ArevaEPRDCPEm Resource

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Sent:	Thursday, April 30, 2009 7:50 PM
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Subject:	Draft - U.S. EPR Design Certification Application RAI No. 221 (2611), FSAR Ch. 6
Attachments:	Draft RAI_221_SPCV_2704.doc

Attached please find draft RAI No. 221 regarding your application for standard design certification of the U.S. EPR. If you have any question or need clarifications regarding this RAI, please let me know as soon as possible, I will have our technical Staff available to discuss them with you.

Please also review the RAI to ensure that we have not inadvertently included proprietary information. If there are any proprietary information, please let me know within the next ten days. If I do not hear from you within the next ten days, I will assume there are none and will make the draft RAI publicly available.

Thanks,
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Request for Additional Information No. 221 (2704), Revision 0

4/30/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.01 - Containment Functional Design
Application Section: 6.2.1, Technical Report ANP-10299P

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

06.02.01-15

RAIs on Technical Report ANP-10299P

1. The last paragraph of Section 2.2 on page 2-10 states that the convection foils provide the minimum free-flow cross-sectional area needed to mitigate a small break LOCA event. Provide analyses of potential design basis small break LOCA events within the US-EPR containment to justify this conclusion.

2. Section 2.2.3 describing the mixing dampers states that they open with a differential pressure of plus of minus 35 mille bar or an absolute pressure of 1.2 bar. Discuss the redundancy of these sensors and actuation logic.

3. The Δp signal to open the mixing dampers is stated to be across the pressure equalization ceiling of the SG compartments. Provide the exact location of this Δp instrumentation. Justify that the dynamic conditions in the broken loop SG compartment will not interfere with the Δp signal in the early stages of blowdown, the time when the dampers need to open.

4. For both the differential pressure instrumentation and absolute pressure instrumentation which open the mixing dampers, demonstrate that the actuation sensors as well as associated instrumentation and wiring, are environmentally qualified for the conditions that might occur within a reactor containment following a LOCA or MSLB.

5. The dampers can be closed by the operators from the control room. Could any single failure inside containment close the dampers following their actuation? What failure mode could close the dampers? What protection is provided to prevent this failure mode? How long following actuation is the protection provided?

6. Section 2.2 describes the CONVECT system which establishes a circulation pattern within the containment building following a high energy piping break. The degree of circulation will depend on the opened areas and the resulting flow losses. Provide the effective open area of the rupture and convection foils and the flow loss coefficients. Discuss how these values were determined.

7. Pages 6-117 and 6-118 describe doors between the accessible and non-accessible areas of the containment which are safety-related to prevent compartment over-pressurization. On page 6-120 non-safety-related access doors ("failure" junctions) are described. Provide a complete description of both the safety and non-safety related doors. Show their location and describe their operation. Provide analyses showing the effect on containment and compartment pressure if the doors function as designed and if they do not function.

8. For the safety-related doors provide justification that the requirements of the Commission's regulations for safety related equipment are met.

9. Page 6-117 states that there are many safety-related doors in containment to prevent compartment over pressurization. This statement indicates the existence of "closed compartments" within containment. Please list all "closed compartments together with their volume. How are these compartments considered in containment pressure buildup calculations? Are there high energy lines in any of these compartments? If so provide appropriate subcompartment analyses.

10. Provide technical specification surveillance requirements which will ensure that the foils and dampers of the CONVECT system and the safety-related doors perform their intended safety functions. The NRC staff requested that ITAACs be provided for these components in RAI 104:14-03.2.

11. Formation of a panel to identify and rank significant phenomena which might affect the US-EPR containment analysis for the development of a PIRT is discussed in Section 3.4.1 beginning on page 3.21. Identify the individuals who served on the panel and provide their qualifications to serve this function.

12. Section 5.3.1.5.6 discusses hot leg nozzle bypass and states that during later blowdown and early reflood phases, the thinner core barrel structure is cooled and the gaps grow to their maximum size. It is further stated that during the post-reflood phase the reactor vessel shell will cool and approach the pumped ECCS injection temperature but this may take several hours. The effect of hot leg injection is stated to have the effect of cooling portions of the core barrel faster than the reactor vessel shell and to keep the gaps open longer. Since the effect of hot leg nozzle gaps might have the effect of permitting hot leg injection to drain to the downcomer and thereby not be available for core mixing, provide an evaluation of this phenomenon showing its effect on steam condensation in the reactor vessel during hot leg injection.

13. Section 6.1.1 describes assumptions used with RELAP5-BW to calculate core heat transfer. The discussion indicates that departure from nucleate boiling is generally calculated to occur very quickly and that subsequent core cooling is by film boiling, however a return to transition boiling is allowed to enhance heat transfer. For the reflood period RELAP5 predictions for FLECHT-SEASET tests are presented showing good agreement with data for the test facility. Standard Review Plan 6.2.1.3 recommends that nucleate boiling be assumed.

a. For the US-EPR containment calculation in Section 8 using the new EM model, provide the heat transfer coefficient as a function of time that is calculated at the middle of an average core channel and the cladding surface to bulk temperature difference as a function of time. Indicate the mode of heat transfer that is occurring associated with the differential temperature and heat transfer coefficient plots. Discuss the conservatism of the RELAP5 calculated heat transfer compared to the nucleate boiling assumption recommended by the SRP.

b. During the reflood period provide the core flooding rate as a function of time as indicated by the progress of the quench front for the US-EPR using the new EM model. Based on experimental data show that the heat transfer coefficient calculated for an average core channel location of the EPR is conservative based on test data for the predicted flooding rate.

14. For the US-EPR containment calculation in Section 8 using the new EM model, provide the heat transfer coefficient as a function of time that is calculated between the reactor vessel shell and the downcomer fluid and the temperature difference to the downcomer fluid as a function of time. Indicate the mode of heat transfer that is occurring associated with the differential temperature and heat transfer coefficient plots. Discuss the conservatism of the RELAP5 calculated heat transfer compared to the nucleate boiling assumption recommended by the SRP.

15. Section 6.1.2 describes calculation of the carryout rate fraction (CRF) by RELAP5-BW. RELAP5 predictions of the CRF for FLECHT-SEASET tests are presented showing good agreement with data from the test facility. For the US-EPR containment analyses with the new EM model and using the core flooding rate derived in the response to RAI 8.b demonstrate that the CRF for US-EPR is conservative based on the experimental data.

16. Section 6.1.3 describes calculation of steam generator heat transfer by RELAP5-BW. Predictions for FLECHT-SEASET tests are presented which show good agreement when the test facility is modeled. The prediction of steam generator heat transfer appears to be a function of the steam and liquid flow rates within the steam generator tubes. For the US-EPR containment analysis with the new EM model show that with the predicted steam generator tube flow rates that the heat transfer predicted for the US-EPR is conservative based on comparison to experimental data.

17. The text in the paragraph in the middle of page 6-17 for timing of steam generator tube quenching does not appear to agree with the times indicated in Figure 6-15 on the same page. Further clarification is needed.

18. The table on page 6-30 states that fuel cladding swelling and rupture was included in the RELAP5-BW prediction of mass and energy release. SRP 6.2.1.3 recommends that fuel swelling and rupture not be considered for containment mass and energy release calculations. Provide an assessment of the affect of any predicted cladding swelling and rupture on the calculated containment

pressure for US-EPR and justify that the inclusion of these models leads to conservative results.

19. On October 31, 2008, Areva made a presentation to the NRC staff describing calculation of EPR reactor vessel mixing using the CATHARE 3D computer code. Provide a discussion comparing the reactor vessel mixing results from the CATHARE 3D analyses with the reactor vessel mixing analytical assumptions described in ANP-10299P. What value of $\eta(mix)$ as defined in equation of 6-1 of the report would be predicted by CATHARE 3D? Provide a discussion of the use, validation and acceptance of CATHARE 3D in Europe.

20. For the new EM containment M&E model described in Chapter 8, RELAP5-BW is used to calculate the break flow to the containment until the containment loop seals are assumed to fill with water. After the loop seals are assumed to have filled, the GOTHIC code is utilized to calculate the break flow to the containment. Provide justification for the time selected for loop seal closing. Would an earlier time result in a higher containment pressure prediction?

21. Section 8.2.3.2 describes the removal of the remainder of the steam generator stored energy using the GOTHIC code to model the reactor system. Five percent of the total ECCS flow is assumed to be transferred to the steam generators as liquid.

    a. Provide justification for the assumed liquid carryout. For example, compare this liquid fraction to that calculated by RELAP5 or to that which would be obtained using a two phase level swell model such as the Yeh correlation that is programmed into the GOTHIC code.

    b. Page 8-12 states that the 5% liquid flow is distributed equally among the 4 steam generators. The intact loops are assumed to be blocked with water in the pump suction lines at this time. Discuss the conservatism of the equal distribution assumption compared to the case of all liquid flow traveling to the broken loop steam generator.

22. Pages 8-24 through 8-26 describe derivation of the hot leg injection mixing model used with the GOTHIC simulation of hot leg injection. The staff understands that these pages are being revised. Provide the revisions and provide a step-wise derivation for the equations that are used in the hot leg injection and mixing model for GOTHIC.

23. Figure 9-12 presents the long term steam flow to the containment calculated by the GOTHIC reactor system model. The figure shows the steam flow to: 1. drop to almost zero following the initiation of hot leg injection and to partially recover, 2. slowly increase from 5400 seconds to approximately 12000 seconds and 3. suddenly decrease at approximately 12000 seconds. Explain the processes in the GOTHIC model which cause these effects.

24. Page 8-23 states that the flow split that is assumed between cold leg and hot leg safety injection after hot leg injection is initiated was determined using a piping network analysis.

a. Provide additional details concerning the network analysis including a description of the computer code that was used and the single failures that were assumed.

b. Describe the technical specification surveillance and ITAAC requirements that will be established to ensure that the assumed flow split is maintained.

c. The three components of the ECCS, MHSI pumps, LHSI pumps and accumulators are designed to inject into the RCS at the same time. The three injection lines merge into a single line that leads to the injection nozzle. The accumulators inject first borated water, then nitrogen gas. There must be interference among the competing flows. The applicant performed steady state piping network flow analyses, but no calculations were done with all three components delivering at the same time. How is the transient injection rate established for the various LOCAs considered in containment analysis?

25. The table starting on page 8-33 and ending on page 8-37 discusses assumptions used in the analysis of secondary system pipe ruptures. Items 4 and 6 indicate that liquid entrainment from the break was assumed in the main steam line break analyses. Page 6.2.-21 of the FSAR indicates that during periods when liquid entrainment would be predicted, the break energy is set to that of saturated steam so that there would be no liquid entrainment. The response to RAI 82 #06.02.01.04-1.f further explains how liquid entrainment is prevented by the setting of control variables in RELAP5. FSAR table 6.2.1-22 for MSLB mass and energy release shows no liquid entrainment. If liquid entrainment is assumed, provide the appropriate experimental justifications and break size analyses as recommended in SRP 6.2.1.4.

26. Similarly Item 4.2.3.2.6 on page 8-36 states that for MSLB a drop diameter of 100 microns was used to determine the interface area between the steam and water. The staff does not understand the use of this parameter if no liquid droplets are assumed to be released to the atmosphere as discussed on page 6.2-21 of the FSAR. Provide additional details and justifications for use of the 100 micron parameter.

27. The staff understands that Areva takes credit for steam condensation within the reactor coolant cold legs in the RELAP5 BW predictions of mass and energy release for containment evaluation. As discussed in Standard Review Plan 6.2.1.3, provide justification for the condensation assumptions by comparing the RELAP5 BW predictions of flow conditions within the US-EPR cold legs with applicable experimental data. Provide these comparisons for both the reflood and post reflood periods.

28. FSAR Section 5.2.3.4.3 documents that reflective metal insulation (RMI) will be used to cover the primary and secondary side system components. In Section 8.1.1 the energy sources for mass and energy discharge are discussed but RMI is not included. During LBLOCA or MSLB, some of the RMI insulation is expected to be detached so that the sensible heat from this RMI would be directly discharged to the containment while remaining intact RMI would contribute to the

heat added to the containment. Provide an assessment of the effect of the addition of RMI sensible heat to the containment peak pressure and temperature following a LBLOCA or MSLB.

29. Figure 9-14 presents the containment pressure calculated using the new evaluation model for US-EPR. The mass and energy release was calculated using RELAP5-BW for the first 1200 seconds and containment pressures were calculated using a one node GOTHIC containment model. For the first 1200 seconds, this is the same methodology as described in the FSAR which is used to produce FSAR Figure 6.2.2-16. Both analyses are for a postulated double ended break at the suction of a reactor coolant pump, yet different results were obtained for the first 1200 seconds. Describe the changes in models or assumptions which produced the different results.

30. During the April 6 and 7 audit at Lynchburg, a discussion of the CONVECT system indicated that the pressurizer compartment is only compartment that remains closed post accident. No foils or dampers are provided to include this compartment in the post accident "one room" containment. Other components in this compartment are the pressurizer relief tank, CVCS tank and heat exchanger, core instrumentation, and at least 2 PARs. Confirm that this compartment remains isolated post accident.

31. During the April 6 and 7 audit at Lynchburg, handout slides were presented indicating post accident convection flow paths in containment. Provide a copy of slides #11 and #17.

32. The discussions in Chapters 8 and 9 of ANP-10299P prescribe an analytical approach to calculate the mass and energy release following for a large cold leg break at the suction of a reactor coolant pump. Describe how the methodology will be applied to other break sizes and locations and how the methodology will be made to be conservative for the containment analyses of these break locations.

33. The staff understands that a 2.0 percent calorimetric uncertainty in initial reactor power is being applied to the Chapter 15 safety analysis instead of a 0.5 percent calorimetric uncertainty that was originally assumed. Will the Chapter 6 containment analyses also be revised to assume a 2.0 percent calorimetric uncertainty? If not provide justification for using a different value.