ArevaEPRDCPEm Resource

From:	Tesfaye, Getachew
Sent:	Wednesday, June 02, 2010 7:41 AM
To:	'usepr@areva.com'
Cc:	Forsaty, Fred; Lu, Shanlai; Donoghue, Joseph; Carneal, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject:	U.S. EPR Design Certification Application RAI No. 403(4439), FSAR Ch. 15
Attachments:	RAI_403_SRSB_4439.doc

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on May 7, 2010, and discussed with your staff on May 17, 2010. Draft RAI Questions 15.06.05-74 and 15.06.05-78 were deleted 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
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 1490

Mail Envelope Properties (0A64B42AAA8FD4418CE1EB5240A6FED113451EC0AC)

Subject: U.S. EPR Design Certification Application RAI No. 403(4439), FSAR Ch. 15
Sent Date: 6/2/2010 7:40:58 AM
Received Date: 6/2/2010 7:41:00 AM
From: Tesfaye, Getachew

Created By: Getachew.Tesfaye@nrc.gov

Recipients:
"Forsaty, Fred" <Fred.Forsaty@nrc.gov>
Tracking Status: None
"Lu, Shanlai" <Shanlai.Lu@nrc.gov>
Tracking Status: None
"Donoghue, Joseph" <Joseph.Donoghue@nrc.gov>
Tracking Status: None
"Carneal, Jason" <Jason.Carneal@nrc.gov>
Tracking Status: None
"Colaccino, Joseph" <Joseph.Colaccino@nrc.gov>
Tracking Status: None
"ArevaEPRDCPEm Resource" <ArevaEPRDCPEm.Resource@nrc.gov>
Tracking Status: None
"'usepr@areva.com'" <usepr@areva.com>
Tracking Status: None

Post Office: HQCLSTR02.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	778	6/2/2010 7:41:00 AM
RAI_403_SRSB_4439.doc	44538	

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

Request for Additional Information No. 403(4439), Revision 1

6/02/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
Application Section: 15.06.05

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

15.06.05-61

Follow-up to RAI 167, Question 15.06.05-29

In response to Question 15.06.05-29, the applicant did not provide an assessment of the amount of condensate generated by reflux condensation as was requested. Instead, predictions for the liquid content in control areas defined as “steam generator (SG) outlet plenum,” “loop crossover pipe,” and “cold leg” were presented. Provide a calculation of the amount of condensate generated by reflux condensation accounting for conditions with emergency feed water (EFW) supply present for two or more SGs. The mass of steam due to decay heat is considerably larger than the volume of the loop seals. The staff requests a mass balance accounting for the steam generated in the core by decay heat, steam lost out the break, steam condensed in the SGs, condensate in countercurrent flow returned to the reactor vessel hot leg, condensate collected on the SG, loop crossover pipe, and cold leg, condensate lost out the break, and condensate transported to the vessel downcomer. The staff requests a description of situations involving stratified conditions in the cold leg and downcomer regions.

15.06.05-62

Follow-up to RAI 167, Question 15.06.05-30

As follow-up to response to question 15.06.05-30, demonstrate that deborated condensate accumulated in one or more loops (SG plena, loop seals, cold legs, downcomer) experiencing a complete or partial depravation of SI will not pose a recriticality threat to the U.S. EPR if transported towards the core due to natural circulation restart to identify and consider limiting conditions, assumptions, and scenarios in terms of condensate accumulation in individual loops and associated regions as well as transportation mechanisms involving possible restart in multiple primary loops. The dynamics of reboration of the crossover pipe in any idle loop prior to restart should be explained and justified. If the cold leg pipe break is below the elevation of the impeller discharge there does not appear to be a mechanism for backfill of the crossover pipe. Explain which of the postulated scenarios identified in the response to question 156.06.05-30 provides the greatest challenge to core recriticality and explain why.

15.06.05-63

Follow-up to RAI 167, Question 15.06.05-36

As follow-up to response to question 156.06.05-36, present the available experimental database pertaining to boron dilution relevant to the U.S. EPR boron dilution analysis. The staff considers limiting the database to Primärkreislauf-Versuchsanlage (PKL) Test F1.1 only, to be insufficient. Explain why experimental observations and in particular PKL findings can be applied to justify the assumptions and conditions used in the analysis of the U.S. EPR under critical LOCA conditions of interest. Explain how the entire matrix of relevant tests conducted at PKL or other facilities validates the assumptions in the boron dilution analysis including: (1) restart of natural circulation in only one loop at a time, (2) initial restart in a loop without SI, (3) justification of the boundary conditions assumed in the CFD mixing analysis of core inlet boron concentration and in particular substantiation of the slug injection rate deduced from the PKL experiments.

15.06.05-64

The analysis of boric acid build-up and precipitation was also requested by the staff with the break located on the top of the discharge leg piping, since the analysis assumed a less limiting location which was the double-ended guillotine break. With respect to two-phase mixture level, which was also assumed to be based on a fixed volume, this assumption was not justified and may not be conservative since the volume occupied by the two-phase mixture is increasing with time following the start of reflood. Provide an analysis of the boric acid build-up with a break on the top of the pipe and the loop seal vertical section completely filled with two-phase fluid. Justify and identify the limiting conditions and assumptions for this analysis. Include the locked rotor k-factor in computing loop resistance and its' influence on level depression in the core. Show the mixture volume with time.

15.06.05-65

Show the sensitivity of the timing for boric acid precipitation to axial power shape. A bottom peak will generate more vapors in the core and cause an earlier precipitation time.

15.06.05-66

Since the hot side injection at 60 minutes will be entrained into the hot legs and inlet plenum, there is no assurance that sufficient water will enter the core in a timely manner to prevent boron precipitation. As water enters the steam generators slug flow can increase the loop resistance and upper plenum pressure which can limit the growth of the mixing volume and lower the reflood rate. Stating the water will eventually drain back into the core is inappropriate. Provide the model and results to demonstrate that hot side injection is not entrained into the loops causing a potential inadequate core cooling conditions. Describe the entrainment model and show the results demonstrating that hot leg injection is effective in preventing boron precipitation.

15.06.05-67

The level swell validations described for S-RELAP5 were pertinent to large break loss of coolant accident (LBLOCA) short term conditions during the periods of significant entrainment. No comparisons of the models to long term level swell when entrainment subsides were provided. Show validation of the level swell model against low pressure level swell data such as those, for example but not limited to, the Achilles and Thetis low pressure level swell tests. For clarification, it is understood that an under predicted void fraction value in the upper plenum compensated will significantly increase the liquid mass within the mixing volume.

15.06.05-68

The average concentration of all of the boric acid sources was calculated to be 1,929 ppm based on their volumetric contents and boric acid concentrations. Since liquid from the various sources is injected into the reactor coolant system (RCS) at individual flow rates and concentrations over different periods of time, setting the concentration of the fluid entering the core equal to the volume-averaged value is not justified. If the EBS is injecting at its maximum rate, this concentration at this flow rate can be conservatively postulated to enter the core region along with the remainder needed to supply the core boil-off rate at the in-containment refueling water storage tank (IRWST) concentration. The excess spills to containment. Show the timing to boric acid precipitation under these specific flow conditions using all other limiting conditions suggested/questioned above.

15.06.05-69

Follow-up to 241, Question 15.06.05-51

The response to Question 15.06.05-51 includes reference to three two-phase correlations: Zuber-Findlay, Cunningham-Yeh, and Wilson. Explain their applicability and accuracy under post LOCA low pressure conditions. If these correlations are not based on low pressure test data consider validation of these correlations under low pressure atmospheric conditions, or use of alternate methods for level swell.

The chosen model for the evaluation of level swell should be selected based on comparisons of the proposed model to low pressure test data. As such, show the predictions of the model used in the analysis to low pressure level swell data; for example, the Achilles and Thetis low pressure data. The model in FLASH-6 (see eqs. C.2-8 through C.2-11)for level swell, for example, provides an alternate method for predicting two-phase level well that can be compared to Wilson (see Beyer, J. et al, "FLASH-6; A Fortran IV Computer Program for Reactor Plant Loss-of Coolant Accident Analysis," WAPD-TM-1249, July 1976) . The drift velocity correlation, eq. 5.189, pg 248, from Lahey and Moody, "The Thermal Hydraulics of a Boiling Water Nuclear Reactor," American Nuclear Society, Second edition, 1993, provides an additional model for level swell. These models can be compared to low pressure level swell data to choose the appropriate method and validate the approach and its particular use in the application. Sensitivity studies on the key model parameters should also be provided.

15.06.05-70

Follow-up to 241, Question 15.06.05-51

The calculations in the response to Question 15.06.05-51 take credit for bypass identified as Path 1 in Figure 15.06-51-1. Since it is difficult to predict the gap sizes and the dimensional changes as the vessel and core barrel cool down, explain why credit for bypass is appropriate and conservative. Justify the minimum gap resistance value used in the analysis.

15.06.05-71

The axial power distribution is taken as uniform. The staff believes that a top skewed power distribution will result in a lower two-phase mixture level due to less void swell. Quantitatively show the sensitivity of the two-phase mixture level to a top skewed axial power distribution under most limiting physically realizable top peak profile.

15.06.05-72

Explain the sensitivity of the two-phase mixture level in the core to loop seal water temperature. What would happen to the two-phase mixture level in the core if the water temperature in the loop seal reaches safety injection (SI) temperature with saturated conditions remaining in the downcomer?

15.06.05-73

Follow-up to 241, Question 15.06.05-51

What degree of depression of the liquid level below the top of the loop seal horizontal piping (elevation Z_{LS} in Figure 15.06.05-51-1 in response to Question 15.06.05-51) is needed to vent steam through the loop seal to prevent further pressure buildup and corresponding level suppression in the core? Provide a conservative estimate of the degree of depression of the liquid level in the horizontal section of the loop seal pipe to provide a steam relief path. What is the two-phase mixture level in the core if the water level in the loop seal (Z_3 in Figure 15.06.05-51-1 in response to Question 15.06.05-51) is assumed at the middle or bottom of the horizontal portion of the loop seal?

15.06.05-74

[Question intentionally deleted]

15.06.05-75

The analysis assumed the liquid at the center line of the cold leg at the discharge. As this is not limiting, provide the results with the break and liquid level located at the top elevation of the discharge piping. Provide the highest elevation of the SI lines downstream of the check valve connected to the discharge legs. If this elevation is above the top of the discharge leg, provide an evaluation of the two-phase mixture level in the core with the break at this highest elevation.

15.06.05-76

Describe how the void fraction in the loop seal vertical section was calculated and justify the model.

15.06.05-77

For the worst case, show the following plots: (1) axial void distribution in the vessel at the minimum two-phase mixture level; (2) core steaming rate as a function of time; (3) vapor mass flow rates in the loops as a function of time; (3) liquid/boric acid density in the inner vessel region when the level is at a minimum in the core; (4) liquid density and void fraction in the vertical section of the loop seal as a function of time; (5) mass flow rate through the bypass as a function of time. Provide an analytical description/write-up of the model used to compute the system response for these evaluations. Provide a copy of the computer program used to produce these results.

15.06.05-78

[Question intentionally deleted]