## ArevaEPRDCPEm Resource

**From:** WELLS Russell (AREVA) [Russell.Wells@areva.com]
**Sent:** Friday, April 01, 2011 1:24 PM
**To:** Tesfaye, Getachew
**Cc:** BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 467, FSAR Ch. 3, Supplement 1
**Attachments:** RAI 467 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for the 14 questions of RAI No. 467 on February 24, 2011. The attached file, “RAI 467 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to 4 of the remaining 14 questions, as committed.

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 467 Questions 03.09.02-158, 03.09.02-159, and 03.09.02-164.

The following table indicates the respective pages in the response document, “RAI 467 Supplement 1 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 467 — 03.09.02-158 | 6 | 6 |
| RAI 467 — 03.09.02-159 | 7 | 7 |
| RAI 467 — 03.09.02-164 | 12 | 12 |
| RAI 467 — 03.09.02-166 | 14 | 14 |

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

| Question # | Response Date |
|---|---|
| RAI 467 — 03.06.03-28 | August 15, 2011 |
| RAI 467 — 03.09.02-155 | April 28, 2011 |
| RAI 467 — 03.09.02-156 | April 28, 2011 |
| RAI 467 — 03.09.02-157 | April 28, 2011 |
| RAI 467 — 03.09.02-160 | April 28, 2011 |
| RAI 467 — 03.09.02-161 | April 28, 2011 |
| RAI 467 — 03.09.02-162 | April 28, 2011 |
| RAI 467 — 03.09.02-163 | April 28, 2011 |
| RAI 467 — 03.09.02-165 | April 28, 2011 |
| RAI 467 — 03.09.02-167 | April 28, 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*

---

**From:** WELLS Russell (RS/NB)
**Sent:** Thursday, February 24, 2011 2:08 PM
**To:** 'Tesfaye, Getachew'
**Cc:** DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); BRYAN Martin (External RS/NB)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 467, FSAR Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 467 Response US EPR DC.pdf" provides a schedule for a technically correct and complete response to the 14 questions.

The following table indicates the respective pages in the response document, "RAI 467 Response US EPR DC.pdf" that contain AREVA NP's response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 467 — 03.06.03-28 | 2 | 2 |
| RAI 467 — 03.09.02-155 | 3 | 3 |
| RAI 467 — 03.09.02-156 | 4 | 4 |
| RAI 467 — 03.09.02-157 | 5 | 5 |
| RAI 467 — 03.09.02-158 | 6 | 6 |
| RAI 467 — 03.09.02-159 | 7 | 7 |
| RAI 467 — 03.09.02-160 | 8 | 8 |
| RAI 467 — 03.09.02-161 | 9 | 9 |
| RAI 467 — 03.09.02-162 | 10 | 10 |
| RAI 467 — 03.09.02-163 | 11 | 11 |
| RAI 467 — 03.09.02-164 | 12 | 12 |
| RAI 467 — 03.09.02-165 | 13 | 13 |
| RAI 467 — 03.09.02-166 | 14 | 14 |
| RAI 467 — 03.09.02-167 | 15 | 15 |

A complete answer is not provided for the 14 questions. The schedule for a technically correct and complete response to these questions is provided below.

| Question # | Response Date |
|---|---|
| RAI 467 — 03.06.03-28 | August 15, 2011 |
| RAI 467 — 03.09.02-155 | April 28, 2011 |
| RAI 467 — 03.09.02-156 | April 28, 2011 |
| RAI 467 — 03.09.02-157 | April 28, 2011 |
| RAI 467 — 03.09.02-158 | April 28, 2011 |
| RAI 467 — 03.09.02-159 | April 28, 2011 |
| RAI 467 — 03.09.02-160 | April 28, 2011 |

| | |
|---|---|
| RAI 467 — 03.09.02-161 | April 28, 2011 |
| RAI 467 — 03.09.02-162 | April 28, 2011 |
| RAI 467 — 03.09.02-163 | April 28, 2011 |
| RAI 467 — 03.09.02-164 | April 28, 2011 |
| RAI 467 — 03.09.02-165 | April 28, 2011 |
| RAI 467 — 03.09.02-166 | April 28, 2011 |
| RAI 467 — 03.09.02-167 | April 28, 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*

---

**From:** Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
**Sent:** Wednesday, January 26, 2011 3:34 PM
**To:** ZZ-DL-A-USEPR-DL
**Cc:** Reichelt, Eric; Terao, David; Wong, Yuken; Dixon-Herrity, Jennifer; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
**Subject:** U.S. EPR Design Certification Application RAI No. 467 (5333, 5344), FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on January 6, 2011, and discussed with your staff on January 20 and 24, 2011. No change is made to the draft RAI as a result of those discussions. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

**Hearing Identifier:** AREVA_EPR_DC_RAIs
**Email Number:** 2801

**Mail Envelope Properties** (1F1CC1BBDC66B842A46CAC03D6B1CD41042BA0ED)

**Subject:** Response to U.S. EPR Design Certification Application RAI No. 467, FSAR Ch. 3, Supplement 1
**Sent Date:** 4/1/2011 1:23:57 PM
**Received Date:** 4/1/2011 1:24:30 PM
**From:** WELLS Russell (AREVA)

**Created By:** Russell.Wells@areva.com

**Recipients:**
"BENNETT Kathy (AREVA)" <Kathy.Bennett@areva.com>
Tracking Status: None
"DELANO Karen (AREVA)" <Karen.Delano@areva.com>
Tracking Status: None
"ROMINE Judy (AREVA)" <Judy.Romine@areva.com>
Tracking Status: None
"RYAN Tom (AREVA)" <Tom.Ryan@areva.com>
Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

**Post Office:** AUSLYNCMX02.adom.ad.corp

| **Files** | **Size** | **Date & Time** |
|---|---|---|
| MESSAGE | 5522 | 4/1/2011 1:24:30 PM |
| RAI 467 Supplement 1 Response US EPR DC.pdf | | 177286 |

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

**Response to**

**Request for Additional Information No. 467(5333, 5344)**
**Supplement 1**

**1/26/2011**

**U.S. EPR Standard Design Certification**
**AREVA NP Inc.**
**Docket No. 52-020**
**SRP Section: 03.06.03 - Leak-Before-Break Evaluation Procedures**
**SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components**
**Application Section: FSAR Chapter 3**

**QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)**
**QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)**

**Question 03.09.02-158:**

In FSAR Appendix 3C.1.1, paragraph 4, the applicant derives the shape factor for a hollow cylinder as follows:

SF = Shape Factor for a hollow cylinder (=4/3)

The commonly accepted value is 4/p = 1.27 (e.g. reference Handbook of Engineering Mechanics, Editor W. Flugge). The staff requests the applicant to explain if the above approximate value derived is correct and conservative.

**Response to Question 03.09.02-158:**

The shape factor provided in U.S. EPR FSAR Tier 2, Appendix 3C.1.1 is incorrect. However, the equation for calculating plastic moment (Equation 3C-1) is correct. The shape factor is for a thin walled cylinder and is an acceptable approximation in most cases. However, the corrected shape factor is appropriate for any hollow cylinder and is obtained from Table 6.1 of Reference 1:

$$SF = \frac{16 R_o (R_o^3 - R_i^3)}{3\pi (R_o^4 - R_i^4)}$$

Where:

$R_o$ = Outside Radius

$R_i$ = Inside Radius

U.S. EPR FSAR Tier 2, Section 3C.1.1 will be revised to reflect the changes to the shape factor.

**References**

1. Faupel, J., “Engineering Design – A Synthesis of Stress Analysis and Materials Engineering,” John Wiley and Sons, Inc., New York, 1964.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3C.1.1 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.09.02-159:**

The applicant defines the mass in FSAR, Appendix 3C.1.1, paragraph 4 as follows:

M = (length)(volume)(density)

The applicant is requested to confirm if this is correct and conservative.

**Response to Question 03.09.02-159:**

There is an error in the first part of U.S. EPR FSAR Tier 2, Section 3C1.1, Equation 3C-3. The middle term should be "area" instead of "volume." The corrected equation is as follows:

M = (length)(area)(density) = $\frac{L_P\left(A_M\rho_M + A_F\rho_F\right)}{g_c}$

U.S. EPR FSAR Tier 2, Section 3C.1.1 will be revised to reflect the changes to the formula for calculation of mass.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3C.1.1 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.09.02-164:**

FSAR, Appendix 3C.2.1.5, paragraph 2 states that "The SL has two dead weight hangers that are represented by vertical forces in the dead weight analysis." The applicant is requested to describe the type of dead weight hangers used, i.e. rigid hangers, spring hangers etc.

**Response to Question 03.09.02-164:**

The dead weight hangers used on the surge line are constant force spring hangers. These hangers incorporate a design that generates a constant supporting force throughout its total travel range. The design, using a compression spring, a lever, and a spring tension rod, creates a counterbalancing moment about the main pivot pin. This concept uses the principle of a varying leverage around a main pivot that compensates for the varying spring force as the lever travels from high to the low, or from low to the high. The dead weight hangers are selected from available vendor catalogues based on the dead weight force required to be supported and the expected travel during service conditions.

The term "deadweight hangers" in U.S. EPR FSAR Tier 2, Section 3C.2.1.5 will be replaced by "constant force spring hangers".

**FSAR Impact:**

The U.S. EPR FSAR Tier 2, Section 3C.2.1.5 will be revised as described in the response and indicated on the enclosed markup.

.

**Question 03.09.02-166:**

The applicant in USEPR FSAR Tier 2, Rev. 2, Section 3.9.2.7, page 3.9-35 states the following as Reference 2:

> ANP-10264NP-A, Revision 0, "U.S. EPR Piping Analysis and Pipe Support Design Topical Report," AREVA NP Inc., November 2008.

Also, the applicant in USEPR FSAR Tier 2, Rev. 2, Section 3.9.2.7, page 3.9-36 states the following as Reference 6:

> ANP-10264NP, Revision 1, "U.S. EPR Piping Analysis and Pipe Support Design Topical Report," AREVA NP INC., May 2010.

Further, the applicant in USEPR FSAR Tier 2, Rev. 2, Appendix 3C, states the following as Reference 1:

> ANP-10264NP-A, Revision 0, "U.S. EPR Piping Analysis and Pipe Support Design Topical Report," AREVA NP Inc., November 2008.

The staff requests that the applicant to explain why references have been made to two different revisions of the same Topical Report, particularly reference to an earlier edition of the report.

**Response to Question 03.09.02-166:**

ANP-10264NP-A, Revision 0, is the version that was approved by the NRC (References 1 and 2). Revision 1 of ANP-10264NP was submitted May 21, 2010 as part of the Response to RAI 365, Supplement 1, Question 05.02.01.01-5.c. The revision was requested by the NRC to change the reference from the 2001 Edition with the 2003 Addenda to the 2004 Edition with no Addenda for design and analysis of piping and supports consistent with the remainder of the U.S. EPR FSAR. Based on discussions with the NRC, this change did not require NRC approval. Therefore, the following sections of the U.S. EPR FSAR that made reference to ANP-10264NP with respect to codes and standards were revised to include a reference to Revision 1 of ANP-10264NP:

- U.S. EPR FSAR Tier 2, Sections 3.12.1, 3.12.2, 3.12.6.1, and 3.12.7.
- U.S. EPR FSAR Tier 2, Sections 3.9.2.1.1 and 3.9.2.7.
- U.S. EPR FSAR Tier 2, Sections 3.9.3 and 3.9.3.5.

The remaining references to ANP-10264NP-A, Revision 0 in the U.S EPR FSAR, including U.S. EPR FSAR Tier 2, Appendix 3C, are still valid because they reflect the methodology approved by the NRC for the U.S. EPR piping analysis and pipe support design.

**References:**

1. Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Final Safety Evaluation Report Regarding ANP-10264NP, 'U.S. EPR Piping Analysis and Pipe Support Design Topical Report' (TAC No. MD3128)," August 11, 2008.

2. AREVA NP letter NRC:08:086, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), “Publication of ANP-10264NP-A “U.S. EPR Piping Analysis and Pipe Support Design Topical Report,” November 7, 2008.

**FSAR Impact:**

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

# U.S. EPR Final Safety Analysis Report Markups

or component), and form loss factors (entrance and exit losses) to approximate the effect of sudden contractions and expansions that may exist between the control volumes. The unrecoverable losses (friction and form losses) in each flow path are back calculated from the initial steady state pressure drops, which are obtained from an analysis performed to evaluate Chapter 15 events. Recoverable losses (momentum and elevation losses) are calculated by CRAFT2 as part of the transient solution.

Special flow paths (leak paths) are defined from the RCS to the control volume representing the containment free volume at those locations where the primary side breaks are postulated to occur. Lengths and unrecoverable losses are not defined for leak paths, but break opening times and discharge coefficients are. The break opening area versus time relationships are determined as follows:

03.09.02-158

- The plastic moment is calculated:

$$M_P = SF\left(\frac{I}{c}\right)S_Y$$

$$= \frac{4}{3}\left(\frac{\pi/4\left(R_o^4 - R_i^4\right)}{R_o}\right)S_Y$$

$$M_P \approx \frac{4}{3}\left(R_o^3 - R_i^3\right)S_Y$$

~~(Eqtn 3C-1)~~

~~where:~~

~~SF = Shape Factor for a hollow cylinder (=4/3)~~

~~I = moment of inertia~~

~~c = distance to outermost fiber~~

~~$S_Y$ = yield strength~~

~~$R_o$ = outside radius~~

~~$R_i$ = inside radius~~

$$M_P = SF\left(\frac{I}{c}\right)S_Y$$

$$= \left[\frac{16R_o(R_o^3 - R_i^3)}{3\pi(R_o^4 - R_i^4)}\right]\left[\frac{\pi/4(R_o^4 - R_i^4)}{R_o}\right]S_Y$$

$$M_P = \frac{4}{3}(R_o^3 - R_i^3)S_Y \qquad (Eqn\,3C-1)$$

03.09.02-158

where:

SF = Shape Factor for a hollow cylinder

$$= \frac{16R_o(R_o^3 - R_i^3)}{3\pi(R_o^4 - R_i^4)}$$

(Eqtn 3C-12)

I = moment of inertia

c = distance to outermost fiber

$S_Y$ = yield strength

$R_o$ = outside radius

$R_i$ = inside radius

- The plastic length of the pipe is calculated assuming that the thrust force caused by a full circumferential guillotine break at the pipe-to-nozzle weld is applied perpendicular to the pipe axis at the break location:

$$M_P = (\text{force})(\text{distance}) = C_D\, P\, A_F\, L_P$$

$$L_P = \frac{M_P}{C_D\, P\, A_F} \qquad \text{(Eqtn 3C-2)}$$

where:

$L_P$ = plastic length of pipe

$C_D$ = hydraulic discharge coefficient

P = pressure in pipe prior to break

$A_F$ = pipe fluid area

03.09.02-159

- The mass of the plastic length of pipe is calculated:

$$M = (\text{length})(\text{area})(\text{density}) = \frac{L_P\left(A_M\rho_M + A_F\rho_F\right)}{g_c} \qquad \text{(Eqtn 3C-3)}$$

$$M = (\text{length})(\text{volume})(\text{density}) = \frac{L_P\left(A_M\rho_M + A_F\rho_F\right)}{g_c} \qquad \text{(Eqtn 3C-3)}$$

where:

appropriate elevations. Local flexibility of the PZR shell at the support lug and lateral bumper connections is accounted for in the model.

The PZR model is connected to the RBIS through representations of the PZR support lugs, and PZR bumpers. Beam elements represent the support lugs and bumpers. The stiffness of the concrete at the locations where the support lugs and bumpers connect to the RBIS is also accounted for in the model.

Figure 3C-5 depicts the PZR model used in the RCS four loop structural model.

### 3C.2.1.5 Reactor Coolant System Piping Model

The MCL and SL piping is represented by beam elements that connect the primary components. These elements are assigned distributed mass reflecting the weight of the pressure boundary, entrained fluid, and thermal insulation and are assigned cross-sectional properties representative of the pipe pressure boundary.

03.09.02-164

The SL has two ~~deadweight~~constant force spring hangers that are represented by vertical forces in the deadweight analysis. The MCL piping does not have any supports other than the primary components.

Figure 3C-5 depicts the MCL and SL piping model used in the RCS four loop structural model.

### 3C.2.1.6 Reactor Building Internal Structures Model

The RBIS "stick" model that is coupled with the RCS model in the RCS four loop structural model was originally created for building analysis purposes and is tuned to match the frequencies of a three-dimensional finite element model of the RBIS. Refer to Section 3.7.2 for a description of this process. The original RBIS stick model input was converted to the input format of the RCS structural analysis code being used (BWSPAN, see Section 3C.6).

In the RCS four loop structural model, beam elements represent the RBIS. These elements are assigned lumped mass and cross-sectional properties reflecting the mass, stiffness, and frequency characteristics of the RBIS. Separate elements represent the shear stiffness and the bending stiffness. Lumped masses are located eccentrically to represent the mass distribution of the physical structure accurately. Rigid members connect the RBIS model to the building end of the RCS component supports.

### 3C.2.2 Reactor Pressure Vessel Isolated Structural Model

The RPV isolated structural model consists of representations of the RPV pressure boundary, CRDMs, CRDM nozzles, CHE, lower internals, upper internals, and fuel assemblies. Beam elements represent the pressure boundary; beam elements and springs represent the internals and fuel assemblies to simulate the physical