

ArevaEPRDCPEm Resource

From: WELLS Russell D (AREVA NP INC) [Russell.Wells@areva.com]
Sent: Wednesday, January 28, 2009 10:26 AM
To: Getachew Tesfaye
Cc: Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 137, FSAR Ch 15, Supplement 1
Attachments: RAI 137 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. provided a schedule for technically correct and complete response to the three (3) questions of RAI No. 137 on January 6, 2009. The attached file, "RAI 137, Supplement 1 Response US EPR DC.pdf," provides technically correct and complete responses to 3 of the 3 questions as committed.

The following table indicates the respective pages in the response document, "RAI 137, Supplement 1 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

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RAI 137 — 15.00.03-33	2	4
RAI 137 — 15.00.03-34	5	9
RAI 137 — 15.00.03-35	10	11

This concludes the formal AREVA NP response to RAI 137, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

(Russ Wells on behalf of)

Ronda Pederson

ronda.pederson@areva.com

Licensing Manager, U.S. EPR Design Certification
New Plants Deployment

AREVA NP, Inc.

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From: Pederson Ronda M (AREVA NP INC)
Sent: Tuesday, January 06, 2009 10:24 AM
To: Getachew Tesfaye
Cc: WELLS Russell D (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 137 (1348), FSARCh. 15

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 137 Response US EPR DC.pdf," provides a schedule since a technically correct and complete response to the three (3) questions is not provided.

The following table indicates the respective pages in the response document, "RAI 137 Response US EPR DC.pdf," that contain AREVA NP's schedule for response to the subject questions.

Question #	Start Page	End Page
RAI 137 — 15.00.03-33	2	2
RAI 137 — 15.00.03-34	3	3
RAI 137 — 15.00.03-35	4	4

The schedule for a technically correct and complete response to each of these 3 questions is provided below.

Question #	Response Date
RAI 137 — 15.00.03-33	February 4, 2009
RAI 137 — 15.00.03-34	February 4, 2009
RAI 137 — 15.00.03-35	February 4, 2009

Sincerely,

Ronda Pederson

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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]

Sent: Tuesday, December 02, 2008 2:42 PM

To: ZZ-DL-A-USEPR-DL

Cc: Jeffrey Poehler; David Terao; Prosanta Chowdhury; Jason Carneal; Joseph Colaccino; John Rycyna

Subject: U.S. EPR Design Certification Application RAI No. 137 (1348), FSARCh. 15

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on November 6, 2008, and discussed with your staff on November 25, 2008. No change was made to the draft RAI as a result of that discussions. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs, excluding the time period of December 20, 2008 thru January 1, 2009, to account for the holiday season as discussed with AREVA NP Inc. For any RAIs that cannot be answered within 45 days, it is expected that a date for receipt of this information will be provided to the staff within the 45-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: 161

Mail Envelope Properties (1F1CC1BBDC66B842A46CAC03D6B1CD410106D730)

Subject: Response to U.S. EPR Design Certification Application RAI No. 137, FSAR Ch
15, Supplement 1
Sent Date: 1/28/2009 10:26:06 AM
Received Date: 1/28/2009 10:26:09 AM
From: WELLS Russell D (AREVA NP INC)

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Files	Size	Date & Time
MESSAGE	4016	1/28/2009 10:26:09 AM
RAI 137 Supplement 1 Response US EPR DC.pdf		93159

Options

Priority: Standard

Return Notification: No

Reply Requested: No

Sensitivity: Normal

Expiration Date:

Recipients Received:

Response to

Request for Additional Information No. 137, Supplement 1

12/2/2008

U. S. EPR Standard Design Certification

AREVA NP Inc.

Docket No. 52-020

SRP Section: 15.00.03 - Design Basis Accidents Radiological Consequence

Analyses for Advanced Light Water Reactors

Application Section: 15.0.3

QUESTIONS for Component Integrity, Performance, and Testing Branch 1

(AP1000/EPR Projects) (CIB1)

Question 15.00.03-33:

The information provided in the FSAR Tier 2 Chapter 15.0.3 Table 15.0.3-15 provides the data for parameters affecting the pH of the containment sump at one day after the LOCA. In order to ensure that the pH remains within the bounds of the pH required over the thirty day period of the event, the trend of these variables would need to be estimated and the pH calculated based on the changes in all the values affecting pH.

1. Provide the estimated pH over the thirty day period at reasonable intervals (once per two days).
2. Provide the data for the thirty day period on which these calculations are based.

Response to Question 15.00.03-33:

The pH versus time for the 30-day duration following the design basis loss of coolant accident (LOCA) (assuming 100,000 lb_m of Hypalon material and 4,000 lb_m of polyvinyl chloride (PVC) material are present) is shown in Table 15.00.03-33-1—IRWST pH vs. Time.

The data supporting Table 15.00.03-33-1 are provided in Table 15.00.03-33-2—Acid Added to IRWST vs. Time and Table 15.00.03-33-3—IRWST pH vs. Acid Added.

FSAR Impact:

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

Table 15.00.03-33-1—IRWST pH vs. Time

Time (hours)	pH
0	7.5
48	7.38
96	7.34
144	7.30
192	7.26
240	7.23
288	7.21
336	7.2
384	7.19
432	7.18
480	7.17
528	7.16
576	7.15
624	7.14
672	7.13
720	7.12

Table 15.00.03-33-2—Acid Added to IRWST vs. Time

Time	[HNO ₃] (mol/L)	[HCl] (mol/L)			
		Hypalon Jacket			PVC Jacket
		60000 lb _m	80000 lb _m	100000 lb _m	4000 lb _m
1h	3.51E-06	5.99E-05	7.98E-05	9.98E-05	1.47E-05
2h	4.83E-06	1.02E-04	1.36E-04	1.70E-04	2.49E-05
5h	7.57E-06	1.95E-04	2.61E-04	3.26E-04	4.78E-05
12h	1.21E-05	3.47E-04	4.63E-04	5.79E-04	8.50E-05
1d	1.80E-05	5.36E-04	7.15E-04	8.94E-04	1.31E-04
3d	5.16E-05	8.72E-04	1.16E-03	1.45E-03	2.13E-04
10d	1.14E-04	1.47E-03	1.96E-03	2.45E-03	3.59E-04
20d	1.53E-04	1.77E-03	2.36E-03	2.95E-03	4.33E-04
30d	1.78E-04	1.92E-03	2.56E-03	3.21E-03	4.70E-04

Table 15.00.03-33-3—IRWST pH vs. Acid Added¹

pH	[H ⁺] (mol/L)
7.5	0.00E+00
7.4	1.24E-03
7.3	2.31E-03
7.2	3.23E-03
7.1	4.03E-03
7	4.71E-03

- 1) Based on a molarity of 0.0062 mol/L PO₄ as TSP and 1904 ppm boron as boric acid. The actual PO₄ concentration established in the final analysis is 0.00607 mol/L, but this 2 percent reduction in the PO₄ concentration (as compared to the 0.0062 Mol/L assumption in Table 15.00.03-33-3) has about a 1 percent effect on the “acid added” values corresponding to each pH level in Table 15.00.03-33-3.

Question 15.00.03-34:

Regulatory Guide 1.183, Appendix A, Item 2 identifies the performance characteristic of the containment sump water chemistry as being able to maintain pH greater than 7.0 to minimize the volatilization of iodines into the containment atmosphere and thus minimize dose offsite and to plant personnel.

The results of the calculation are presented in Tables 15.0-55 and 15.0-56, but the calculational methodology and assumptions (amount of HCl, HNO₃ the concentration of boric acid, lithium etc. at the start of the LOCA on pH) are not presented. The use of NUREG-CR/5950 as a guide does not address the specific parameters that may have been considered in calculating the final pH of the solution. What assumptions have been made for pH calculation regarding the concentration of contaminants in the Containment Building sump that may affect pH.?

1. What concentrations of the following species were used in the calculation, and what was the algorithm that was used? (No algorithm is present in the NUREG that identifies these parameters.)
 - a. Chlorides (as a result of radiolysis of organic materials like cable coverings),
 - b. Boric acid in the IRWST water and the RCS
 - c. Nitrates
 - d. Sulfates
 - e. Silica
 - f. Calcium (especially as regards the precipitation of calcium phosphate)
 - g. Sodium
 - h. Phosphate (residual after the precipitation of calcium phosphate)
2. How was the temperature of the water and the ionic strength of the solution accounted for in the calculation as both these affect the acid constant for boric acid, as well as its ability to form polymeric species?

Response to Question 15.00.03-34:

1. The algorithm used to identify the parametric input for the chemical species considered in U.S. EPR FSAR Tier 2, Table 15.0-55—H⁺ Added to IRWST and Table 15.0-56—Mass of TSP vs. pH at 30 Days pH calculation is identical to that used for the South Texas Project (STP) pH calculation as described in Reference 1. Differences in the input (and the associated results) of the STP application of that algorithm versus the U.S. EPR application are summarized in Table 15.00.03-34-1—Comparison of pH Calculations (STP and U.S. EPR).
 - 1.a. The time-dependent chloride concentration used in U.S. EPR FSAR Tier 2, Table 15.0-55 and Table 15.0-56 is the same as that used for hydrochloric acid (HCl) in Table 15.00.03-33-2—Acid Added to IRWST vs. Time.
 - 1.b. The post-accident in-containment refueling water storage tank (IRWST) boron concentration (as boric acid) is 1904 ppm. This includes boric acid initially in the reactor coolant system (RCS) as well as in the IRWST.

- 1.c. The time-dependent concentration of nitric acid (HNO_3) is presented in Table 15.00.03-33-2.
- 1.d-1.f. No sulfur-bearing, silica-bearing, or calcium-bearing compounds were considered in the calculation. Calcium silicate insulation materials will not be used on RCS piping and components inside containment. Where clearances permit, the RCS insulation will be reflective metal insulation (RMI). Calcium-silicate insulation is not used inside reactor containment.
- 1.g-1.h. Sodium and phosphate (as trisodium phosphate) were considered. The phosphate concentration credited is 0.00607 moles PO_4 /liter.
2. The acid dissociation constant (K_{A1}) for H_3BO_3 is based on a representative IRWST temperature of 78°C with the actual value being $9.03\text{E}-10$ (i.e., the negative log of the dissociation constant ($\text{p}K_A$) = 9.04). This temperature is the same as that used for STP (Reference 1), which was conservatively selected because it is lower than a value that would result in significant re-evolution of elemental iodine from the IRWST.

Only the first ionization of H_3BO_3 itself is taken into account. Given the relatively low boric acid concentration and overall ionic strength of the IRWST water (0.178 mol/L boric acid and 0.0061 mol/L trisodium phosphate (TSP) at near-neutral pH and less than 0.004 mol/L strong acid), neither the ionic strength nor the formation of polymeric borate species was explicitly considered.

References for Question 15.00.03-34-1:

1. U.S. Nuclear Regulatory Commission, Letter to Mr. James J. Sheppard, President and Chief Executive Officer, STP Nuclear Operating Company from Mohan C. Thadani, NRC Office of Nuclear Reactor Regulation, "South Texas Project, Units 1 and 2 - Issuance of Amendment Nos. 182 and 169, regarding Adoption of Alternate Radiological Source Term in Assessment of Design-Basis Accident Dose Consequences," March 6, 2008 (ADAMS Accession No. ML080160013).

FSAR Impact:

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

**Table 15.00.03-34-1—Comparison of pH Calculations (STP and U.S. EPR)
 (3 Sheets)**

NRC Safety Evaluation Statement for STP	Applicability to U.S. EPR
<p>The loss of coolant accident (LOCA) analysis assumes that iodine will be removed from the containment atmosphere by both containment sprays and natural diffusion to the containment walls. As a result of these removal mechanisms, a large fraction of the released activity will be deposited in the containment sump. The sump water will retain soluble gases and soluble fission products such as iodines and cesium, but not noble gases. Guidance from RG 1.183 specifies that the iodine deposited in the sump water can be assumed to remain in solution as long as the containment sump pH is maintained at or above 7.</p>	<p>Activity is deposited in the IRWST more slowly (by natural deposition and carryover of spilled injection water and condensation).</p>
<p>The licensee conducted an evaluation of containment sump pH in order to verify that particulate iodine deposited into the containment sump water does not re-evolve beyond the amount recognized in the design basis analysis (DBA) LOCA analysis. The licensee’s determination of pH was performed using the methodology outlined in NUREG/CR-5950, “Iodine Evolution and pH Control,” December 1992, and NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants,” February 1995. The licensee also performed an analysis of the associated iodine decontamination factor (DF) for containment iodine removal and retention.</p>	<p>The same methodology was used for the U.S. EPR analysis, except the iodine is deposited in the IRWST instead of the containment sump.</p>
<p>The design inputs for calculating the containment sump pool pH were conservatively established by the licensee to maximize the acidic contribution to sump pH and minimize the basic contribution. The licensee’s pH analysis credits the buffering effect of trisodium phosphate (TSP), which is stored in baskets in the containment sump. The licensee credits the post-LOCA dissolution of the TSP in the containment sump water resulting from the released reactor coolant and injected spray water coming in contact with the stored TSP in the lower elevation of containment. The baskets of TSP are assumed to be submerged during a DBA LOCA, thereby buffering the sump pH against LOCA-induced acidity. Contributors to acidity in the sump pool at STP include: boric acid from the RCS, the accumulators, and the refueling water storage tank (RWST); nitric acid from radiolysis of water; and, hydrochloric acid from radiolysis of chloride-bearing cable jacket insulation.</p>	<p>The same methodology was used for the U.S. EPR analysis, except for the use of an IRWST and the absence of spray water.</p>

**Table 15.00.03-34-1—Comparison of pH Calculations (STP and U.S. EPR)
 (3 Sheets)**

NRC Safety Evaluation Statement for STP	Applicability to U.S. EPR
<p>The licensee made conservative assumptions regarding the amount of cable insulation present and included a factor to account for the addition of more cable in the future. In the containment sump pH analysis, the licensee did not credit the basic alkali metal compounds and cesium compounds that result from fission products co-released with radioactive iodine.</p>	<p>The same methodology was used for the U.S. EPR analysis, except that no factor was defined to account for more cable in the future. A high estimate of cable insulation was made.</p>
<p>To add to the conservatism of the pH analysis, the licensee assumed that 10 percent of non-noble gas activity remains airborne in the containment for the entire duration of the accident evaluation, even in the presence of sprays. In addition, the licensee assumed that all of the noble gas activity remains airborne in the containment for the duration of the accident. These assumptions result in an increase in the amount of radiation exposure to cables which subsequently results in a higher production of hydrochloric acid due to radiolysis of the cable jacket insulation.</p>	<p>Because sprays are not used for the U.S. EPR, the 10 percent value is increased to 66 percent for the first 24 hours and 33 percent for the remainder of the 30 days.</p>
<p>The licensee’s analysis credits a reduction of a factor of two for beta shielding of cable in trays to account for the layering of cables which provides a significant amount of self shielding. A beta shielding factor of ten is credited for the 16 percent of cable that is estimated to be in conduit.</p>	<p>The same methodology was used for the U.S. EPR analysis, except no credit is taken for cable being in conduit.</p>
<p>The licensee has determined that the buffering effect of TSP is sufficient to maintain the sump pH at or above 7 for the first day following a DBA LOCA. However, after the initial 24 hours following the LOCA, the licensee’s evaluation indicates that the sump pH begins to slowly decrease reaching a lower limit of approximately 6.8 by the end of the 30-day duration of the analysis. The RG 1.183 position on postulated iodine re-evolution is based on the sump pH being maintained at or above 7. Therefore, with the pH dropping below 7 during the DBA LOCA, the licensee determined the extent to which iodine re-evolution would increase in response to this effect.</p>	<p>The same methodology was used for the U.S. EPR analysis, except the pH does not drop below 7.1 during the full 30-day duration.</p>

**Table 15.00.03-34-1—Comparison of pH Calculations (STP and U.S. EPR)
 (3 Sheets)**

NRC Safety Evaluation Statement for STP	Applicability to U.S. EPR
<p>Iodine re-evolution is enhanced by higher temperatures and lower levels of pH in the sump water. To conservatively bound the dose consequence from iodine re-evolution, the licensee assumed that the maximum sump temperature of 266 °F and the minimum pH value of 6.8 would persist for the entire 30-day duration of the accident. To account for the drop in pH below 7 and the subsequent potential increase in iodine re-evolution, the licensee limited the assumed DF for elemental iodine for spray and natural removal mechanisms inside containment to a value of 60.</p> <p>The licensee conservatively applied a DF of 60 which corresponds to a pH of 6.8 in the dose analysis, even though the calculated value of pH after 30 days is just below 6.85. This approach is conservative in that the highest sump temperature is used and the lowest pH is assumed throughout the duration of the accident. The licensee asserts that in reality, the assumed DF of 60 should be exceeded at all times since early in the accident the sump pH is greater than 6.8 and later in the accident the sump temperature is much less than the maximum value of 266 °F.</p>	<p>Because the IRWST pH never falls below 7.1, there is no need to limit the elemental iodine DF to 60. However, for conservatism, the elemental iodine DF is limited to 100 even with the pH remaining above 7.1.</p>
<p>The licensee’s conservative evaluation indicates that the sump pH is transient and would range from 7 at the onset of the DBA LOCA, to approximately 6.8 at the end of the 30-day duration of the accident. The assumed corresponding DF would also be transient and vary from a value of 150 at the onset of the event to a value of 60 at the end of the DBA LOCA analysis. For conservatism the licensee used a DF of 60 for the entire 30-day DBA LOCA analysis to calculate the radiological doses at EAB, LPZ, and in the CR. The staff finds that the licensee used conservative assumptions to bound the radiological consequences of the potential re-evolution of iodine from the containment sump and that the analysis is acceptable for use in the AST LOCA analysis.</p>	<p>The IRWST pH range for the U.S. EPR is 7.5 at the onset of the DBA LOCA to approximately 7.1 at the end of the 30-day duration. A conservative maximum DF of 100 has been applied to elemental iodine removal. Using the same methods as those used to calculate the DF for South Texas, the calculated 30-day DF for the US would be an order of magnitude greater than 100.</p>

Question 15.00.03-35:

Technical Specification 3.6.8 identifies the minimum quantity of trisodium phosphate (TSP) as 5.97 m³ (211 ft³). Surveillance Requirement Basis 3.6.8.1 describes the reason that a volumetric measurement is used versus a gravimetric measurement. This assumption relies on a manufactured density of 0.97 g/mL (58 lbm/ft³), which when multiplied by a volume of 5.97 m³ (211 ft³) yields the assumed mass of 5534 kg (12,200 lbm). This manufactured density differs significantly from the handbook density of TSP of 1.62 g/mL (96.4 lbm/ft³). Additionally, there are no controls on the manufacturing process for chemical purity, nor are there any ITAAC requirements for verifying that the mass of TSP required is present in the volume identified.

1. Explain why manufactured density of 0.93 g/mL (58 lbm/ft³) for trisodium phosphate dodecahydrate cited in Surveillance Requirement Basis 3.6.8.1 differs so significantly from the handbook density for trisodium phosphate dodecahydrate of 1.62 g/mL (96.4 lbm/ft³).
2. What controls will be placed upon:
 - a. The measurement of the volume of TSP-C located in containment?
 - b. The purity of the TSP-C purchased?
 - c. The manufactured density being significantly more or less than 0.93 g/mL (58 lbm/ft³)?
 - d. The purity of the TSP-C every 24 months assuring it has not had its neutralizing capability compromised?
 - e. In addition, what changes may be necessary, if any, in the EPR FSAR and ANP-10293 based on the responses to the above questions?

Response to Question 15.00.03-35:

1. The manufactured density of trisodium phosphate in crystalline form (TSP-C) is approximately 58 lb_m/ft³, as given in the Bases for Technical Specifications, Section 3.6.8. The handbook density cited for TSP is based on a denser, powder form. The TSP-C will be used in the U.S. EPR for pH control following a design basis loss of coolant accident (LOCA). The density is dependent on a number of factors affecting the TSP-C purity and morphology. The impact of these variations is discussed in the following responses.
 - 2.a. The Technical Specifications control the TSP-C volume located in containment.
 - 2.b-2.c. The purity and density of TSP-C are included in purchase specifications to provide a minimum assay in accordance with Technical Specification requirements. Purchase requirements are then used to assess the vendors Certificate of Analysis (C of A). The known assay and as-purchased density are used to establish equivalency to the assumed 100 percent assay and 58 lb_m/ft³ density used for determining the volume required by the Technical Specifications.
 - 2.d. Although some loss of water of hydration may occur, further decomposition of the TSP-C is not expected. The neutralization capability of the PO₄ would not be compromised.

2.e. No changes to the U.S. EPR FSAR or ANP-10293 are needed.

FSAR Impact:

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