From: Chandu Patel
To: john.leatherman@ge.com
Date: 05/15/2007 10:20:51 AM
Subject: supplmental request for information on ESBWR Chapter 3, Section 3.9.2

John,

We have identified several more supplemental request for information for Section 3.9.2 of ESBWR. We will appreciate your quick response in order to resolve these open items. Please call me if you have any questions.

Thanks,
Chandu

CC: AEC; Arnold Lee; james.kinsey@ge.com; JRR; kathy.sedney@ge.com

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Subject: supplmental request for information on ESBWR Chapter 3, Section 3.9.2
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From: Chandu Patel

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Priority: Standard
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Concealed Subject:	No
Security:	Standard

Request for Supplemental Information on Previous Request for Additional Information
ESBWR Chapter 3.9

Comment on response to RAI 3.9-117 S01:

In RAI 3.9-117, the staff requested the applicant to (1) discuss the procedure and scope of production test and qualification test programs, separately, for both mechanical and hydraulic snubbers of different sizes and manufacturers; (2) discuss how the criteria of each pertinent snubber functional parameters are met in the testing; and (3) provide the codes and standards used for the programs. In its response dated February 16, 2007, the applicant stated that DCD Tier 2, Subsection 3.9.3.7.1(3)c will be revised in Rev. 03 to add the following statement:

> "Production and qualification test programs for both hydraulic and mechanical snubbers are carried out by the snubber vendors in accordance with the snubber installation instruction manual required to be furnished by the snubber supplier. Acceptance criteria to assure compliance with ASME Section III Subsection NF are cited in this manual, and applicable codes and standards are referenced."

The staff found the above applicant's response to be inadequate in resolving RAI 3.9-117. The staff, therefore, requests that the applicant supplement its response to the previously requested additional information on the snubber production and qualification test programs. For a more specific delineation, the staff requests the applicant to address the following, for mechanical and hydraulic snubbers of all makes and sizes: (1) how are the snubber production and qualification test programs carried out in accordance with the snubber installation instruction manual, as stated in the February 16, 2007, response; (2) confirmation that the production tests consider all snubbers in the population, or justification if not so; (3) how are the samples selected for the qualification tests; (4) what are procedures taken to get the required snubber load ratings demonstrated; (5) what are the acceptance criteria cited in the installation instruction manual that would ensure compliance with ASME Code Section III, Subsection NF, and what are the referenced Subsection NF requirements; (6) what are the specific functional parameters (activation level, release rate, drag, dead band, etc.) considered for all snubber production and qualification testing, and the bases of their acceptance; (7) what are the acceptable codes and standards (including editions) used for the snubber qualification and production testing; and (8) verify that the production operability tests for the large bore hydraulic snubbers (LBHSs) (greater than 50kips load rating) include (i) a full Service Level D load test to verify sufficient load capacity, (ii) testing at the full load capacity to verify proper bleed with the control valve closed, (iii) testing to verify that the control valve closes within the specified velocity range, and (iv) testing to demonstrate that breakaway and drag forces are within the acceptable design limits.

Comment on response to RAI 3.9-47:

The staff finds that the applicant has provided the relevant information regarding the forcing functions, as requested. However, the applicant should include this information in the ESBWR DCD.

Comment on response to RAI 3.9-48:

The staff finds that the applicant has provided an explanation of how the various parameters are used in the special analysis, as requested. However, the applicant should include this information in the ESBWR DCD.

Comment on response to RAI 3.9-49:

Based on its review of the referenced documents and the applicant's commitment to perform startup testing on components where necessary, the staff finds the applicant's response to perform testing where necessary is reasonable. However, the response and referenced documents are inadequate in identifying for flow induced vibrations (FIV) evaluation, and the similarities and dissimilarities between the components and flow conditions of ESBWR and other reactors.

The FIV response of a component depends on its structural characteristics (geometry, mass distribution, including added fluid mass, and boundary conditions) and the character of the pressures exerted on the component by the local flow field (as represented by pressure amplitudes, frequencies, spatial and time distributions and their correlations). In turn, the structural characteristics determine the modal characteristics (modal frequencies, mode shapes, modal masses, and modal damping) used in FIV evaluations. As the flow passes past the component and upstream flow obstructions and other components, the character of the flow (including the velocity vector field, the density, the viscosity, and the flow regimes) determines the pressures, FIV forcing functions, and FIV excitation mechanisms. All these variables should be discussed for each reactor component, when identifying similar components in other reactors that will be used for FIV evaluation. Using GE's examples of the incore monitor guide tube, the in-core monitor housings, and the control rod guide tube (CRGT), outstanding structural information includes a discussion of: the similarity of their boundary conditions, the similarity of their interconnections, of whether the components respond individually or in a group, and the similarity of the structural modal frequencies, mode shapes, modal masses, and modal damping. Outstanding fluid flow information includes a discussion of why the pressures exerted on these components by the natural convection flow in the ESBWR is expected to be similar to the near-field flow from the jet pumps in other reactors.

When FIV response results from other reactors are used to predict ESBWR component responses, complete justifications for the structural and flow similarities between the ESBWR and the other reactors for each ESBWR reactor component, should be provided. The structural justifications should include discussions of geometry, mass distribution, and boundary conditions, modal frequencies, mode shapes, modal masses, and modal damping. The fluid flow justifications should include discussions of pressure amplitudes, frequencies, spatial and time distributions and their correlations, the flow properties, the flow velocity vector fields, the flow regimes and the turbulent characteristics of the flow, and the potential FIV forcing functions and mechanisms.

As discussed above, the applicant should provide additional information to that provided in its response to RAI 3.9-49, comparing the components and flow conditions of ESBWR and other reactors so that reliable FIV evaluation can be made.

<u>Comment on response to RAI 3.9-51:</u>

The applicant has provided in its response to RAI 3.9-51 an extent of the variation in the response amplitudes for the shroud separator in BWRs of differing size and design as requested. However, response amplitudes of other major components were not provided. The applicant should provide a more complete list of predominant vibration response amplitudes of major ESBWR components in other BWRs of differing size and design.

<u>Comment on response to RAI 3.9-52:</u>

The staff finds that the applicant's response to RAI 3.9-52 has provided parameters that are expected to influence vibration response amplitudes among the reference plants with one exception: the relative phases of the forcing functions. The applicant should discuss the importance of the relative phases of the forcing functions and identify any components where relative phase could affect the response significantly.

<u>Comment on response to RAI 3.9-53:</u>

The staff finds the applicant's response to RAI 3.9-53 not completely acceptable because it has not fully justified the applicability of the data from other reactors to the ESBWR components. In particular, the statement, "Since all BWRs are geometrically similar, the BWRs that have been vibration tested represent very good models of other reactor internals to be tested," is not necessarily true. Geometric similarity is only one consideration to determine if a component is a good model for ESBWR components.

Before using any data from other reactor components to develop correlations, the applicant should justify the similarity of each component using all parameters relevant to FIV excitation, as elaborated in RAI 3.9-49. Also, see applicant's response to NRC RAI 3.9- 52 for a discussion of relevant parameters.

Comment on response to RAI 3.9-59:

The applicant has provided, in response to RAI 3.9-59, descriptions of two components, their structural boundary conditions and FEM modeling (including assumed damping), the flow conditions, the FIV load definitions, the modal characteristics, and results of the response analyses, including acceptance criteria, as requested. The staff finds the applicant's response acceptable for the components reported, with three exceptions: (1) The applicant's response will be considered incomplete until the similarity for FIV evaluations are justified on a component-by-component basis. (2) The axisymmetric analysis of the freestanding shroud/chimney/steam separator structure does not allow evaluation of torsion modes. The applicant should provide justification that excitation of torsion modes is not significant and include a discussion of any torsion constraint between the chimney and the RPV at the lateral constraint as well as potential FIV excitation sources that could excite torsion modes, and (3) In RAI 3.9-59 the staff requested a response for all components with significantly different features and loading conditions, per RG 1.20 and SRP Section 3.9.2. The applicant should confirm whether the FEM evaluations provided in response to RAI 3.9-59 are the only components considered to have significantly different features and justify the exclusion of others.

Comment on response to RAI 3.9-72:

The applicant's response is incomplete until analyses and testing for all internal components are provided, or component-by-component justifications are provided that show, as discussed earlier, a "similar" component has been tested in another reactor. Further, the applicant promises updates and revisions to documents after additional work is performed. The revised documents should be submitted for the staff review.

Comment on response to RAI 3.9-73:

A stated criterion for the selection of components to be tested is based on whether or not the component is subjected to significantly different or new flow conditions. In light of this and other criteria the applicant should justify why the components below the core (i.e., control rod guide tubes, in-core guide tubes and stabilizers, and non-pressure boundary portion of control rod housing and in-core housings) are not being instrumented for testing. These are critical safety related components and DCD information indicates that less turbulent convective flow passes by new core support structures before impinging on the core-control components. In particular, discuss potential FIV excitation mechanisms associated with the upstream core support structures. See also RAI 3.9-79.

Comment on response to RAI 3.9-75:

The response of the applicant is acceptable because the use of terms has been made clear and a schedule for providing startup information at the time of COL application has been identified. RAI 3.9-75 is a COL action item. However, classification of the ESBWR, as a whole as Non-Prototype Category II, will not be considered until responses to all the open items are received.

Comment on response to RAI 3.9-76:

The applicant's response is incomplete and needs clarification. The applicant has indicated that additional information will be provided for the chimney head. Further, clarification of the uncertainty associated with the terminology "anticipated" is required, as used in the phrase "even though the ESBWR feedwater flow is about ten percent higher, no unacceptable vibration amplitudes are anticipated." We therefore have the following comment:

The applicant is requested to identify and describe the structures and flow conditions in the valid prototype that correspond to the chimney-head, and provide additional evaluation and evidence to show that the differences, if any, have no significant effects on the vibratory response. In addition, clarify the uncertainty in the use of the term anticipated in the phrase "even though the ESBWR feedwater flow is about 10 percent higher, no unacceptable vibration amplitudes are anticipated." In particular, discuss whether past feedwater sparger leakage flow testing included the 10 percent higher flows of the ESBWR. If 10 percent higher flows were not achieved, provide the data/analysis that assures 10 percent higher flows will not lead to unacceptable vibration amplitudes. The occurrence of leakage flow instabilities is notoriously dependent on geometry of the leakage-flow paths, including alignment of the joined components, the vibration modes of the joined components, and especially small increases in flow rate. For further elaboration, see "Leakage Flow-Induced Vibrations of Reactor Components, Shock and Vibration Digest, 15(9), 11-18 (1983). A conservative rule of thumb is to test leakage flow joints to 120 percent of operating flow rates.

Comment on response to RAI 3.9-77 (MFN 07- 207):

In its response to RAI 3.9-77, the applicant has not provided the engineering analysis or experimental evidence as requested in the RAI 3.9-77 and as required by Reg. Guide 1.20. In particular, an uninformative description of the ESBWR of the Guide Plate is given and it is only mentioned that the ABWR and ESBWR plates are connected to different components and the ESBWR plate has more cut outs and a larger diameter than the ABWR. Indeed, these are the issues that prompted the RAI. The ESBWR Guide plate supports in a cantilevered fashion a very long chimney on which the steam separators are attached. No long chimney (longer than either the shroud or separator components) exists in the ABWR between the Guide Plate and the Separators. Also, more of the Guide plate has been cutout in the ESBWR than in the ABWR, which may create greater stress concentration factors. Further, the fluid dynamic forces that will be transmitted to the Guide Plate will be different for the ESBWR: the fluid forces on the chimney do not exist in the ABWR and the steam separator unit is of a different design. The lateral motion of the guide plate is not of main interest; the dynamic stresses induced by dynamic deformation are of concern.

In accordance with Regulatory Guide 1.20, Revision 2, May 1976, and SRP-3.9.2, guidelines, show that the differences between the ABWR and the ESBWR Top Guide Plate will have no significant effects on the vibratory response. The applicant is requested to describe the modifications made to the analytical or experimental vibration analysis of the ABWR Top Guide Assembly used to predict the response of ESBWR's Top Guide Plate and demonstrate that the FIV response of ESBWR's top guide plate is not significantly modified by the structural and FIV loading differences with the ABWR's. If the information is not provided, then the ESBWR Guide Plate will be classified as a prototypic component, per Reg. Guide 1.20.

Comment on response to RAI 3.9-79:

The applicant's response is acceptable, with one exception, because turbulent flow differences and how they will not have a significant effect on the FIV response were presented. However, a discussion of the potential effects of organized wake flows downstream of the shroud supports was not given. The applicant needs to provide a satisfactory response to the staff concern discussed below:

"According to the applicant's response, the ESBWR core flow has lower flow turbulence than the flow from past reactors that use jet pumps. But lower flow turbulence promotes the shedding of more organized shear layers from the smaller 12 shroud-support brackets upstream of the lower plenum components such as the CRGT and the ICGT/housing. The applicant is requested to discuss the potential effects of organized wake flows from the shroud supports shedding and impinging on downstream lower plenum components. In particular, include an assessment of the coincidence of the frequencies of organized wakes with the natural frequencies of the lower plenum components."

Comment on response to RAI 3.9-96:

The applicant's response is unacceptable, because it only identifies the differences in the tests that were conducted on the ABWR, which the applicant considers to be prototypical of the ESBWR reactor internals design, and those tests that the applicant proposes to conduct on the reactor internal of the first ESBWR plant. The applicant did not explain why the testing for the first ESBWR plant is restricted only to those aspects that are perceived to demonstrate that the FIVs expected during operation do not cause damage. Further the applicant did not discuss how its testing program is consistent with the vibration assessment program delineated in Regulatory Position C.2.2 of RG 1.20, Revision 2, May 1976, associated with the testing program for Non- Prototype Category II reactor internals. The applicant should justify Non-Prototype Category II classification of the ESBWR on a component-by-component basis, as outlined in the five Open Items and one Confirmatory Item, related to this concern and listed in SER Sections 3.9.2.3 and 3.9.2.4. Also, the applicant should explain why the testing for the first ESBWR plant is restricted only to those aspects that are perceived to demonstrate that the FIVs expected during operation do not cause damage.