ArevaEPRDCPEm Resource

From: Tesfaye, Getachew
Sent: Tuesday, August 03, 2010 2:01 PM
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. 422 (4792), FSAR Ch. 3
Attachments: RAI_422_EMB2_4792.doc

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on June 15, 2010, and discussed with your staff on July 29, 2010. Drat RAI Question 03.09.02-83 was 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: 1772

Mail Envelope Properties (0A64B42AAA8FD4418CE1EB5240A6FED11B56C93ADD)

Subject: U.S. EPR Design Certification Application RAI No. 422 (4792), FSAR Ch. 3
Sent Date: 8/3/2010 2:00:31 PM
Received Date: 8/3/2010 2:00:31 PM
From: Tesfaye, Getachew

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

Post Office: HQCLSTR02.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	763	8/3/2010 2:00:31 PM
RAI_422_EMB2_4792.doc	271354	

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

Request for Additional Information No. 422(4792), Revision 0

8/3/2010

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)

03.09.02-82

Follow-up to RAI 245, Question 03.09.02-42

The staff issued RAI 03.09.02-42 to request further clarification of three items described below:

Item 1. piping attached to the reactor cooling system (RCS) was selected for measurement;

Item 2. the required specifications for the handhelds;

Item 3. discussion for the plans for use of handhelds in characterizing the piping system response relative to the analytical predictions.

The applicant responded to RAI 03.09.02-42 in the Response to RAI 245, Question 03.09.02-42, on August 12, 2009 by stating that that clarifications requested in items 1 and 3 are contained in Comprehensive Vibration Assessment Program (CVAP) Technical Report (AREVA NP Inc. Technical Report ANP-10306P, dated 12/11/09), Appendix A and the required specifications for the handhelds, Item 2, will be determined as part of the initial test program. References to the CVAP Technical Report will be added to the U.S. EPR FSAR Tier 2, Section 3.9.2.1.1 and Table 1.6-1 as shown below (underlined):

The staff reviewed CVAP Appendix A and noted that the applicant provided general plans in Figure A-3 for instrumenting each loop of the RCS to determine fluctuating pressure, in-plane displacement of the reactor coolant pump shaft, in-plane reactor coolant pump frame velocity, and the relative displacement of the RCS cold legs. The placement of these transducers will follow the guidelines of ASME OM-SG 2007, Part 3 (reference 12 of ANP 10306P), for vibration monitoring group 2, VMG2, and that the actual placement will be made by experienced engineering personnel. The applicant also stated that small bore piping that is difficult to access will be monitored per the ASME OM-SG guidelines for vibration monitoring group 3, VMG3. VMG3 involves visual inspection of vibration by trained personnel. However, the applicant is requested to provide an explanation of how piping attached to the reactor cooling system (RCS) was selected for measurement. Therefore, Item 1 of RAI 03.09.02-42 remains open.

In reviewing CVAP section 5, appendix A, and the applicant's "Response to Request for Additional Information No 245 (2981, 3036), Revision 0", the applicant did not provide the detailed information described in SRP 3.9.2 and RG 1.20 for all instrumentation, including the hand held devices. This information includes specifications, locations, and bias and error information; therefore Item 2 of 03.09.02-42 remains open.

In responding to Item 3 of RAI 03.09.02-42, the applicant stated that discussion of the plans for using handheld devices in characterizing the piping system response relative to analytical predictions is found in Appendix A of the CVAP. The staff noted that CVAP Section A.3 of Appendix A provides a discussion that frequency limits associated with accelerometers mounted to an object and hand-held vibration instruments will be considered in the choice of which vibration instrument is selected for a particular application. Both handheld devices and mounted instrumentation are used in assessing piping system vibrations. However, the applicant is requested to provide the plans for use of handhelds in characterizing the piping system response relative to the analytical predictions. Therefore Item 3 of 03.09.02-42 remains open.

03.09.02-83

[Intentionally deleted.]

03.09.02-84

Follow-up to RAI 245, Question 03.09.02-44

The applicant responded to RAI 03.09.02-44 in Response to RAI 245, by referring to the CVAP Technical Report ANP 10306P. The applicant also stated that the spacing between the strain gage stations along the Reactor Cooling System piping, the Main Steam Lines and the Main Feedwater System is variable to prevent the multiple stations from having the same acoustic half-wavelength. The applicant also stated in the CVAP that the two microphone method will be used to compute the amplitude, phase and frequency of the pressures within the pipes, The staff concurs that the two microphone method is an acceptable approach. However, the applicant is requested to provide the equations for the two microphone technique and a discussion of how pressure measurement within the piping systems is used to determine piping integrity.

03.09.02-85

This is related to RAI 03.09.02-44.

The staff noted that SRP 3.9.2 recommends that if the internal pressure is measured using strain gages, they should be placed in a symmetrical pattern circumferentially around the pipe and that a minimum of four strain gages equally placed around the pipe circumference may be used to measure the hoop strain and that the SRP recommends logarithmic spacing of a minimum of three measurement stations along the pipe. The applicant is requested to discuss the numbers and spacing of strain gages, how the strain gages will be calibrated for the pipe they will be mounted on. This requested information is required to complete the review of how pressure fluctuations would be measured and analyzed.

03.09.02-86

Follow-up to RAI 160, Question 03.09.02-18

The staff reviewed the assumptions used in the analysis of non-seismic piping systems. In RAI 03.09.02-18, the applicant is requested to justify why the assumption that all flanges on bolted connections on the non-seismic piping system are assumed to fail, thus allowing each section of piping to fall independently is conservative with respect to the impact evaluation of target components. The applicant responded to RAI 03.09.02-18 by stating that the information in ANP-10264(NP)-A, Section 4.4.2 was evaluated and approved by the NRC in Section 3.2.8 of the Final Safety Evaluation Report for ANP-10264NP-A, which states “All other non-seismic/seismic interaction criteria discussed in TR Sections 4.4.1 and 4.4.2 are found reasonable and acceptable to the staff.”

The staff reviewed the applicant’s response and noted that in the SER of ANP-10264(NP)-A, the staff had raised questions on non-seismic piping isolation criteria in RAI EPR-14 (dated November 2007). The applicant agreed to remove (emphasis added to highlight the issue) some of the interaction criteria given in TR Section 4.4.2 and two other criteria on the failure of the non-seismic piping based on the pipe break analysis procedures. The staff could not determine when the applicant added the assumption that all flanges on bolted connections on the non-seismic piping system are assumed to fail, thus allowing each section of piping to fall independently was added to TR Section 4.4.2, and if this assumption was reviewed and accepted by the staff. Therefore, this issue remains open.

03.09.02-87

Follow-up to RAI 245, Question 03.09.02-45(a)

The staff issued RAI 03.09.02-45(a) requesting the applicant to provide details of the preoperational vibration and test program so that a determination could be made as to whether the applicant followed the recommendations in SRP 3.9.2 Subsection II Acceptance Criteria (4) for a prototype reactor. As stated in the SRP, requirements of GDCs 1 and 4 are met if the preoperational vibration and stress test program for the internals of a prototype reactor conform to the requirements for a prototype test as specified in RG 1.20. In addition, the test program to demonstrate design adequacy of the reactor internals should include those criteria described in letters A through I of Subsection II Acceptance Criteria (4). The applicant responded to RAI 03.09.02-45(a) in the response to RAI 245, by referring to the CVAP Technical Report ANP-10306P, which is described as conforming to the guidance of RG 1.20, Revision 3. The staff noted that the CVAP does not discuss the criteria described in letters A through I of SRP 3.9.2 SRP Subsection II Acceptance Criteria (4) and omits recommendations for vibration predictions, test acceptance criteria and bases, and permissible deviations from the criteria required before testing, as recommended in SRP 3.9.2 Subsection II.4 letter “G”. The staff determined that the proposed CVAP test plan did not meet all recommendations of SRP 3.9.2 Subsection II Acceptance Criteria (4) and therefore could not determine if requirements of GDCs 1 and 4 are met. Therefore, this item remains open.

03.09.02-88

Follow-up to RAI 245, Question 03.09.02-59

The applicant responded to RAI 03.09.02-59 in the response to RAI 245 by referencing the CVAP. The staff noted that the analysis of other components within the recirculating steam generator (RSG) is briefly discussed in CVAP Section B.5 together with a statement that the analyses show that the components will not experience excessive flow induced vibration. The staff noted that neither the analyses nor the results are provided and therefore the staff could not determine if RSG components are vulnerable to flow induced vibration. Each issue associated with FIV of RSG components that requires resolution of RAI 03.09.02-59 is described below.

Four units currently operating in Europe have similar upper internals to the U.S. EPR RSG design and have been operating for a significant period of time:

1. 79/19T RSG – Doel unit 4, in service since 1996 (13 years)
2. 79/19T RSG – Tihange Unit 3, in service since 1998 (11 years)
3. 73/19TE RSG of CZB1, in service since 1996 (13 years)
4. 73/19TE RSG of CV2, in service since 1999 (10 years).

The staff noted that the U.S. EPR has a significantly higher mass flow of steam through the RSG (17.8 percent higher than Doel and Tihange units, and 8.5 percent higher than the CZB and CV units). The applicant is request to discuss the significance of the higher flow rate through the steam dryers with respect to nominal velocity, surface area and the similarity of the four comparison plants.

03.09.02-89

This is related to RAI 03.09.02-59.

The staff noted that “E” in the designator refers to the addition of an axial economizer in the tube bundle used to improve the thermal efficiency to greater than the 79/19T RSG design. The applicant is requested to discuss the influence of the economizer with respect to the impact on the FIV performance and the validity of comparing the Doel and Tihange experience to the U.S. EPR RSG.

03.09.02-90

This is related to RAI 03.09.02-59.

The applicant stated that the primary steam separators are a new design and that the applicant has performed a flow induced vibration analysis to demonstrate the integrity of these separators. The upper frequency limit of this analysis is 350 Hz. The applicant is requested to provide the basis for the 350 Hz upper frequency limit used in the flow induced vibration analysis to demonstrate the integrity of these separators.

03.09.02-91

This is related to RAI 03.09.02-59.

The applicant provided an analysis for the steam separators that follows the analysis performed on the FDD. The damping applied to the model is briefly summarized in CVAP Section B.3.1. The applicant is requested to explain the several damping mechanisms that constitute the total damping coefficient listed below:

a. Structural damping associated with hysteresis of the material,

b. Structural damping created by the non-linear interactions of the lateral supports,

c. Hydrodynamic damping of steam mixture.

The explanation should include the value of these mechanisms and clarification as to whether the uniform structural damping coefficient of 1 percent represents the total damping employed in this analysis or provide the total damping and explain how it was derived. The discussion should follow the same format and level of detail presented in CVAP Section 4.2.5.3.

03.09.02-92

This is related to RAI 03.09.02-59.

The applicant included Figure B-6 from Au-Yang (Flow-Induced Vibration of Power and Process Plant Components, New York, 2001 in discussing the forcing function for the steam separators. This forcing function shows peaks that exceed the Upper Bound curve the applicant used in the analysis. These are at a nondimensional frequency of F=2.5 (+3 dB) and F=3.0 (+30 dB).

Au-Yang presented this pressure psd data from his journal article:

M.K. Au-Yang, K.B. Jordan, Dynamic pressure inside a PWR -- A study based on laboratory and field test data, Nuclear Engineering and Design, Volume 58, Issue 1, May 1980, Pages 113-125.

The staff noted that the pressure psds were measured in the downcomer and that the referenced peaks are due to the cooling pump rotational tones. The reactor cooling pump (RCP) tones are not expected to be present in the recirculating steam generator outside of the primary cooling loop. The applicant is requested to verify that there are no other sources of tones (such as pumps on the feedwater system) or pressure fluctuations in the other components of the main steam and main feedwater systems that may cause the forcing function to exceed the upper bound curve in CVAP figure B-6.

03.09.02-93

This is related to RAI 03.09.02-59.

The applicant is requested to justify the conservatism of the CVAP figure B-6, F>4 portion of the psd where the data exceeds the “upper bound” line by 2 to 7 dB and identify the conservatism of the downcomer turbulent pressures relative to the turbulent pressures in the steam flow in the steam separator.

03.09.02-94

This is related to RAI 03.09.02-59.

The applicant described the fatigue acceptance criteria in CVAP section B.3.2.2 and stated that a fatigue strength reduction factor (FSRF) of 1.0 is applied to unflawed cross sections and 4.0 is applied to flawed cross sections. The applicant is requested to describe how flawed sections are defined and how an FSRF of 1.0 is conservative when applied to such sections. These details must be provided to assess the conservatism of the criteria.

03.09.02-95

This is related to RAI 03.09.02-59.

The applicant provided a comparison of the steam separator response to both the displacement and fatigue criteria and the frequency response functions (FRFs) and mode shapes for the primary steam separator in CVAP section B.3.3. As shown in Tables B-2 and B-3 acceptance criteria are met with very large margins. This is acceptable to the staff. However the applicant did not provided a discussion of bias error or uncertainty for this analysis as recommended in SRP 3.9.2. The applicant is requested to explain the effects of bias error and uncertainty on the results of the analysis shown in Tables B-2 and B-3.

03.09.02-96

This is related to RAI 03.09.02-59.

In CVAP section B.3.3.2, the applicant discusses axial leakage flow vibrations. The staff agrees that restricted channels or tight clearances are a requirement for this type of excitations and therefore, the primary steam separator will not be affected by this mechanism. The applicant is requested to clarify if the statement, “The magnitude of this flow is less than 5 percent of the secondary side flow conditions” relates to recirculation flow less than 5 percent of the mean flow conditions (< 1 fps) and therefore concludes that it is too low to excite the structures.

03.09.02-97

This is related to RAI 03.09.02-59.

The staff noted that acoustic resonances in the piping system due to flow past valve bodies, and branch lines, etc, can excite the structures of the RSG, The applicant is using the methods described in CVAP Appendix A, to ensure that this mechanism is not present in the design of the piping system. The staff agrees that the resonance condition in piping systems due to this mechanism is unlikely as long as this design criteria is met. The applicant is requested to identify all sources of acoustic pressure fluctuation that could excite the volume and structures of the RSG and provide a discussion that addresses excitation of the steam separators due to turbulent cross flow.

03.09.02-98

This is related to RAI 03.09.02-59.

The staff reviewed the applicant's description of the instrumentation for the piping systems external to the RSG but have a contact with RSG (e.g. the main steam, main feedwater and the reactor cooling system) as outlined in Appendix A.3 and shown in Figures A-2 and A-3. The applicant is requested to provide the details of the instrumentation, including types, locations, specifications/ accuracy and ability to detect acoustic resonances that affect the RSG.

03.09.02-99

Follow-up to RAI 245, Question 03.09.02-46

RAI 03.09.02-46 was issued to request details of the assessment of acoustic resonances and self-excited response, along with discussion of the bias errors, uncertainties, and operational experience as described in the vibration assessment program for the U.S. EPR RPV internals.

The applicant responded to RAI 03.09.02-46 in Response to RAI 245, by citing the CVAP. The staff requests the applicant to address the following concerns with acoustic excitation due to loop oscillations described below.

In CVAP section 4.2.5.2.2 (and referenced by CVAP ref. 4.3.2), the pressure fluctuations associated with loop acoustics are not included in the numerical simulations (lower internals). The applicant states that under the appropriate circumstances, it is possible for the fluid momentum change as the coolant enters the downcomer to exhibit large magnitude and coherent pressure fluctuations that can excite the large structures. The applicant further stated that if significant response of the RV lower internals to loop acoustics is observed during HFT, then the numerical model will be modified to include this source. Given this understanding and stated capability, the applicant is requested to either include the loop acoustics in the model prior to the HFT or to strongly justify reserving the analysis until a problem is discovered.

03.09.02-100

This is related to RAI 03.09.02-46.

The flow distribution device, FDD, (CVAP section 4.3.2) and the irradiation specimen basket (CVAP section 4.4) analyses also do not include loop acoustic pressures. The applicant justifies not including this forcing function on the relatively high frequencies of lowest modes of these structures; 68 Hz for the FDD and 427 Hz for the irradiation specimen basket. The applicant is requested to provide the anticipated frequency range and amplitude of the loop acoustic source together with the source of that estimate.

03.09.02-101

This is related to RAI 03.09.02-46.

For the other structures of the Upper Internals, the applicant justifies not including the loop acoustic source based upon an anticipated inability of the acoustic pressures to pass through the fuel bundle, this is a potential if viscous losses through the core are high enough to dissipate such potentially long wavelengths. In typical noise control applications, a baffle or absorber is required to be a minimum of ¼ of the wavelength of the sound intended to be treated. Assuming that a height of the fuel bundle of 15 feet, this would place the frequencies on the order of 60 Hz for this mechanism. With lowest predicted modal frequencies for the columns in the upper internals ranging from 40 to 80 Hz, the applicant is requested to provide justification or documentation for anticipating that propagation through the fuel bundle removes the possibility of exciting the upper internals.

03.09.02-102

Follow-up to RAI 245, Question 03.09.02-47(a-c)

RAI 03.09.02-47(a through d) was issued to request the method for combining the uncertainties and bias errors and the effect of these on the resulting overall stress and vibration response prediction of the RPV internals. The applicant responded to RAI 03.09.02-47 in Response to RAI 245, by citing the CVAP vibration assessment program for the U.S. EPR RPV internals. The applicant is requested to address the following concerns based on the staff's review of the CVAP as it relates to RAI 03.09.02- 47(a through c) (note that the applicant's response to RAI 03.02.02-47d is acceptable and open item RAI 03.02.02-47d is closed).

The staff noted that in CVAP paragraph 4.2.5.1.3, the applicant stated that the structural frequencies of the lower internals are not altered by the FA loaded core. The applicant also stated that FA add significant damping to the structure. Therefore, the model without including FA is conservative because the frequencies are the same (as shown in CVAP Tables 4-5 and 4-6) and lower damping resulting from the absence of the FA will result in higher predicted vibration amplitudes that result in conservative stress levels. The applicant is requested to provide the different FA damping values associated with an empty and full core used for determining the results tabulated in CVAP Tables 4-5 and 4-6 that accounts for the relative minor change (i.e 5%) in Core Barrel (CB) and Heavy Reflector (HR) beam frequencies.

03.09.02-103

This is related to RAI 03.09.02-47 (a).

The staff noted that HFT Test number 17 requires that the core to be loaded with dummy fuel assemblies. The staff estimated the mass of the FA to be approximately 412,000 lbs based on a core consisting of 241 fuel assemblies, with each assembly weighing 1730 lbs. The applicant is requested to provide the mass of the CB and HR and explain why the additional FA mass will not impact the structural frequency.

03.09.02-104

This is related to RAI 03.09.02-47 (a).

The staff noted that the applicant described viscous damping was the only mechanism found to contribute to the shell modes. The contribution of viscous damping over the frequency band of 2.5 to 10 Hz was calculated using formulation by R. J. Gibert. The staff noted that the cited reference has not been used by other applicants. The applicant is requested to provide documentation that the methodology is an approved industry approach accepted by the NRC or an alternate source for this calculation.

03.09.02-105

This is related to RAI 03.09.02-47 (a).

The dynamic model of the upper internals is described in CVAP sections 4.5.1 and 4.5.3. The damping used in the analysis is provided in CVAP sections 4.5.1.1.2, 4.5.1.1.3, 4.5.1.1.4 and Table 4-17. Values used for the upper internals are acceptable. However, the applicant is requested to provided either FRFs or mode shapes for the upper internals that form the basis of the upper internals dynamic model.

03.09.02-106

This is related to RAI 03.09.02-47 (a).

The CRGA, the normal support column, the level measurement probe (LMP) and the guide tubes modal frequencies are provided in CVAP Table 4-18. The staff reviewed CVAP section 4.6.5 and did not locate the modal frequencies, the mode shapes or the FRF for these components. The applicant is requested to provided the modal frequencies, the mode shapes and the FRFs that form the basis of the CRGA and RCCA dynamic models.

03.09.02-107

This is related to RAI 03.09.02-47 (a).

The tie rods are described as (8) pre-stressed, long hollow tubes in CVAP section 4.7.1, used to hold the HR slabs together during removal of the lower internals. The applicant stated that tie rods are “not absolutely needed from an FIV perspective” during normal operating or transient conditions. The applicant is requested to explain what is meant by “not absolutely needed from an FIV perspective” and provide the modal frequencies, the mode shapes and the FRFs that form the basis of the tie rod dynamic model, details of the analysis and evaluation of the measurements.

03.09.02-108

The staff requested the applicant to provide the method for combining the uncertainties and bias errors and the effect of these on the resulting overall stress and vibration response prediction of the RPV internals in RAI 03.09.02-47c. The applicant responded by referencing CVAP sections 4.2.2.4 for the lower internals, 4.3.2.1 for the FDD, 4.5.1.1.4 for the upper internals, 4.6.3.2 for the CRGA and RCCA and section 4.7 for the heavy reflector tie rods. The staff did not find a discussion of the bias errors and uncertainties associated with the analysis of these components. The applicant is requested to discuss in quantitative and definitive terms, the methods for ascertaining and incorporating the bias errors and uncertainties in the calculation of the natural (resonant) frequencies, the peak response magnitude, mean FE response, the stress magnitude and tabulate the values of these bias errors and uncertainties.

03.09.02-109

Follow-up to RAI 245, Question 03.09.02-48 (a-d)

RAI 03.09.02-48 was initiated to request that the applicant to provide the description of the CVAP program that is referenced in the response to RAI 03.09.02-29, letters A through G. The applicant responded to RAI 03.09.02-48 in Response to RAI 245, by citing the CVAP. The applicant is requested to address the following concerns based on the staff’s review of the CVAP as it relates to RAI 03.09.02- 48(a through d).

Section 4.2.1.2 of the CVAP indicates that for the first three phases, specific instrumentations, including force transducers, displacement sensors, and accelerometers, are used depending upon the objective of the tests. A description of instrumentation and placement of transducers for the flow portion of the testing is included in Figure 4-3 and 4-4, but a comprehensive description of instrumentation for all phases of testing and the required specifications for the transducers is not provided. Therefore, the applicant is requested to explain how the CVAP program is meeting the requirements of SRP 3.9.2 acceptance criteria 4 (B), which states that the vibration monitoring instrumentation should be described briefly, including instrument types and specifications (including useful frequency and amplitude ranges) and diagrams of locations, including those with the most severe vibratory motions or the most effect on safety functions.

03.09.02-110

This is related to RAI 03.09.02-48 (a).

The applicant was requested to explain the dynamic similarity of the model tests to the full scale structures and operating conditions being analyzed. CVAP section 4.2.5.2.1

states that the dynamic similitude between the scale model and full scale is created using Strouhal Number scaling of the Turbulent Pressure Spectra, while noting that the Reynolds Numbers between model scale and full scale are different by a factor of nearly 100. The staff noted that dynamic similarity between any two scales requires that force ratios be the same between the two scales. Since the Reynolds number is the ratio of viscous to inertial forces, the fact that it is different between scales, indicates that dynamic similitude between the scale model and full scale has not been achieved. The staff noted that partial similarity is sufficient provided it is justified through application of conservatism as required in the SRP, Acceptance Criteria, paragraph 3.A.ii.1.a. Therefore, the applicant is requested to explain:

1. the large difference between model and full-scale Reynolds Number;

2. if Strouhal number scaling of the pressure spectra results in a conservative estimate of the turbulent pressure spectra that supports the partial similarity between the model scale and full scale; and

3. the significance of operating the model scale with the same mean flow speed in the downcomer as the full scale.

03.09.02-111

This is related to RAI 03.09.02-48 (b).

The applicant provided a comparison of the modal response of the HYDRAVIB test facility to the FEA model of the HYDRAVIB in CVAP section 4.2.2.3 of ANP 10306P. The techniques employed in modeling the 1/8.168 scale structure are used in modeling the full scale structure. Thus, the model scale could be used to assess the bias and uncertainty in the FEA modeling technique. Two tests models were developed; one without the effects of water and one with the effects of water. The results indicate that the scale model measured results and the FEA structural model computed results for the lower frequency core barrel (CB) “pendulum” mode are closely matched within 4 percent but are mismatched (13 to 26 percent) for the other modes occurring at higher frequencies for the “dry” model without the effects of water. This indicates a strong frequency bias in the modeling technique. The staff noted that modal testing was repeated only for the CB “pendulum” mode under “wet” conditions and did not include the other modes occurring at higher frequencies as was done for the “dry” model. The applicant is requested to provide a discussion of the rational for the differences in the wet and dry testing.

03.09.02-112

This is related to RAI 03.09.02-48 (b).

The applicant is requested to provide a discussion and of the application of a frequency bias and uncertainty in their FEA predictions and the specifics about the locations, models, and reason for placement of transducers for the water filled modal testing (as originally requested in RAI 03.09.02-29b).

03.09.02-113

This is related to RAI 03.09.02-48 (b).

The applicant described the modal damping ratio for the HYDRAVIB model in CVAP Section 4.2.3. The scale model was tested to determine the damping but only the CB beam-type modes were acquired. The result of the CB beam-type mode determined a damping ratio of 3.1 percent, which is applied throughout the model for both beam-type modes and shell modes. It is noted that RG 1.20 recommends justification of damping ratios greater than 1%. The staff did not find justification for the use of such a high modal damping ratio for submerged components in a water environment or the frequency response functions (FRFs) used to compute the damping. The applicant is requested to provide a detailed description of the testing that determined the 3.1% damping ratio, including a discussion of the instrumentation, instrumentation locations and rationale for their placement.

03.09.02-114

This is related to RAI 03.09.02-48 (b).

The CVAP includes descriptions of pressure transducer locations and the models of the transducers used for developing the turbulent pressure spectra and the input forcing functions in the FEA model. The placement of the transducers for their intended measurement is acceptable. However, the applicant is requested to provide additional detail describing each of the primary forcing locations, inlet jets, RV downcomer and lower support plate to determine if the scale model pressure measurements are acceptable. Figures 4-12, 4-13, and 4-14 should include the information provided in figure B-6 specific to their locations. Discussion of the figures should include whether the final forcing function curve represents an upper bound of the measurements, or justify the type of averaging (power, linear, ensemble, etc) used to obtain the forcing function for use in the models, the impact of the transducer accuracy on the final curve and if any peaks exceed the final curve. The discussion should include how the final curve serves as a conservative estimate of the forcing function. Lastly, the parameter Stc (see pg 4-28) should be defined in the text.

03.09.02-115

This is related to RAI 03.09.02-48c, (follow-up RAI to 03.09.02-29).

In RAI 03.09.02-29, letter (c) the staff requested the applicant to explain how comparisons of small scale model and analytical model results are used, specifically with respect to the procedures used for the full scale structure. The applicant provided the approach in CVAP sections 4.2.2.3, 4.2.3.2, 4.2.4 and information on the implications of the comparison to full scale model is found in CVAP section 4.2.8. This includes a comparison of the numerical and the experimentally derived modal solutions of the HYDRAVIB 1/8.168 scale model of the RV internals for non-operational modes in air (dry) and in water (wet). These comparisons were performed to verify modeling techniques for the FEM and forcing functions for application to the full scale EPR reactor vessel lower internals. In CVAP section 4.2.2.3, the scale model modal numerical (i.e.

FEA) results are considerably higher in frequency than the corresponding experimental results for dry HR modes. The applicant states that this indicates that the model of the HR is stiffer than the experimental structure and that “no attempt was made to precisely match the experimentally obtained frequencies because these values are only representative of the HR mockup structure.” The staff noted that the wet modal results, while matching experimentally determined CB pendulum modes well, have no corresponding comparison to any of the HR modes because the modes were “not identified” in the experimental results. Therefore, the staff concluded that the basis for the validation of the numerical solution is from comparison of the results of only the CB “pendulum” mode. The applicant is requested to confirm this assumption.

03.09.02-116

This is related to RAI 03.09.02-48c.

The staff did not find a discussion or supporting data from the experimental wet modal testing to indicate why the HR modes were not identified in the results. In addition, the staff noted that the description of the CB “pendulum” mode does not describe the modeling of the water in the downcomer and the annulus between the CB and the HR. The applicant is requested to explain the basis for the water coupled HR/CB mode modeling and the conservatism in the modeling procedure and the corresponding conservatism applied to the full scale FEM.

03.09.02-117

This is related to RAI 03.09.02-48c.

The staff noted that data in the CVAP indicates that a large frequency shift by more than a factor of 10 lower occurs from the dry to wet case modes for the HR. The staff agrees that a downward shift in frequencies is to be expected due to the effects of water loading and the coupling of the structures because of thin water annuli between them. However, modeling the HR as a stiffer structure than the experimental model may also affect the magnitude of this frequency shift. The applicant is requested to:

1. explain how the lack of a basis for the water coupled HR/CB modes affects the conservatism of modeling procedures and on the conservatism of the full scale FEM

2. explain the difference in the modeling of the HYDRAVIB HR and the modeling of the full-scale HR and why the full scale HR does not have the same higher stiffness indicated by the HYDRAVIB dry and wet modal responses discussed in section 4.2.2.3.

03.09.02-118

This is related to RAI 03.09.02-48c.

The small scale HYDRAVIB experimental program was also used to develop turbulent pressure forcing functions for the full scale RV lower internals. As described in CVAP section 4.2.3.2, these experimentally derived pressure spectra were applied to the numerical model of the HYDRAVIB and compared to the numerical and experimental structural responses. Numerical results were provided from 0 to 1.5 times the “global beam” mode frequency and indicated that the dominant response could be expected to be from the global beam mode. A comparison of the maximum response for the 45 to 75 Hz to the experimental results (see CVAP Tables 4.3 and 4.4) indicates that the FEM model tends to under predict both the frequency and the amplitude of the response relative to the listed experimental results. The applicant is requested to explain how the comparison of experimental modal response to numerical modal response shown in CVAP section 4.2.3.2, Tables 4.3 and 4.4, relates to the comparison of the “global beam mode” with the “global pendulum” motion listed in CVAP Table 4.2. The applicant should explain if these comparisons refer to the same mode and why there a discrepancy between the frequencies listed for the mode.

03.09.02-119

This is related to RAI 03.09.02-48c.

The staff noted that the conclusions discussed in CVAP Section 4.2.4 do not agree with the results tabulated in CVAP Table 4.4. Further, the response curves of CVAP Figures 4.16 and 4.17 do not appear to agree with the values listed in CVAP Tables 4.3 or 4.4, but rather indicate frequencies closer to those listed in CVAP Table 4.2. The applicant is requested to reconcile the values used for conclusions reached in CVAP Section 4.2.4 with those tabulated in the CVAP Tables 4.2, 4.3 and 4.4, and CVAP Figures 4.16 and 4.17.

03.09.02-120

This is related to RAI 03.09.02-48c.

As shown in CVAP Table 4.4, the 0 to 100 Hz response was not determined for the CB and HR. The applicant is requested to explain why the broadband response was omitted from the displacements that were measured during the HYDRAVIB Mockup Flow Test and provide experimental response PSDs consistent with CVAP Figures 4.16 and 4.17 for comparison.

03.09.02-121

This is related to RAI 03.09.02-48c.

The staff noted that the CVAP tables list the response amplitudes in mils, rms while the PSDs are in mm^2, rms. The applicant is requested to provide consistent units for both the numerical and the experimental response spectra to aid in comparison of the tabulated results.

03.09.02-122

This is related to RAI 03.09.02-48c.

The staff concluded that results of the HYDRAVIB Mockup Flow Test indicate that the dominant response of the lower internals is the global pendulum mode. The applicant is requested to explain how non-symmetric loading from one, two and three RCPs in service affect the magnitude of the response and the implications on the full-scale RV lower internals.

03.09.02-123

This is related to RAI 03.09.02-48c.

The applicant stated in CVAP Section 4.2.1, that the HYDRAVIB scale model was designed to make an assessment of the lower internals vibrations induced by flow turbulences in the downcomer and the RV bottom head, and to identify other potential sources of flow-induced vibration phenomena like vortex shedding (discrete frequency). The staff noted that the applicant only included an assessment of flow-induced vibration due to turbulence and did not include an assessment of flow-induced vibration from other sources. The applicant is requested to provide an assessment of other sources of flow induced vibration that could be determined by the HYDRAVIB and the implications of the testing on the full scale RV internals.

03.09.02-124

This is related to RAI 03.09.02-48d, (follow-up RAI to 03.09.02-29).

In RAI Question 03.09.02-29 letter (d), the staff requested the applicant to discuss the analysis methodologies or software used in the modeling of both the full scale and the scale model structures, including the methodology used to assess the accuracy, limitations and applicability of the software package or analysis procedure. The applicant described the use of the PCRANDOM software in CVAP Section 4.3.2 for the flow distribution device (FDD). The modal responses of the column supports were determined at full power operating temperatures and conditions using the applicant’s CASS structural analysis program. The applicant stated that the limitations and accuracy verification against the classical closed form solutions are documented in the applicant NP Inc certification reports for the CASS software. The applicant employs AREVA NP computer code PCSTAB2 to perform the fluid-elastic instability analysis. These software codes are internally developed and maintained analysis software programs, therefore the applicant is requested to supply evidence that they have been used in a previously accepted NRC applications.

03.09.02-125

This is related to RAI 03.09.02-48d.

The staff noted that CVAP section 4.3.2.1 describes the development of the turbulent pressure forcing function that was the turbulent pressure spectrum prior to performing the HYDRAVIB model scale test. CVAP Figure 4.28 demonstrates that the forcing function is conservative over the range of nondimensional frequencies from 0.5 to 10. Comparing CVAP Figure 4.28 to 4.29 based upon the inflection point at F=2 (25 Hz), indicates that the conservative range of the forcing function covers a frequencies from about 6 Hz to 125 Hz. The staff noted that this appears to indicate that the lower frequency limit is acceptable based upon the first modal frequency of the FDD of 68 Hz, the applicant is requested to confirm this comparison and discuss the comparison of the HYDRAVIB and the estimated nondimensional pressure spectrum below F=0.5.

03.09.02-126

This is related to RAI 03.09.02-48d.

Based on the upper limit discussed in CVAP section 4.3.2.1, the applicant is requested to expand CVAP Figure 4-28 to include the full range of CVAP Figure 4.29 and the analysis of the FDD so that the conservatism of the turbulent pressure spectrum can be assessed.

03.09.02-127

This is related to RAI 03.09.02-48d.

The applicant included the RCP shaft rate and blade rate acoustic pressure estimates of 0.1 psi, rms in the pressure forcing function. The staff did not find where the applicant discussed the basis of the estimated RCP shaft rate and blade rate acoustic pressure amplitudes. The applicant is requested to provide the basis for determining the RCP shaft rate and blade rate acoustic pressure amplitudes.

03.09.02-128

This is related to RAI 03.09.02-48d.

The applicant estimated a bandwidth of the acoustic signal based upon the viscous damping of the fluid. The frequency of the shaft rate tone and its harmonics will be governed by the stability of the rpm of the RCP. Variations in the RCP rpm will cause corresponding variations in the frequency of the shaft rate tone. Operating the RCP at 23 Hz will result in the pump blade passing frequency increasing to 138 Hz which corresponds to the 138 Hz plate mode of the FDD. Additionally, a 10 percent RCP over speed will place the rpm of the RCP at 22 Hz which results in the center frequency of the blade passing frequency increasing to 132 Hz which is very close to the 138 Hz plate mode of the FDD. The staff noted that the bandwidth of the RCP shaft rate harmonics are not wide enough to cover this contingency. Therefore, the applicant is requested to discuss how the analysis accounts for frequency bias and uncertainty in the modeling and in the forcing function which includes these potential effects.

03.09.02-129

This is related to RAI 03.09.02-48d.

The staff noted that the amplitude of the pressure does not appear to change when a comparison of CVAP Figures 4.28 and 4.29 is made. The amplitude in both figures at

F=0 (0 Hz), F=2, (25 Hz) and F=10 (125 Hz) appear to have the same numerical value. The applicant is requested to verify the axis label on figure 4-29. If correct, the applicant is requested to provide the numerical values of the normalizing variables.

03.09.02-130

This is related to RAI 03.09.02-48d.

The staff noted that in CVAP Section 4.5.1.1.2, the applicant detailed the analysis of the columns for vortex shedding induced vibration. The staff agrees that the procedure to estimate the response of the columns to off-resonant conditions by applying the fluctuating lift and drag forces with an appropriate amplification factor is acceptable. However, the applicant is requested to provide the fluctuating lift and drag forces for use with this procedure along with the methods used to derive them.

03.09.02-131

This is related to RAI 03.09.02-48d.

The applicant detailed the analysis procedure for fluid-elastic instability in CVAP Section 4.5.1.1.3. The applicant states that the fluid-elastic calculations will be performed for the CRGA but fluid-elastic analysis was not performed for the Normal columns, the LMP and the Instrumentation Guide Tube. The applicant is requested to provide justification for not performing the fluid-elastic instability analysis for the normal columns, the LMP and the instrumentation guide tube.

03.09.02-132

This is related to RAI 03.09.02-48d.

The staff reviewed the applicant’s use of the FSM to insure that the pitch velocity is less than the critical velocity given by Conner’s equation and determined that it is acceptable. The applicant uses a factor of safety for this ratio of 30%. The applicant is requested to discuss this factor of safety in relation to the bias and errors in the calculations that underlie the estimation of the pitch velocity in order to justify the value.

03.09.02-133

This is related to RAI 03.09.02-48d.

The applicant detailed the analysis procedure for the upper plenum internals random turbulence induced vibrations in CVAP Section 4.5.1.1.4,. This is also known as turbulent buffeting and results from cross flow conditions above the upper core plate as flow progresses to the outlet nozzles. The methodology is standard and follows the work of Pettigrew and Gorman, referenced in the ASME Boiler and Pressure Vessel Code, 2004. Further, the applicant discuss the mean square vibratory amplitude in terms of a single sided random force PSD. The applicant is requested to provide a discussion of the derivation of this force PSD form the pressure PSD obtained from the Random Lift Coefficient of CVAP Figure 4-34.

03.09.02-134

This is related to RAI 03.09.02-48d.

The applicant is requested to review (and correct) a possible discrepancy in the definitions of the Random Lift Coefficient given in the CVAP text on pg 4-131, where it is listed as having the value of 0.01 for f > 120 Hz, while in CVAP Figure 4-34, it is listed as possessing a value of 0.01 for f = 65 Hz. The staff noted that this correction is especially important since the analysis of the turbulent buffeting extends above 300 Hz for the instrumentation guide tube.

03.09.02-135

This is related to RAI 03.09.02-48d.

The staff noted that the applicant uses acceptable values for the correlation length (2*OD) and for the structural damping coefficient (1 percent) for the instrumentation guide tube. The applicant is requested to provide a discussion of the use of the correlation length in the analysis procedure and the calculation of the Joint Acceptance integral.

03.09.02-136

This is related to RAI 03.09.02-48d.

The applicant described the CRGA (tie rods, c-tubes, rod cluster control assembly (RCCA) in CVAP Section 4.6.3.1. The internal components of the CRGA and which portions of the structure will be susceptible to FIV are described in CVAP Section 4.6.3. The applicant is requested to provide a diagram of the CRGA showing the relationship of the various components, the position relative to the UCP, and the USP as well as which components are exposed to the flow. Such a diagram is required to adequately assess the statements on CVAP page 4-149 regarding which components are not evaluated for FIV.

03.09.02-137

Follow-up to RAI 245, Question 03.09.02-49

The applicant responded to RAI 03.09.02-49 in Response to RAI 245, by citing the CVAP. The applicant described justification for not performing an explicit transient analysis of the reactor vessel (RV) lower internals in CVAP Sections 4.2.8 and 4.3.5. The staff noted that justification given for not explicitly analyzing transients is that the primary loading for the lower internals is high cycle fatigue and that transient analysis is not warranted. To bolster the argument, the applicant estimates the response of the lower internals to a 10 percent reactor coolant pump over speed by considering the effect of increasing the coolant flow through the reactor by 10 percent and scaling the turbulent forcing functions on the increased dynamic pressure and results in an increase in the turbulent forcing functions of $(1.1)^2$. The staff noted that this type of increase would occur if all four pumps were simultaneously operating at a 10 percent overspeed. However, in CVAP Section 4.5.1, the applicant indicates that the four RCP line-up 10% overspeed condition may not be the highest transient to consider. The applicant suggests that the two pump operation will result in higher response by the upper internals. The applicant is requested to discuss this statement and explain why the 10 percent overspeed for all four RCPs is the bounding case for the RCP operation.

03.09.02-138

This is related to RAI 03.09.02-49.

The applicant stated that the piping system design is not completed, but provides assurance that the design process discussed in CVAP Section A.2.1 will prevent the flow excitation of acoustic resonances in the piping system. The mechanism discussed is due to shear wave resonance from flow over the cavities in safety relief valves, standoff pipes for valves and branch lines coupling with the acoustic modes of the piping branch. The staff noted that the applicant is extending the range of Strouhal number to 0.3 to 0.63 based on their response to RAI 03.09.02-65. The staff accepts that the applicant's design practice will make acoustic resonances in the RCS and piping attached to the RSG unlikely and thus, for the conditions of plant operation through normal full power operation, will be met when the applicant provides a piping design which meets this Strouhal number standard. In addition, the applicant stated that sensitivities in the arrangement, design and operating conditions on the degree of margin to acoustic resonance will be considered later in the design process. The applicant is requested to verify that these requirements are included in the design ITAAC for these piping systems.

03.09.02-139

Follow-up to RAI 245, Question 03.09.02-51

The staff issued RAI 03.09.02-51 as a follow-up to RAI 03.09.02-32 requesting the analysis of the full-scale CRGA components that demonstrates acceptable vibrational behavior.

The applicant responded to RAI 03.09.02-51 in Response to RAI 245, by stating that the details of the analyses and testing that will indicate acceptable behavior, including the acceptance criteria, details on the validations of the test plan, and the instrumentation and test conditions that will be used in the U.S. EPR preoperational testing, to confirm the acceptable CRGA design, are provided in Sections 4.6 and 5.0 of the CVAP Report.

The staff reviewed the applicants response to RAI 03.09.02-51 and noted that the applicant references CVAP section 4.6 for the analysis of the CRGA design. The acceptance criteria for the CRGA was reviewed by the staff in response to RAI 03.09.02-48E.

The analysis techniques follow those for the rest of the upper internals found in CVAP Sections 4.6.3 that were reviewed by the staff in response to the applicant's answer to RAI 03.09.02-48D.

The applicant referenced CVAP Section 5.0 for the test details, the instrumentation details and the test conditions. The instrumentation for the CRGA are found in CVAP section 5.2.2.3 and all are intended to be temporary. Only the portions of the HFT that pertain directly to the CRGA are discussed in the response to RAI 03.09.02-51. The remainder of the test requirements are discussed in the review of the applicant's response to RAI 03.09.02-48G and RAI 03.09.02-54.

The staff reviewed the applicants description of the intended instrumentation suite as described in CVAP Section 5. The set of instrumentation specified for determining the response of the CRGA column and CRGA internals is sufficient to obtain the upper bound response provided most of the instrumentation survives throughout testing.

The staff noted that one of the CRGAs which is located in a region anticipated to offer the highest cross flows has been chosen to measure the reaction of the CRGA column. This column is located at S6, which is on the outer periphery, near the center outlet jet port for loop 4. This CRGA column has been instrumented with four strain gages near the connection to the Upper Support Plate (USP). Two of these are intended to be redundant. However, if only two of these fail on opposite sides of the column, one of the principle directions will be lost. One of the guide plates, located at midspan of the CRGA at S6, has been instrumented with two accelerometers, oriented to measure in the horizontal plane at 90 degrees to each other.

Based on the CVAP description, the applicant is requested to:

A. Confirm that the instrumentation on the CRGA at S6 is intended to be oriented in the mean flow direction and transverse to the mean flow direction. Under this assumption, if either accelerometer fails, one of the principal directions will be lost.

B. Discuss the impact of failing transducers and the potential negative impact to achieving the stated HFT goal of characterizing the behavior of the CRGAs and columns (see CVAP Section 5.2.2.3).

C. Discuss options or plans for increasing the number of transducers installed or replacing failed transducers during the test phase. Note that the guide plate of a second CRGA, located at J9, in the center of the core support plate, is instrumented with two radial accelerometers, oriented at 90 degrees to each other.
D. Discuss the methodology, analysis, or rationale used for selecting the guide plate in these two CRGAs, one at the periphery and the second in the center.

03.09.02-140

Follow-up to RAI 245, Question 03.09.02-53

The staff issued RAI 03.09.02-53 as a follow-up to RAI Question 03.09.02-34. The staff concludes that the applicant needs to provide the comprehensive vibration assessment program for review by the NRC staff as part of the FSAR to meet 10 CFR 52.47. Therefore, RAI 03.09.02-53 is initiated requesting the program with a description of the nondestructive testing.

Tha applicant responded to RAI 03-09.02-53 in their Response to Request for Additional Information No. 245, Supplement 4. The applicant stated that process and type of nondestructive testing planned during the inspections process, the monitoring and testing equipment, and the manner in which the components will be removed from the reactor vessel (RV) and placed on the storage stand is outlined in CVAP, Section 6.0. As stated in Section 6.0, the inspection results of the RV and the RV internals will be considered acceptable if there is no indication of abnormally large vibration amplitudes or excessive wear. The applicant also stated in Section 6.1 that non-destructive testing is not planned for the inspection of the RV or the RV internals.

The staff noted that Section 2.3 (3) of Reg. Guide 1.20 (Rev-3) recommends that an applicant provide description of the inspection procedure, including the method of examination (e.g., visual and nondestructive surface examinations), method of documentation, provisions for access to the reactor internals, and specialized equipment to be employed during the inspections to detect and quantify evidence of the effects of vibration.

The applicant is requested to explain why they have excluded the non-destructive testing as recommended by Reg. Guide 1.20, (particularly surface examinations) when it is known that visual inspections will not be sufficient to reveal any cracks that might have initiated due to Flow Induced Vibrations during the HFT lasting a duration to fatigue cycle the RV internals to10^6 cycles.

03.09.02-141

Follow-up to RAI 245, Question 03.09.02-54

The applicant responded to RAI 03.09.02-54 in Response to RAI 245, by stating that a response to this question will be provided in the CVAP Technical Report ANP-10306P.

The staff noted that applicant was requested to provide a discussion of the factors that influence the comparison of the test results to the analysis and how they will be incorporated into the testing program. The applicant states that the experimentally obtained vibration amplitudes, frequencies and stresses will be compared to the analytical values and the appropriate criteria developed in CVAP Section 4. The applicant is requested to explain:

a. what is meant by sufficient safety margin

b. what will constitute a match between the experimental and analytical frequencies or amplitudes

c. quantitatively how the errors will be combined with the measurements to indicate sufficiently good comparisons

d. how fluid-elastic instability, acoustic resonance and vortex-shedding lock-in will be quantitatively determined.

The applicant provided a discussion of the test acceptance criteria and many of the parameters that can influence the collection of the data in CVAP sections 4, 5.4 and 5.5.

The applicant has stated that deviation between theoretical predictions and measured values may result in changes to the theoretical evaluation if the differences have an impact on the integrity of the RV internals. The applicant is requested to explain how it will determine that a particular deviation between experimental results and analytical results impact the integrity of the RV internals.

03.09.02-142

Follow-up to RAI 245, Question 03.09.02-60

The staff issued RAI 03.09.02-60 as a follow-up to RAI 03.09.02-26.

The applicant responded to RAI 03.09.02-60 in Response to RAI 245, by referencing their response to RAI 03.09.02-40, which states that the Initial Test Program (ITP) contains several tests that will require monitoring vibration and dynamic effects. The applicant further stated that the ITP "will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the steam generation system." These tests are found in U.S. EPR FSAR Tier 2, Section 14.2. Specifically, tests 164 and 165 as examples of the tests that will be conducted which apply to measurement of the steam system vibration response. The staff examined these tests and the others found in Section 14.2 in abstract form and did not find where the applicant discussed the sensitivities of the steam system components and operating points which could result flow-induced resonance effects in the steam system and steam generator as requested above. Further, the staff could not locate discussion of how the startup test plan will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the steam generation system. Therefore, this item remains open.

03.09.02-143

Follow-up to RAI 287, Question 03.09.02-61

The applicant stated that as a result of the ASME response for ductwork stress allowables, U.S. EPR FSAR Tier 2, Section 3A.2.4.1 will be revised to show the combined membrane and bending stress allowable for Level C as 1.8 x 0.6Fy to be consistent with Table AA-4321 of ASME AG-1, 2003. The proposed markup to U.S. EPR FSAR Tier 2, Section 3A.2.4.1 is shown below.

3A.2.4.1 Allowable Stress Criteria

Ductwork stresses are based on Reference 4. Ductwork support stresses are based on AISC "Specification for the Structural Steel Buildings - Allowable Stress Design and Plastic Design," contained in Reference 3.

03.09.02-61

The basic general membrane design stress for Service Level A condition does not exceed 0.6 F_y and is reduced as appropriate to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level A does not exceed 1.5 x 0.6 F_y. The basic general membrane design stress allowable, and the combined membrane and bending stress allowable for Level B are the same as those for Level A. The basic general membrane stress for Service Level C condition does not exceed 1.2 x 0.6 F_y and is reduced as necessary to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level C does not exceed ~~0.9~~1.8 x 0.6 F_y. The basic general membrane design stress for Service Level D condition does not exceed the lesser of 1.5 x 0.6F_y or 0.4S_u, where S_u is the ultimate stress. The combined membrane and bending stress for Service Level D does not exceed the lesser of 2.25 x 0.6F_y or 0.6S_u.

The staff reviewed the proposed revision to U.S. EPR FSAR Tier 2, Section 3A.2.4.1 and identified the following issues:

a. The applicant has identified various references for ductwork stresses. For example, the applicant stated in U.S. EPR FSAR Tier 2, Section 3A.2 that safety related, seismic category I and II HVAC ductwork, supports and restraints meet the stress allowables provided in ASME AG-1-2003, Code on Nuclear Air and Gas Treatment, with 2004 Addenda (reference 2). The applicant also stated in U.S. EPR FSAR Tier 2, Section 3A.2.4.1 that ductwork stresses are based on Reference 4, (American Iron and Steel Institute (AISI), North American Specification for the Design of Cold-Formed Steel Structural Members, 2001 Edition with 2003 Errata), which is referenced in paragraph SA-4220 of ASME AG-1. However, the applicant stated in response to RAI 287 03.09.02-61 that ductwork stresses are based on paragraph AA-4300 of ASME AG-1, which uses the allowable stress from Article AA-3000. The applicant is requested to clarify the basis for ductwork stresses.

b. The applicant stated the ductwork allowable stress is consistent with Table AA-4321 of ASME AG-1, 2003. ASME AG-1 Table AA-4321 primary stress allowables are based on design stress (S). Design stress (S) for ASME materials is tabulated in various tables, such as Tables 1A and 1B of ASME Section II, Part D. The design stress (S) for the materials in each table is derived as described in mandatory appendices. For example, design stress (S) in Tables 1A and 1B is derived as described in Mandatory Appendix-1, "Basis for Establishing Stress values in Tables 1A and 1B" of ASME Section II, Part D. The design stress (S) includes affects of various factors such as factor of safety against yield, factor of safety against rupture, yield at at room temperature, yield at design temperature and others factors. The staff noted that allowable stress in American Iron and Steel Institute (AISI) is based on the term (F_y). The applicant is requested to reconcile the use of the term

($0.6F_y$) in place of the design stress (S) term in Table AA-4321 to derive the stress allowables for service levels A through D.

03.09.02-144

The applicant stated that only representative trains of piping systems are monitored as part of the CVAP. The staff requested an explanation of how a problem area will be identified so that corrective action can be taken, or describe how measuring representative piping systems will determine that excessive vibration is not occurring in non-instrumented piping systems. The applicant explained in their response to Question 03.09.02-64, in Response to Request for Additional Information No. 331, Supplement 2, that if an acoustic resonance occurs on one line, the same is expected at nearly the same flow conditions in the other representative lines. In the event that a resonant response is measured, the piping will be identified by determining the characteristic dimensions, e.g. diameter and length, required for the resonant frequency to occur. These characteristic parameters will be used to identify the piping that is in resonance.

The staff reviewed this approach and noted that the applicant's definition of a representative piping system requires meeting the criteria described below:

1. It must be part of the same overall plant system (e.g. Main Steam System)

2. It must have the same components and similar piping routing – particularly for branch piping.

3. The main piping must have the same diameter and have essentially the same flow conditions.

4. Distances to the first upstream elbow and distances between standpipes need to be essentially the same.

5. Branch piping needs to have the same length and diameter in the systems.

The applicant is requested to provide the criteria and /or metrics employed to determine when piping meets the "essentially the same" criteria used in determining distance to the upstream elbow, distance between standpipe and flow conditions and clarify if elbows are required to have the same orientation relative to the branch line.

03.09.02-145

Follow-up to RAI 331, Question 03.09.02-66 (follow-up to RAI 03.09.02-60).

The staff noted that detailed information requested in RAI 03.09.02-60, such as sensitivities of the steam system components and operating points which could result in flow-induced resonance in the steam piping or steam generator were not provided. In addition, the staff could not locate where the applicant discussed how the startup test plan will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the recirculating steam generator (RSG). The applicant responded to the request for this information by citing the responses to RAI 331 Questions 03.09.02-64 and 03.09.02-65, which state that screening for acoustic resonances will be performed to determine if acoustic resonances will occur, and preventive actions will be taken if needed in the design of the piping.

The staff reviewed the applicant's response and noted that it does not explain if there are mechanisms or pumps that may produce high level acoustic tones (vane rate, shaft rate, etc) that can excite components, structures or volumes of the RSG into resonance. (Note - This information has been requested in RAI 03.09.02-59-5 and 03.09.02-59-9.) In addition, the applicant is requesting an exception to SRP 3.9.2 to include instrumentation within the RSG. The staff noted that without this instrumentation, RSG internal vibration test data will not be available. The applicant is proposing that test data from accelerometers placed on piping systems will be used to determine that there are acceptable stress and vibration levels within the RSG and that no resonance response to operating conditions has occurred. The applicant stated that the specific details of the test plan will be developed later in the design process. The staff cannot determine if this approach is acceptable without reviewing the actual test plan. The applicant is requested to supply the startup test plan that will demonstrate that no flow-induced resonance effects will occur that could lead to excessive vibration and damage to components in the RSG during the design life of the plant. Therefore, this item remains open.