AREVAEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Thursday, November 12, 2009 1:57 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); NOXON David B (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 276, FSARCh. 11, Supplement 2
Attachments: RAI 276 Supplement 2 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 276 on October 14, 2009. Supplement 1 to RAI No. 276 was sent on November 6, 2009 which responded to 1 of the 2 remaining questions. The attached file, "RAI 276 Supplement 2 Response US EPR DC.pdf," provides a technically correct and complete response to the one remaining question, as committed.

Appended to this file are two of the affected pages of the U.S. EPR Final Safety Analysis Report (FSAR) in redline-strikeout format which support the response to RAI 276 Question 11.05 -13.

A complete FSAR markup is not provided for the RAI 276 questions. As agreed by NRC staff during an FSAR Chapter 11 audit on October 7, 2009, FSAR markups may be submitted after Phase 2 completion to support Staff review to close confirmatory items. Therefore, a complete FSAR markup for the RAI 276 questions will be provided as indicated in the following table:

Question #	Supplement Date (providing FSAR Markup)
RAI 276 — 11.05-13	March 31, 2010
RAI 276 — 11.05-14	March 31, 2010

The following table indicates the respective pages in the response document, "RAI 276 Supplement 2 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 276 — 11.05-13	2	15

This concludes the formal AREVA NP response to RAI 276, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Ronda Pederson
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From: Pederson Ronda M (AREVA NP INC)
Sent: Friday, November 06, 2009 8:32 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); WILLIFORD Dennis C (AREVA NP INC); SLIVA Dana (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 276, FSARCh. 11, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 276 on October 14, 2009. The attached file, "RAI 276 Supplement 1 Response US EPR DC.pdf," provides a technically correct and complete response to 1 of the 2 questions, as committed.

Appended to this file is one of the affected pages of the U.S. EPR Final Safety Analysis Report (FSAR) in redline-strikeout format which support the response to RAI 276 Question 11.05 -14c.

A complete FSAR markup is not provided for Question 11.05 -14. As agreed by NRC staff during an FSAR Chapter 11 audit on October 7, 2009, FSAR markups may be submitted after Phase 2 completion to support Staff review to close confirmatory items. Therefore, a complete FSAR markup for this portion of the question will be provided as indicated in the following table:

Question #	Supplement Date (providing FSAR Markup)
RAI 276 — 11.05-14	March 31, 2010

The following table indicates the respective page(s) in the response document, "RAI 276 Supplement 1 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 276 — 11.05-14	2	4

A complete answer is not provided for 1 question. The schedule for a technically correct and complete response to the remaining question has been revised as provided below.

Question #	Response Date
RAI 276 — 11.05-13	November 25, 2009

Sincerely,

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From: Pederson Ronda M (AREVA NP INC)
Sent: Wednesday, October 14, 2009 5:47 PM
To: 'Tesfaye, Getachew'

Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); WILLIFORD Dennis C (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 276, FSARCh. 11

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 276 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 2 questions is not provided.

The following table indicates the respective page(s) in the response document, "RAI 276 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 276 — 11.05-13	2	2
RAI 276 — 11.05-14	3	4

A complete answer is not provided for the 2 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 276 — 11.05-13	November 6, 2009
RAI 276 — 11.05-14	November 6, 2009

Sincerely,

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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Monday, September 14, 2009 3:18 PM
To: ZZ-DL-A-USEPR-DL
Cc: Dehmel, Jean-Claude; Frye, Timothy; Jennings, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 276 (3496), FSARCh. 11

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on August 17, 2009, and discussed with your staff on August 25, 2009. No changes were made to the draft RAI questions as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,

Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 950

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D31016380C2)

Subject: Response to U.S. EPR Design Certification Application RAI No. 276, FSARCh. 11, Supplement 2
Sent Date: 11/12/2009 1:57:02 PM
Received Date: 11/12/2009 1:57:07 PM
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MESSAGE	6631	11/12/2009 1:57:07 PM
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Options
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Response to

Request for Additional Information No. 276, Supplement 2

9/14/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 11.05 - Process and Effluent Radiological Monitoring Instrumentation and Sampling Systems
Application Section: 11.5 and 5.2.5

QUESTIONS for Health Physics Branch (CHPB)

Question 11.05-13:

FSAR Sections 11.5.1.2 and 5.2.5.1.2 address instrumentation and methods used to quantify reactor coolant system leakage and leakage rates, as required by EPR Technical Specifications (TS) 16.3.4.12 and TS B16.3.4.12. The technical basis for RCS leakage detection instrumentation [see (TS) 16.3.4.14 and TS B16.3.4.14, RG 1.45 (Rev. 1), and RIS 2009-02 (Rev. 1)] establish radiation monitor sensitivity requirements for a leakage detection increase of 1 gpm within 1 hour, using a realistic primary coolant concentration. A review of Sections 11.5.1.2 and 5.2.5.1.2 indicates that although Section 5.2.5.1.2 refers to Section 11.5 for information on the associated radiation monitoring instrumentation, Section 11.5.4 and Table 11.5-1 do not identify instrumentation and do not describe the methodology that would be used by COL applicants to monitor containment atmosphere for the presence of radioactive particulates capable of satisfying the requirements of EPR TS 16.3.4.12 on RCS leakage rates. Accordingly, the applicant is requested to review and revise Section 5.2.5 and 11.5 and address the following in the FSAR:

a. Revise Table 11.5-1 to include the appropriate numbers of particulate radiation monitors used to satisfy (TS) 16.3.4.14 and TS B16.3.4.14, and specify the minimum required radiation monitor sensitivities for the containment particulate radiation monitors necessary to satisfy the required RCS leakage rate technical basis. Indicate whether noble gas radiation monitors will be used to supplement the particulate radiation monitor, given RG 1.45 regulatory position C.2.3, and, if so, provide similar supporting information for that type of monitoring method.

b. In Section 11.5.2, provide the methodology to demonstrate that particulate radiation monitors will be capable of satisfying the technical basis for RCS leakage detection instrumentation using a realistic radioactive concentration in the RCS. Include descriptions of the model, methodology, assumptions, and parametric values used in the calculations and their basis, and references to enable the staff to conduct an independent evaluation.

c. In Sections 5.2.5.1.2 and 5.2.5.5, revise the descriptions and discussions on which type of radiation monitor instrumentation will be used to comply with EPR TS 16.3.4.14, and update all internal citations in referencing Section 11.5 for specific details on the associated radiation instrumentation.

Response to Question 11.05-13:

11.05-13.a:

As specified in U.S. EPR Technical Specification (TS) 16.3.4.14, the reactor coolant system (RCS) leakage detection instrumentation at the U.S. EPR consists of the following:

- One containment sump (level or discharge flow) monitor,
- One containment atmosphere radioactivity (particulate) monitor, and
- One containment air cooler condensate flow rate monitor.

With respect to the containment radiation monitor for airborne particulates, the range of the monitor has been specified as 3E-10 to 1E-6 μCi/cc. Its lower limit of detection (LLD) (3E-10 μCi/cc) satisfies the required RCS leakage rate technical basis. It was determined that the radiation monitor will alarm in about 17 minutes, based on the following: an initial background radiation of 1.5E-9 µCi/cc, i.e., equal to five times the monitor LLD, a monitor alarm set point equal to twice the background level, a RCS concentration equal to one percent of the ANSI/ANS 18.1 normal operation source term for the U.S. EPR, and a step increase in the RCS leakage rate by one gpm.

In addition to the particulate monitor described above, the monitoring system for airborne radioactivity within the containment also includes an iodine monitor and a gaseous (noble gas) monitor. These other monitors are, however, strictly for ALARA purposes. As described in RG 1.45 (Part B, Monitoring System Performance), and because of improvements in fuel integrity and the ensuing lower primary coolant radioactivity, these gaseous monitors cannot be relied upon for prompt RCS leakage detection as required by regulation (namely, a response time of no greater than one hour for a leakage rate increase of one gal/min).

RG 1.45 (Part C, 2.3) states that in addition to the monitoring systems detailed in the technical specifications for RCS leakage detection, other supplemental systems should be used to detect and monitor for leakage, even if such systems do not have the capability for prompt leakage detection. The U.S. EPR TS Bases B16.3.4.14, Background, lists the following as potential supplemental systems:

- Monitoring the humidity inside containment,
- Monitoring the temperature of the containment,
- Monitoring the pressure of the containment.

11.05-13.b:

1. Presented below is the methodology to be used to demonstrate that the installed U.S. EPR particulate radiation monitor will be capable of satisfying the technical basis for RCS leakage detection instrumentation using a realistic radioactive concentration in the RCS. The monitor range is specified as 3E-10 to 1E-06 µCi/cc. The monitor sensitivity requirement is for detection of a leakage increase of 1 gal/min within one hour [EPR TS 16.3.4.12 and bases, RG 1.45 (Rev.1) and RIS-2009-02 (Rev.1)].
2. General Approach and Assumptions

   The proposed methodology to meet the detection requirement of a one gpm increase in the RCS leakage within one hour consists of providing a correlation between an abrupt increase in the RCS leakage rate and the corresponding time-dependent increase in the radiation monitor reading (from a normal background reading with minimal unidentified RCS leakage). The expected increase in the radiation monitor reading is then compared with the alarm setpoint to determine if the one gpm leakage rate is being exceeded.

   The step increase in the RCS leakage shall be referred to as “failure of the RCS pressure boundary”, or simply “failure.” for the remainder of this response. The assumptions used in the analytical model include the following:

   - Constant RCS leakage into the equipment area, both prior to and after the failure (in cold gpm).
   - Instantaneous uniform mixing within the equipment area.
   - No plate-out of particulates within the equipment area.

- No leakage from the equipment area to the service area.
- Normal/continuous operation of the non-safety KLA-6 ventilation system for the equipment area, and of the safety-related KLA-5 ventilation system (to which the radiation monitoring sampling line is connected) for filtration of the same area.

In addition to the above, the one-hour detection requirement specified in RG 1.45 is reduced to 50 minutes for the U.S. EPR design to accommodate the following:

- The transit time in the sampling line (which is relatively low, based on a 1” line and a typical flow of few cfm)
- The sampling filter accumulation time, and
- The radioactivity transport time from the least ventilated subcompartment of the equipment area to the radiation monitor sampling location (determined to be about 5 min, based on an 18-subcompartment representation of the equipment area). [Note: The ventilation flow within the equipment area corresponds to one air change in every 3.6 min.]

3. List of Variables in Mathematical Model

The mathematical model considers both one- and two-member decay chains, as applicable to each radionuclide of interest. The list of variables is as follows:

A_{Pe} = pre-failure number of atoms of parent nuclide airborne in the equipment area (initial equilibrium condition for post-failure activity buildup)

A_P = number of atoms of parent nuclide airborne in equipment area at end of interval

A_{De}, A_D = similar to A_{Pe} and A_P, for the daughter product

B_f = decay branching fraction (parent to daughter)

C_P = RCS concentration of parent nuclide (μCi/gm), assumed constant

C_D = RCS concentration of daughter product (μCi/gm), assumed constant

$\tilde{C}_P$ = equipment-area airborne concentration of parent nuclide (μCi/cc)

$\tilde{C}_D$ = equipment-area airborne concentration of daughter product (μCi/cc)

$\tilde{C}_{Pe}$ = similar to $\tilde{C}_P$ under equilibrium conditions

$\tilde{C}_{De}$ = similar to $\tilde{C}_D$ under equilibrium conditions

f_P = RCS leakage flashing fraction for parent nuclide

f_D = RCS leakage flashing fraction for daughter product

F_r = filtered recirculation flow within the equipment area (cfm)

L_e = pre-failure RCS leakage rate into the equipment area (gpm, cold) (i.e., prior to step increase in the RCS leakage rate)

L = post-failure RCS leakage rate into the equipment area (gpm, cold), assumed constant during the analysis interval

M_e = pre-failure radiation monitor reading (any given units)

M = post-failure radiation monitor reading

R_{Pe} = pre-failure RCS leakage rate of parent nuclide into the equipment area (atoms/min)

= $(C_P L_e \rho f_P / \lambda_P)$ * 3785.4 (cc/gallon) * 60 (sec/min) * 3.7E+04 (dis/sec- μCi)

= $(C_P L_e \rho f_P / \lambda_P)$ * 8.4035E+09 Eq. (1)

R_P = post-failure RCS leakage rate of parent nuclide into the equipment area (atoms/min)

= $(C_P L \rho f_P / \lambda_P)$ * 8.4035E+09 Eq. (2)

R_{De} = pre-failure RCS leakage rate of daughter product into the equipment area (atoms/min)

= $(C_D L_e \rho f_D / \lambda_D)$ * 8.4035E+09 Eq. (3)

R_D = post-failure RCS leakage rate of daughter product into the equipment area (atoms/min)

= $(C_D L \rho f_D / \lambda_D)$ * 8.4035E+09 Eq. (4)

t = time span from high leakage initiation (min)

V = equipment-area free volume (ft^3)

ε = radionuclide-specific relative detection efficiency by monitoring system (implicitly includes the emission abundance)

η_P = recirculation-flow filtration efficiency for parent nuclide

η_D = recirculation-flow filtration efficiency for daughter product

λ_P = decay constant for parent nuclide (1/min)

λ_D = decay constant for daughter product (1/min)

λ_A = $\lambda_P + \eta_P (F_r / V)$ Eq. (5)

λ_B = $\lambda_D + \eta_D (F_r / V)$ Eq. (6)

ρ = density of leaking coolant (g/cc) in RCS leakage rates Le and L (assumed to be 1 g/cc)

4. Mathematical Model

The differential equations governing the buildup of radioactivity within the containment equipment area with time as a result of RCS leakage, and their solutions (based on the methodology in Nuclear Technology, Vol. 11, pg. 84, 1971, John N. Hamawi, "A Useful Recurrence Formula for the Equations of Radioactive Decay"), are as follows (for a two-member decay chain):

Parent Nuclide

$(dA_P/dt) = R_P - \lambda_A A_P$ (Eq. 7)

$A_P = R_P E_{0A} + A_{Pe} E_A$ (Eq. 8)

Daughter Product

$(dA_D/dt) = R_D + B_f \lambda_P A_P - \lambda_B A_D$ (Eq. 9)

$A_D = R_D E_{0B} + B_f \lambda_P (R_P E_{0AB} + A_{Pe} E_{AB}) + A_{De} E_B$ (Eq. 10)

where

E_0 = 1.0 [equivalent to $E_0 = \exp(-\lambda_0 t)$ with $\lambda_0 = 0$] (Eq. 11)

$E_A = \exp(-\lambda_A t)$ (Eq. 12)

$E_B = \exp(-\lambda_B t)$ (Eq. 13)

$E_{0A} = (E_0 - E_A) / \lambda_A$ (Eq. 14)

$E_{0B} = (E_0 - E_B) / \lambda_B$ (Eq. 15)

$E_{AB} = (E_A - E_B) / (\lambda_B - \lambda_A)$ (Eq. 16)

$E_{0AB} = (E_{0A} – E_{AB}) / \lambda_B$ (Eq. 17)

The number of atoms for the parent nuclide and daughter product airborne within the equipment area (AP and AD, respectively) are then converted to (μCi/cc), as follows:

$\tilde{C}_P = (A_P \lambda_P / V) / [3.7E{+}04 \text{ (dis/sec- μCi)} * 60 \text{ (sec/min)} * 2.8317E{+}04 \text{ (cc/ft}^3\text{)}]$

$\tilde{C}_P = (A_P \lambda_P / V) * 1.5907E{-}11$ Eq. (18)

$\tilde{C}_D = (A_D \lambda_D / V) * 1.5907E{-}11$ Eq. (19)

It is noted that Eq. 18 applies to single-member decay chains (such as Na-24, for instance), and Eq. 19 applies to the second member of two-member decay chains (such as Rb-88, with Kr-88 as the parent nuclide, for instance).

5. Equilibrium Conditions

For an RCS leakage of long duration, such that equilibrium concentrations are attained within the equipment area for the particulates of interest, the time-dependent variables EA and EB reduce to zeros, and consequently equations. 8 and 10 for the parent nuclide and daughter product reduce to the following:

$$A_{Pe} = R_{Pe} / \lambda_A \qquad \text{(Eq. 20)}$$

$$A_{De} = R_{De} / \lambda_B + B_f \lambda_P R_{Pe} / (\lambda_A \lambda_B) \qquad \text{(Eq. 21)}$$

It is these values that become the initial conditions in equations. 8 and 10. The corresponding concentrations (in μCi/cc) are as follows:

$$\tilde{C}_{Pe} = (A_{Pe} \lambda_P / V) * 1.5907E\text{-}11 \qquad \text{Eq. (22)}$$

$$\tilde{C}_{De} = (A_{De} \lambda_D / V) * 1.5907E\text{-}11 \qquad \text{Eq. (23)}$$

6. Expected Radiation Monitor Readings

Prior to failure in the RCS pressure boundary, and under equilibrium conditions, the equation for the monitor response is:

$$M_e = K \left[\Sigma (\varepsilon_i \tilde{C}_{Pei}) + \Sigma (\varepsilon_j \tilde{C}_{Dej}) \right] \qquad \text{(Eq. 24)}$$

where the summations are over the indices i for the nuclides without parents contributing to the monitor reading, and indices j for the daughter products,

K = constant specific to the radiation monitoring system, accounting for the following:

- sampling line flow rate
- line losses (assumed to be the same for all particulates)
- filter media collection/retention efficiency
- sample collection time
- geometric effects
- unit conversions

and ε is the nuclide-specific relative detection efficiency.

The corresponding monitor reading after the step change in the RCS leakage rate into the equipment area is:

$$M = K \left[\Sigma (\varepsilon_i \tilde{C}_{Pi}) + \Sigma (\varepsilon_j \tilde{C}_{Dj}) \right] \qquad \text{(Eq. 25)}$$

and is time dependent.

The increase in the radiation monitor reading is simply:

$$r_M = M / M_e \quad \text{(Eq. 26)}$$

and is independent of the constant K when the sampling line losses are the same for all particulates. The radiation monitor reading (r_M) is also independent of the RCS concentration level, as long as the step increase in the RCS leakage rate does not change the relative composition of the radionuclides.

7. Monitor Alarm Set Point to Meet TS Requirement

The approach to be followed to demonstrate that the U.S. EPR installed particulate radiation monitor satisfies the technical basis for RCS leakage rate detection instrumentation is as follows:

a) Determine (through actual laboratory analyses) the RCS concentration of the primary particulates (C_P and C_D) contributing to the radiation monitoring reading during normal operation. [A sample listing of important radionuclides and their parents is given in Tables 11.05-13-1 and 11.05-13-2. F-18, which was excluded from the sample application because it is not listed in the ANSI/ANS 18.1 standard, is an important radionuclide for RCS leakage rate detection and will be considered.]

b) Use the measured concentrations in the RCS and the equations for equilibrium conditions given above to determine the RCS leakage rate (L_e in Eqs. 1 and 3) that will yield the measured airborne particulate concentration at the monitor sampling point (i.e., the summation of the $\tilde{C}_{Pe}$ and $\tilde{C}_{De}$ terms for the selected radionuclides should match the measured value).

c) Use the measured concentrations in the RCS, along with the RCS leakage rate L_e from Step (b) plus an additional 1 gpm (for a total leakage rate of L gpm) to determine the total airborne particulate concentrations $\tilde{C}_P$ and $\tilde{C}_D$ (Eqs. 18 and 19) at the monitor sampling location at 50 min after the assumed step increase in the RCS leakage rate.

d) Compute the ratio of the concentrations at the monitor location as calculated in Steps (c) and (b) and apply this ratio to the indicated radiation monitor reading in Step (a).

e) Compare the result from Step (d) with the radiation monitor alarm set point to confirm that the set point will be exceeded.

8. Sample Application

Presented in this section are the results of a sample application of the above methodology based on the following:

- RCS radionuclide concentration at one percent of the ANSI/ANS 18.1 standard (from U.S. EPR FSAR Tier 2, Table 11.1-17, with the exception of Rb-88 which was conservatively reduced from 0.22 to 0.0235 µCi/gm to bring it into secular equilibrium with its parent, Kr-88), under the assumption that both the fission-product and activation-product concentrations will be equally reduced.
- Radionuclides of interest:

1-member decay chains:	Na-24
	Y-93
	Te-129
	Ba-140
2-member decay chains:	Kr-88 / Rb-88
	Ru-106 / Rh-106
	Xe-138 / Cs-138
	Ba-140 / La-140

[Note: The listed particulates account for about 83.5 percent of the total particulate activity in U.S. EPR FSAR Tier 2, Table 11.1-17.]

- Pre-failure total concentration at monitor sampling point (assigned to the above particulates) = 1.5E-9 µCi/cc (arbitrarily selected, for demonstration purposes, to be 5 times above the monitor LLD)
- Alarm set point = twice the background of 1.5E-09 µCi/cc, i.e., 3.0E-9 µCi/cc
- Relative detection efficiency (ε) = 100 percent for all the selected particulates, and the monitor calibration is such that the monitor reading matches the actual concentrations at the sampling location.
- Assessment time = 50 minutes after the step increase in the RCS leakage rate by one gpm.

Through iterative analysis, the pre-failure RCS leakage that would yield a concentration of 1.5E-09 µCi/cc at the monitor sampling location was determined to be 0.0442 gpm. Increasing the leakage rate to 1.0442 gpm leads to a total particulate concentration of 1.22E-08 µCi/cc, i.e., an increase by a factor of 8.10. Details appear in Tables 11.05-13-1 through 11.05-13-3.

Based on these results, the monitor alarm set point is about four times lower than the expected monitor reading at 50 min after the step increase in the RCS leakage, and the TS requirement will therefore be met.

The following are noted with respect to this sample application:

a. The increase in the airborne concentrations (at 50 minutes) for the individual particulate varies between 4.5 (for Rb-88) and 14.7 (for Te-129).

b. The overall increase in the radiation monitor reading in 50 minutes (by a factor of 8.10) increases monotonically with time until new equilibrium conditions are attained, at which time the increase in the reading would be the same as the increase in the leakage rate (i.e., equal to 1.0442 / 0.0442 = 23.62).

c. The increase in the monitor reading is a strong function of the initial RCS leakage. For informational purposes, the monitor reading increase (in 50 minutes) due to a one gpm increase in the initial leakage is shown in Figure 11.05.13-1.

11.05-13.c:

As described in the response to Question 11.05-13.b, it is only the particulate radiation monitor for airborne radioactivity inside containment that will be used for RCS leakage detection, in compliance with TS 16.3.4.14. U.S. EPR FSAR Tier 2, Section 5.2.5.1.2 will be revised to remove the discussion of the ability of the gaseous radiation monitor to detect a one gpm leakage rate within one hour at full power operation. Note, however, that there are other systems capable of detecting a one gpm leakage rate as discussed in the response to Question 11.05-13.a.

In addition, a new subsection will be added to U.S. EPR FSAR Tier 2, Section 5.2.5.5 (Instrumentation Requirements) to describe the containment atmosphere particulate radiation monitoring based on the following:

> Containment atmosphere particulate radioactivity monitoring is one of the systems used in the US EPR design for RCS leakage detection.
>
> The particulate monitor is a low range monitor capable of detecting 3E-10 to 1E-6 µc/cc. The monitor sensitivity requirement is to detect a leakage increase of one gpm within one hour (see U.S. EPR FSAR, Tier 2, Chapter 16, TS 16.3.4.12 and corresponding Bases, RG 1.45 and RIS-2009-02), based on a realistic RCS source term.
>
> The particulate radiation monitoring system continuously monitors airborne radioactivity in the containment equipment area. Radiation levels are indicated in the MCR. Alarms alert the operators of elevated levels of radioactivity to allow for prompt identification of RCS leakage into the equipment area. The monitor is located in the service area of the containment which is accessible during normal operation. It draws air from the containment building ventilation system which filters airborne radioactivity within the equipment area. The monitoring system will be designed to function properly in the containment environment.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 5.2.5.1.2, Section 5.2.5.5, will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR, Tier 2, Section 11.5.2, and Table 11.5-1 will be revised as described in the response and the FSAR markups provided by March 31, 2010.

Table 11.05-13-1 — Computation of Airborne Concentrations at Radiation Monitor Sampling Location – Single-Member Decay Chains

Variable	Equation	Value			
V (ft^3)	N/A	4.769E+05			
ρ (g/cc)	N/A	1.000E+00			
F_r (cfm)	N/A	4.120E+03			
Pre-Failure Equilibrium Conditions					
t (min)	N/A	infinity			
L_e (gpm)	N/A	4.420E-02			
Nuclide		**Na-24**	**Y-93**	**Te-129**	**Ba-140**
f_P (fraction)	N/A	4.380E-01	4.380E-01	4.380E-01	4.380E-01
C_P (μCi/gm)	N/A	3.700E-04	3.500E-05	2.600E-04	8.400E-05
η_P	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
λ_P (1/min)	N/A	7.702E-04	1.144E-03	9.959E-03	3.764E-05
λ_A (1/min)	5	9.409E-03	9.783E-03	1.860E-02	8.677E-03
R_{Pe} (atoms/min)	1	7.816E+07	4.978E+06	4.247E+06	3.631E+08
A_{Pe} (atoms)	20	8.307E+09	5.089E+08	2.284E+08	4.185E+10
$\tilde{C}_{Pe}$ (μCi/cc)	22	2.134E-10	1.941E-11	7.586E-11	5.254E-11
Post-Failure Conditions					
t (min)	N/A	5.000E+01			
L (gpm)	N/A	1.044E+00			
Nuclide		**Na-24**	**Y-93**	**Te-129**	**Ba-140**
f_P (fraction)	N/A	4.380E-01	4.380E-01	4.380E-01	4.380E-01
C_P (μCi/gm)	N/A	3.700E-04	3.500E-05	2.600E-04	8.400E-05
η_P	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
λ_P (1/min)	N/A	7.702E-04	1.144E-03	9.959E-03	3.764E-05
λ_A (1/min)	5	9.409E-03	9.783E-03	1.860E-02	8.677E-03
R_P (atoms/min)	2	1.846E+09	1.176E+08	1.003E+08	8.578E+09
E_0	11	1.000E+00	1.000E+00	1.000E+00	1.000E+00
E_A	12	6.247E-01	6.131E-01	3.946E-01	6.480E-01
E_{0A}	14	3.988E+01	3.954E+01	3.255E+01	4.057E+01
A_P (atoms)	8	7.884E+10	4.963E+09	3.356E+09	3.751E+11
$\tilde{C}_P$ (μCi/cc)	18	2.025E-09	1.893E-10	1.115E-09	4.709E-10

Table 11.05-13-2 — Computation of Airborne Concentrations at Radiation Monitor Sampling Location – Two-Member Decay Chains

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Variable	Equation	Value			
V (ft^3)	N/A	4.769E+05			
ρ (g/cc)	N/A	1.000E+00			
F_r (cfm)	N/A	4.120E+03			
Pre-Failure Equilibrium Conditions					
t (min)	N/A	infinity			
L_e (gpm)	N/A	4.420E-02			
Parent		**Kr-88**	**Ru-106**	**Xe-138**	**Ba-140**
f_P (fraction)	N/A	1.000E+00	4.380E-01	1.000E+00	4.380E-01
C_P (μCi/gm)	N/A	2.100E-04	5.700E-04	7.000E-04	8.400E-05
η_P	N/A	0.000E+00	1.000E+00	0.000E+00	1.000E+00
λ_P (1/min)	N/A	4.069E-03	1.307E-06	4.892E-02	3.764E-05
λ_A (1/min)	5	4.069E-03	8.640E-03	4.892E-02	8.677E-03
R_{Pe} (atoms/min)	1	1.917E+07	7.093E+10	5.315E+06	3.631E+08
A_{Pe} (atoms)	20	4.710E+09	8.209E+12	1.087E+08	4.185E+10
$\tilde{C}_{Pe}$ (μCi/cc)	22	6.394E-10	3.580E-10	1.773E-10	5.254E-11
Daughter		**Rb-88**	**Rh-106**	**Cs-138**	**La-140**
B_f	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
f_D (fraction)	N/A	4.380E-01	4.380E-01	4.380E-01	4.380E-01
C_D (μCi/gm)	N/A	2.350E-04	5.700E-04	0.000E+00	1.700E-04
η_D	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
λ_D (1/min)	N/A	3.894E-02	1.391E+00	2.153E-02	2.872E-04
λ_B (1/min)	6	4.758E-02	1.400E+00	3.017E-02	8.926E-03
R_{De} (atoms/min)	3	9.818E+05	6.667E+04	0.000E+00	9.629E+07
A_{De} (atoms)	21	4.235E+08	7.716E+06	1.762E+08	1.096E+10
$\tilde{C}_{De}$ (μCi/cc)	23	5.501E-10	3.580E-10	1.265E-10	1.050E-10

Table 11.05-13-2 — Computation of Airborne Concentrations at Radiation Monitor Sampling Location – Two-Member Decay Chains

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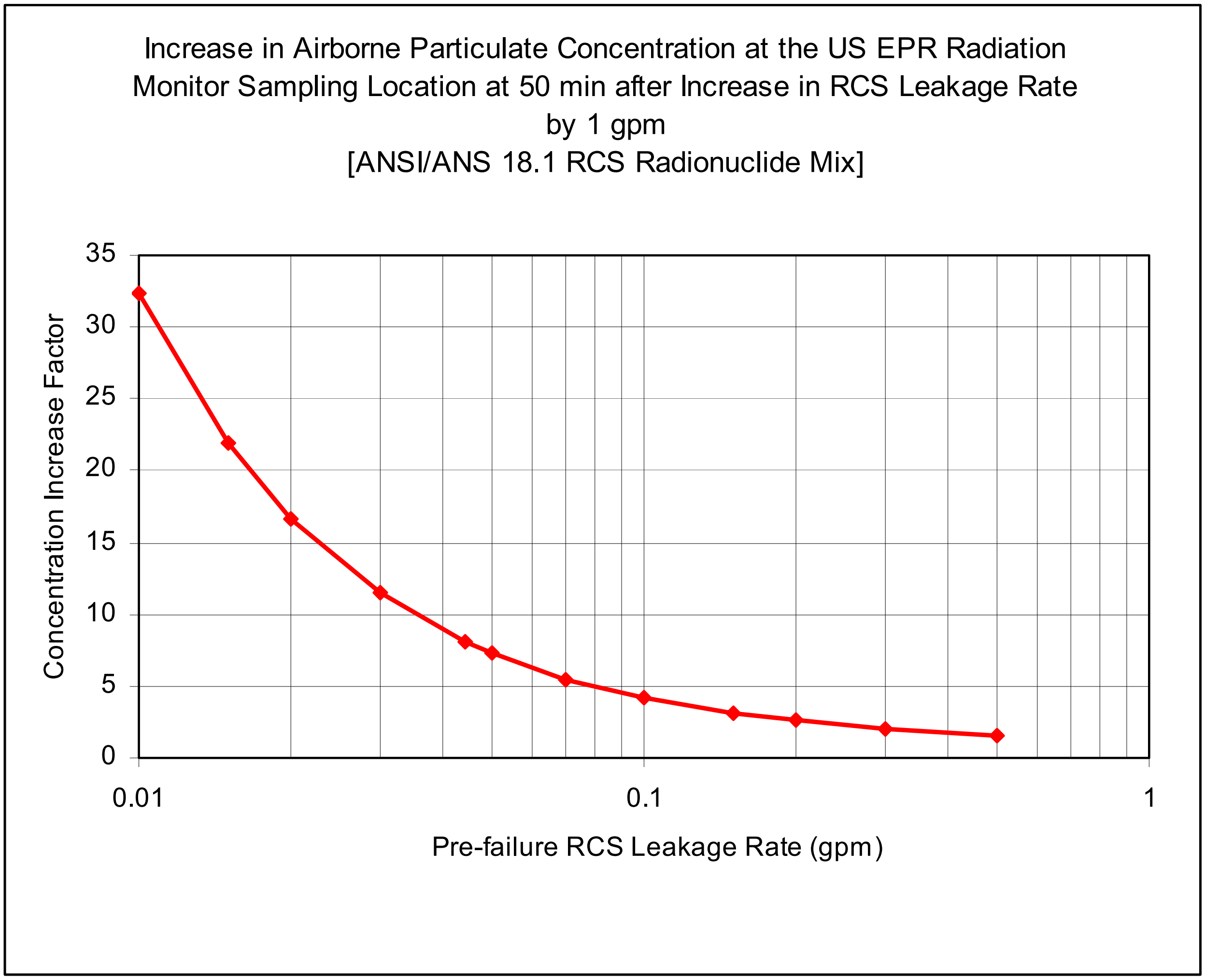
Variable	Equation	Value			
Post-Failure Conditions					
t (min)	N/A	5.000E+01			
L (gpm)	N/A	1.044E+00			
Parent		**Kr-88**	**Ru-106**	**Xe-138**	**Ba-140**
f_P (fraction)	N/A	1.000E+00	4.380E-01	1.000E+00	4.380E-01
C_P (uCi/gm)	N/A	2.100E-04	5.700E-04	7.000E-04	8.400E-05
η_P	N/A	0.000E+00	1.000E+00	0.000E+00	1.000E+00
λ_P (1/min)	N/A	4.069E-03	1.307E-06	4.892E-02	3.764E-05
λ_A (1/min)	5	4.069E-03	8.640E-03	4.892E-02	8.677E-03
R_P (atoms/min)	2	4.528E+08	1.676E+12	1.256E+08	8.578E+09
E_0	11	1.000E+00	1.000E+00	1.000E+00	1.000E+00
E_A	12	8.159E-01	6.492E-01	8.665E-02	6.480E-01
E_{0A}	14	4.524E+01	4.060E+01	1.867E+01	4.057E+01
A_P (atoms)	8	2.433E+10	7.336E+13	2.354E+09	3.751E+11
$\tilde{C}_P$ (uCi/cc)	18	3.303E-09	3.199E-09	3.841E-09	4.709E-10
Daughter		**Rb-88**	**Rh-106**	**Cs-138**	**La-140**
B_f	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
f_D (fraction)	N/A	4.380E-01	4.380E-01	4.380E-01	4.380E-01
C_D (uCi/gm)	N/A	2.350E-04	5.700E-04	0.000E+00	1.700E-04
η_D	N/A	1.000E+00	1.000E+00	1.000E+00	1.000E+00
λ_D (1/min)	N/A	3.894E-02	1.391E+00	2.153E-02	2.872E-04
λ_B (1/min)	6	4.758E-02	1.400E+00	3.017E-02	8.926E-03
R_D (atoms/min)	4	2.319E+07	1.575E+06	0.000E+00	2.275E+09
E_B	13	9.264E-02	4.061E-31	2.213E-01	6.400E-01
E_{0B}	15	1.907E+01	7.145E-01	2.581E+01	4.033E+01
E_{AB}	16	1.662E+01	4.667E-01	7.180E+00	3.220E+01
E_{0AB}	17	6.015E+02	2.868E+01	3.809E+02	9.373E+02
A_D (atoms)	10	1.909E+09	6.896E+07	2.417E+09	9.912E+10
$\tilde{C}_D$ (uCi/cc)	19	2.479E-09	3.199E-09	1.736E-09	9.496E-10

Table 11.05-13-3 — Pre- and Post-Failure Airborne Particulate Concentrations at the Radiation Monitor Sampling Location – Summary of Results

Nuclide	Relative Detection Efficiency (%) (assumed)	Pre-Failure Equilibrium Conditions (0.0442 gpm RCS leakage)		50 min after RCS Pressure Boundary Failure (1.0442 gpm RCS leakage)		Increase in Airborne Concentration
		Concentration (μCi/cc)	Concentration Adjusted for Detection Relative Efficiency	Concentration (μCi/cc)	Concentration Adjusted for Detection Relative Efficiency	
Na-24	100	2.134E-10	2.134E-10	2.025E-09	2.025E-09	9.49
Y-93	100	1.941E-11	1.941E-11	1.893E-10	1.893E-10	9.75
Te-129	100	7.586E-11	7.586E-11	1.115E-09	1.115E-09	14.70
Ba-140	100	5.254E-11	5.254E-11	4.709E-10	4.709E-10	8.96
Rb-88	100	5.501E-10	5.501E-10	2.479E-09	2.479E-09	4.51
Rh-106	100	3.580E-10	3.580E-10	3.199E-09	3.199E-09	8.94
Cs-138	100	1.265E-10	1.265E-10	1.736E-09	1.736E-09	13.72
La-140	100	1.050E-10	1.050E-10	9.496E-10	9.496E-10	9.04
Total			1.501E-09		1.216E-08	8.10

Figure 11.05-13-1—Increase in Airborne Particulate Concentration at the U.S. EPR Radiation Monitor Sampling Location at 50 min after Increase in RCS Leakage Rage by 1 gpm [ANSI/ANS 18.1 RCS Radionuclide Mix]



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- RCS inventory balance.
- Localized humidity and temperature monitoring.

5.2.5.1.1 Containment Sump Level and Discharge Flow Monitoring

The nuclear island drain and vent system (NIDVS) leakage detection function consists of water level measurements provided within the system sumps and collection tanks. The NIDVS instrumentation is credited for main reactor coolant loop and PZR surge line LBB monitoring and can reliably detect a leakage rate of 0.5 gpm in one hour.

Increased frequency of sump pump actuation may be an indication of RCS leakage. An alarm is provided to the operator in the MCR when a pump is running. An alarm is also generated if the pump continues to run for an extended period without reaching the low level, indicating that there is a large continuous flow towards the reactor building sump.

The NIDVS is designed and equipped with provisions to permit testing for operability and calibration.

The reactor building floor drains collect leakage from contaminated spaces in the Reactor Building and from process drains that cannot be recycled. The RCPB leakage drains to the floor drains system and ultimately to the sump where it is identified and quantified by the sump instrumentation. The reactor building floor drains have five small intermediate collection sumps where separate branches of the drain system intersect. The total volume of all five of these intermediate sumps is less than 0.5 gallons, so that they have no significant effect on the flow from an unidentified leakage source, or the prompt identification of it by the sump instrumentation.

5.2.5.1.2 Containment Atmosphere Radiation Monitoring

Gaseous and airborne particulate radiation monitors continuously monitor radioactivity levels in the containment atmosphere. Radiation levels are indicated in the MCR and alarms alert the operator to elevated levels of radioactivity.

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The airborne particulate radiation monitors can detect a 1.0 gpm leakage rate within one hour at full power operation. ~~The gaseous radiation monitors can detect a 1.0 gpm leakage rate within one hour at full power operation.~~ The sensitivity of the containment atmosphere particulate radiation monitors is sufficient for detection of the limiting leakage based on the realistic source terms analysis presented in the environmental report as addressed in Section 11.1. Section 11.5 addresses radiation monitors in more detail.

The airborne particulate radioactivity monitors are designed to withstand the effects of the safe shutdown earthquake and remain functional.

The additional monitored leakage connections that discharge to the RCDT include the PSRV valve body drains, the reactor vessel O-ring seal leakoff, RCP static seal (main flange) leakoff, valve stem packing leakage, and safety valve discharge lines from the combined RCP #1 seal return line, the four RCP thermal barrier return lines, the CVCS letdown line, and the CVCS charging line. Additional equipment and component drain connections to the RCDT are used only during shutdown or during startup operations and are isolated from the RCDT by a closed manual valve, or are disconnected and flanged, during power operation and are not expected to affect RCPB leakage monitoring efforts.

5.2.5.5.2 Reactor Building Sump Level

During normal operation the Reactor Building sump collects water from the reactor building floor drains and the Reactor Building annular space floor drain sump. Sump level and automatic pump operation for both sumps are indicated in the MCR to allow prompt identification of any unidentified leakage in the Reactor Building.

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5.2.5.5.3 Containment Atmosphere Particulate Radiation Monitoring

Containment atmosphere particulate radioactivity monitoring is one of the systems used in the US EPR design for RCS leakage detection. The particulate monitor is a low range monitor capable of detecting 3E-10 to 1E-6μc/cc. The monitor sensitivity requirement is to be able to detect a leakage increaseof one gpm within one hour (see U.S. EPR FSAR, Tier 2, Chapter 16, TS 16.3.4.12 andcorresponding Bases, RG 1.45 and RIS-2009-02), based on a realistic RCS sourceterm. The particulate radiation monitoring system continuously monitors airborne radioactivity in the containment equipment area. Radiation levels are indicated in theMCR. Alarms alert the operators of elevated levels of radioactivity to allow forprompt identification of RCS leakage into the equipment area. The monitor islocated in the service area of the containment, which is accessible during normaloperation. It draws air from the containment building ventilation system which filters airborne radioactivity within the equipment area. The monitoring system will be designed to function properly in the containment environment.

5.2.6 References

1. ASME Boiler and Pressure Vessel Code, Section III," Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, 2004.

2. ASME Code for Operation and Maintenance of Nuclear Power Plants, The American Society of Mechanical Engineers, 2004.

3. EPRI Report 1014986, "Pressurized Water Reactor Primary Water Chemistry Guidelines," Volume 1, Revision 6, Electric Power Research Institute, December 2007.