## ArevaEPRDCPEm Resource

**From:** Tesfaye, Getachew
**Sent:** Friday, December 18, 2009 5:47 PM
**To:** 'usepr@areva.com'
**Cc:** Phan, Hanh; Fuller, Edward; Clark, Theresa; Mrowca, Lynn; Chowdhury, Prosanta; Colaccino, Joseph; ArevaEPRDCPEm Resource
**Subject:** Draft - U.S. EPR Design Certification Application RAI No. 349 (4164, 4165), FSAR Ch. 19 OPEN ITEM
**Attachments:** Draft RAI_349_SPLB_4164_4165.doc

Attached please find draft RAI No. 349 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,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

**Hearing Identifier:** AREVA_EPR_DC_RAIs
**Email Number:** 1049

**Mail Envelope Properties** (0A64B42AAA8FD4418CE1EB5240A6FED10818DA92E8)

**Subject:** Draft - U.S. EPR Design Certification Application RAI No. 349 (4164, 4165), FSAR Ch. 19 OPEN ITEM
**Sent Date:** 12/18/2009 5:47:04 PM
**Received Date:** 12/18/2009 5:47:05 PM
**From:** Tesfaye, Getachew

**Created By:** Getachew.Tesfaye@nrc.gov

**Recipients:**
"Phan, Hanh" <Hanh.Phan@nrc.gov>
Tracking Status: None
"Fuller, Edward" <Edward.Fuller@nrc.gov>
Tracking Status: None
"Clark, Theresa" <Theresa.Clark@nrc.gov>
Tracking Status: None
"Mrowca, Lynn" <Lynn.Mrowca@nrc.gov>
Tracking Status: None
"Chowdhury, Prosanta" <Prosanta.Chowdhury@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 | 727 | 12/18/2009 5:47:05 PM |
| Draft RAI_349_SPLB_4164_4165.doc | 43514 | |

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

Draft

Request for Additional Information No. 349 (4164, 4165), Revision 0

12/18/2009

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

QUESTIONS for PRA Licensing, Operations Support and Maintenance Branch 2 (ESBWR/ABWR Projects) (SPLB)

19-330

OPEN ITEM

DCD Section 19.1.5.1.1.5 states that the "product of this evaluation is identification of the structures and components that arise in the core damage cutsets...HCLPF results and PRA insights from this evaluation are assessed to identify potential seismic vulnerabilites relative to the RLE [review level earthquake] and to suggest potential measures to reduce their impact." Please provide additional information regarding the results of the HCLPF sequence assessment, i.e., identification of the structures and components that may limit the plant-level HCLPF capacity, the potential seismic vulnerabilities relative to the RLE, and the proposed measures to reduce risk impact.

19-331

OPEN ITEM

For the seismic risk evaluation during low power and shutdown (LPSD) conditions, please describe the following:

1. Systems and accident sequence analysis (including consequential initiating events)
2. HCLPF sequence assessment
3. Results, key assumptions, and insights.

19-332

OPEN ITEM

Follow-up to RAI No. 236, Question 19-312

The responses to the various questions listed as part of the subject RAI were for the most part satisfactory. In several areas, however, the information provided is insufficient for developing  sufficient confidence that the integrity of the proposed material for the U.S. EPR reactor pit can be maintained during potential severe accidents.

Further clarification is requires, as follows:

(a) The information provided on the material characteristics of the stabilized $ZrO_2$ does not include the solidus temperature of the U.S. EPR-specific MgO-stabilized Zirconia. Please provide the solidus temperature of Zettral 95GR that is planned to be installed in the U.S. EPR reactor pit.

(b) The MgO-stabilized $ZrO_2$-tested for compatibility with metallic melts was found to be stable to 2200°C for duration of six hours under relatively oxygen-free melt condition. However, it was mentioned that melt infiltration (but no significant thinning) of the ceramics was observed for oxygen contents higher than postulated for U.S. EPR severe accident melts. Please provide justification by presenting available experimental evidence on the compatibility of U.S. EPR specific zirconia (or similar zirconia) with metallic melts having oxygen contents in the range expected for severe accidents in the U.S. EPR.

(c) A summary of data on thermal up-shock experiments with molten iron from thermite reaction with U.S EPR-specific Zettral 95GR bricks and the refractory mortar between the bricks, was indicated to show that the bricks and associated mortar survived without significant damage thermal-up shock caused by pouring molten iron from thermite reaction onto the bricks.  Please provide the measured temperature-time histories in the Zettral 95GR bricks for the thermal up-shock experiments.  Show a comparison of the measured parameters to predictions under severe accident conditions in the U.S. EPR.  In addition, provide a comparison of melt impact velocities and mass of melt arrival per unit area of zirconia per unit time in the experiments to predictions under typical severe accidents in the U.S. EPR.

(d) A summary of experiments on the interaction of oxidic melts with $ZrO_2$, including Zettral 95 GR sample materials (not bricks) under MCCI conditions are stated to show that the zirconia samples survived with minimal attack because, it is asserted, the MCCI causes the addition of low-melting concrete decomposition products into the corium melt, thus keeping the melt temperature below the liquidus, and causes the melt to be saturated with zirconia. The interaction time between the melt and the $ZrO_2$ varied from 5 to 15 minutes for the four experiments. This time range is small compared with the estimated time of 3 hours for retention of the melt in the reactor pit.  Reference is also made to the MACE experiments.  Please provide experimental evidence (e.g., AREVA, MACE, etc.) on the time evolution of melt temperatures during sustained tests, including MCCI, supporting the compatibility oxidic melts with Zirconia.

(e) A discussion of the “adapted” microstructure of Zettral 95GR was provided, in which features such as granular structure, internal microscopic cracks, thermal strain of texture, expansion of sintering bridges, formation of collective pores, and curing of microcracks are described.  Also, the discussion of the mechanical behavior of Zettral 95GR is inscrutable without further explanation.  Please provide a more precise description of what is meant by the “adapted” microstructure of Zettral 95GR. Furthermore, provide a more clear discussion of the wedge splitting test, how crack openings (strains) in the range 1E-5 to 1E-4 are derived, and provide a description of the material transfer forces in the presence of such cracks.

19-333

OPEN ITEM

Follow-up to RAI 22, Question 19-158

The response to Question 19-158 is, for the most part, satisfactory. However, it does not address the risk implications of enhanced Ru release, especially, relative to the early and latent fatality safety goals. Please include a discussion on air ingression and enhanced release of Ru in the FSAR. In addition, please provide sensitivity calculations on the potential impact of increased Ru releases on the early and latent fatalities (as compared to the NRC Safety Goals).

19-334

OPEN ITEM

Follow-up to RAI 133, Question 19-230

In general, large phenomelogical uncertainties are associated with the pre-mixing, detonation and propagation phases fuel-coolant interactions and the resulting energetics from steam explosions. These phenomenological uncertainties are, to some extent, reflected in the differences in the models and computer codes that are currently available worldwide.
In the pre-mixing phase, computer code differences include those affecting the modeling of fuel jet fragmentation and flow regime transition, among others. In the TEXAS and PH-ALPHA computer codes, the concept of leading edge jet breakup is used. On the other hand, the IKEMIX computer code used by the applicant is based on a continuous jet fragmentation concept. The RAI response claims that the leading edge break-up model results in more fuel mass participating in the pre-mixing process.

In addition, TEXAS and PM-ALPHA codes are based on the conceptualization of churn flow, while the IKEMIX code assumes a combination of bubbly and droplet flow. These differences affect the quantity of fuel that is in contact with the coolant, and it is expected to be higher for the TEXAS and PM-ALPHA codes, and affects the degree of void generation.

Therefore, given the uncertainties in the phenomenological representation of the premixing and propagation phases of steam explosions, the quantifications of the steam explosion-induced loads need to reflect these uncertainties. The documented uncertainty analysis that was performed by the applicant does not consider the larger loads that are envisioned using models such as TEXAS and PM/ALPHA/ESPROSE.
Furthermore, given the results of the recent staff confirmatory calculations using MELCOR, it has been noted that there is a potential for a delayed relocation of some of the core debris into the reactor pit, after the reactor pit plug melt-through Therefore, the frequency of accidents where steam explosions are conceivable cannot be limited only

to those involving high reactor coolant system pressure and creep-induced failure of the hot-leg nozzles. The majority of accidents in U.S. EPR result with melt cooling on the spreading compartment; therefore, any delayed release of core debris from the RPV into the reactor pit (i.e., after pit plug failure) could result in energetic fuel-coolant-interactions.

Please revise the ex-vessel steam explosion analysis to reflect the potential impact of phenomenological uncertainties, especially, during the pre-mixing phase of a steam explosion. In addition, please discuss the consequences of steam explosions from delayed relocation of core debris from the reactor vessel (following pit plug melt-through) on the structural integrity of the pit, transfer channel, the spreading area (including the debris cooling structures), and the containment.

19-335

OPEN ITEM

Follow-up to RAI 133, Question 19-233

This was a follow-up to Question 19-84e. The response shows a calculation of likelihood of multiple Steam Generator Tube Rupture (SGTR) using a Poisson distribution due to random flaws in the tubes under creep-induced conditions. The analysis does not treat/consider the potential implication of failure propagation due to the continued heat-up of the steam generator tubes, after the initial tube failure. Natural circulation and steam generator tube heat-up is expected to continue well beyond the failure of a single tube. Therefore, the analysis of the calculated failure likelihoods is incomplete.

The calculated fission product releases to the environment for the single and multiple tube failure based on MAAP results are low. In comparison to the recent NRC MELCOR calculations for a single double-ended induced-SGTR scenario, the MAAP results cited in AREVA response, are about 50% too low. One reason is the termination of MAAP calculations after 24 hours, thus limiting the releases due to revaporization. These differences are significant and need to be reconciled.

a. Please revise the analysis to reflect the potential impact of continued heatup of the steam generator tubes, and determine at what level of failure (number of tubes), RCS depressurization occurs, terminating additional tube failures.

b. Please extend the present source term calculations to at least 48 hours, and report the impact on fission product releases and severe accident risk for U.S. EPR, including comparisons to the NRC early and latent fatality Safety Goals.