April 12, 2010

Mr. Jerald G. Head
Senior Vice President, Regulatory Affairs
GE Hitachi Nuclear Energy
3901 Castle Hayne Road MC A-18
Wilmington, NC 28401

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 411 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION

Dear Mr. Head:

By letter dated August 24, 2005, GE Hitachi Nuclear Energy (GEH) submitted an application for final design approval and standard design certification of the economic simplified boiling water reactor (ESBWR) standard plant design pursuant to 10 CFR Part 52. The U.S. Nuclear Regulatory Commission (NRC) staff is performing a detailed review of this application to enable the staff to reach a conclusion on the safety of the proposed design.

The NRC staff has identified that additional information is needed to continue portions of the review. The staff's request for additional information (RAI) is contained in the enclosure to this letter.

If you have any questions or comments concerning this matter, you may contact me at 301-415-3179 or Ilka.Berrios@nrc.gov or you may contact Amy Cubbage at 301-415-2875 or Amy.Cubbage@nrc.gov.

Sincerely,

/RA/

Ilka Berrios, Project Manager
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-010

Enclosure:
Request for Additional Information

cc: See next page

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Ilka Berrios, Project Manager
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
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Distribution: See next page

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SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 411 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION DATED APRIL 12, 2010

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Requests for Additional Information (RAIs)
ESBWR Design Control Document (DCD), Revision 7

RAI Number	Reviewer	Question Summary	Full Text
6.2-202 S01	Wagage H Le T Davis R Gilmer J Thomas G	Explain how ESBWR would address possible accumulation of high concentrations of hydrogen and oxygen in the PCCS and the ICS.	A. The title of the Licensing Topical Report (LTR) NEDE-33572P report "ESBWR PCCS condenser structural evaluation" does not include the evaluation of the ICS. Update the title of this report to include the evaluation of the ICS. B. Because of the potential for accumulation of noncondensable gas in the ICS condensers, the ICS condensers will be designed using the methodology described in NEDE-33572P. In the revised response to RAI 6.2-202 and the LTR NEDE-33572P Revision 0 (both dated 3-23-10), GEH stated that LOCA analyses presented in DCD Tier 2 Sections 6.2 and 6.3 do not credit heat transfer for the ICS. However, GEH also indicated that main steam line break (MSLB) analysis does credit heat transfer, as shown in Figures B.1 and B.2. Figure B.1 shows accumulation of non-condensable gas within the first few hours of a MSLB in the tubes. Because the non-condensable gas is not vented, the tube's condensation rate is quickly reduced. The ICS vent lines do not open during LOCA conditions. The lower drum and drain line will be subject to the same accumulation. From Figure B.2, the upper drum accumulates non-condensable gas for the first hours then drops below for the remainder of the 72 hours. In its response to Item B of this RAI, GEH is now committed to design the ICS using the methodology described in NEDE-33572P for the PCCS. Therefore, in the design of the ICS including its condensers GEH is requested to address all PCCS-related concerns included in the RAI supplement to ITEM C. In addition, GEH is also requested to address the following specific concerns that are not applicable to the PCCS: 1. Justify the use of Service Level D of the ASME Code Section III, Subsection NC for the detonation load. 2. Explain how the heat transfer function of the ICS condensers is demonstrated during a main steam line break (MSLB) LOCA, since Appendix F of the ASME Code acceptance criteria for Service Level D load combinations are applicable to the pressure boundary function only.

RAI Number	Reviewer	Question Summary	Full Text
			The staff emphasizes that, in order to arrive at a safety determination, the complete analysis and design of the ICS condensers needs to be reviewed. In the revised response to RAI 6.2-202, GEH states that this information will be submitted as part of LTR NEDE-33572P. Therefore, the staff requests the final version of this report for review, including all appendices. C. In the response to RAI 6.2-202, Revision 1, Figures 6.2-202-1, 2 (Pages 6 and 7 of the Letter) indicate potentially flammable/detonable mixture of non-condensable gases in ICS tubes and top drums at Post LOCA conditions. Even though the IC tubes and drums are designed to withstand the potential detonation, as a defense in depth measure, it is prudent to take preventive actions to mitigate the detonation. For high levels of non-condensable gases, what mitigating actions planned to prevent the potential detonation inside the IC tubes and drums? 1. Are you planning to provide instrumentation for hydrogen monitoring of the ICS tubes and drum? 2. If the Hydrogen level is high inside the IC Tubes and drums, what manual or automatic actions planned for IC operation? 3. Revise DCD Section 5.4.6 to describe the system design and operation changes to incorporate mitigating actions for hydrogen control D. In NEDE-33572P, Revision 0, GEH stated that the evaluation for PCCS is described in Appendix A (modified by Appendix B to include detonation). A similar evaluation will be performed for the ICS to validate the design using the same methodology described in this report. Based on initial pressure and temperature condition, a peak pressure ratio of 19:1 is used on the PCCS for the calculation of peak pressures. During the LOCA and Post LOCA condition, the ICS has not the same initial temperature and pressure as PCCS has experienced. The staff requests GEH to provide the following:

RAI Number	Reviewer	Question Summary	Full Text
			1. Discussion of the initial pressure and temperature of ICS during the LOCA and Post LOCA condition. 2. Provide the technical justification of the use of peak pressure ratio for ICS. 3. Provide the configuration of added vent line, ICS assembly, flow paths of ICS and its function. E. The revised response to RAI 6.2-202 and the LTR NEDE-33572P Revision 0 provide information regarding the potential accumulation of high concentrations of hydrogen and oxygen in certain components of the PCCS during a LOCA, and how the PCCS design addresses the resulting possibility of deflagrations or detonations in these components. The RAI response further states that, in the event of a combustible gas mixture (hydrogen and oxygen) accumulation, the PCCS is designed to withstand overpressures from possible deflagrations or detonations such that: (a) the structural integrity of the containment pressure boundary is maintained, and (b) the long term heat removal function is not compromised. However, the staff finds that the information provided appears to be insufficient to support the stated design intent; therefore, additional information is requested as described below. 1. The response to Item C.1 of the RAI indicates that the methodology of assessment for hydrogen and oxygen accumulation in the PCCS condenser is contained in the LTR. However, the version of the LTR provided to the staff is not finalized because it focuses on the preliminary sizing of the PCCS condenser tubes, and does not contain a complete stress analysis of the PCCS assembly. It is emphasized that to arrive at a safety determination, the complete analysis and design of the PCCS needs to be reviewed by the staff. Therefore, provide the final version of the LTR for review, including all its appendices. 2. The response to Item C.2 of the RAI indicates that a new detonation load case and new load combinations for PCCS design are added to the DCD, as detailed in the LTR. In addition, the response states that the acceptance criterion used for the load combinations that include detonation loads is

RAI Number	Reviewer	Question Summary	Full Text
			Service Level D per the ASME Code, Section III, Division I, Subsection NE. Provide technical justification for the load combinations and the corresponding acceptance criteria used in the PCCS design, and include this information in the LTR. A detailed discussion of the following issues should be included: a. Since the PCCS is required to maintain the containment pressure boundary and also meet its functional requirement of heat removal during the 72-hour period associated with a LOCA, the proposed acceptance criteria of satisfying Service Level D of the ASME Code, Section III, Division I, Subsection NE may not be appropriate. Service Level D permits stresses beyond yield and may thereby result in distortions such that the PCCS is not able perform its function of heat removal. Therefore, the analytical approach and the acceptance criteria used to demonstrate both PCCS functions of maintaining pressure boundary and removal of heat must be technically justified. Note that if the analysis and design allow strains beyond yield, then the method for developing equivalent static pressures (for detonation loads) proposed in the current version of the LTR may not be valid because it is based on an essentially elastic response of the component. b. Regarding the acceptance criteria used to demonstrate heat removal functionality, explain what subsection of the ASME Code Section III, Division I, is being followed. Note that neither Subsection NE nor Appendix F address functionality of mechanical components. c. If plastic deformation does occur at any location in the PCCS, discuss the ratcheting effects for five or more detonations, and the combination with elastically calculated stresses due to other non-detonation load cases (e.g., seismic, dead weight and thermal). 3. The response to Item C.3 of the RAI indicates that detonation pressures and dynamic load factors are derived from experiments described in the technical literature, as described in the LTR. Provide the following additional information on the detonation pressure load values used in the analysis and design of PCCS, and include this information in the LTR:

RAI Number	Reviewer	Question Summary	Full Text
			Confirm the number of multiple detonations that are expected to occur (previous statements were made that it is 5 or more) during the 72-hour period associated with a LOCA. a. LTR Table 3-3 listed the dynamic load factors (DLF) used for various components of the PCCS. The report provides detailed analysis of DLF only for the PCCS tubes. Provide detailed justification of DLFs for all other components listed in LTR Table 3-3. b. Provide a detailed discussion of the effect of the deflagrations or detonation waves in all components of the PCCS, not only the lower drums and the condenser tubes. In particular, discuss the estimation of loads in various components associated with flame acceleration (FA) and deflagration-to-detonation transition (DDT). The staff notes that the calculations in the LTR assume the highest possible concentrations of hydrogen and oxygen (in stoichiometric ratio without steam) which leads to detonations without delay. However, steam could be present in the mixture delaying DDT in the PCCS drain and vent pipes which are relatively long. Delayed DDT could generate higher pressures than those calculated in the LTR. Therefore, provide analyses of DLF including occurrence of delayed DDT with presence of steam in PCCS drain and vent pipes to determine conservative loading scenarios. c. Discuss the use of Chapman-Jouguet (CJ) pressure versus the DDT pressure, which could be much higher than the CJ pressure in certain cases. d. Discuss the bounding effect of reflected CJ detonation waves. e. Discuss the effect of the uncertainty in the combustible gas concentrations and the presence of dilutants (e.g., steam); specifically, with regard to possible variations in peak pressure values, detonation velocities, and LFs used in the analysis.

RAI Number	Reviewer	Question Summary	Full Text
			f. Discuss the effect of initial temperature conditions on the peak pressure. g. Discuss the effect of PCCS geometry (e.g., presence of bends, tees, tube size) if the experimental values of different configurations are used. h. Provide the modified PCCS assembly and flow paths of PCCS. 4. The response to Item C.4 of the RAI indicates that certain sections of the DCD have been modified to include a description of detonation loads, to delete information referring to stress analysis results, and to refer to the LTR for these stress analysis results as well as for other analysis and design details. As indicated under Item E.1 above, the complete analysis and design of the PCCS needs to be reviewed by the staff. Therefore, the final version of the LTR should be provided, including all its appendices. In addition, the DCD should also contain a summary of analysis and design results from the LTR, as well as sufficient information to support a safety determination. 5. The response to Item C.5 of the RAI indicates that detonations inside the PCCS have negligible impact on the overall containment pressure. The response also provides the magnitude of the energy released during a detonation event. However, the response does not explain how this energy release is translated into stresses in the PCCS support frame, floor anchors, and other PCCS components not directly affected by the detonation and, therefore, not captured in the stress analysis described in the LTR. To address this and other related issues, provide a detailed discussion of the following: a. The assumptions and methods used in the stress analyses of the various PCCS components, especially if elastic-plastic analysis is used; include this information in the LTR. b. The effect of detonations on the entire PCCS assembly, including: the PCCS support frame, support frame floor anchors, and pressure retaining components beyond the tubes and drums (e.g., steam inlet connections to the pool floor), etc.; include this information in the LTR.

RAI Number	Reviewer	Question Summary	Full Text
			c. Technical justification for using a margin of 40 percent for all support values to account for all uncertainties. d. The effect of stress concentrations and potential plastic deformations at applicable locations such as pipe and tube bends, and the weld junction of the tubes to the drums. Confirm that the FE mesh used in the stress analysis is sufficiently refined to capture these effects. F. LTR NEDE-33572P, Revision 0 Section 5.0 discusses inservice inspections and fabrication inspections for the PCCS and ICS. The staff requests that the applicant address the following: 1. Section 5.1 discusses PCCS and ICS inservice inspection (ISI) but does not provide a clear description of the ISI that will be performed on the PCCS and ICS. The staff requests that the applicant provide a detailed description of the ISI that will be performed on the PCCS and ICS including references to applicable portions of ASME Code. The staff notes that ESBWR Section 5.4.6.4 states that UT is required for the ISI of IC tube-to-header welds but the applicant proposes to delete this statement and replace it with Ref . 5.4-3 which does not require UT examination for ISI. 2. Section 5.2.1 describes tube-to-header weld fabrication examinations. The applicant states that a PT will be performed and references the requirements of NE-5350. The staff requests that the applicant also address the required inspections for ICS welds. In addition, the staff requests that the applicant provide the category of these welds and discuss how it came to the conclusion that a PT is sufficient and RT is not required. The staff notes that if a PT examination only is to be performed on tube welds and tube-to-header welds, the staff expects that the applicant will perform a VT-1 examination of ID surface of the welds. 3. Section 5.2.2 describes the applicant's tube bending requirements for the PCCS tubes. The staff requests that the applicant also provide tube bending requirements for ICS tubes.

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			4. Section 5.2.3 lists weld filler materials for the tube-to-header welds. The staff assumes that the filler materials listed are for the PCCS and not the ICS. The staff requests that the applicant also list weld filler materials for the ICS tube-to-header welds. G. Provide clarification of the use of TRACG code results in the structural evaluation of PCCS and ICS components for detonation of accumulated noncondensable gas mixtures. The staff has concerns about the capability of TRACG to predict transient behavior with noncondensable gas present. It may be acceptable to utilize the TRACG results for trending and in support of key assumptions, such as the location of gas accumulation during a LOCA, but specific quantitative results should not be utilized without additional code qualification using test measurements or other benchmarks.

cc:

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