ArevaEPRDCPEm Resource

From: WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent: Tuesday, April 30, 2013 6:05 PM
To: Snyder, Amy
Cc: Ford, Tanya; ANDERSON Katherine (EXTERNAL AREVA); DELANO Karen (AREVA); HONMA George (EXTERNAL AREVA); LEIGHLITER John (AREVA); LEWIS Ray (EXTERNAL AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); TOLLEY Tracey (AREVA); VANCE Brian (AREVA); NOXON David (AREVA); RITCHEY Calvin (AREVA)
Subject: Advanced Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Question 19-351
Attachments: Advanced Response to RAI 495 Question 19-351 US EPR DC.pdf

Amy,

Attached is an Advanced Response to RAI No.495, Question 19-351 in advance of the final response date of June 28, 2013.

To keep our commitment to send a final response to this question by the commitment date, we need to receive all NRC staff feedback and comments no later than **June 14, 2013**.

Please let me know if NRC staff has any questions or if this response can be sent as final.

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Sunday, February 26, 2012 7:17 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Supplement 5

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the one question in RAI 495 on July 11, 2011. Supplement 1 sent on October 18, 2011, Supplement 2 sent on November 17, 2011, Supplement 3 sent on December 13, 2011, and Supplement 4 sent on January 24, 2012 provided a revised schedule for this response.

The schedule for a technically correct and complete response to the remaining question has been changed as provided below. This schedule was transmitted to the NRC in AREVA NP letter NRC:12:008 dated February 21, 2012.

Question #	Response Date
RAI 495 — 19-351	**June 28, 2013**

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, January 24, 2012 5:00 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB); 'Michael.Miernicki@nrc.gov'; 'tanya.ford@nrc.gov'
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Supplement 4

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the one question in RAI 495 on July 11, 2011. Supplement 1 sent on October 18, 2011, Supplement 2 sent on November 17, 2011, and Supplement 3 sent on December 13, 2011 provided a revised schedule for this response.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by February 21, 2012.

Question #	Response Date
RAI 495 — 19-351	**February 21, 2012**

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, December 13, 2011 4:50 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David

(RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Supplement 3

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the one question in RAI 495 on July 11, 2011. Supplement 1 sent on October 18, 2011, and Supplement 2 sent on November 17, 2011 provided a revised schedule for this response.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by January 25, 2012.

Question #	Response Date
RAI 495 — 19-351	**January 25, 2012**

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Thursday, November 17, 2011 6:45 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the one question in RAI 495 on July 11, 2011. Supplement 1 sent on October 18, 2011 provided a revised schedule for this response.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by December 14, 2011.

Question #	Response Date
RAI 495 — 19-351	**December 14, 2011**

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, October 18, 2011 5:20 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the one question in RAI 495 on July 11, 2011.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by November 17, 2011.

Question #	Response Date
RAI 495 — 19-351	**November 17, 2011**

Sincerely,

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

From: WILLIFORD Dennis (RS/NB)
Sent: Monday, July 11, 2011 8:26 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 495 Response US EPR DC.pdf," provides a schedule since a technically correct and complete response to the single question is not provided.

The following table indicates the respective pages in the response document, "RAI 495 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 495 — 19-351	2	2

The schedule for a technically correct and complete responses to the single question is provided below.

Question #	Response Date
RAI 495 — 19-351	October 19, 2011

Sincerely,

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

From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Thursday, June 09, 2011 7:57 PM
To: ZZ-DL-A-USEPR-DL
Cc: Xu, Jim; Hawkins, Kimberly; Ford, Tanya; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on June 8, 2011, and on June 9, 2011, 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 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: 4362

Mail Envelope Properties (554210743EFE354B8D5741BEB695E65614B698)

Subject: Advanced Response to U.S. EPR Design Certification Application RAI No. 495 (5841), FSAR Ch. 19, Question 19-351
Sent Date: 4/30/2013 6:04:50 PM
Received Date: 4/30/2013 6:04:56 PM
From: WILLIFORD Dennis (AREVA)

Created By: Dennis.Williford@areva.com

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"Ford, Tanya" <Tanya.Ford@nrc.gov>
Tracking Status: None
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Tracking Status: None
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Tracking Status: None
"Snyder, Amy" <Amy.Snyder@nrc.gov>
Tracking Status: None

Post Office: FUSLYNCMX03.fdom.ad.corp

Files	**Size**	**Date & Time**	
MESSAGE	9459	4/30/2013 6:04:56 PM	
Advanced Response to RAI 495 Question 19-351 US EPR DC.pdf			173923

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

Advanced Response to

Request for Additional Information No. 495(5841), Revision 0

6/9/2011

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation
Application Section: FSAR Chapter 19

QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

Question 19-351:

OPEN ITEM

Follow-up to RAI 234, Question 19-307

The response to RAI 234, Question 19-307described that the containment pressure fragility was developed based on an approach that the containment is sub-divided into six structural parts including the equipment hatch. It also stated that major penetrations, and personnel and emergency airlocks are not currently modeled because design details for these will be developed later in the design process.

In a draft response to RAI 448, Question 3.8.1-49, the applicant described a containment deterministic pressure capacity assessment based on the guidance provided in SRP 3.8.1.II.4.K. This assessment was performed based on the latest design information which includes all major containment penetrations. These penetrations include: equipment hatch, construction opening closure, personnel airlocks, fuel transfer tubes, and main steam and feedwater line penetrations. The results of the deterministic containment pressure capacity are provided in Table 3.8.6 of the FSAR markup, rev. 3-interim. As indicated in this table, the pressure capacity for containment penetrations is governed by the construction opening closure which is 118.5 psig or 1.91 times design basis pressure that is much lower than the 95th percentile capacity of 197 psig or 3.18 times design basis pressure reported in Table 19.307-7 of the response to RAI 234, Question 19-307.

Therefore, the staff requests that the applicant revise the containment fragility analysis to include the latest design details and provide revised containment pressure fragility.

Response to Question 19-351:

Development of the U.S. EPR Containment Fragility Analysis:

The U.S. EPR containment fragility curve considers that the containment building structure and local openings, when assembled together, represent a continuous model of the entire containment structure.

The approach presented in the Response to RAI 234, Question 19-307 was updated based on the latest design information available and extended to include major containment penetrations. The containment fragility analysis presented in this RAI Response includes nine structural sections: The cylinder wall, spherical dome, dome belt, gusset base, equipment hatch, construction opening closure, personnel airlocks, fuel transfer tube, and the main steam and feedwater line penetrations.

Various sections of the US EPR FSAR Tier 2 present different analyses of the containment pressure capacitates. These analyses have different purposes and are based on different sets of inputs.

- **Deterministic Structural Containment Pressure Capacity**: The deterministic results for the Level D analysis presented in Table 3.8-6 of the FSAR are developed in accordance with the ASME code requirements as applicable to the listed structure

or component. The applied loads for the analyses include containment accident temperature and pressure, as well as other mechanical loads. For example: seismic accelerations.

- **Probabilistic Structural Containment Pressure Capacity**: This method uses a best-estimate approach with loading based on the containment accident temperature and pressure only. Pressure values are therefore associated with failure of the structure or component in this manner are, as expected, greater than those calculated in the deterministic analysis. The results of this analysis are used as inputs to the containment fragility analysis presented in the Level 2 Probabilistic Risk Assessment (PRA).
- **Level 2 PRA Containment Fragility Analysis**: This analysis uses the results of the Probabilistic Structural Containment pressure Capacity and represents the failure pressure of each part of the containment as a probability distribution. The results of this analysis are discussed in this RAI response.

The probabilistic structural containment pressure capacities, calculated for each of the sections at a structural temperature of 309 °F, are used as an input to the Level 2 PRA. For each of the structural sections, the main failure mode is listed in Table 351-1.

Table 351-1- Failure Modes of the U.S. EPR Containment Structure

Containment area	Failure mode
Cylinder wall	Hoop membrane failure
Spherical dome	Membrane failure
Dome belt	Flexural failure
Gusset (base of cylinder wall)	Flexural failure
Equipment hatch (horizontal section)	Flexural failure
Equipment hatch (vertical section)	Flexural failure
Equipment hatch	Buckling
Construction opening closure	Buckling
Airlock assembly shell	Non-linear buckling
Airlock assembly hatch	Non-linear buckling
Main steam lines	Internal pressure
Feedwater lines	Flexural
Fuel transfer tube	Buckling

The results are summarized in Table 351-2. The median failure pressure values from the probabilistic fragility analyses exceed the deterministic capacities.

Table 351-2- Containment Sections Pressure Capacities

Failure Location and mode	Mean (psig)	Median (psig)	β (=σ)	5th Percentile (psig)	95th Percentile (psig)
Cylinder wall	284.1	284	0.027	271.6	296.9
Spherical dome	217.1	217	0.026	207.9	226.5
Dome Belt	221.1	221	0.028	211.1	231.4
Gusset base - base of cylinder wall	331.1	331	0.028	316.1	346.6
Equipment hatch vertical section V2	229.9	229	0.09	197.5	265.5
Equipment hatch horizontal section H2	297.2	296	0.09	255.3	343.2
Equipment hatch	323.6	317	0.196	229.8	438.4
Construction opening closure	271.4	266	0.2	191.4	369.6
Airlock assembly shell	236.1	231	0.21	163.6	326.2
Airlock assembly hatch	321.9	316	0.19	231.3	432.1
Main steam line	3549.7	3467	0.217	2425.8	4955.1
Feedwater line 3	4374.1	4281.	0.207	3046.4	6017.4
Feedwater line 4	4378.9	4287	0.2054	3058.2	6011.0
Fuel transfer tube	1068.8	1017	0.314	607.4	1704.4

As a result of the partially overlapping fragility curves, the curves for the different structural sections have been combined to calculate the containment composite fragility curve (CCFC). The CCFC, generated through the use of a Monte Carlo sampling, combines the results from each of the individual failure areas into a single distribution representing the containment fragility. For every pressure sampled, the lowest failure probability of all containment locations is assigned.

The resulting pressure probability distribution is shown on Figure 351-1. A Monte Carlo simulation with 1,000,000 trials, and no correlation between the different structural sections, provided the following results for the composite fragility curve:

- Mean: 201 psig (about 3 times the design pressure).
- Media: 207 psig.
- Minimum (of all the values generated during the run): 87 psig.
- Maximum (of all the values generated during the run): 234 psig.
- Standard Deviation: 19 psig.

A sensitivity analysis was performed to assess the impact of the correlation assumptions used. The un-correlated case resulted in a more conservative fragility curve.

Treatment of Containment Rupture and Leakage:

When the containment composite fragility (see Figure 19-351-2) is needed in the Level 2 PRA to calculate the split fractions for the phenomenological evaluations, it is usual to distinguish between leakages and ruptures failure modes of the containment.

A leakage failure mode is characterized by a containment failure size that prevents a rapid depressurization of containment. The smaller containment failure size leads to a smaller source term if a subsequent rupture does not occur.

Whether rupture subsequently occurs depends on the load and, in particular, the pressurization rate of the containment at the time of failure and the leakage area. For rupture, it is assumed that the containment breach would arrest a gradual pressure increase, and would cause a rapid depressurization of the entire containment. To account for both leakage and rupture failure modes, the following steps are performed:

- Characterize each containment section (including penetrations) as either a leak or rupture failure mode as summarized in Table 351-3. The characterization is carried out by comparison to similar containment types based on NUREG/CR-6906 – "Containment Integrity Research at Sandia National Laboratories".
- For every section of the containment, use the failure probability distribution defined in Table 351-2.
- For every pressure value from a given phenomenological load, sample the fragility distributions of the sections with rupture and leak failure modes.
- Compare the load pressure to the sampled rupture and leak pressures as follows:
  - For fast rising pressure loads a leak can only occur if a rupture did not occur.
  - For slow rising pressure loads a rupture can occur if a leak did not occur.

A sensitivity analysis has been carried out to assess the impact of the assumptions on the failure modes assigned to a particular containment section. In conclusion, there were no significant changes in the results.

FSAR markups and impact on the Level 2 PRA results will be included with the response to RAI-289, Question 19-329.

Table 351-3- Characterization of EPR Containment Failure Modes as Leak or Rupture

Area of containment	Failure mode	Proposed characterization (leak / rupture)
Cylinder wall	Hoop membrane failure	Rupture
Spherical dome	Membrane failure	Rupture
Dome belt	Flexural failure	Rupture
Gusset (base of cylinder wall) Equipment hatch (horizontal section)	Flexural failure	Rupture
Equipment hatch (vertical section)	Flexural failure	Rupture
Equipment hatch	Buckling	Rupture
Construction opening closure	Buckling	Rupture
Airlock assembly shell	Non-linear buckling	Leakage
Airlock assembly hatch	Non-linear buckling	Rupture

FSAR Impact:

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

Figure 351-1- Fragility curves for the sub-areas of the U.S.EPR™ containment and the composite fragility curve at 309ºF

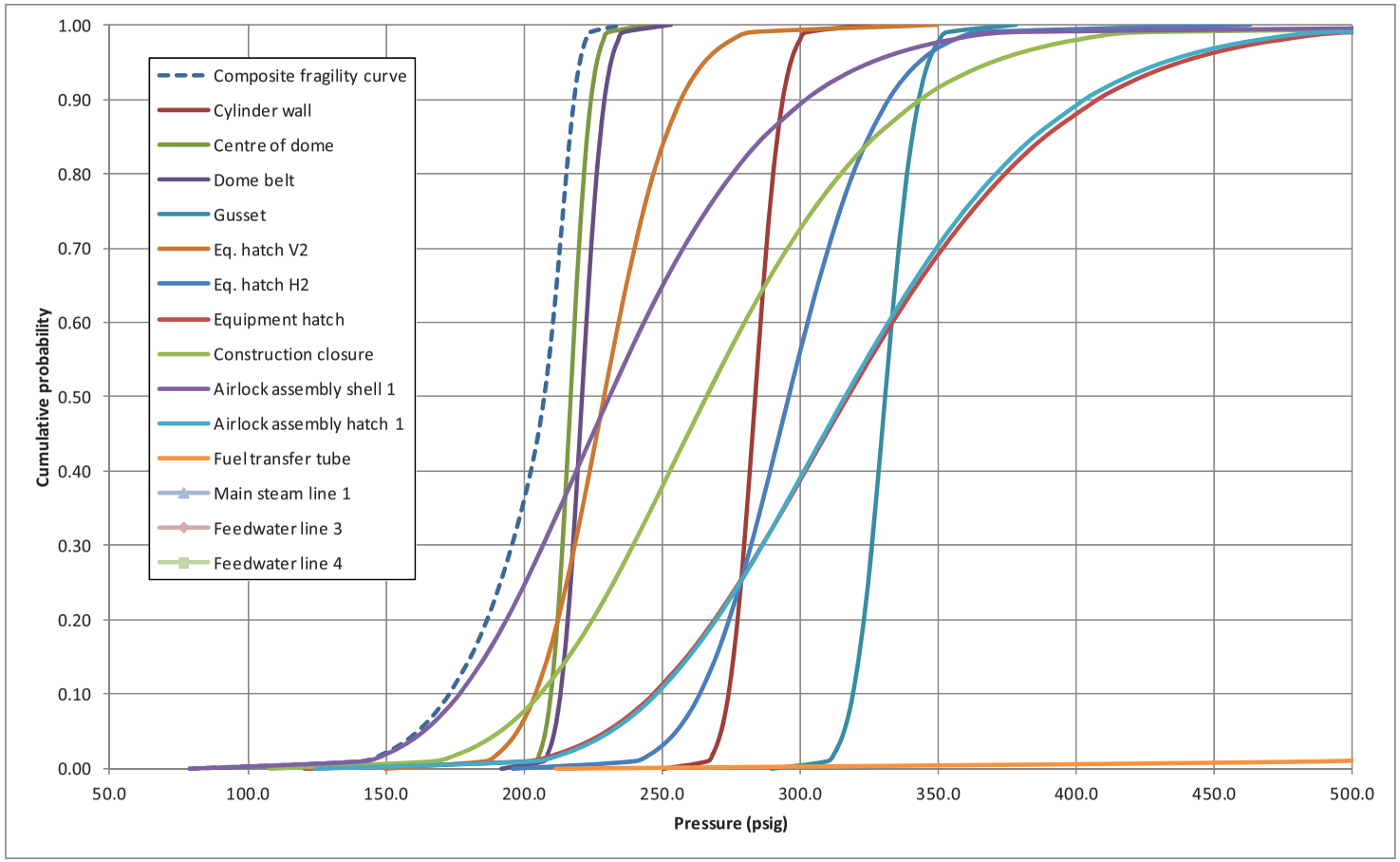

Figure 351-2 - Composite Containment Fragility Curve at 309ºF