
RAI 403—15.06.05-75	November 30, 2010
RAI 403—15.06.05-76	November 30, 2010
RAI 403—15.06.05-77	November 30, 2010
RAI 403—15.06.05-78	Question Deleted by NRC

Sincerely,

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: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Wednesday, June 02, 2010 7:41 AM
To: ZZ-DL-A-USEPR-DL
Cc: Forsaty, Fred; Lu, Shanlai; Donoghue, Joseph; Carneal, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 403(4439), FSARCh. 15

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on May 7, 2010, and discussed with your staff on May 17, 2010. Draft RAI Questions 15.06.05-74 and 15.06.05-78 were deleted as a result of that discussion. 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
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 4608

Mail Envelope Properties (AF843158D8D87443918BD3AA953ABF78DB6C99B89A)

Subject: PUBLIC- cover letter and affavidit only -FW: PROPRIETARY Response to U.S. EPR Design Certification Application RAI No. 403, FSARCh. 15, Supplement 11
Sent Date: 7/19/2013 7:35:51 AM
Received Date: 7/19/2013 7:35:54 AM
From: Snyder, Amy

Created By: Amy.Snyder@nrc.gov

Recipients:
"ArevaEPRDCPEm Resource" <ArevaEPRDCPEm.Resource@nrc.gov>
Tracking Status: None

Post Office: HQCLSTR02.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	24989	7/19/2013 7:35:54 AM
NRC-13-059.pdf	205156	
RAI 403 Supplement 11 Response US EPR DC Non-Proprietary.pdf	354605	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

AREVA

July 18, 2013
NRC:13:059

U.S. Nuclear Regulatory Commission
Document Control Desk
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Rockville, MD 20852

Response to U.S. EPR Design Certification Application RAI 403, Supplement 11

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Martin Bryan (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 403 (4439), FSAR Ch. 15," June 2, 2010.

Ref. 2: Letter, Sandra Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 403, Supplement 4," NRC:11:052, May 31, 2011.

Ref. 3: Letter, Pedro Salas (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 403, Supplement 9," NRC:12:013, March 9, 2012.

Ref. 4: E-mail, Dennis Williford (AREVA NP Inc.), "Response to U.S. EPR Design Certification Application RAI No. 403, FSAR Ch. 15, Supplement 10," June 5, 2012.

In Reference 1, the NRC provided a Request for Additional Information (RAI) regarding the U.S. EPR design certification application. AREVA NP Inc. (AREVA NP) provided a response to ten of the 16 questions in this RAI on May 31, 2011 (Reference 2). AREVA NP provided a response to an additional three questions in this RAI on March 9, 2012 (Reference 3). The schedule for providing a response to the remaining three questions was provided on June 5, 2012 (Reference 4).

The enclosure to this letter provides a complete response to the remaining three questions in RAI 403. AREVA NP considers some of the material contained in the enclosed response to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. A proprietary and non-proprietary version of this response is enclosed.

The following table indicates the respective pages that contain AREVA NP's final response to the subject questions:

Question #	Start Page	End Page
RAI 403 Q15.06.05-61	2	11
RAI 403 Q15.06.05-62	12	19
RAI 403 Q15.06.05-63	20	27

This concludes the formal AREVA NP response to RAI 403, and there are no questions from this RAI for which AREVA NP has not provided a response.

AREVA NP INC.

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Tel.: 434 832-3000 - www.areva.com

If you have any questions related to this information, please contact Len Gucwa by telephone at 434-832-3466, or by e-mail at Len.Gucwa.ext@areva.com.

Sincerely,

Pedro Salas, Director
Regulatory Affairs
AREVA NP Inc.

Enclosures:

1. Proprietary Version of "Response to Request for Additional Information No. 403, Supplement 11"
2. Non-Proprietary Version of "Response to Request for Additional Information No. 403, Supplement 11"
3. Notarized Affidavit

cc: A. M. Snyder
Docket 52-020

A F F I D A V I T

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) 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 the document titled "Response to U.S. EPR Design Certification Application RAI 403, Supplement 11," 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(c) and 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 18th

day of July 2013.

Sherry L. McFaden
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 10/31/2014
Reg.#7079129

SHERRY L. MCFADEN
Notary Public
Commonwealth of Virginia
7079129
My Commission Expires Oct 31, 2014

Response to

Request for Additional Information No. 403(4439), Supplement 11

6/02/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
Application Section: 15.06.05

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

Question 15.06.05-61:

Follow-up to RAI 167, Question 15.06.05-29

In response to Question 15.06.05-29, the applicant did not provide an assessment of the amount of condensate generated by reflux condensation as was requested. Instead, predictions for the liquid content in control areas defined as "steam generator (SG) outlet plenum," "loop crossover pipe," and "cold leg" were presented. Provide a calculation of the amount of condensate generated by reflux condensation accounting for conditions with emergency feed water (EFW) supply present for two or more SGs. The mass of steam due to decay heat is considerably larger than the volume of the loop seals. The staff requests a mass balance accounting for the steam generated in the core by decay heat, steam lost out the break, steam condensed in the SGs, condensate in countercurrent flow returned to the reactor vessel hot leg, condensate collected on the SG, loop crossover pipe, and cold leg, condensate lost out the break, and condensate transported to the vessel downcomer. The staff requests a description of situations involving stratified conditions in the cold leg and downcomer regions.

Response to Question 15.06.05-61:

For the boron dilution event, the most important parameter relative to the reflux condensation is the volume of condensate that accumulates as a coherent, deborated slug. It has been conclusively shown, in the Primärkreislauf-Versuchsanlage (PKL) III tests, that the thermal-hydraulic phenomena occurring during the evolution of the event limit the volume of the slug size to the volume of the loop seal and steam generator (SG) outlet plenum. More discussion on these phenomena, and the applicability to the U.S. EPR plant, is provided in the Response to RAI 403, Questions 15.06.05-62 and 15.06.05-63. The volume corresponds to 11 m^3 for the U.S. EPR plant. The total amount of condensate generated by reflux condensation is not unimportant though. The reflux condensation phase must be long enough such that the assumed slug volume can be created. Additionally, the condensate impacts the boron concentrations in the downcomer and in the core. The amount of condensate generated by reflux condensation is highly variable based on break size, system availabilities, and operator actions.

Many thermal-hydraulic aspects of boron dilution, except the mixing effects, can be analyzed by using system codes such as TRACE and RELAP. The mixing processes from the loop seal to the core involve multidimensional flow effects which typically are not modeled in system codes. Furthermore, these codes exhibit far too much numerical diffusion to be useful for tracking a relatively sharp concentration gradient around the system (Reference 1). Such system code analyses are used to look at the overall system evolution as a result of break sizes in the range of concern. The depletion and refill characteristics of the transient are well captured by system codes. Since the timing of the different phases in the boron dilution event evolution are dependent of the system inventory, system codes can be used to provide an indication of the critical times in the event. The system characteristics: pressure, temperature, flow rates, etc. at these times are relevant. The condensation in the SGs during the phases can also be captured by the system code analyses.

Additionally, systems analyses can provide a means to compare the effects of different break sizes, equipment availabilities, and operator actions. As described in the Response to RAI 403, Question 15.06.05-62, a spectrum of cases was analyzed with S-RELAP5 to determine the effect of these parameters on the transient evolution. Limiting characteristics were identified from the results of the studies and a case demonstrating these characteristics was selected in order to provide the information requested by this RAI. [

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In this case, the reactor coolant system (RCS) pressure reaches the low primary pressure setpoint at 101 seconds and the reactor is tripped. With an assumed loss of offsite power the pumps trip and forced circulation stops. Steam is produced in the core and a period of two-phase natural circulation begins. Any condensate generated during this period is borated by the continued circulation of liquid flow through the system. The RCS pressure continues to fall and reaches the low-low primary pressure setpoint at 710 seconds which actuates the SI system and initiates the automatic partial cooldown at a rate of 180ºF/hr (Figure 15.06.05-61-1). The medium head safety injection (MHSI) flow increases as pressure decreases but it is not enough to compensate yet for the flow out the break. The RCS inventory continues to decrease (Figure 15.06.05-61-2) and continuous natural circulation is lost at ~1300 seconds (Figure 15.06.05-61-3). A period of intermittent flow begins in which the high steam flow rates continue to carry borated liquid over the SG apex and mix with any condensate. At ~2000 seconds, intermittent flow stops and the period of single-phase steam flow begins (Figure 15.06.05-61-3). This begins the reflux condensation period during which deborated condensate could accumulate as a slug below the SG outlet tube sheet. The RCS continues to cooldown and depressurize due to the operator-initiated cooldown following the completion of the automatic partial cooldown. The ECC flow eventually exceeds the break flow rate due the increase in MHSI flow and the contribution from the accumulators. The minimum RCS mass occurs at ~4300 seconds and the system refill begins (Figure 15.06.05-61-2). Intermittent flow in which borated liquid is carried over the SG apex starts at ~9300 seconds (Figure 15.06.05-61-3). Further increases in the RCS level lead to the conclusion of the intermittent flow period and the first restart of continuous natural circulation at ~11,600 seconds (Figure 15.06.05-61-3).

Table 15.06.05-61-1 presents integrated masses for each loop in the time periods from reactor trip (RT) (~100 seconds) to the end of continuous natural circulation (ENC) at ~1300 seconds, to the end of intermittent flow (EIF) at ~2000 seconds, to the restart of intermittent flow (RIF) at ~9300 seconds, and to the first restart of continuous natural circulation (RNC) at ~11600 seconds. For each time period, the amount of steam which enters the SG inlet due to the core decay heat and any vaporization in the hot legs is provided. The amount of steam which condenses on the upside and downside of the SG is also provided. Figure 15.06.05-61-4 depicts an example of this mass balance. It shows the integrated steam flow in and out of the four SGs (in red) and the upside and downside condensate masses generator (in blue) generated during the time period between the end and restart of intermittent flow. This time period corresponds to the period when the lack of liquid circulation would allow for the accumulation of deborated condensate.

Table 15.06.05-61-2 presents the integrated steam flow out of the break during the same time periods. With the small break size, the break flow is single-phase liquid until ~1320 seconds. After this point, there are periods where the break flow is two-phase, but the MHSI injects into the broken loop and the break flow returns to single-phase liquid by 5000 seconds. As such, there is very little steam lost out the break; [

] The total masses from all four loops, steams flows and condensate, and steam break flow from RT to RIF are provided in Table 15.06.05-61-3.

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References

1. Nourbakhsh, H.P. and Z. Cheng "Mixing Phenomena of Interest to Boron Dilution During Small Break LOCAs in PWRs" 7th International Meeting on Nuclear Reactor Thermal-Hydraulics, Saratoga Springs, NY, September 10-15, 1995.

FSAR Impact:

U.S. EPR FSAR, Section 15.6.5.4.2, summarizes the conclusions for the SBLOCA inherent boron dilution event. U.S. EPR FSAR Tier 2, Section 15.6.5.4.2 will be revised consistent with the response and as indicated on the enclosed markup.

Technical Report Impact:

AREVA Technical Report ANP-10288, "U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report," describes the boron dilution evaluation in more detail and will be revised consistent with the response.

Table 15.06.05-61-1: Per Loop SG Masses, Per Phase

Table 15.06.05-61-2: Integrated Break Steam Flow, Per Phase

Table 15.06.05-61-3: Masses from Reactor Trip to First Restart of Continuous Natural Circulation

Table 15.06.05-61-3: Condensate Volumes from the End of Intermittent Flow to the Restart of Intermittent Flow*

Figure 15.06.05-61-1: Primary and Secondary Pressures

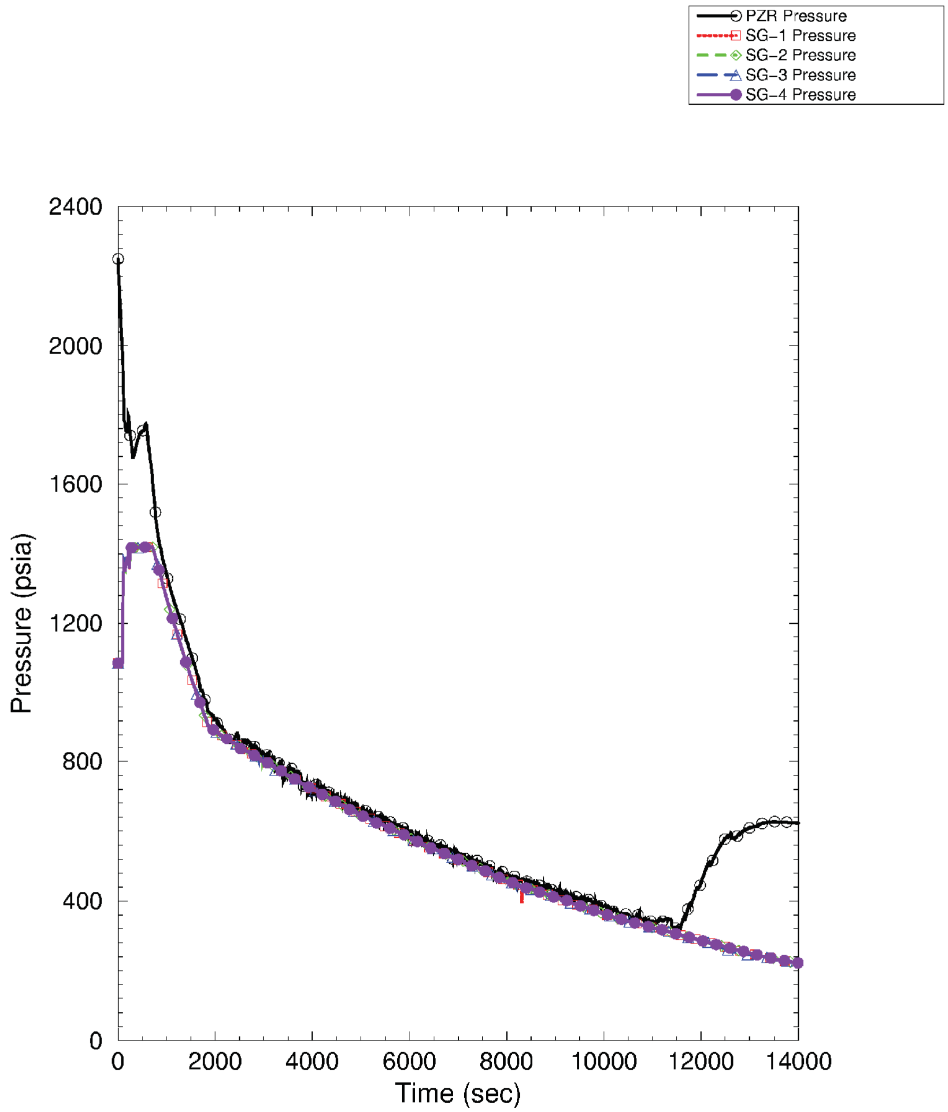

Figure 15.06.05-61-2: RCS Inventory

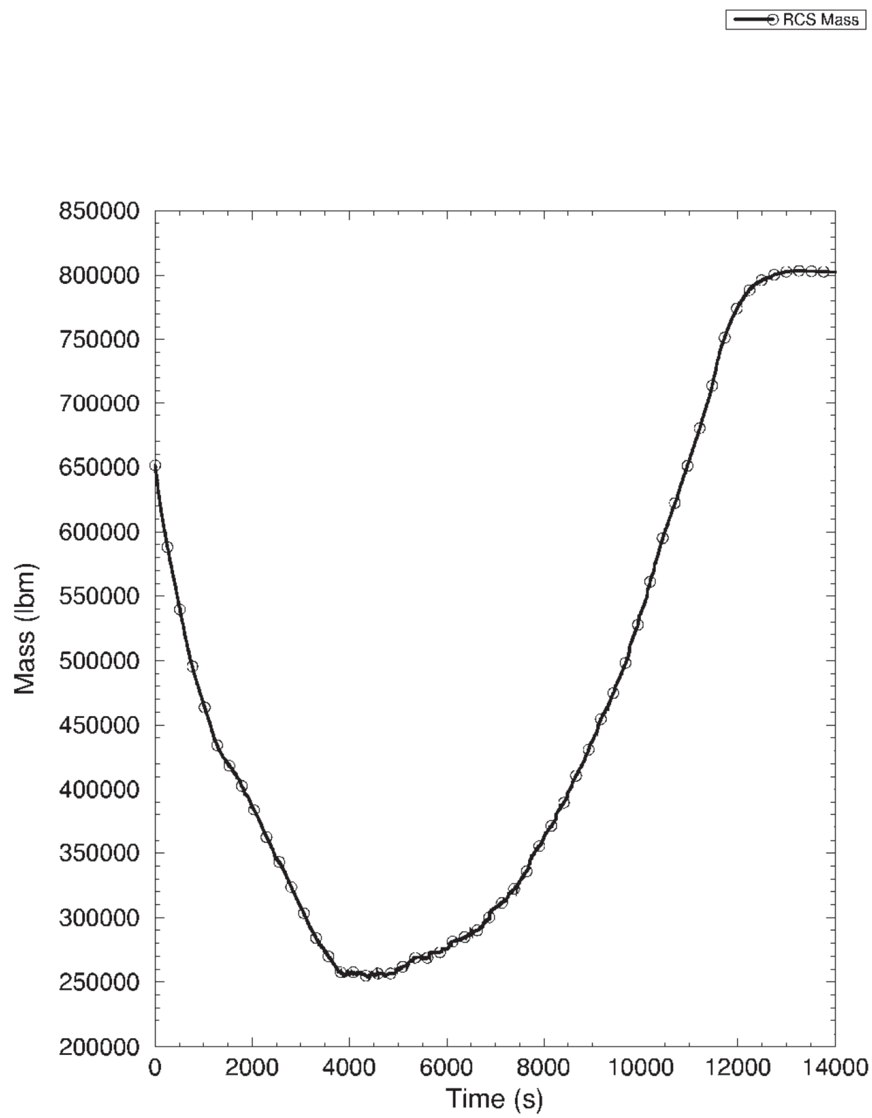

Figure 15.06.05-61-3: SG Apex Liquid Flow

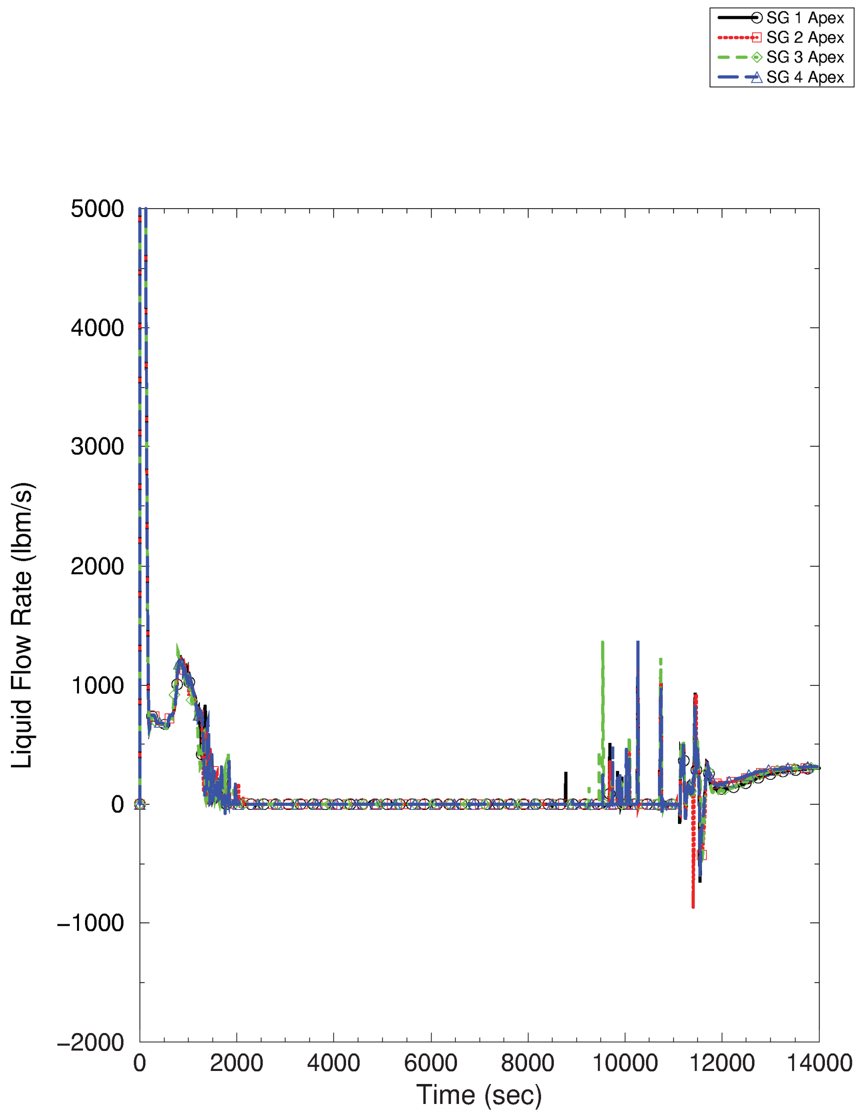

Figure 15.06.05-61-4: Mass Balance for the Period between Loss and Restart of Natural Circulation

Question 15.06.05-62:

Follow-up to RAI 167, Question 15.06.05-30

As follow-up to response to question 15.06.05-30, demonstrate that deborated condensate accumulated in one or more loops (SG plena, loop seals, cold legs, downcomer) experiencing a complete or partial depravation of SI will not pose a recriticality threat to the U.S. EPR if transported towards the core due to natural circulation restart to identify and consider limiting conditions, assumptions, and scenarios in terms of condensate accumulation in individual loops and associated regions as well as transportation mechanisms involving possible restart in multiple primary loops. The dynamics of reboration of the crossover pipe in any idle loop prior to restart should be explained and justified. If the cold leg pipe break is below the elevation of the impeller discharge there does not appear to be a mechanism for backfill of the crossover pipe. Explain which of the postulated scenarios identified in the response to question 156.06.05-30 provides the greatest challenge to core recriticality and explain why.

Response to Question 15.06.05-62:

<u>System Refill and Restart of Natural Circulation Dynamics</u>

The automatic partial cooldown and later the operator-initiated cooldown, in the event of a small break loss-of-coolant accident (SBLOCA), reduce the primary side pressure and temperature at a prescribed rate. The safety injection (SI) flow rate increases due to the decreasing primary pressure. When the injected flow exceeds the break flow, the system refill begins. The filling of the reactor coolant system (RCS) is achieved, for the smaller SBLOCA breaks, by medium head safety injection (MHSI) alone; or, for the larger SBLOCA breaks, by the addition of the accumulators and/or the low head safety injection (LHSI). [

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Limiting Conditions, Assumptions, and Scenario

The phenomenology of the boron dilution event, as evidenced in tests and in system analyses, can be used to identify limiting characteristics of the inherent boron dilution event. The Response to RAI 167, Question 15.06.05-30 and Table 15.06.05-30-2, focused on the impact of assumed single failures and preventative maintenance on safety injection (SI) delivery. A more extensive evaluation of potential scenarios including the extra borating system (EBS) and emergency feedwater (EFW) systems was used to select a subset of cases for S-RELAP5 sensitivity studies. The following conclusions are drawn from those studies and the inherent boron dilution tests (see Response to RAI 403, Question 15.06.05-63):

- The PKL tests showed that the loop most probable to restart NC first will be a loop without SI.
- The PKL tests showed that the size of the slug is limited to the volume of the loop seal and the SG outlet plenum. For the EPR RCS, this is 11 m^3.
- [

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  The break sizes in these ranges are large enough that intermittent flow over the SG apex stops, but not so large as to depressurize the system well below that of the secondary, which allows for the condensation and potential accumulation of deborated condensate. The break size is also not so large as to require LHSI for the system refill and restart of natural circulation. For the U.S. EPR plant, the LHSI flow rates greatly exceed those of the MHSI which enhances the mixing and reboration. The LHSI trains are also cross-connected, which in some SF/PM scenarios alleviates the concern for a loop without direct boration.

- With respect to EFW, since the primary side cooldown rate for the U.S. EPR is fixed, the total condensate generated in the primary side is approximately the same regardless of the number of fed SGs. Once an un-fed SG dries out, no more condensate will be produced in that loop.
- A slower operator-initiated cooldown results in longer times until the restart of natural circulation and results in larger amounts of condensate. Physically, this is counterbalanced by the extended period of SI injection and increased boron concentration in the core. [

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- The slower cooldown is tied to the operation of only one EBS pump. While the time to restart is extended, the total amount of EBS injected at the time of restart of continuous natural circulation is less.

A scenario that demonstrates the limiting characteristics is:

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Demonstration of No Return to Criticality

CFD analyses simulate the transport of the deborated slug and the mixing between the slug and the surrounding borated water in the cold leg, downcomer, and lower plenum in order to determine the local distribution of boron concentrations at the core inlet as a function of time. The CFD models the EPR geometry and uses conditions based on system analyses (RCS pressure and temperature, downcomer concentration and temperature) and extrapolated results from the tests (slug size and concentration, scaled restart of NC flow rate). Instead of relying on a detailed neutronics and 3-D core mixing analysis, a decoupled criterion is used to assess the threat of recriticality: as long as the minimum boron concentration anywhere at the core inlet is greater than the critical boron concentration then the core will not return to criticality. The use of the decoupled criterion is a large conservatism because it neglects the mixing in the core which is at a substantially elevated concentration.

As described in the Response to RAI 403, Question 15.06.05-63, the conditions of the CFD analysis are consistent and/or conservative relative to those predicted by the S-RELAP5 analysis of the scenario identified above. The critical boron concentration that the CFD results are compared to is calculated for the U.S. EPR core at 350ºF, beginning of cycle (BOC), with equilibrium xenon, and all rods in, neglecting the most reactive rod (ARI-MRR). The critical concentration at those conditions, with an additional 100 ppm uncertainty applied, is 1005 ppm, natural boron. [

] Figure 15.06.05-62-3 displays the slug minimum local and average core inlet concentrations as a function of time for the 11 m^3 slug. [

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] These figures, along with Figure 15.06.05-62-3, clearly demonstrate that the minimum concentration is both localized to the periphery and short-lived. The lowest concentration water will rapidly mix with the more borated water following it and with the surrounding water in the highly borated core.

<u>Conclusion</u>

The system refill process establishes the conditions at the restart of natural circulation. Flow oscillations between the cold leg and loop seal and entrainment and intermittent flow in the SG apex limit the slug size to the loop seal and SG outlet plenum. [

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Therefore, for the U.S. EPR plant, it is concluded that there is no risk of recriticality in the inherent boron dilution event.

FSAR Impact:

U.S. EPR FSAR, Section 15.6.5.4.2, summarizes the conclusions for the SBLOCA inherent boron dilution event. U.S. EPR FSAR Tier 2, Section 15.6.5.4.2 will be revised consistent with the response and as indicated on the enclosed markup.

Technical Report Impact:

AREVA Technical Report ANP-10288, “U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report,” describes the boron dilution evaluation in more detail and will be revised consistent with the response.

Table 15.06.05-62-1: U.S. EPR CFD Minimum Core Inlet Boron Concentration and U.S. EPR Critical Boron Concentration

		Concentration (ppm, natural boron)
Slug Size (m^3)	11.0	[ ]
	[ ]	[ ]
	[ ]	[ ]
Critical Boron Concentration		1005

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Figure 15.06.05-62-1: Test E2.2 Loop Flows Prior to Restart

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Figure 15.06.05-62-2: Test F1.1 Loop Flows Prior to Restart

Figure 15.06.05-62-3: 11 m^3 Slug – Minimum Local and Average Core Inlet Concentrations (natural boron)

Figure 15.06.05-62-4: 11 m^3 Slug – Core-Wide Inlet Concentrations (natural boron) at Time of Minimum Local Concentration)

Figure 15.06.05-62-5: [ ] – Core-Wide Inlet Concentrations (natural boron) at Time of Minimum Local Concentration

Question 15.06.05-63:

Follow-up to RAI 167, Question 15.06.05-36

As follow-up to response to question 156.06.05-36, present the available experimental database pertaining to boron dilution relevant to the U.S. EPR boron dilution analysis. The staff considers limiting the database to Primärkreislauf-Versuchsanlage (PKL) Test F1.1 only, to be insufficient. Explain why experimental observations and in particular PKL findings can be applied to justify the assumptions and conditions used in the analysis of the U.S. EPR under critical LOCA conditions of interest. Explain how the entire matrix of relevant tests conducted at PKL or other facilities validates the assumptions in the boron dilution analysis including: (1) restart of natural circulation in only one loop at a time, (2) initial restart in a loop without SI, (3) justification of the boundary conditions assumed in the CFD mixing analysis of core inlet boron concentration and in particular substantiation of the slug injection rate deduced from the PKL experiments.

Response to Question 15.06.05-63:

Test facilities have examined the various aspects associated with the inherent boron dilution event following a small break loss-of-coolant accident (SBLOCA). The Primärkreislauf-Versuchsanlage (PKL) test facility investigated the thermal-hydraulic phenomena associated with the event. The PKL III E and F test series were comprised of several integral tests to investigate the dominant physical principles of the event related to the size of the condensate slug and the restart of natural circulation. Both simulation of real transients and separate effects tests were performed. The PKL test facility though is not designed for the simulation of the mixing process in the downcomer annulus and the lower plenum. For this, additional mixing tests and computational fluid dynamics (CFD) analysis are needed to compliment the PKL tests. CFD analyses, when validated by tests, are capable of accurately simulating the mixing processes in the cold legs, downcomer, and lower plenum, and determining the boron concentration at the core inlet.

<u>PKL Tests and Conclusions</u>

The PKL test facility is based on a typical western-type, four- loop PWR (Reference1). The entire primary side, the most significant components of the secondary side (excluding the turbine and condenser), and the appropriate system technology are represented. The major components heights on the primary and secondary side are scaled with a 1:1 ratio. The volumes, power, and mass flows are scaled with a ratio of 1:145. For some components, the exact volume scaling is not applied in order to simulate certain thermal-hydraulic phenomena; for example, counter current flow limitation in the hot legs. This allowed dimensionless numbers (e.g., the Froude number) to be maintained in the correct parameter range. Due to its full-scale height and symmetric layout of the four loops, the PKL test facility is well suited for the study of reflux condensation and natural circulation phenomena.

Four tests relevant to the inherent boron dilution event were conducted with the PKL III E and F test series. Test E2.2 and Test F1.1 were transient simulations. Test E2.2 simulated a cold leg break with asymmetric cold leg injection from only two safety injection pumps. This is representative of the U.S. EPR design with two out of four safety injection (SI) trains not available due to single failure and preventative maintenance assumptions. The test had a very long reflux condenser period and excessive condensate production in order to obtain the maximum possible volume of accumulated condensate (Reference 1). Test F1.1 also simulated a cold leg break, but with symmetric cold leg injection into all four loops. A major focus of this test was to investigate the potential for simultaneous restart of natural circulation. Test F1.2 and Test F4.1 were parametric studies that investigated the relationship between the primary inventory drain and refill and the start and end of reflux condensation and condensate accumulation. The matrix of tests allowed for conclusive findings to be made relative to the boron dilution processes and to the refill and restart of natural circulation.

While Test E2.2 had a long condensation period, the refill and restart of natural circulation processes limited the amount of condensate which could accumulate as a slug. [

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As soon as the refill allows for a level above the SG outlet side tube sheet, transport phenomena over the SG apex enable further disintegration and reboration of the slug. These transport phenomena were investigated in detail and confirmed with the parametric studies, Test F1.2 and Test F4.1. Therefore, the size of the slug is limited to the loop seal and SG outlet plenum.

The tests also concluded that natural circulation arises in different loops at different times due to the inherent asymmetries between the tubes of a single SG and between the refill processes of the individual loops. Test E2.2 demonstrated that the loop which restarts first is a loop without injection. The colder water in the loop seal of the loops with injected ECC creates a temperature and density difference which delays the restart of natural circulation. The restart of natural circulation in one loop causes a decrease in the steam production, which reduces the swell levels in the other generators and delays the restart of natural circulation in subsequent loops. [

] Test F1.1, which was set up for the most symmetric boundary conditions, confirmed the single loop restart and delay to restart of natural circulation in the other loops.

The main results from the test matrix are:

- In order for the accumulation of condensate, the water level must be below the steam generator (SG) outlet tube sheet.
- The size of the deborated slug is limited to the volume of the loop seal and the SG outlet plenum.
- The exchanges between the SG inlet plenum, hot leg, upper plenum, and core region prevent the formation of a deborated slug on the SG upside.
- Natural circulation does not restart simultaneously, regardless of whether ECC injection is symmetric or asymmetric.
- Natural circulation (NC) restarts first in legs without ECC.
- The first restart of natural circulation (RNC) impedes the restart of natural circulation in subsequent loops.

- During the refill phase, there are intermittent flows of borated water from the cold leg back into the loop seal and from the inlet SG plenum, over the SG tubes apex. These flows mix, reborate, and partly disintegrate the deborated slug prior to its transport towards the core.
- Weakly borated slugs were observed only in legs without ECC.

PKL Applicability to U.S. EPR

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Mixing Experiments and CFD Analysis

The PKL test results demonstrate the phenomena that occur during the long-term SBLOCA inherent boron dilution event evolution up to the transport of the slug. The tests are used to define important input parameters to the transport phase, particularly the slug size and slug flow rate. The transport phase and the mixing that occurs in the cold leg, downcomer, and lower plenum during the transport are evaluated with CFD analyses.

CFD analyses have been proven to be an effective tool for calculating three-dimensional mixing flows, but the applied numerical methods and turbulence models require experimental validation with detailed local resolution of flow and temperature fields. There are several facilities, such as the University of Maryland 2x4 Thermal Hydraulic Loop Facility (UM 2x4 Loop) and the Rossendorf Coolant Mixing Model (ROCOM) facility, which have performed mixing tests to study the rapid transport of low boron slugs. International Standard Problem (ISP) 43 was defined specifically for the validation of CFD tools in simulating the fluid dynamic aspects of rapid boron dilution transients (Reference 2).

Experimental data was collected using the UM 2x4 Loop and the Boron-mixing Visualization Facility. The UM 2x4 Loop is a scaled-down model of the Three Mile Island Unit 2 B&W pressurized water reactor (PWR). Ten organizations from eight countries participated in the exercise using such codes as Fluent, CFX, and PLASHY. The code predictions were in good agreement with the experimental data and the program concluded that CFD can be used to investigate the mixing in rapid boron dilution transients. In the European project FLOMIX-R

(References 3 and Reference 4), slug mixing and the flow distribution in the reactor pressure vessel (RPV) have been comprehensively investigated and simulated using CFD. Slug mixing experiments were performed at the ROCOM facility, a 1:5 model of a KONVOI reactor, and the Vattenfall test facility, a 1:5 model of a Westinghouse three-loop PWR. One of the main objectives was to investigate how well mixing during boron dilution transients in PWRs can be modeled by CFD codes. As with ISP 43, it was concluded that CFD methods can be suitably applied (Reference 4). These programs validate the application of CFD to the boron dilution event, but they do not simulate and provide qualification for the EPR plant. The JULIETTE test facility, described in more detail in Response to RAI 231, Question 04.04-56, is fully representative of the U.S. EPR reactor vessel internals at a 1:5 scale. [

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The boundary conditions for the CFD analyses are based on the combination of system analyses and the PKL conclusions. [

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Response to RAI 403, Question 15.06.05-62, based on a spectrum of S-RELAP5 analyses, identified a case demonstrating limiting characteristics for the boron dilution event. To justify the applicability of the CFD analysis, the results of that analysis are compared to the inputs to the CFD analysis in Table 15.06.05-63-1. [

]

Conclusion

The matrix of tests performed at the PKL facility provides a comprehensive examination into the various thermal-hydraulic phenomena which occur during the evolution of the inherent boron dilution event following a SBLOCA. The combination of real transient simulations and parametric tests allowed for conclusions to be drawn that can be applied to the U.S. EPR plant. The conclusions from the test matrix and results from EPR specific systems analysis are inputs to the CFD analyses. The CFD model is qualified based on inherent boron tests at the JULIETTE facility. Based on the justified PKL assumptions and the consistent and conservative inputs, the conditions of the U.S. EPR CFD analyses are appropriate and the results can be used to demonstrate that no recriticality will occur during the event.

Table 15.06.05-63-1: CFD Input Comparison

References:

1. Umminger, K., Thomas Mull, and Bernhard Brand. "Integral Effect Tests in the PKL Facility with International Participation." *Nuclear Engineering and Technology* Vol. 41, No. 6 (2009): 765-774.
2. ISP-43: Rapid Boron Dilution Transient Experiment, Comparison Report, NEA/CSNI/R(2000)22.
3. Rohde U., et. al. "Fluid Mixing and Flow Distribution in the Reactor Circuit, Measurement Data Base." *Nuclear Engineering and Design* 235 (2005): 421-443.
4. Rohde, U., et. al. "Fluid Mixing and Flow Distribution in the Reactor Circuit – Validation of CFD Codes." *Nuclear Engineering and Design* 237 (2007): 1639-1655.

FSAR Impact:

U.S. EPR FSAR, Section 15.6.5.4.2, summarizes the conclusions for the SBLOCA inherent boron dilution event. U.S. EPR FSAR Tier 2, Section 15.6.5.4.2 will be revised consistent with the response and as indicated on the enclosed markup.

Technical Report Impact:

AREVA Technical Report ANP-10288, "U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report," describes the boron dilution evaluation in more detail and will be revised consistent with the response.

U.S. EPR Final Safety Analysis Report Markups

All indicated changes are in response to RAI 403, Questions 15.06.05-61, -62, and -63

Table 1.6-1—Reports Referenced
Sheet 2 of 5

Report No. (See Notes 1, 2, and 3)	Title	Date Submitted to NRC	FSAR Section Number(s)
[*ANP-10287P* *ANP-10287NP*	*Incore Trip Setpoint and Transient Methodology for U.S. EPR Topical Report*]*	11/27/07	4.3, 4.4, 7.1, 7.2, 15.0, 15.1, 15.2,15.3,15.4,15.6, 16
ANP-10288P ANP-10288NP Revision 2~~1~~	U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report	6/13~~1/10~~	15
ANP-10290 Revision 1	AREVA NP Environmental Report Standard Design Certification	9/11/09	19.2
ANP-10291P ANP-10291NP	Small Break LOCA and Non-LOCA Sensitivity Studies and Methodology Technical Report	5/09	15
ANP-10292 Revision 1	U.S. EPR Conformance with Standard Review Plan (NUREG-0800) Technical Report	5/09	1.9
ANP-10293P, Revision 4	U.S. EPR Design Features to Address GSI-191 Technical Report	11/11	6.3 and 15.6.5.4.3
ANP-10294 Revision 1	U.S. EPR Reactor Coolant Pump Motor Flywheel Structural Analysis Technical Report	3/09	5.4.1.6.6
ANP-10295P ANP-10295NP Revision 4~~3~~	U.S. EPR Security Design Features Technical Report	4/13~~2/12~~	13.6 and 19.2.7
ANP-10296 Revision 1	U.S. EPR Design Features that Enhance Security	4/13~~12/08~~	13.6 and 19.2.7
ANP-10299P Revision 2	Applicability of AREVA NP Containment Response Evaluation Methodology to the U.S. EPR for Large Break LOCA Analysis, including Supplement 1, August 2011.	12/09	6.2.1 and 6.2.5
[*ANP-10304 Revision 6~~5~~*	*U.S. EPR Diversity and Defense in Depth Assessment Technical Report*]*	5/13~~2~~	1.9, 7.1, 7.2, 7.3, 7.8, 18.7, 19.1
ANP-10306P, Revision 1	Comprehensive Vibration Assessment Program for U.S. EPR Reactor Internals Technical Report	1/13 ~~12/09~~	3.9.2.1.1, 3.9.2.3, 3.9.2.4, and 3.9.2.7
[*ANP-10309P* *ANP-10309NP* *Revision 5~~4~~*	*U.S. EPR Protection System Technical Report*]*	5/13~~2~~	4.6, 7.1, 7.2, and 7.3

All indicated changes are in response to RAI 403, Questions 15.06.05-61, -62, and -63

used in the calculation of concentration over time using the methodology described in U.S. EPR Boron Precipitation and Boron Dilution (Reference 9).

The calculation conservatively neglects the following mitigating processes:

- Increased boron solubility due to other solutes.
- Increased boiling temperature due to boric acid concentration.
- Carryout of dissolved boric acid by steam generated in the core.
- Carryout of boric acid due to droplet entrainment.
- Addition of nonborated water from sources such as the CVCS.

Figure 15.6-92—Time Dependent Boron Concentration During the Pool Boiling Period with and without Hot Leg Injection at 60 Minutes shows the predicted boron concentration over time for the limiting LBLOCA PCT case. The LBLOCA has a shorter time to precipitation than the SBLOCA, and therefore is the boundary boron precipitation event. The curve demonstrates that boric acid does not concentrate to the degree that boron precipitates out of solution. Moreover, there is adequate time for the operator to initiate hot leg injection to limit the buildup of boron in the core region and prevent precipitation in other regions of the RCS.

15.6.5.4.2 SBLOCA Boron Dilution

GSI-185, “Control of Recriticality Following Small-Break LOCAs~~S~~ in PWRs,” identified a ~~raises the~~ concern ~~for SBLOCA events~~ that, during an SBLOCA event, de~~-~~borated water could accumulate ~~in cold leg pump suction piping~~ due to the condensation of steam in the SGs and be transported to the TV and core when circulation is restored~~. When natural circulation is restored, this de-borated water gets flushed as a slug to the RV and core~~, potentially causing a recriticality and fuel damage.

There is a narrow range of break sizes in the SBLOCA spectrum which are susceptible to this event. ~~The conditions necessary for this condition to occur develop for a narrow range of break sizes.~~ Breaks smaller than this range do not interrupt natural circulation and therefore do not accumulate de~~-~~borated water. Those larger than this range depressurize quickly such that ~~to low pressure, during which time~~ the secondary sides of the SGs are a heat source to the primary system. Even if heat transfer is re-established to the SGs after they are depressurized, the break is too large for the LHSI to refill the loops and restart. ~~Because natural circulation does not restart, de-borated water is not flushed to the core as a slug.~~

The evaluation of the SBLOCA boron dilution event is described in Reference 9. The evaluation incorporates experimental results from the PKL test facility, EPR plant-specific system code analyses, and CFD analyses. The evaluation demonstrates that the minimum concentration at any location across the core inlet is above the critical concentration. Therefore, recriticality is not challenged and there is no safety concern for the U.S. EPR plant in an SBLOCA boron dilution event.~~AREVA performed tests at the PKL integral loop test facility to investigate boron dilution during SBLOCA, as described in Final Report of the PKL Experimental Program Within the OECD/SETH Project (Reference 10). Some of the tests simulate the controlled cooldown of the SGs representative of the U.S. EPR plant design. The tests demonstrate that natural circulation does not restart abruptly. It is preceded by a period of intermittent circulation. Moreover, the circulation starts first in one active loop and is followed independently by circulation in other active loops. This thermal-hydraulic behavior provides a basis for evaluating boron concentrations in the cold legs and core.~~

~~Bounding calculations of boron concentration in the cold legs, RV, and core are performed assuming different natural circulation restart scenarios. These calculations are described in Reference 9. The calculations demonstrate that the concentration in coolant entering the core does not fall to the minimum core average concentration for recriticality of 1005 ppm with equilibrium xenon.~~

15.6.5.4.3 IRWST Recirculation Cooling

GSI-191, "Assessment of Debris Accumulation on PWR Sump Performance," raises the concern that the high-energy jet from a LOCA may rip away insulation, pulverize concrete, and create other miscellaneous debris particles. Debris generated and transported to the IRWST may potentially penetrate the strainers and screens, degrade the performance of plant mitigating systems, and block coolant channels in the core.

ANP-10293 (Reference 11) describes the design features that address the GSI-191 concerns. The U.S. EPR design reduces the potential for debris generation by using reflective metal insulation to insulate RCS components. This insulation does not produce particulate or fibrous debris that is easily transported to the SIS inlet and ingested. In addition, a defense in depth approach is used to enable heavy materials to settle out in the Containment Building. Multiple levels of filtration prevent debris from reaching the SIS pumps and being transported to the RCS. This system is described in Section 6.3.

15.6.5.4.4 Conclusions

The evaluations described in the preceding sections demonstrate that the U.S. EPR satisfies the requirement that following the initial mitigation of a LOCA, the calculated core temperature is maintained at an acceptably low value and decay heat is removed for the extended period required by the long-lived radioactivity.

- Boron precipitation. Calculations demonstrate that for the complete spectrum of breaks, boric acid does not concentrate to the degree that boron precipitates out of

All indicated changes are in response to RAI 403, Questions 15.06.05-61, -62, and -63

solution. Moreover, the operator has adequate time to initiate hot leg injection to limit the buildup of boron in the core region and, if started early, precipitation in other regions of the RCS.

- Boron dilution during SBLOCA. PKL test results and bounding scenario calculations demonstrate that the boron concentration in coolant entering the core during the restart of natural circulation does not fall below the minimum core average concentration for recriticality.
- Containment debris. The use of reflective metal insulation on RCS components to reduce the generation of particulate and fibrous debris and a defense in depth approach to preventing its migration to the ECCS pump inlet effectively mitigates the concern for equipment degradation and blockage due to the ingestion of debris.

15.6.6 References

1. ANP-10263P-A, Revision 0, "Codes and Methods Applicability Report for the U.S. EPR," AREVA NP Inc., August 2007.
2. ANP-10287P, Revision 0, "Incore Trip Setpoint and Transient Methodology for U.S. EPR," AREVA NP Inc., November 2007.
3. ANP-10269P, Revision 0, "The ACH-2 CHF Correlation for the U.S. EPR," AREVA NP Inc., November 2006.
4. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, March 2007.
5. ANP-10278P-A, Revision 1, "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report," AREVA NP Inc., November 2011.
6. ANP-10291P, Revision 0, "Small Break LOCA and Non-LOCA Sensitivity Studies and Methodology," October, 2007.
7. ANS-5.1-1973, "Decay Energy Release Rates Following Shutdown of Uranium-Fueled Thermal Reactors," American Nuclear Society, October 1971, revised October 1973.
8. BAW-10227P-A, Revision 1, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel," Framatome Cogema Fuels, February 2000.
9. ANP-10288P, Revision 2~~1~~, "U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report," AREVA NP Inc., June 2013~~January 2010~~.
10. Deleted.~~FANP NGTT1/04/en/04, Revision A, "Final Report of the PKL Experimental Program Within the OECD/SETH Project," Framatome ANP, December 2004.~~
11. ANP-10293P, Revision 4, "U.S. EPR Design Features to Address GSI-191 Technical Report," AREVA NP Inc., November 2011.