

## ArevaEPRDCPEm Resource

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**From:** McLellan, Judith  
**Sent:** Wednesday, February 27, 2013 3:27 PM  
**To:** ArevaEPRDCPEm Resource  
**Subject:** FW: Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 23  
**Attachments:** RAI 294 Response Supplement 23 US EPR DC.pdf  
**Importance:** High

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**From:** Dennis.Williford@areva.com [mailto:Dennis.Williford@areva.com]  
**Sent:** Monday, March 26, 2012 9:59 AM  
**To:** Tesfaye, Getachew  
**Cc:** Kathy.Bennett@areva.com; Karen.Delano@areva.com; Judy.Romine@areva.com; Tom.Ryan@areva.com; David.Kowalski@areva.com  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 23  
**Importance:** High

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16, Supplement 17, Supplement 18 and Supplement 19 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011, September 15, 2011, October 14, 2011 and November 18, 2011, respectively, to provide a revised schedule. Supplement 20 response to RAI No. 294 was sent on December 15, 2011 to provide technically correct and complete responses to Questions 10.02.03-19 and 10.02.03-22. Supplement 21 and Supplement 22 responses to RAI No. 294 were sent on January 27, 2012 and February 24, 2012, respectively, to provide a revised schedule.

The attached file, "RAI 294 Response Supplement 23 US EPR DC.pdf," provides a technically correct and complete final response to the remaining three questions (Questions 10.02.03-17, 10.02.03-20 and 10.02.03-23).

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 294 Questions 10.02.03-17, 10.02.03-20 and 10.02.03-23.

The following table indicates the respective pages in the response document, "RAI 294 Response Supplement 23 US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 294 — 10.02.03-17	2	7
RAI 294 — 10.02.03-20	8	15
RAI 294 — 10.02.03-23	16	17

This concludes the formal AREVA NP response to RAI 294, and there are no questions from this RAI for which AREVA NP has not provided responses.

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](mailto:Dennis.Williford@areva.com)

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**From:** WILLIFORD Dennis (RS/NB)  
**Sent:** Friday, February 24, 2012 4:05 PM  
**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 22  
**Importance:** High

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16, Supplement 17, Supplement 18 and Supplement 19 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011, September 15, 2011, October 14, 2011 and November 18, 2011, respectively, to provide a revised schedule. Supplement 20 response to RAI No. 294 was sent on December 15, 2011 to provide technically correct and complete responses to two questions (Questions 10.02.03-19 and 10.02.03-22). Supplement 21 response to RAI No. 294 was sent on January 27, 2012 to provide a revised schedule.

In order to provide an opportunity to interact with NRC staff on these responses, the schedule for the remaining three questions has changed as provided below:

<b>Question #</b>	<b>Response Date</b>
RAI 294 — 10.02.03-17	<b>March 29, 2012</b>
RAI 294 — 10.02.03-20	<b>March 29, 2012</b>
RAI 294 — 10.02.03-23	<b>March 29, 2012</b>

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](mailto:Dennis.Williford@areva.com)

---

**From:** WILLIFORD Dennis (CORP/QP)  
**Sent:** Friday, January 27, 2012 8:41 AM  
**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB); [Michael.Miernicki@nrc.gov](mailto:Michael.Miernicki@nrc.gov); [peter.hearn@nrc.gov](mailto:peter.hearn@nrc.gov)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 21

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16, Supplement 17, Supplement 18 and Supplement 19 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011, September 15, 2011, October 14, 2011 and November 18, 2011, respectively, to provide a revised schedule. Supplement 20 response to RAI No. 294 was sent on December 15, 2011 to provide technically correct and complete responses to two questions (Questions 10.02.03-19 and 10.02.03-22).

The schedule for technically correct and complete responses to the remaining three questions has changed as provided below:

<b>Question #</b>	<b>Response Date</b>
RAI 294 — 10.02.03-17	<b>February 24, 2012</b>
RAI 294 — 10.02.03-20	<b>February 24, 2012</b>
RAI 294 — 10.02.03-23	<b>February 24, 2012</b>

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](mailto:Dennis.Williford@areva.com)

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**From:** WILLIFORD Dennis (RS/NB)  
**Sent:** Thursday, December 15, 2011 11:22 AM  
**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 20

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and

Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16, Supplement 17, Supplement 18 and Supplement 19 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011, September 15, 2011, October 14, 2011 and November 18, 2011, respectively, to provide a revised schedule.

The attached file, "RAI 294 Supplement 20 Response US EPR DC.pdf" provides technically correct and complete FINAL responses to Questions 10.02.03-19 and 10.02.03-22.

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 294 Question 10.02.03-22.

The following table indicates the respective pages in the response document, "RAI 294 Supplement 20 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 294 — 10.02.03-19	2	5
RAI 294 — 10.02.03-22	6	7

The schedule for technically correct and complete responses to the remaining three questions has not changed as provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	January 27, 2012
RAI 294 — 10.02.03-20	January 27, 2012
RAI 294 — 10.02.03-23	January 27, 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](mailto:Dennis.Williford@areva.com)

---

**From:** WILLIFORD Dennis (RS/NB)  
**Sent:** Friday, November 18, 2011 3:38 PM  
**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 19

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010,

February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16, Supplement 17 and Supplement 18 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011, September 15, 2011 and October 14, 2011, respectively, to provide a revised schedule.

The schedule for technically correct and complete responses to the five remaining questions has been revised as provided below:

<b>Question #</b>	<b>Response Date</b>
RAI 294 — 10.02.03-17	<b>January 27, 2012</b>
RAI 294 — 10.02.03-19	<b>December 15, 2011</b>
RAI 294 — 10.02.03-20	<b>January 27, 2012</b>
RAI 294 — 10.02.03-22	<b>December 15, 2011</b>
RAI 294 — 10.02.03-23	<b>January 27, 2012</b>

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](mailto:Dennis.Williford@areva.com)

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**From:** WILLIFORD Dennis (RS/NB)  
**Sent:** Friday, October 14, 2011 10:22 AM  
**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 18

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15, Supplement 16 and Supplement 17 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011, August 17, 2011 and September 15, 2011, respectively, to provide a revised schedule.

The schedule for technically correct and complete responses to the five remaining questions has been changed as provided below:

<b>Question #</b>	<b>Response Date</b>
RAI 294 — 10.02.03-17	<b>November 18, 2011</b>
RAI 294 — 10.02.03-19	<b>November 18, 2011</b>
RAI 294 — 10.02.03-20	<b>November 18, 2011</b>
RAI 294 — 10.02.03-22	<b>November 18, 2011</b>

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](mailto:Dennis.Williford@areva.com)

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**From:** RYAN Tom (RS/NB)  
**Sent:** Thursday, September 15, 2011 4:35 PM  
**To:** Tesfaye, Getachew  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB); WILLIFORD Dennis (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 17

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14, Supplement 15 and Supplement 16 responses to RAI No. 294 were sent on June 24, 2011, July 22, 2011 and August 17, 2011, respectively, to provide a revised schedule.

The schedule for technically correct and complete responses to the five remaining questions has been revised and is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	October 14, 2011
RAI 294 — 10.02.03-19	October 14, 2011
RAI 294 — 10.02.03-20	October 14, 2011
RAI 294 — 10.02.03-22	October 14, 2011
RAI 294 — 10.02.03-23	October 14, 2011

Sincerely,

Tom Ryan for  
**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](mailto:Dennis.Williford@areva.com)

**From:** WILLIFORD Dennis (RS/NB)

**Sent:** Wednesday, August 17, 2011 1:37 PM

**To:** [Getachew.Tesfaye@nrc.gov](mailto:Getachew.Tesfaye@nrc.gov)

**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)

**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 16

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14 and Supplement 15 responses to RAI No. 294 were sent on June 24, 2011 and July 22, 2011, respectively, to provide a revised schedule.

The schedule for technically correct and complete responses to the five remaining questions has been revised and is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	<b>September 16, 2011</b>
RAI 294 — 10.02.03-19	<b>September 16, 2011</b>
RAI 294 — 10.02.03-20	<b>September 16, 2011</b>
RAI 294 — 10.02.03-22	<b>September 16, 2011</b>
RAI 294 — 10.02.03-23	<b>September 16, 2011</b>

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](mailto:Dennis.Williford@areva.com)

---

**From:** WELLS Russell (RS/NB)

**Sent:** Friday, July 22, 2011 4:22 PM

**To:** Tesfaye, Getachew

**Cc:** KOWALSKI David (RS/NB); ROMINE Judy (RS/NB); WILLIFORD Dennis (RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); RYAN Tom (RS/NB)

**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 15

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010,

February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21. Supplement 14 response to RAI No. 294 was sent on June 24, 2011 to provide a revised schedule.

The schedule for technically correct and complete responses to the five remaining questions has been revised and is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	August 17, 2011
RAI 294 — 10.02.03-19	August 17, 2011
RAI 294 — 10.02.03-20	August 17, 2011
RAI 294 — 10.02.03-22	August 17, 2011
RAI 294 — 10.02.03-23	August 17, 2011

Sincerely,

*Russ Wells for*

**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](mailto:Dennis.Williford@areva.com)

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**From:** WILLIFORD Dennis (RS/NB)  
**Sent:** Friday, June 24, 2011 10:58 AM  
**To:** Tesfaye, Getachew  
**Cc:** BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 14

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule. Supplement 13 response to RAI No. 294 was sent on May 19, 2011 to provide technically correct and complete responses to Questions 10.02.03-18 and 10.02.03-21.

The schedule for technically correct and complete responses to the five remaining questions has been revised and is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	July 22, 2011
RAI 294 — 10.02.03-19	July 22, 2011
RAI 294 — 10.02.03-20	July 22, 2011
RAI 294 — 10.02.03-22	July 22, 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](mailto:Dennis.Williford@areva.com)

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**From:** WELLS Russell (RS/NB)  
**Sent:** Thursday, May 19, 2011 11:06 AM  
**To:** Tesfaye, Getachew  
**Cc:** WILLIFORD Dennis (RS/NB); KOWALSKI David (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. 294, FSAR Ch. 10, Supplement 13

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10, Supplement 11 and Supplement 12 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011, March 11, 2011 and April 14, 2011, respectively, to provide a revised schedule.

The attached file, "RAI 294 Supplement 13 Response US EPR DC.pdf" provides technically correct and complete FINAL responses to two of the seven questions.

The following table indicates the respective pages in the response document, "RAI 294 Supplement 13 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 294 — 10.02.03-18	2	2
RAI 294 — 10.02.03-21	3	3

The schedule for technically correct and complete responses to the five remaining questions has been revised and is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	June 24, 2011
RAI 294 — 10.02.03-19	June 24, 2011
RAI 294 — 10.02.03-20	June 24, 2011
RAI 294 — 10.02.03-22	June 24, 2011
RAI 294 — 10.02.03-23	June 24, 2011

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](mailto:Russell.Wells@Areva.com)

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**From:** WELLS Russell (RS/NB)

**Sent:** Thursday, April 14, 2011 2:33 PM

**To:** 'Tesfaye, Getachew'

**Cc:** KOWALSKI David (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. 294, FSAR Ch. 10, Supplement 12

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9, Supplement 10 and Supplement 11 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010, February 10, 2011 and March 11, 2011, respectively, to provide a revised schedule.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to the seven questions is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	May 19, 2011
RAI 294 — 10.02.03-18	May 19, 2011
RAI 294 — 10.02.03-19	May 19, 2011
RAI 294 — 10.02.03-20	May 19, 2011
RAI 294 — 10.02.03-21	May 19, 2011
RAI 294 — 10.02.03-22	May 19, 2011
RAI 294 — 10.02.03-23	May 19, 2011

*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](mailto:Russell.Wells@Areva.com)

**From:** WELLS Russell (RS/NB)  
**Sent:** Friday, March 11, 2011 1:03 PM  
**To:** Tesfaye, Getachew  
**Cc:** KOWALSKI David (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. 294, FSAR Ch. 10, Supplement 11  
**Importance:** High

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8, Supplement 9 and Supplement 10 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010, December 20, 2010 and February 10, 2011, respectively, to provide a revised schedule.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to the seven questions is provided below:

<b>Question #</b>	<b>Response Date</b>
RAI 294 — 10.02.03-17	April 15, 2011
RAI 294 — 10.02.03-18	April 15, 2011
RAI 294 — 10.02.03-19	April 15, 2011
RAI 294 — 10.02.03-20	April 15, 2011
RAI 294 — 10.02.03-21	April 15, 2011
RAI 294 — 10.02.03-22	April 15, 2011
RAI 294 — 10.02.03-23	April 15, 2011

*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\*](mailto:Russell.Wells@Areva.com)

---

**From:** BRYAN Martin (External RS/NB)  
**Sent:** Thursday, February 10, 2011 9:49 AM  
**To:** Tesfaye, Getachew  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 10

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7, Supplement 8 and Supplement 9 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010, November 17, 2010 and December 20, 2010, respectively, to provide a revised schedule.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to the seven questions is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	March 11, 2011
RAI 294 — 10.02.03-18	March 11, 2011
RAI 294 — 10.02.03-19	March 11, 2011
RAI 294 — 10.02.03-20	March 11, 2011
RAI 294 — 10.02.03-21	March 11, 2011
RAI 294 — 10.02.03-22	March 11, 2011
RAI 294 — 10.02.03-23	March 11, 2011

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (External RS/NB)  
**Sent:** Monday, December 20, 2010 11:58 AM  
**To:** Tesfaye, Getachew  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB); 'Carneal, Jason'  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 9

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6, Supplement 7 and Supplement 8 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010, October 15, 2010 and November 17, 2010, respectively, to provide a revised schedule.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to the seven questions is provided below:

Question #	Response Date
RAI 294 — 10.02.03-17	February 10, 2011
RAI 294 — 10.02.03-18	February 10, 2011
RAI 294 — 10.02.03-19	February 10, 2011
RAI 294 — 10.02.03-20	February 10, 2011

RAI 294 — 10.02.03-21	February 10, 2011
RAI 294 — 10.02.03-22	February 10, 2011
RAI 294 — 10.02.03-23	February 10, 2011

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (External RS/NB)  
**Sent:** Wednesday, November 17, 2010 12:04 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB); 'Miernicki, Michael'  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 8

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4, Supplement 5, Supplement 6 and Supplement 7 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010, August 13, 2010, September 10, 2010 and October 15, 2010, respectively, to provide a revised schedule.

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

The schedule for technically correct and complete responses to the seven questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	December 22, 2010
RAI 294 — 10.02.03-18	December 22, 2010
RAI 294 — 10.02.03-19	December 22, 2010
RAI 294 — 10.02.03-20	December 22, 2010
RAI 294 — 10.02.03-21	December 22, 2010
RAI 294 — 10.02.03-22	December 22, 2010
RAI 294 — 10.02.03-23	December 22, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (External RS/NB)  
**Sent:** Friday, October 15, 2010 9:40 AM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 7

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4 and Supplement 5 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010 and August 13, 2010, respectively, to provide a revised schedule. Supplement 6 response to RAI No. 294 was sent on September 10, 2010, to revise the schedule to allow time for further interaction between AREVA and the NRC staff.

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

The schedule for technically correct and complete responses to the seven questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	November 17, 2010
RAI 294 — 10.02.03-18	November 17, 2010
RAI 294 — 10.02.03-19	November 17, 2010
RAI 294 — 10.02.03-20	November 17, 2010
RAI 294 — 10.02.03-21	November 17, 2010
RAI 294 — 10.02.03-22	November 17, 2010
RAI 294 — 10.02.03-23	November 17, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (External RS/NB)  
**Sent:** Friday, September 10, 2010 9:55 AM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 6

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3, Supplement 4 and Supplement 5 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010, July 13, 2010 and August 13, 2010, respectively, to provide a revised schedule.

On June 11, 2010, AREVA provided DRAFT responses to the seven questions in RAI No. 294. To allow time for further interaction between AREVA and the NRC staff, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to the seven questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	October 15, 2010
RAI 294 — 10.02.03-18	October 15, 2010
RAI 294 — 10.02.03-19	October 15, 2010
RAI 294 — 10.02.03-20	October 15, 2010
RAI 294 — 10.02.03-21	October 15, 2010
RAI 294 — 10.02.03-22	October 15, 2010
RAI 294 — 10.02.03-23	October 15, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (EXT)  
**Sent:** Friday, August 13, 2010 7:14 AM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); KOWALSKI David (RS/NB); NOXON David (RS/NB)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 5

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1, Supplement 2, Supplement 3 and Supplement 4 responses to RAI No. 294 were sent on April 16, 2010, May 12, 2010, June 11, 2010 and July 13, 2010, respectively, to provide a revised schedule.

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

The schedule for technically correct and complete responses to the questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	September 10, 2010
RAI 294 — 10.02.03-18	September 10, 2010
RAI 294 — 10.02.03-19	September 10, 2010
RAI 294 — 10.02.03-20	September 10, 2010

RAI 294 — 10.02.03-21	September 10, 2010
RAI 294 — 10.02.03-22	September 10, 2010
RAI 294 — 10.02.03-23	September 10, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (EXT)  
**Sent:** Tuesday, July 13, 2010 4:37 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); KOWALSKI David J (AREVA NP INC)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 4

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1 and Supplement 2 responses to RAI No. 294 were sent on April 16, 2010 and May 12, 2010, respectively, to provide a revised schedule.

Supplement 3 and Supplement 4 responses to RAI No. 294 were sent on June 11, 2010 to provide a revised schedule and a draft response, respectively.

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

The schedule for technically correct and complete responses to the questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	August 13, 2010
RAI 294 — 10.02.03-18	August 13, 2010
RAI 294 — 10.02.03-19	August 13, 2010
RAI 294 — 10.02.03-20	August 13, 2010
RAI 294 — 10.02.03-21	August 13, 2010
RAI 294 — 10.02.03-22	August 13, 2010
RAI 294 — 10.02.03-23	August 13, 2010

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](mailto:Martin.Bryan.ext@areva.com)



---

**From:** BRYAN Martin (EXT)  
**Sent:** Friday, June 11, 2010 12:28 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); KOWALSKI David J (AREVA NP INC)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 3

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the seven questions in RAI No. 294 on February 25, 2010. Supplement 1 and Supplement 2 responses to RAI No. 294 were sent on April 16, 2010 and May 12, 2010, respectively, to provide a revised schedule.

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

The schedule for technically correct and complete responses to the questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	July 14, 2010
RAI 294 — 10.02.03-18	July 14, 2010
RAI 294 — 10.02.03-19	July 14, 2010
RAI 294 — 10.02.03-20	July 14, 2010
RAI 294 — 10.02.03-21	July 14, 2010
RAI 294 — 10.02.03-22	July 14, 2010
RAI 294 — 10.02.03-23	July 14, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (EXT)  
**Sent:** Wednesday, May 12, 2010 5:19 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); KOWALSKI David J (AREVA NP INC)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 2

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the 7 questions in RAI No. 294 on February 25, 2010. Supplement 1 response to RAI No. 294 was sent on April 16, 2010 to provide a revised schedule. An interaction to discuss the proposed responses was originally scheduled on March 26, 2010, but has been subsequently rescheduled. As agreed with the NRC, additional time is needed for AREVA to discuss the responses to these questions.

The schedule for technically correct and complete responses to these questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	June 11, 2010
RAI 294 — 10.02.03-18	June 11, 2010
RAI 294 — 10.02.03-19	June 11, 2010
RAI 294 — 10.02.03-20	June 11, 2010
RAI 294 — 10.02.03-21	June 11, 2010
RAI 294 — 10.02.03-22	June 11, 2010
RAI 294 — 10.02.03-23	June 11, 2010

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](mailto:Martin.Bryan.ext@areva.com)

---

**From:** BRYAN Martin (EXT)  
**Sent:** Friday, April 16, 2010 12:31 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); KOWALSKI David J (AREVA NP INC)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10, Supplement 1

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the 7 questions in RAI No. 294 on February 25, 2010. To allow time for AREVA to discuss the response to these questions with the NRC, a revised schedule is provided in this e-mail.

The schedule for technically correct and complete responses to these questions has been revised as provided below.

Question #	Response Date
RAI 294 — 10.02.03-17	May 12, 2010
RAI 294 — 10.02.03-18	May 12, 2010
RAI 294 — 10.02.03-19	May 12, 2010
RAI 294 — 10.02.03-20	May 12, 2010
RAI 294 — 10.02.03-21	May 12, 2010
RAI 294 — 10.02.03-22	May 12, 2010
RAI 294 — 10.02.03-23	May 12, 2010

Sincerely,

Martin (Marty) C. Bryan  
Licensing Advisory Engineer

AREVA NP Inc.  
Tel: (434) 832-3016  
[Martin.Bryan.ext@areva.com](mailto:Martin.Bryan.ext@areva.com)

---

**From:** DUNCAN Leslie E (AREVA NP INC)  
**Sent:** Thursday, February 25, 2010 1:55 PM  
**To:** 'Tesfaye, Getachew'  
**Cc:** DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); ROMINE Judy (AREVA NP INC); KOWALSKI David J (AREVA NP INC); BRYAN Martin (EXT)  
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 294, FSAR Ch. 10

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 294 Response US EPR DC.pdf," provides a schedule since a technically correct and complete response to the seven questions is not provided.

The following table provides the pages in the response document, "RAI 294 Response US EPR DC.pdf," containing the response to each question.

Question #	Start Page	End Page
RAI 294 — 10.02.03-17	2	2
RAI 294 — 10.02.03-18	3	3
RAI 294 — 10.02.03-19	4	4
RAI 294 — 10.02.03-20	5	5
RAI 294 — 10.02.03-21	6	6
RAI 294 — 10.02.03-22	7	7
RAI 294 — 10.02.03-23	8	8

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

Question #	Response Date
RAI 294 — 10.02.03-17	April 16, 2010
RAI 294 — 10.02.03-18	April 16, 2010
RAI 294 — 10.02.03-19	April 16, 2010
RAI 294 — 10.02.03-20	April 16, 2010
RAI 294 — 10.02.03-21	April 16, 2010
RAI 294 — 10.02.03-22	April 16, 2010
RAI 294 — 10.02.03-23	April 16, 2010

Sincerely,

Les Duncan  
Licensing Engineer  
**AREVA NP Inc.**  
An AREVA and Siemens Company  
Tel: (434) 832-2849  
[Leslie.Duncan@areva.com](mailto:Leslie.Duncan@areva.com)

**From:** Tesfaye, Getachew [<mailto:Getachew.Tesfaye@nrc.gov>]

**Sent:** Monday, October 05, 2009 5:22 PM

**To:** ZZ-DL-A-USEPR-DL

**Cc:** Honcharik, John; Terao, David; Hearn, Peter; Colaccino, Joseph; ArevaEPRDCPEm Resource

**Subject:** U.S. EPR Design Certification Application RAI No. 294 (3758), FSARCh. 10

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 18, 2009, and on the October 5, 2009, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. The questions in this RAI are considered potential open items for Phases 2 and 3 reviews. As such, the schedule we have established for your application assumes technically correct and complete responses prior to the start of Phase 4 review. For any RAI that cannot be answered prior to the start of Phase 4 review, it is expected that a date for receipt of this information will be provided 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:** 4180

**Mail Envelope Properties** (A41C2340DAB39B44AD0B9623285CB333C956447236)

**Subject:** FW: Response to U.S. EPR Design Certification Application RAI No. 294, FSAR  
Ch. 10, Supplement 23  
**Sent Date:** 2/27/2013 3:27:05 PM  
**Received Date:** 2/27/2013 3:27:08 PM  
**From:** McLellan, Judith

**Created By:** Judith.McLellan@nrc.gov

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

**Post Office:** HQCLSTR02.nrc.gov

<b>Files</b>	<b>Size</b>	<b>Date &amp; Time</b>
MESSAGE	47014	2/27/2013 3:27:08 PM
RAI 294 Response Supplement 23 US EPR DC.pdf		1208440

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

**Response to**

**Request for Additional Information No. 294 (3758), Supplement 23**

**Questions 10.02.03-17, 10.02.03-20 and 10.02.03-23**

**10/5/2009**

**U.S. EPR Standard Design Certification**

**AREVA NP Inc.**

**Docket No. 52-020**

**SRP Section: 10.02.03 - Turbine Rotor Integrity**

**Application Section: 10.2.3**

**QUESTIONS for Component Integrity, Performance, and Testing Branch 1  
(AP1000/EPR Projects) (CIB1)**

**Question 10.02.03-17:**

## POTENTIAL OPEN ITEM

In response to RAI No. 100, Question 10.02.03-1, the applicant responded that the COL applicant will procure a turbine that meets or exceeds the FSAR bounding specifications, or provide suitable justification for the departure. The staff notes that the FSAR does not provide applicable material specifications for procuring the turbine rotors and, therefore, the staff requests that the applicable material specifications be included in the FSAR in order to determine if the chemical composition (i.e., limiting trace elements, etc.) will improve fracture toughness, along with any operating experience of these materials. In addition, the description of the procedures used to minimize flaws, improve toughness, and minimize chemical segregation should be discussed as requested in the above RAI.

**Response to Question 10.02.03-17:**

The materials used in the high/intermediate pressure (HIP) and low pressure (LP) rotors are the manufacturer's standard material for turbine rotors. The materials specifications are not identical to ASTM standards.

U.S. EPR FSAR Tier 2, Section 10.2.3.1, was revised in Revision 3 to include the following three new tables, which contain the chemical compositions and mechanical properties used for the turbine rotors:

- U.S. EPR FSAR Tier 2, Table 10.2-3—HP Rotor.
- U.S. EPR FSAR Tier 2, Table 10.2-4—IP Discs and Shaft End.
- U.S. EPR FSAR Tier 2, Table 10.2-5—LP Rotors.

These new tables contain information for a standard turbine rotor that is considered in the U.S. EPR design certification. U.S. EPR FSAR Tier 2, Section 10.2.5 and Table 10.2-2—Turbine-Generator Material Data were also revised in Revision 3 to reflect information in the three new tables.

U.S. EPR FSAR Tier 2, Table 10.2-3, Table 10.2-4, and Table 10.2-5, were revised in Revision 3 to include additional changes to the mechanical property requirements and notch impact property requirements. U.S. EPR FSAR Tier 2, Tables 10.2-3 and 10.2-4, were also revised in Revision 3 to include the material designation.

U.S. EPR FSAR Tier 2, Table 10.2-2, identifies the material designation. Table 10.02.03-17-1—HIP Rotor, in this response, gives the material designation for the high pressure (Table 10.02.03-17-2—HP Rotor) and intermediate pressure (Table 10.02.03-17-3—IP Discs and Shaft End) portions of the HIP rotor. Refer to Figure 10.02.03-19-1—HIP Rotor Forgings in the Response to RAI 294, Supplement 20, Question 10.02.03-19, for an illustration of the HIP rotor, which consists of an HP and IP section.

U.S. EPR FSAR Tier 2, Tables 10.2-3 and 10.2-5, will be revised to include revised notch impact property requirements.

Rotor forgings procurement is based on the requirements from the turbine supplier's material specification, similar in scope to the requirements of ASTM A 470, Section 4. For each foundry identified as a potential supplier, a product qualification with specific stringent requirements is performed to validate the forging process. Results are controlled by a Manufacturing Inspection and Control Process Plan. This includes the following information:

- Steelmaking method, including deoxidation and degassing practice.
- Pouring practice.
- Ingot hot topping practice.
- Aim composition of the specified elements.
- Ingot and head weights and dimensions.
- Ingot discards top and bottom.
- Orientation of the forging with respect to the ingot.
- Number of forgings to be manufactured from the ingot, if more than one state positions.
- Sketch of forging sequence, including forging dimensions and outline shape after each operation and final forging weight.
- Details of the preliminary heat treatment cycle.
- Sketch of forging profile for quality heat treatment, including location of thermocouples on the forging and statement of forging orientation for heat treatment.
- Details of the quality heat treatment cycle, including temperatures and soak times, method of cooling, whether forging is static or rotated and terminal temperatures.
- Sketches of forging profile for ultrasonic examinations.
- Sketch of forging profile showing location of test material and tests to be undertaken.
- Standards to be used for tensile and Charpy V-notch tests.
- Sequence of manufacturing operations, heat treatments, mechanical tests, and non-destructive examination.

Operating experience for each material used for the turbine rotors includes the following:

**HIP Rotor Material:**

- Four HIP rotors in France (Chooz and Civaux) with 252,000 cumulated operating hours for the four units at the end of June 2008.
- Twenty-two LP rotors in France and Belgium (CP1 steam turbines) with 533,000 cumulated operating hours for the seven units at the end of June 2008.
- San Onofre 2 and 3 (six LP rotors) in the U.S. with 140,000 cumulated operating hours for the two units at the end of October 2008.

**LP Rotor Material:**

- Four LP rotors in France (Chooz and Civaux) with 252,000 cumulated operating hours for the four units at the end of June 2008.



- Twenty four LP rotors in France and Belgium (CP2 steam turbines) with 1,640,000 cumulated operating hours for the 12 units at the end of December 2007.
- Sixty LP rotors in France (P4 steam turbines) with 2,730,000 cumulated operating hours for the 20 units at the end of December 2007.
- Uljin in South Korea with 300,000 cumulated operating hours for the two units estimated at the end of 2008.
- Retrofit of Diablo Canyon, Callaway and Fort Calhoun in the U.S. The unit at Diablo Canyon went into service at the end of 2005.

This operating experience corresponds to a turbine design with welded rotors. There were no defects detected.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Tables 10.2-3 and 10.2-5, will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Sections 10.2.3.1 and 10.2.5 and Tables 10.2-2, 10.2-3, 10.2-4 and 10.2-5, were revised in Revision 3 as described in the response and indicated on the enclosed markup.

**Table 10.02.03-17-1–HIP Rotor**

<b>Material Designation</b>	22NiCrMoV12-7
<b>Material Type</b>	Low alloy steel
<b>Applicable Product Form(s)</b>	Forgings

**Table 10.02.03-17-2–HP Rotor**

<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>		<b>Symbol</b>	<b>Minimum</b>	<b>Maximum</b>
Carbon		C	0.20	0.25
Silicon		Si	0.10 <sup>(1)</sup>	0.40
Manganese		Mn	0.40	0.80
Phosphorous		P	-	0.012
Sulfur		S	-	0.012
Nickel		Ni	2.80	3.20
Chromium		Cr	1.50	2.00
Molybdenum		Mo	0.40	0.60
Vanadium		V	-	0.11
Copper		Cu	-	0.12
Phosphorous + Tin		P + Sn	-	0.018
Arsenic		As	-	0.018
Antimony		Sb	-	0.003
Aluminum		Al	-	0.015
<b>Material Property Requirements at 23°C ± 5°C at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv.	660	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv.	550	650
Elongation on 5.65 √So	%	Long. / Transv.	15 / 14	-
Reduction of Area	%	Long. / Transv.	50	-
<b>Notch Impact Property Requirements at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at Minimum Operating Temperature	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long. / Transv.	-	-30

(1) In case of vacuum carbon deoxidation, the minimum silicon content is reduced to 0.04%.

**Table 10.02.03-17-3—IP Discs and Shaft End**

<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>	<b>Sym- bol</b>	<b>Minimum</b>	<b>Maximum</b>	
Carbon	C	0.20	0.25	
Silicon	Si	0.10 <sup>(1)</sup>	0.40	
Manganese	Mn	0.40	0.80	
Phosphorous	P	-	0.012	
Sulfur	S	-	0.012	
Nickel	Ni	2.80	3.20	
Chromium	Cr	1.50	2.00	
Molybdenum	Mo	0.40	0.60	
Vanadium	V	-	0.11	
Copper	Cu	-	0.12	
Phosphorous + Tin	P + Sn	-	0.018	
Arsenic	As	-	0.018	
Antimony	Sb	-	0.003	
Aluminum	Al	-	0.015	
<b>Material Property Requirements at 23°C ± 5°C at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv.	740	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv.	635	735
Elongation on 5.65 √So	%	Long. / Transv.	15 / 14	-
Reduction of Area	%	Long. / Transv.	50	-
<b>Notch Impact Property Requirements at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at Minimum Operating Temperature	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long. / Transv.	-	-30

(1) In case of vacuum carbon deoxidation, the minimum silicon content is reduced to 0.04%.

**Table 10.02.03-17-4—LP Rotors**

<b>Material Designation</b>		23CrNiMo7-4		
<b>Material Type</b>		Low alloy steel		
<b>Applicable Product Form(s)</b>		Forgings		
<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>	<b>Symbol</b>	<b>Minimum</b>	<b>Maximum</b>	
Carbon	C	0.20	0.26	
Silicon	Si	-	0.30	
Manganese	Mn	0.50	0.80	
Phosphorous	P	-	0.010	
Sulfur	S	-	0.015	
Nickel	Ni	0.90	1.20	
Chromium	Cr	1.70	2.00	
Molybdenum	Mo	0.60	0.80	
Vanadium	V	-	0.050	
Phosphorous + Tin	P + Sn	-	0.020	
<b>Material Property Requirements at 23°C ± 5°C at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>Delivery Condition and After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv.	740	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv.	635	735
Elongation on 5.65 √So	%	Long. / Transv.	17 / 15	-
Reduction of Area	%	Long. / Transv.	50	-
<b>Notch Impact Property Requirements</b>				
<b>Heat Treatment Stage</b>		<b>Delivery Condition and After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at Minimum Operating Temperature	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long. / Transv.	-	-18

**Question 10.02.03-20:**

## POTENTIAL OPEN ITEM

The applicant's response to RAI No. 100, Question 10.02.03-6, provided that, since these are weld rotors, keyways are not used as in shrunk-on turbine rotor discs. However, in response to RAI No. 100, Question 10.02.03-8, the applicant stated that holes are drilled for the pins used to fix the moving blades to the turbine rotors. These holes are drilled once the blades are assembled to the turbine rotor and, therefore, a surface examination is not performed. However, to account for not performing a magnetic-particle or liquid penetrant examination of the holes, the turbine missile analysis will account for this by considering a potential initial defect in the turbine rotor at the zero point. In addition, ultrasonic examination is performed on the forged pieces. Also, there are no finished bores in this turbine design. Based on this information, the staff needs the following information to determine whether the integrity of the turbine rotor can be determined prior to service:

- a. Confirm this is a solid cored rotor (non-bored). If this is the case, provide the following:
  1. Discuss the method for obtaining, for the non-bored rotor, 100 percent ultrasonic inspection in accordance with the FSAR Tier 2, Sections 10.2.3.5 and 10.2.3.6, since there is no bore to gain access to perform the ultrasonic inspection.
  2. Typically, each fabricated rotor has destructive testing performed at various locations to ensure homogeneity and acceptable material properties. Justify that the material properties for each rotor fabricated will have the required material properties and homogeneity throughout the forged rotor, including the interior, which is normally bored out. Also, provide any supporting evaluations or tests.
- b. Confirm that ultrasonic testing is performed on the forged parts after the holes are drilled. Also confirm that this inspection can detect defects at the hole region to account for not performing a magnetic-particle or liquid penetrant examination of the holes so that no flaws are allowed in the keyway and hole regions as specified in SRP 10.2.3 guidance.
- c. Clarify the term "zero point" in your response to RAI No. 100, Question 10.02.03-6, and in the turbine missile analysis discuss accounting for not performing a magnetic-particle or liquid penetrant examination of the holes. Also, provide a COL information item addressing that the COL applicant's turbine missile analysis will account for not performing a magnetic-particle or liquid penetrant examination of the holes by considering a potential initial defect in the turbine rotor.

**Response to Question 10.02.03-20:**

- a. Both the low pressure (LP) and the high/intermediate pressure (HIP) rotors are non-bored rotors. Refer to the Response to Question 10.02.03-19, Figure 10.02.03-19-1—HIP Rotor Forgings and Figure 10.02.03-19-2—LP Rotor Forgings, for an illustration of the turbine rotors.
  1. Each forging is 100 percent ultrasonic tested after quality heat treatment in a machined condition and before welding. After welding, each weld in the turbine rotor assembly is subjected to 100 percent ultrasonic examination in the radial,

longitudinal, and tangential directions. Both LP and HIP rotors are 100 percent ultrasonic tested.

The main steps in the rotor manufacturing process include the following:

- Discs forgings.
- One hundred percent ultrasonic tests.
- Pre-machining of discs (weld preparation).
- Rotor welding (discs staking plus welding).
- One hundred percent radiographic inspection of root pass weld. (Radiographic inspection will be performed after the root pass welds of the disc connections are completed in order to confirm an acceptable weld seam before a fill weld will be started.)
- One hundred percent ultrasonic test of welds.
- Rotor machining (rotor turning and machining of balancing groove and drilling of the coupling and balancing holes).

Radiographic inspection of the root pass weld is performed in accordance with the turbine manufacturer's qualified process. As a result of applying the root pass weld, the temperature of the rotor increases; however, it is still possible to carry out the inspection with the rotor at elevated temperatures. The radiographic inspection is a dual wall and dual film exposure process. Refer to Figure 10.02.03-20-2—Radiographic Inspection of Root Pass Weld.

The source is outside of the rotor, which provides the radiographic device with enough energy to penetrate the two walls. The focalization is done on the opposite wall in order to display on the film this weld only. Scale effects are taken into account using specifically designed image quality indicators, but remains in compliance with European Standard EN 462-2, "Image Quality of Radiographs, Image Quality Indicators (step/hole type), Determination of Image Quality Value."

2. Each forged component constituting an LP or HIP rotor is subjected to mechanical tests as described in the Response to RAI 100, Supplement 1, Question 10.02.03-1 (tensile test, Charpy V-notch impact tests and FATT determination).

Tests in delivered condition are tests made from test material that is not given further heat treatment after removal from the forging.

Tests after simulated post-weld heat treatment are tests made from test material that is removed from the forging and subjected to a laboratory heat treatment simulating the post-weld heat treatment of the welded rotor.

The site-specific turbine manufacturer defines the mechanical tests performed on the HIP and LP rotors. Typically, there are several series of mechanical tests performed on the rotors:

### HIP Rotor

- “At Delivered Condition.” A first series of mechanical tests done on test material that is not given further heat treatment after removal from the forging.
- “After Simulated Heat Treatment.” A second series of mechanical tests done on test material that is removed from the forging and subjected to laboratory heat treatment simulating the post-weld heat treatment of the welded rotor. The intent of this test is to confirm that the forging material can undergo a post-weld heat treatment and still have the required properties. The test is performed to identify any problems prior to the welding operations.
- “After Post Weld Heat Treatment.” A third series of mechanical tests done on test material that is removed from the forging and that accompany the welded rotor when it is subject to post weld heat treatment. This test provides test results that are representative of the final state of the rotor.

For the HP rotor material, the post-weld heat treatment must be done at a higher temperature than the quality heat treatment of the forging. The quality heat treatment is the heat treatment done on the forged part at the foundry. The material properties would, therefore, be modified. That is why the acceptance criteria for the HP and IP rotors only address the post-weld heat treatment conditions.

The simulated post-weld heat treatment is done in a laboratory with a laboratory oven. Due to the size effect and to prevent the eventuality of a temperature repartition slightly different from the oven used for the rotor post-weld heat treatment, the third series of tests is done, which gives the final material properties.

### LP Rotor

- “At Delivered Condition.” A first series of mechanical tests done on test material that is not given further heat treatment after removal from the forging.
- “After Simulated Heat Treatment.” A second series of mechanical tests done on test material that is removed from the forging and subjected to laboratory heat treatment simulating the post-weld heat treatment of the welded rotor. The intent is to have mechanical test results representative of the rotor final state.

For the LP rotor material, the quality heat treatment of the forging is done at a temperature 30°C higher than the post-weld heat treatment. This means that the post-weld heat treatment will not affect the mechanical properties of the forging. The acceptance criteria are the same at the delivered condition and after the post-weld heat-treatment. Nevertheless, as verification and in order to get the mechanical properties at the final condition, a simulated heat-treatment is carried out at the foundry.

- b. The manufacturing process for the pin holes includes the following:
- Ultrasonic and magnetic particle examination of the accessible disc surfaces.
  - Rotor discs milling and pre-drilling (pre-drilling of the discs for the standard blades attachment and milling of the fir tee grooves for the last stage blade (LSB) attachment.
  - Cleaning of pin holes and visual inspection of the holes.
  - Assembly of the pre-drilled blades.
  - Reaming of the pin holes to the final diameter with assembled blade.
  - Cleaning of the hole and visual inspection of the hole.
  - Installation of pins.

The areas in the discs, which are drilled for the blade attachment, are ultrasonic tested before the holes are drilled. Drilling is done on a material without unacceptable defects. The blades are assembled to the disc, the pin holes are reamed, and the pins inserted. At this point, magnetic or liquid penetrant examination of the pin holes is not possible due to restricted accessibility.

Drilling on a sound material will not initiate any flaws (no surface examinations are done on machined surfaces).

After drilling the pin holes, the holes must be visually inspected:

- Visual examination is performed with the naked eye; and, where necessary, using a magnifying glass. Zones which can not be directly observed are examined using indirect methods such as mirrors, endoscopes, replicas or any suitable means or apparatus. Examination conditions are in conformance with the EN 13018 standard.
- Dimensional inspection at the entry, middle, and exit of the hole (bore diameters are confirmed).
- Surface finish measurement.

The visual inspection of the pin holes confirms surface quality and geometrical correctness before installation of the pins.

U.S. EPR FSAR Tier 2, Section 10.2.3.5, was revised in Revision 3 to include the visual inspection requirements for the pin holes.

U.S. EPR FSAR Tier 2, Sections 10.2.3.5 and 10.2.5, will be revised to include the EN 13018 standard in the list of references.

The last two LP blades are equipped with a fir tree root attachment, which does not require pins.

Magnetic particle examination is done on the accessible external surface of the discs.



As indicated in U.S. EPR FSAR Tier 2, Section 3.5.1.3, the COL applicant is required to provide the results of the turbine manufacturer's turbine missile analysis. The missile analysis will consider the conservative assumption of an initial existing defect in the disc when calculating the probability of missile generation.

Surface examination of the drilled holes is not considered necessary.

- c. The "zero point" discussed in the Response to RAI 100, Question 10.02.03-8 means that at  $t = 0$ , an initial defect  $a_0$  (see Figure 10.02.03-20-1—Initial Defect  $a_0$ ) in the axial radial plane, which includes the discs fingers and lies from the disc outer diameter to the bottom of the inner pin hole, is taken into account in the missile analysis.

The turbine missile analysis accounts for not performing a magnetic-particle or liquid-penetrant examination of the drilled holes by considering a potential initial defect in the turbine rotor.

To satisfy U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items, COL Item No. 3.5-2, the COL applicant references a standard analysis that calculates the probability of turbine missile generation, which reflects this assumption. It is not necessary to prepare a new COL item that states that the "COL applicant's turbine missile analysis will account for not performing a magnetic-particle or liquid penetrant examination of the holes by considering a potential initial defect in the turbine rotor."

The site-specific turbine manufacturer defines the mechanical tests to be implemented during the manufacture of the rotor. The requirements for the mechanical tests are obtained from the material specifications provided in U.S. EPR FSAR Tier 2, Table 10.2-3—HP Rotor, Table 10.2-4—IP Discs and Shaft End and Table 10.2-5—LP Rotors.

The site-specific turbine manufacturer defines how the test coupon should be taken from the forgings. This will be a geometrical indication relative to the forging axis. The forging axis is the actual axis of the finished forged disc, shaft end, or rotor. There are three possible ways to take the coupon:

- Radial.
- Tangential.
- Axial or longitudinal.

These are shown in Figure 10.02.03-20-3—Radial, Tangential and Axial or Longitudinal Locations. The number of test pieces and their various locations confirms that each rotor has the required material properties and homogeneity throughout the forged rotor. COL Items 10.2-2 and 10.2-3 in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items require the COL applicant to provide information on material properties and rotor specimen test data, respectively.

The longitudinal/transverse referenced in material specifications in Table 10.2.3-3, Table 10.2.3-4, and Table 10.2.3-5 is relative to the material fiber orientation. This is either longitudinal or transverse, depending on the forging operation and orientation of the test coupon. When the fiber in the test coupon is determined to be longitudinal, requirements for the longitudinal

orientation apply. When the fiber is determined to be transverse, requirements for the transverse orientation apply. The applicable material requirements are chosen in a conservative manner with respect to fiber orientation.

The welds on the rotors do not directly receive mechanical tests as it is destructive testing which would damage the welds and/or the rotor itself. The rotor welding is a qualified welding process where qualification is done on a trial part. During this qualification, the weld is deeply analyzed and full mechanical tests are carried out (e.g., tensile tests in transversal and longitudinal, hardness, charpy v-notch, bending). When the test results fulfill the requirements, qualification is granted and the process is frozen, to be used on execution.

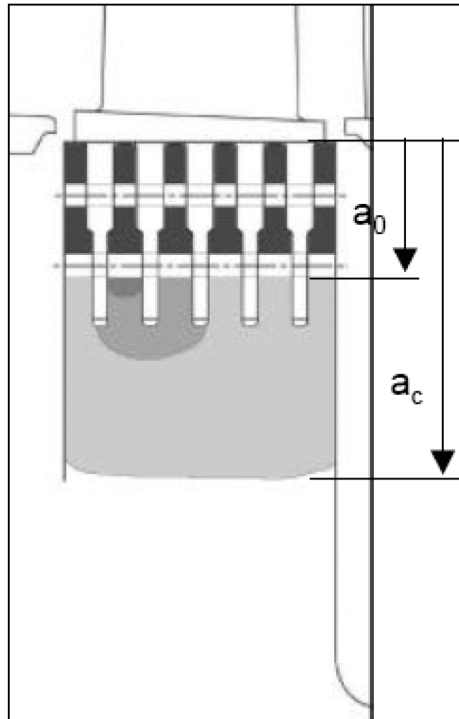
The terminology used to describe the "orientation relative to the forging axis" is consistent with the terminology in ASTM A370. Tests are performed in the longitudinal/transverse as listed in Table 10.2.3-3, Table 10.2.3-4, and Table 10.2.3-5.

**FSAR Impact:**

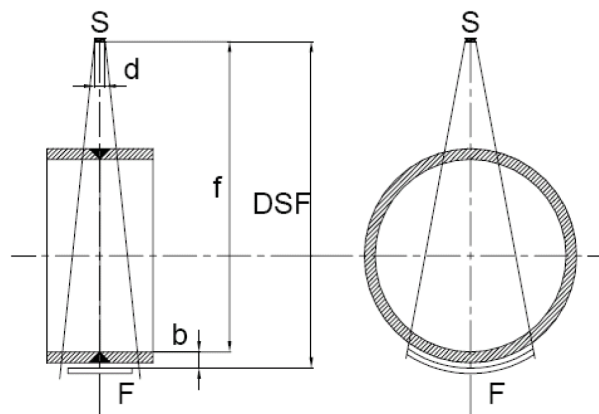
U.S. EPR FSAR Tier 2, Section 10.2.3.5 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Section 10.2.3.5, was revised in Revision 3 as described in the response and indicated on the enclosed markup.

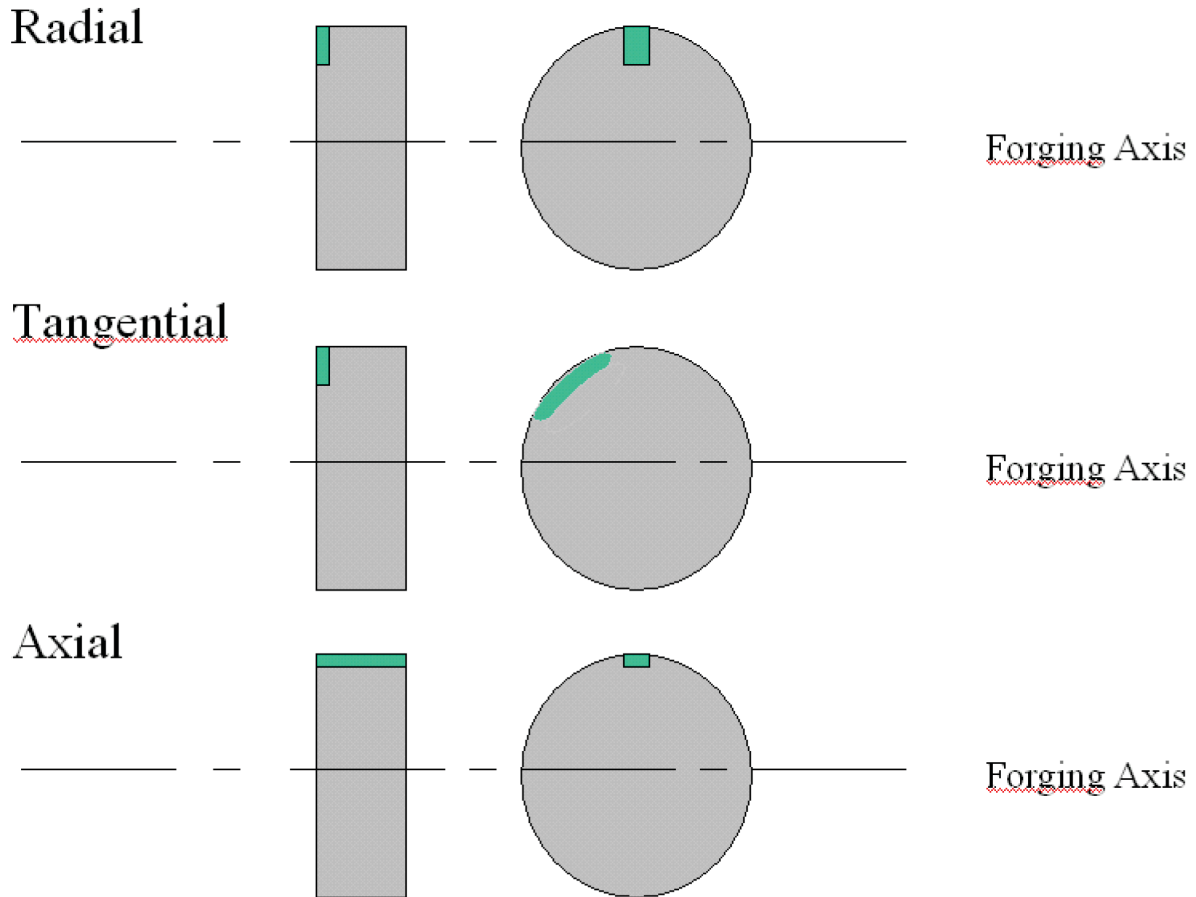
**Figure 10.02.03-20-1—Initial Defect  $a_0$**



**Figure 10.02.03-20-2—Radiographic Inspection of Root Pass Weld**



**Figure 10.02.03-20-3—Radial, Tangential and Axial, or Longitudinal Locations**



**Question 10.02.03-23:**

POTENTIAL OPEN ITEM

In response to RAI 100, Question 10.02.03-10, the FSAR Tier 1 was revised in Revision 1 to clarify Table 2.8.1-3 by having ITAAC commitments 1.0a and 1.0b. In response to RAI 100, Question 10.02.03-11, the FSAR Tier 1 was revised in Revision 1 to clarify ITAAC commitment 1.0a to include that the acceptance criteria for the as-built turbine material property data, rotor and blade design, and preservice testing and inspection meet the requirements of the turbine missile probability analysis. However, the staff notes that ITAAC commitment 1.0a should apply to the "as-built turbine rotor," and the ITAAC should be revised accordingly.

**Response to Question 10.02.03-23:**

As-built will not be applied to the turbine rotor ITAAC in U.S. EPR FSAR Tier 1, Table 2.8.1-3—Turbine-Generator System ITAAC, Item 2.4 because it imposes an unnecessary time constraint on closing the ITAAC.

U.S. EPR FSAR Tier 1, Section 1.1 contains the definition of as-built:

“As-built - the physical properties of a structure, system, or component following the completion of its installation or construction activities at its final location at the plant site. In cases where it is technically justifiable, determination of physical properties of the as-built structure, system, or component may be based on measurements, inspections, or tests that occur prior to installation, provided that subsequent fabrication, handling, installation, and testing do not alter the properties.”

The Responses to RAI 148, Question 14.03.07-26, and RAI 182, Supplement 1, Question 14.03-10 (Part A) clarified the ITAAC wording for the turbine rotor analysis. The ITAAC wording from U.S. EPR FSAR Tier 1, Table 2.8.1-3, Item 2.4 states:

<b>Commitment Wording</b>	<b>Inspections, Tests, Analyses</b>	<b>Acceptance Criteria</b>
Turbine rotor integrity is provided through the combined use of selected materials with suitable toughness, analyses, testing, and inspections.	An analysis of the turbine rotor material property data, turbine rotor and blade design, and pre-service inspection and testing requirements will be conducted.	An analysis exists and concludes that the turbine rotor integrity meets the requirements of the manufacturer’s turbine missile probability analysis: (1) turbine material property data, rotor and blade design analyses (including loading combinations, assumptions and warm-up time) demonstrating safety margin to withstand loadings from overspeed events, and (2) the requirements for preservice testing and inspection information.

As described in the ITAAC, the turbine rotor information (analysis) will be available for review greater than one year before loading the fuel. The analysis can be completed after the rotor is constructed and does not need to be completed “following the completion of its installation or construction activities at its final location at the plant site” as required by the definition of as-built. Applying “as-built” to the turbine rotor analysis ITAAC would require that the turbine rotor analysis be completed and submitted to the NRC after the rotor is installed in its final location at the plant, which would impose an unnecessary time constraint.

Use of the term “as-built” does allow reliance on inspections, tests and analyses that occurs prior to installation, but does not allow submittal of the information until after the completion of installation in its final location is completed.

In place of using the term “as-built,” U.S. EPR FSAR Tier 1, Table 2.8.1-3—Turbine-Generator System ITAAC, Item 2.4, Inspections, Tests, Analyses will be revised to include the following phrase:

“A plant specific analysis of the turbine rotor material property data.....”

U.S. EPR FSAR Tier 1, Table 2.8.1-3—Turbine-Generator System ITAAC, Item 2.4, Acceptance Criteria will be revised to include the following phrase:

“A plant specific analysis exists and concludes that the turbine rotor integrity.....”

**FSAR Impact:**

U.S. EPR FSAR Tier 1, Table 2.8.1-3 will be revised as described in the response and indicated on the enclosed markup.

# U.S. EPR Final Safety Analysis Report Markups

Table 2.8.1-3—Turbine-Generator System ITAAC (3 Sheets)

Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
<p>2.1 The <del>basic configuration</del> functional arrangement of the turbine-generator system is as shown on Figure 2.8.1-1.</p>	<p><del>Inspections</del> An inspection of the as-built system <del>as shown on Figure 2.8.1-1</del> will be performed <del>conducted</del>.</p>	<p>The as-built turbine-generator system conforms <del>with to</del> the <del>basic configuration</del> functional arrangement as shown <del>in</del> on Figure 2.8.1-1.</p>
<p>2.2 The axis of the turbine rotor shafts is positioned such that safety-related structures, except for two of the four Essential Service Water Buildings and <del>the two of the four</del> Emergency Power Generating Buildings, are located outside the turbine <del>missile</del> low-trajectory hazard zone as shown on Figure 2.8.1-2.</p>	<p>An inspection <del>of the location of the axis of the turbine rotor shafts to verify that safety-related structures, except for two of the four Essential Service Water Buildings and two of the four Emergency Power Generating Buildings, are located outside the turbine low-trajectory hazard zone</del> will be performed.</p>	<p><del>The location of the of the axis of the turbine rotor shafts is positioned such that favorable with respect to protection of</del> No safety-related structures, except for two of the four Essential Service Water Buildings and <del>the two of the four</del> Emergency Power Generating Buildings, <del>from turbine missiles</del> are located outside the turbine <del>missile</del> low-trajectory hazard zone.</p>
<p>2.3 The location of the turbine-generator system equipment is as listed in Table 2.8.1-1.</p>	<p>An inspection will be performed <del>of the location of the equipment</del>.</p>	<p>The turbine-generator system equipment is located as listed in Table 2.8.1-1.</p>
<p>2.4 Turbine rotor integrity is provided through the combined use of selected materials with suitable toughness, analyses, testing, and inspections.</p> <div data-bbox="342 1486 570 1562" style="border: 1px solid red; padding: 2px; margin-top: 10px;"> <p>RAI 294, Q. 10.02.03-23</p> </div>	<p>A <del>plant-specific vendor</del> analysis of the <del>site-specific</del> turbine rotor material property data, turbine rotor and blade design, and pre-service inspection and testing requirements will be conducted. <del>This information will be available for review greater than one year before loading the fuel.</del></p>	<p>A <del>plant-specific vendor</del> analysis exists and concludes that the turbine rotor integrity meets the requirements of the manufacturer’s turbine missile probability analysis: (1) turbine material property data, rotor and blade design analyses (including loading combinations, assumptions and warm-up time) demonstrating safety margin to withstand loadings from overspeed events, and (2) the requirements for pre-service testing and inspection information.</p>



reheat intercept valve and one of each type of steam extraction valve are dismantled for examination. Visual and surface examinations of valve seats, disks and stems are conducted. Valve bushings are inspected and cleaned and bore diameters are checked for proper clearance. If any valve is shown to have flaws or excessive corrosion or improper clearances, the valve is repaired or replaced and other valves of that type are also dismantled and inspected.

- The main steam stop and control valves, reheat stop and intercept valves, and steam extraction non-return valves are exercised weekly at 97% to 100% load and observations of the valve motions are made.
- The components of the electro-hydraulic governor system are automatically tested when the turbine is in operation on a daily basis.
- The components of each channel of the primary and backup overspeed protection systems, including the trip block valves, are automatically tested on a daily basis when the turbine is in operation.
- Rate of seat leakage of the main steam stop valves is tested at each refueling.
- The valve closure time and stem thrust of the main steam stop and control valves, and the reheat stop and intercept valves, is tested at each refueling, including a functional test of the hydraulic protection circuit.
- Condition of the valve seats of the extraction non-return valves will be inspected in accordance with the valve manufacturer’s recommendations.
- The control room manual trip and local manual trip are tested prior to startup after each outage or if maintenance has been performed on either system.

**10.2.3 Turbine Rotor Integrity**

Turbine rotor integrity is provided by the integrated combination of material selection, rotor design, fracture toughness requirements, inspections and tests. The combination results in a very low probability of rotor failure.

**10.2.3.1 Materials Selection**

Turbine rotors are made from vacuum melted or vacuum degassed Ni-Cr-Mo alloy steel by processes that minimize flaw occurrence and provide adequate fracture toughness. Tramp elements are controlled to the lowest practical concentrations consistent with good scrap selection and melting practice, and consistent with obtaining adequate initial and long-life fracture toughness for the environment in which the parts operate. The sulfur and phosphorous concentrations are specified below 0.020 percent (chemical product analysis), which is in accordance with specifications ASTM A470 (Reference 11) and ASTM A471 (Reference 4).

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The chemical compositions and mechanical properties used for the turbine rotors are given in Table 10.2-3—HP Rotor, Table 10.2-4—IP Discs and Shaft End, and Table 10.2-5—LP Rotors.

A cast chemical analysis is performed on each rotor forging element. It shall conform to the requirements of the material specification.

Tensile test pieces and procedures are in accordance with the requirements of ASTM A370.

The turbine materials have the lowest fracture appearance transition temperatures (FATT) and highest Charpy V-notch ( $C_v$ ) energies obtainable, on a consistent basis, from water quenched Ni-Cr-Mo material at the sizes and strength levels used. The processing is controlled to maintain the following:

- 50 percent FATT less than 0°F for the LP turbine rotors.
- Charpy V-notch energy at the minimum operating temperature of each LP rotor in the tangential direction greater than or equal to 60 ft-lbs.

The form, dimensions and procedure used for Charpy V-notch impact tests are in accordance with the requirements of ASTM A370. The average value for the Charpy V-notch impact strength obtained on the three test pieces shall not be lower than specified for the material. Not more than one individual value shall be below the specified value and no individual value shall be lower than 70 percent of the specified value.

Curves of Charpy V-notch absorbed energy and percentage crystallinity versus test temperature are plotted for FATT determination. The method of measurement of crystallinity conforms to the requirements of ASTM A370. The FATT is determined as the temperature corresponding to 50 percent crystallinity using a minimum of ten test pieces.

Table 10.2-2—Turbine-Generator Material Data, provides a list of material specifications for turbine-generator components. Actual material properties of turbine rotors are obtained through precise destructive tests of actual samples from each turbine rotor. A COL applicant that references the U.S. EPR design certification will provide applicable material properties of the turbine rotor, including the method of calculating the fracture toughness properties, after the site-specific turbine has been procured.

### 10.2.3.2 Fracture Toughness

As noted in Section 10.2.3.1, a suitable material toughness is obtained through the use of selected materials to produce a balance of adequate material strength and toughness

- Each finished forged or welded rotor is subjected to 100 percent volumetric (ultrasonic), surface and visual examinations using procedures and acceptance criteria equivalent to those specified for Class 1 components in the ASME BPV Code, Section III (Reference 7) and Section V (Reference 8). Before welding or brazing, all surfaces prepared for welding or brazing are surface examined. After welding or brazing, all surfaces exposed to steam are surface examined, giving particular attention to stress risers and welds. Welds are ultrasonically examined (100 percent volumetric examination), equivalent to examinations in Reference 8. Each weld in the turbine rotor assembly is subjected to 100 percent examination in the radial, longitudinal, and tangential directions. Acceptance criteria shall be the most stringent between manufacturer’s standards and ASME Code Section III, subsection NB-5300 (Reference 10).

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- Visual inspection of the pin holes used to assemble the blades to the rotor disc includes an examination performed with the naked eye, and where necessary, using a magnifying glass. Zones, which can not be directly observed, are examined using indirect methods such as mirrors, endoscopes, replicas or any suitable means or apparatus. Examination conditions are in conformance with the EN 13018 standard (Reference 14).

- Each turbine rotor assembly is spin tested at 120 percent of normal operating speed.

**10.2.3.6 Turbine Rotor Inservice Inspection Program Plan**

A turbine rotor inservice inspection program detects rotor or disk flaws that can lead to brittle failure at or below design speed in the steam turbine rotor assembly. The turbine rotor inservice inspection program uses visual, surface and volumetric examinations to inspect components in the steam turbine rotor assembly. The inspections are performed during refueling outages on an interval consistent with the inservice inspection schedules in Reference 3 and the inspection intervals from the turbine manufacturer’s turbine missile analysis provided by the COL applicant as described in Section 3.5.1.3. A COL applicant that references the U.S. EPR design certification will provide the site-specific turbine rotor inservice inspection program and inspection interval consistent with the manufacturer’s turbine missile analysis.

The turbine rotor design allows the weld region to be accessible for ultrasonic inspection.

Inservice inspection activities associated with the steam turbine rotor assembly include:

**HP/IP Cylinder–Rotors (Including Couplings)**

- Visual inspections (surface condition, traces of friction, shaft journals bearings, coupling flange and thrust bearing collar) equivalent to examination defined in Reference 3.

- The TG design includes a redundant overspeed protection system, which terminates an overspeed event prior to reaching design overspeed.
- The TG package and associated piping, valves and controls are located completely within the Turbine Building. There are no safety-related systems or components located in the Turbine Building.
- Turbine speed is continuously monitored. Alarms are issued if specified limits are exceeded.
- The turbine and its auxiliaries are manufactured, erected, tested and operated in accordance with manufacturers standard practices and applicable U.S. codes to engender high reliability of systems and the mechanical integrity of the TG package.

Normally there is no radioactivity in this system. Radioactivity is only present as a result of primary to secondary leakage in the steam generators. If steam generator tube leakage occurs, the small amount of radioactivity which may be present in the secondary system is monitored and detected by the steam generator blowdown system (refer to Section 10.4.8) and in the exhaust air system from the main condenser evacuation system (refer to Section 10.4.2). Information concerning the radiological aspects of primary-to-secondary leakage is presented in Chapter 11 and Chapter 12.

### 10.2.5

#### References

1. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1: "Rules for Construction of Pressure Vessels," The American Society of Mechanical Engineers, 2004.
2. NFPA-55-05, "Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks," National Fire Protection Association, 2005.
3. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, 2004.
4. ASTM A471-06, "Standard Specification for Vacuum-Treated Alloy Steel Forgings for Turbine Rotor Disks and Wheels," American Society for Testing and Materials, 2006.
5. J. A. Begley and W. A. Logsdon, "Correlation of Fracture Toughness and Charpy Properties for Rotor Steels," Scientific Paper 71-1E7-MSLRF-P1, Westinghouse Research Laboratories, 1971.
6. F. J. Witt and T. R. Mager, "Procedure for Determining Bounding Values on Fracture Toughness  $K_{Ic}$  at any Temperature," ORNL-TM-3894, Oak Ridge National Laboratory, 1972.

7. ASME Boiler and Pressure Vessel Code, Section III: “Rules for Construction of Nuclear Facility Components,” The American Society of Mechanical Engineers, 2004.
8. ASME Boiler and Pressure Vessel Code, Section V: “Nondestructive Examination,” The American Society of Mechanical Engineers, 2004.
9. ASTM A370-05, “Standard Test Methods and Definition for Mechanical Testing of Steel Products,” American Society for Testing and Materials, 2005.
10. ASME Boiler and Pressure Vessel Code, Section III: “Rules for Construction of Nuclear Facility Components,” Subsection NB-5300 Acceptance Standards, The American Society of Mechanical Engineers, 2004.
11. ASTM A470-05, “Standard Specification for Vacuum-Treated Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts,” American Society for Testing and Materials, 2005.
12. [ANSI/ASME TDP-1-1998, “Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation,” American National Standards Institute/ The American Society of Mechanical Engineers, 1998.](#)
13. [IEC 61508-1, “Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems” International Electrotechnical Commission, 2010.](#)
14. [DIN EN 13018, “Non-Destructive Testing - Visual Testing - General Principles,” 2001.](#)
15. [EPRI Technical Report 1013461, “Turbine Overspeed Trip Modernization Requirements and Implementation Guidance,” November 2006.](#)
16. [NUREG-1275, Volume 11, “Operating Experience Feedback Report - Turbine-Generator Overspeed Protection Systems,” 1995.](#)

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**Table 10.2-2—Turbine-Generator Material Data**

Component	Nearest ASTM Designation
Stop Valve Bodies	A356:Gr2
Stop Valve Disc	X19CrMoVNbN11-1 No ASTM Equivalent
Stop Valve Seats	A336:F22, Class 3
Control Valve Bodies	A356:Gr2
Control Valve Disc	X19CrMoVNbN11-1 No ASTM Equivalent
Control Valve Seats	A336:F22, Class 3
Combined Reheat Valve Body	Carbon Steel
Combined Reheat Valve Disc	Carbon Steel
High Temp Valve Stems	X19CrMoVNbN11-1 No ASTM Equivalent
Lead Steam Piping	EN10028:P295GH No ASTM Equivalent
Hot Reheat Piping	Carbon Steel
Cold Reheat Piping	Stainless Steel
HIP Rotor	22NiCrMoV12-7 No ASTM Equivalent
HP Diaphragm/Blade Carriers	A182:F6b / A216Gr.WCC
HP Blades	A565:Gr.616
HP Shell	GX6CrNiMo12-1 No ASTM Equivalent
LP Rotor	23CrNiMo 7-4 No ASTM Equivalent
LP Diaphragm/Blade Carriers	A240type405 / A516Gr.70
LP Blades	A565Gr.616/Last 2 Blades A565:XM32
LP Casings	A516Gr.70
LP Outer Casing	A516Gr.60

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22NiCrMoV12-7  
No ASTM Equivalent



Table 10.2-3—HP Rotor

Material Designation		22NiCrMoV12-7		
Material Type		Low Alloy Steel		
Applicable Product Form(s)		Forgings		
<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>	<b>Symbol</b>	<b>Minimum</b>	<b>Maximum</b>	
Carbon	C	0.20	0.25	
Silicon	Si	0.10 <sup>(1)</sup>	0.40	
Manganese	Mn	0.40	0.80	
Phosphorous	P	-	0.012	
Sulfur	S	-	0.012	
Nickel	Ni	2.80	3.20	
Chromium	Cr	1.50	2.00	
Molybdenum	Mo	0.40	0.60	
Vanadium	V	-	0.11	
Copper	Cu	-	0.12	
Phosphorous + Tin	P + Sn	-	0.018	
Arsenic	As	-	0.018	
Antimony	Sb	-	0.003	
Aluminum	Al	-	0.015	
<b>Material Property Requirements at 23°C ± 5°C at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv	660	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv	550	650
Elongation on 5.65 √So	%	Long. / Transv	15 / 14	-
Reduction of Area	%	Long. / Transv	50	-
<b>Notch Impact Property Requirements at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at - <u>20°C Minimum Operating Temperature</u>	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long / Transv	-	-30

**Note:**

1. In case of vacuum carbon deoxidation, the minimum silicon content is reduced to 0.04%.

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**Table 10.2-4—IP Discs and Shaft End**

Material Designation		22NiCrMoV12-7		
Material Type		Low Alloy Steel		
Applicable Product Form(s)		Forgings		
<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>	<b>Symbol</b>	<b>Minimum</b>	<b>Maximum</b>	
Carbon	C	0.20	0.25	
Silicon	Si	0.10 <sup>(1)</sup>	0.40	
Manganese	Mn	0.40	0.80	
Phosphorous	P	-	0.012	
Sulfur	S	-	0.012	
Nickel	Ni	2.80	3.20	
Chromium	Cr	1.50	2.00	
Molybdenum	Mo	0.40	0.60	
Vanadium	V	-	0.11	
Copper	Cu	-	0.12	
Phosphorous + Tin	P + Sn	-	0.018	
Arsenic	As	-	0.018	
Antimony	Sb	-	0.003	
Aluminum	Al	-	0.015	
<b>Material Property Requirements at 23°C ± 5°C at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv	740	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv	635	735
Elongation on 5.65 √So	%	Long. / Transv	15 / 14	-
Reduction of Area	%	Long. / Transv	50	-
<b>Notch Impact Property Requirements at Rim and Subsurface Test Locations</b>				
<b>Heat Treatment Stage</b>		<b>After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at Minimum Operating Temperature	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long / Transv	-	-30

**Note:**

1. In case of vacuum carbon deoxidation, the minimum silicon content is reduced to 0.04%.

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**Table 10.2-5—LP Rotors**

Material Designation		23CrNiMoV7-4		
Material Type		Low alloy steel		
Applicable Product Form(s)		Forgings		
<b>Chemical Composition of Cast – Weight %</b>				
<b>Element</b>		<b>Symbol</b>	<b>Minimum</b>	<b>Maximum</b>
Carbon		C	0.20	0.26
Silicon		Si	-	0.30
Manganese		Mn	0.50	0.80
Phosphorous		P	-	0.010
Sulfur		S	-	0.015
Nickel		Ni	0.90	1.20
Chromium		Cr	1.70	2.00
Molybdenum		Mo	0.60	0.80
Vanadium		V	-	0.050
Phosphorous + Tin		P + Sn	-	0.020
<b>Material Property Requirements</b>				
<b>Heat Treatment Stage</b>		<b>Delivery Condition and After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Tensile Strength	N/mm <sup>2</sup>	Long. / Transv	740	-
0.2% Proof Strength	N/mm <sup>2</sup>	Long. / Transv	635	735
Elongation on 5.65 √So	%	Long. / Transv	17 / 15	-
Reduction of Area	%	Long. / Transv	50	-
<b>Notch Impact Property Requirements</b>				
<b>Heat Treatment Stage</b>		<b>Delivery Condition and After Post-Weld Heat Treatment</b>		
<b>Property</b>	<b>Unit</b>	<b>Orientation</b>	<b>Minimum</b>	<b>Maximum</b>
Notch Impact Strength at <del>0°C</del> <u>Minimum Operating Temperature</u>	J	Transv.	81 (60 ft-lbs)	-
FATT (50%)	°C	Long / Transv	-	-18

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