ArevaEPRDCPEm Resource

From: Tesfaye, Getachew
Sent: Monday, June 07, 2010 9:57 AM
To: 'usepr@areva.com'
Cc: Wong, Yuken; Dixon-Herrity, Jennifer; Patel, Jay; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 407(4654), FSAR Ch. 3
Attachments: RAI_407_EMB2_4654_.doc

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on May 20, 2010, and on June 2, 2010, you informed us that the RAI is clear and no further clarification is needed. You also informed us that the draft RAI contained proprietary information. As a result, draft RAI Questions 03.09.02-70, 03.09.02-71, and 03.09.02-80 were modified to delete the proprietary information. 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
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Created By: Getachew.Tesfaye@nrc.gov

Recipients:
"Wong, Yuken" <Yuken.Wong@nrc.gov>
Tracking Status: None
"Dixon-Herrity, Jennifer" <Jennifer.Dixon-Herrity@nrc.gov>
Tracking Status: None
"Patel, Jay" <Jay.Patel@nrc.gov>
Tracking Status: None
"Miernicki, Michael" <Michael.Miernicki@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

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6/07/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
Application Section: 3.9.2

QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)

03.09.02-69

ANP-10306P, Para 2.1.1 (page 2-1) and Para 4.2.1 (page 4-2)

Section 2.1 (1) of the Reg. Guide 1.20 states that the vibration and stress analysis submittal describe the theoretical structural and hydraulic models, analytical formulations and scaling laws, including errors and uncertainties.

The applicant describes that the prototype HYDRAVIB mock-up represents the lower internal structures consisting of the CB, LSP, FDD, HR, hold down spring, irradiation capsule baskets and the RV inside, including the RC inlet nozzle, and the shape of the radial keys.

The staff noted that Figure 4-1 indicates that individual slabs representing the Heavy Reflector (HR) are positioned by a pair of male and female spigots, which prevents radial sliding between any two HR slabs. However, the details of the HR in Figure 2-3 does not show the spigots (smooth), which can result in radial sliding. In addition, the staff did not find an adequate description of the flow distribution device (FDD) that could be used to verify the FEM input.

The staff was unable to determine if the theoretical structural model of the HYDRAVIB mock-up is an accurate representation of the reactor internals. The applicant is requested to provide details of the following and describe how they have been included in the finite element models:

a. How is the Core Barrel Flange secured in the Reactor Vessel? – It is recommended that the applicant provide a figure that details the retaining assembly.
b. Explain if the scaling is purely geometric for all components
c. Explain the scaling used for the hold down spring
d. Describe the spigot construction of the HR and how they are scaled.
e. Provide details of the FDD that can be used to confirm the FEM input.

03.09.02-70

ANP-10306P, Figures 2-1 through 2-2.5

The staff noted that the applicant did not provide weld information, related to type of weld i.e full penetration, double groove etc, and its code acceptability, that should be included in Figures 2-1 through 2-5. The weld information required is described below:

a. Weld between the Core Barrel Flange and Core Barrel Upper Skirt
b. Weld between the Core Barrel Upper Skirt and Core Barrel Lower Skirt
c. Weld between the Core Barrel Lower Skirt and the Lower Support Plate tongue (unknown thickness)
d. Any longitudinal welds in the Core Barrel Flange, Core Barrel Upper Skirt and Core Barrel Lower Skirt
e. Weld between the Upper Support Flange Skirt and the Upper Support Flange

The applicant is requested to explain how each weld configuration identified above in letters (a) through (e) is in accordance with Article NG-3352 of the ASME code and identify the design factors, both 'n' for static loading and 'f' for fatigue loading, per Table NG-3352-1 used in stress calculations for each weld.

03.09.02-71

ANP-10306P, Para 2.1.1 (page 2-2)

Reg. Guide 1.20, Section 2.1 (2) states that uncertainties are often associated with difference between ideal models and "as manufactured" structures, such as differences in material properties, connections and geometries. These uncertainties and their influence on vibrational responses are to be addressed. The applicant has not described various manufacturing tolerances that can result in geometric uncertainties and also did not describe how they are addressed in the model or in the calculation of flow induced vibrations. The applicant is requested to explain how tolerances in the following members are accounted for:

a. Upper skirt plate
b. Lower skirt plate
c. Reactor Vessel (note that ID tolerance = +/- 1.0 in will also have an effect on the calculation of hydraulic diameters and flow distributions)

03.09.02-72

ANP-10306P, Para 2.1.1 (page 2-2)

The staff noted that Figures 2-1 through 2-5 appear to indicate that bolting is used at the following locations:

- Connection between the Upper Control Rod Guide Assemblies and the Upper Support Plates
- Connection between the Lower Control Rod Guide Columns and the Upper Support Plates
- Connection between the Flow Distribution Device and the Lower Support plate

The staff did not find a description of how the bolts are included in the model or the analysis that was performed to demonstrate bolting integrity is maintained for the required design life. The applicant is requested to provide details of the bolting used in the reactor internals and describe how bolts were addressed in the modeling, including the evaluation of fatigue loading and effects of loss of pre-compression on bolted joint integrity.

03.09.02-73

ANP-10306P, Para 4.2.2.1 and 4.2.2.2 (page 4-10)

The applicant provided a description of the Finite Element Model in Section 4.2.2.1 and in Figures 4-6 through 4-15. The staff reviewed these figures and description and requests the applicant to:

a. Provide the ANSYS element type used to model the Core Barrel (CB) Flange.
b. Provide the ANSYS element type used to model the CB shell.
c. Explain how Core Barrel Skirt shell elements are connected to the Core Barrel Flange brick elements.
d. Provide the ANSYS element type used to model the lower support plate.
e. Provide the ANSYS element type used to model the heavy reflector.
f. Is the volume between the Core Barrel Skirt and Reactor Vessel represented by fluid elements?
g. Is the volume between the Core Barrel Skirt and the HR represented by fluid elements?
h. How many elements or free nodes are present across the thickness of the volume representing the fluid between the Core Barrel Skirt and the HR outer surface?
i. What is aspect ratio (ratio of the length to the thickness) of the elements representing the fluid volumes?
j. Which fluid element type is used to represent the fluid – for example FLUID80, FLUID30 etc.?
k. Provide the fluid volumes and an ANSYS picture of the volumes represented by fluid elements.
l. Provide a picture of the complete finite element model including all components.
m. Provide a picture of the finite element model including all boundary conditions.
n. Describe how force distributing equations representing the Fuel Assemblies are used in the finite element model

03.09.02-74

ANP-10306P, Para 4.2.2.3 (page 4-16)

The applicant stated that static tests were performed on the HYDRAVIB mock-up to verify that the stiffness of the lower internal assembly and its restraint at the CB flange is modeled accurately. The staff did not find a description of how the stiffness was measured during static testing. Therefore, the applicant is requested to explain how stiffness was measured, and to discuss the comparison of the measured stiffness value with the stiffness value obtained in the finite element model.

03.09.02-75

ANP-10306P, Para 4.2.2.3 (page 4-17)

The applicant stated that shell type modes do not produce significant motion of the LSP or the fuel bundle. As shown in Table 4-2, the shell modes are not identified. The staff could not confirm that the FEA model accurately reflects the shell modes. Therefore, the applicant is requested to describe how the shell modes of the HYDRAVIB scale model assembly compare to those determined by the finite element analysis.

03.09.02-76

ANP-10306P, Para 4.2.3.1

The applicant described the power spectral density in paragraph 4.2.3.1 and provided graphs of (3) locations in Figure 4-12, 4-13 and 4-14. The staff could not determine how the applicant input the PSD shown in Figures 4-12, 4-13 and 4-14 into the ANSYS finite element model. The applicant is requested to explain how the PSD data is input into the ANSYS FEM. The explanation should include clarification of application of the following ANSYS modeling techniques:

a. What command was used to input the excitation PSD?
b. If the PSDFRQ command was used to input the excitation PSD, how was the data in Figures 4-12, 4-13 and 4-14 converted to frequency?
c. It is recommended that the applicant include the applied ANSYS generated Frequency vs. Pressure PSD graphs.
d. What were the lower and upper limits of the frequency range?
e. Did the frequency range include vane passing frequencies and their harmonics, effects of multiple pumps in multiple loops, and, as well the expected high frequency random pressure PSD (fluid noise)?
f. How was the excitation PSD applied to the model? Were multiple excitations applied on one finite element model?
g. Was the excitation PSD applied at nodes or on areas (RV Downcomer, Inlet Jets, RV Lower Plenum etc)? It is recommended that the applicant provide an ANSYS pictures indicating the areas where and which excitations were applied to the model.
h. How were the excitation applied when analyzing different RCPs in service?

03.09.02-77

ANP-10306P

The staff noted that Reg. Guide 1.20 Section 2.1, recommends that the conservatism of simulation of boundary conditions shall be considered in the modeling. Industry experience indicates that there is a strong influence from boundary conditions on the vibrations of the reactor core barrel. The staff did not find a description of the conservatisms used for boundary conditions. Therefore, the applicant is requested to provide details on the boundary condition conservatisms that are applied to the finite element model both for the scale model as well the full FEM model. It is recommended that the applicant provide an ANSYS picture of the finite element model that illustrates the boundary conditions.

03.09.02-78

ANP-10306P, Para 4.2.6.2 (Page 4-86)

The applicant stated that the mean stress in core barrel is less than PL+PB+Q stress range of 27.2 psi, therefore, fatigue curve “A” was selected for evaluating the RV Core Barrel.

The staff noted that per ASME NG-3222.4 (c), the fatigue curves of Figure I-9.0, are selected based on meeting specific criteria, including mean stress. The applicant is requested to explain the basis for the selection of fatigue curve “A” and how it was determined that the mean stress in core barrel is less than PL+PB+Q stress range of 27.2 psi..

03.09.02-79

ANP-10306P, Para 4.2.7.2 (page 4-94)

The applicant concluded that high cycle fatigue failure resulting from the random turbulence in the RV downcomer is not likely to occur based on a calculated maximum stress of 1.921 MPa rms. The staff noted that the applicable rules for analyzing fatigue and structural integrity for reactor vessel internals are given in ASME B&PV Code, Section III, Subsection NG, “Core Support Structures – Rules for Construction of Nuclear Facility Components”. The stress criteria that must be satisfied for demonstrating compliance with the ASME Code are as shown in TABLE NG 3221-1 and Appendix-D. The applicant is request to demonstrate that the maximum calculated stress satisfies ASME Section III, Subsection NG.

03.09.02-80

ANP-10306P, Para 4.2.7.2 (page 4-94)

The staff noted that the Core Barrel has the following different thicknesses:

a. Core Barrel Flange at joint
b. Core Barrel Upper Skirt
c. Core Barrel Lower Skirt
d. Lower Support Plate tongue(unknown thickness)

The staff could not determine from the description of the finite element model in Sections 4.2.2.1 or 4.2.5 or in the ANSYS pictures provided in Figures 4.6 through 4.9 if different thicknesses have been included in the FEM. The applicant is requested to explain how the determination of the maximum stress included the effects of different skirt thicknesses, manufacturing tolerances, stress concentrations from geometric discontinuities, and the effects of welds on the maximum calculated stress.

03.09.02-81

ANP 10306P, Para 4.2.7.2 (page 4-94)

The applicant applied a fatigue strength reduction factor (FSRF) of 3.0 for the cylinder to flange junction in the calculation of FIV stress. The staff did not find a justification or definition of the FSRF term. The applicant is requested to explain the basis for the fatigue strength reduction factor and why it is applicable for determining FIV stress levels.