April 25, 2008

Mr. Robert E. Brown
Senior Vice President, Regulatory Affairs
GE Hitachi Nuclear Energy
3901 Castle Hayne Road MC A-45
Wilmington, NC 28401

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 185 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION

Dear Mr. Brown:

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 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 301-415-3025 or Chandu.Patel@nrc.gov, or you may contact Eric Oesterle at 301-415-1365 or Eric.Oesterle@nrc.gov.

Sincerely,

/RA/

Chandu Patel, Senior 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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cc: See next page
Distribution: See next page
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SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO.185 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION DATED APRIL 25, 2008

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Requests for Additional Information (RAIs)
ESBWR Design Control Document (DCD), Revision 4

RAI Number	Reviewer	Question Summary	Full Text
RAI 3.6-6 S02	Li Y	Explain how potential feedback amplification of blowdown force is considered.	GEH provides conflicting answers in its response to RAI 3.6-6 S01, explaining first that feedback amplification of dynamic blowdown forces is calculated using a nonlinear time-history analysis, but then stating that an equivalent static analysis with a dynamic load factor (DLF) may be used instead. GEH uses a DLF of 2. The response is incomplete and unclear. Please explain the following: (a) Which analysis approach will GEH use, the nonlinear time history or the equivalent static calculations with a dynamic load factor of 2? (b) If the nonlinear time history analysis will be used, what tools are employed? How have they been validated and certified? What are the bias errors and uncertainties associated with the tools? Also, how is the time-varying jet impingement loads simulated? (c) If the static analysis approach is used, GEH is requested to respond to the follow-up RAI 3.6-14 S01, which addresses similar concerns the staff has with the response to this RAI concerning the use of DLF of 2.
3.6-11 S01	Li Y	Explain how effects of blast waves will be accounted for.	In its response to RAI 3.6-11, GEH stated that the blast loads will be negligible compared to loads caused by jets, citing a lower density of the fluid outside the high energy pipe compared to the jet fluid, and the decay in load amplitude with increasing distance from the break. Practical experience cited by the international nuclear community, however, clearly shows the strength and damage caused by blast waves (Knowledge Base for Emergency Core Cooling System Recirculation Reliability, February 1996, Issued by the NEA/CSNI, http://www.nea.fr/html/nsd/docs/1995/csni-r1995-11.pdf).

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			It is unclear why GEH refers to the density of the ambient fluid. It is the pressure ratio between the high energy line and the ambient air that is critical in determining the blast strength. Approximated by the conditions quoted for the high energy piping, an idealized spherical blast wave will be of significant strength near the break. The density, pressure and damaging effect of the ideal blast becomes diminished with radius cubed. Based on ACRS concerns, and the information in the Knowledge Base for Emergency Core Cooling System Recirculation Reliability, February 1996, Issued by the NEA/CSNI, http://www.nea.fr/html/nsd/docs/1995/csni-r1995-11.pdf, all high pressure and temperature pipes should be considered as sources of blast waves with initial energy and mass roughly equal to the exposed volume from a hypothesized break. The subsequent damage from such waves has been well documented and is not properly accounted for by the isolated analysis of a pure spherically expanding wave. GEH is requested to address these concerns backed by industry operating experience and to provide a rigorous and thorough explanation of their procedures for estimating the effects of blast waves on nearby safety-related SSCs.
3.6-12 S01	Li Y	Address ANS 58.2 jet expansion model inaccuracies.	(a) In its response to part (a) of RAI 3.6-12, GEH does not explain what analysis and/or testing has been used to substantiate using ANS 58.2 Appendices C and D for defining conservatively which SSCs are in jet paths and the subsequent loading on the SSCs. Instead, GEH maintains that it complies with ANS 58.2. GEH has not provided the requested information, and is advised that the ANS 58.2 standard is no longer universally acceptable for modeling jet expansion in nuclear power plants. GEH is encouraged to review the original RAI, along with the criticisms raised by Wallis (Wallis, G., "The ANSI/ANS Standard 58.2-1988: Two-Phase Jet Model," ADAMS ML050830344, 15 Sep 2004) and Ransom (Ransom, V., "COMMENTS ON GSI-191 MODELS FOR DEBRIS GENERATION," ADAMS ML050830341, 15 Sep 2004) and prepare a thorough response.

RAI Number	Reviewer	Question Summary	Full Text
			(b) In its response to part (b) of RAI 3.6-12, GEH provides a table of maximum pipi and postulated break dimensions and compares 25 diameters to its maximum impingement distance of 9.1 meters. 25 diameter distances from all all piping, except for the Main Steam Lines (MSLs), are less than 9.1 meters. However, 25 diameters from the MSLs is 19.1 meters, 10 meters more than GEH's maximum impingement distance of 9.1 meters. GEH states that "analytical justifications to determine if safety related features require protection against an interacting jet from a pipe break will be provided for targets intercepted by jet outside 25D." However, GEH has not added this commitment the DCD. Since the 25 diameter distance from the Main Steam Lines is 19.1 m, 10 m more than GEH's maximum jet impingement distance of 9.1 m, GEH is requested to revise the DCD to state that the loads on any SSCs within 19.1 m of postulated ruptures of the MSLs will be assessed, along with the structural integrity of the SSCs.
3.6-13 S 01	Li Y	Address ANS 58.2 and DCD Tier 2 jet pressure distribution inaccuracies and inconsistencies.	(a) GEH clarifies in its response to part (a) of RAI 3.6-13 that it will use Appendix D of ANS 58.2 methods to compute pressure distributions on a target, and that DCD Tier 2, Subsection 3.6.2.3 has been modified accordingly. However, GEH has not addressed the second question in part (a), which is to explain what analysis and/or testing has been used to substantiate the use of Appendix D of ANS 58.2 in light of ACRS criticisms. Instead GEH states that it complies with ANS 58.2. It should be noted that the ANS 58.2 standard, including Appendix D, is no longer universally acceptable for specifying jet pressure distributions over SSCs in nuclear power plants. In particular, the effects of compressibility and unsteadiness are neglected. GEH is encouraged to review the original RAI, along with the criticisms raised by Wallis (Wallis, G., "The ANSI/ANS Standard 58.2-1988: Two-Phase Jet Model," ADAMS ML050830344, 15 Sep 2004) and Ransom (Ransom, V., "COMMENTS ON GSI-191 MODELS FOR DEBRIS GENERATION," ADAMS ML050830341, 15 Sep 2004) and prepare a thorough response. (b) GEH has provided only general, incomplete and vague information in response to RAI 3.6-13(b). GEH does state, however, that the pipes have been designed such that breaks may only occur at the terminal ends. The original RAI requested the applicant to submit a table of all postulated break

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			types, along with the properties of the fluid internal and external to the ruptured pipe. The table should specify what type of jet the applicant assumes will emanate from each pipe break—incompressible nonexpanding jet, or compressible supersonic expanding jet—along with how impingement forces will be calculated for each jet. Specific examples of jet impingement loading calculations made using the ANS 58.2 standard and/or the methods in DCD Tier 2 for the postulated piping breaks in an ESBWR should be given, along with proof that the calculations lead to conservative impingement loads in spite of the cited inaccuracies and omissions in the ANS 58.2 models pointed out by Ransom and Wallis. GEH is requested to provide a detailed and thorough response to the original RAI 3.6 -13 (b).
3.6-14 S01	Li Y	Justify neglecting jet dynamic loading and structural dynamic response, and neglecting feedback amplification of dynamic jet loads.	(a) In its response to part (a) of RAI 3.6-14, GEH describes an approach for obtaining the load due to jet impingement. In the GEH approach, it is assumed that there is a thrust coefficient that may be used to obtain a conservative, but static, load applied by the jet. Thus an unsteady, nonuniform load is replaced, for analysis, with a uniform, constant load. It is unclear that this is consistent with a compressible flow analysis. It has been documented, in the comments of Wallis and Ransom and the Knowledge Base for Emergency Core Cooling System Recirculation Reliability (February 1996, Issued by the NEA/CSNI, http://www.nea.fr/html/nsd/docs/1995/csni-r1995-11.pdf) that such high-energy free expanding jets will generally contain a complex of oblique shock and expansion waves and an unsteady shear layer. There will be significant unsteadiness and nonuniformity. GEH is requested to provide a response that clearly demonstrates a conservative approach for what is properly considered as a compressible, turbulent, unsteady flow. (b) GEH states in its response to part (b) of RAI 3.6-14 that dynamic amplification will be automatically accounted for in when blow down time history-dynamic response evaluations for the pipe rupture loads on the impacted component/structure are performed. However, GEH does not provide any details on its analysis approach. GEH also, as in its response to RAI 3.6-6 S01, provides a conflicting static analysis approach using a DLF of 2.0. It is unclear which approach it plan to use. GEH is requested to provide the

RAI Number	Reviewer	Question Summary	Full Text
			additional information to establish that it is conservative to use DLF of 2, if the static analysis approach is used. In addition, GEH is requested to explain how its nonlinear time-history analysis addresses feedback and resonance, including all validation exercises, and bias errors/uncertainties associated with their analysis approach. (c) GEH ignores dynamic jet loads in its response to part (c) of RAI 3.6-14, relying on the assumed 0.001 second rise time in the ANS 58.2 standard as the only time-dependent component of their jet loads. However, much of the original RAI 3.6-14 provides citations to existing literature which clearly substantiate the presence of dynamic effects in actual jets. GEH is advised that the ANS 58.2 standard is no longer universally acceptable for specifying jet loads over SSCs in nuclear power plants, and that dynamic effects beyond those due to the initial transient assumed in ANS 58.2 must now be considered in the DCD. GEH is requested to review the original RAI and provide a detailed and thorough response concerning how the dynamic jet loads are considered and provide the basis for assuming a static analysis with a dynamic load factor of two is conservative.
3.6-15 S01	Li Y	Clarify maximum expected high energy line temperature, pressure, and pipe diameter.	In its response to RAI 3.6-15, GEH provided the table requested. However, to allow the staff to review GEH's future responses to other RAIs associated with jet loads and blast loads on nearby safety-related SSCs, the conditions of regions outside the high energy piping are required. GEH is requested to add the temperature and pressure of the regions outside the high energy piping systems to the table provided in its initial RAI response. This information will also be required for GEH's response to the follow-up RAI 3.6-13(b) S01.
3.6-16 S01	Li Y	Explain how jet reflections will be assessed.	In its response to RAI 3.6-16, GEH states that the reflective force of the jet may be conservatively addressed using a shape factor and the assumed momentum of the jet. GEH has not discussed how they address the unsteadiness, compressibility, and coupled structural interaction with the jet. GEH is requested to modify DCD to clearly delineate how candidate reflecting surfaces are chosen and how this

RAI Number	Reviewer	Question Summary	Full Text
			analysis addresses the unsteadiness, compressibility, and coupled potentially resonant, structural interaction with the jet. GEH is also requested to summarize its quantitative approach for modeling reflections in a revised DCD.
3.6-17 S01	Li Y	Explain barrier, shield, and enclosure design considerations related to jet resonance effects.	In its response to RAI 3.6-17, GEH explains that it plan to use ANS 58.2 to design barriers, shields, and enclosures around high energy lines. An equivalent static analysis with DLF of 2 will be used. GEH does not address the possibility of dynamic jet resonant loading in its response. That is unacceptable to the staff. GEH is advised that the ANS 58.2 standard is no longer universally acceptable for specifying jet loads over barriers, shields, and enclosures in nuclear power plants, and that, dynamic effects beyond those due to the initial transient assumed in ANS 58.2 must now be considered in the DCD. GEH is requested to consider realistic jet loads which include dynamic effects and possible resonant amplification in its response to this RAI.
3.6-19 S01	Li Y	Revise DCD to clarify use of target shape factors.	In its response to RAI 3.6-19, GEH states in its response that target shape factors are applied to target loads, not pressures. However, GEH has not modified the DCD to clarify this point. GEH is requested to modify the DCD to clarify that shape factors are applied to loads, not pressures.
5.4-60 S01	Maker G	Provide a copy of the BWRVIP-130 for water chemistry guidelines.	In a letter dated February 21, 2008, GEH responded to RAI 5.4-60 and stated that the ESBWR reactor water cleanup and shutdown cooling (RWCU/SDC) system would enable operation with water chemistry within the guidelines of both Regulatory Guide 1.56 and BWRVIP-130. Please provide a copy of the BWRVIP-130 water chemistry guidelines in order for the staff to complete its detailed review of materials compatibility with the reactor coolant under SRP Section 5.4.8 (and similarly for reviewing condensate cleanup under SRP Section 10.4.6).

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3.2-19 S04	McNally R	Provide clarifications for the boundary from safety-related QG B to non-safety related QG D.	The applicant's response to RAI 3.2-19 S03 identified that the isolation valves immediately upstream of the steam line drains orifices shown on Figure 3.2-1 in Quality Groups B1 and B2 are normally open and are designed to fail open in order to maintain a drainage path in the event of loss of power to any of the three valves. The proposed revision to Figure 3.2-1 shows another valve in a line that connects the main steam line with the main steam drain line that is now shown as normally closed. However, this normally closed valve is not in series with the main steam drain line. Since the main steam drain line through the orifices represents a normally open flow path to the main condenser, it is not clear that the QG D and seismic Category II line downstream of the orifices and normally open, fail open valves is classified correctly. The boundary from safety-related QG B to non-safety related QG D is normally a closed valve, second automatically closed valve or second remotely operated valve. The applicant is requested to explain the basis for the classification boundary at the restraints considering the normally open, fail open valves. For example, if the orifice is sized to preclude excessive dose levels resulting from a failure of the downstream piping, or if operator action is credited, clarify this in the response.
3.11- 28	Pal A	Clarify the maximum temperature listed in Table 3H-2 through 3H-4 in Appendix 3H.	DCD, Rev. 4, Section 3.H.3.1 states that Tables 3H-2 through 3H-4 define thermodynamic conditions for normal operating conditions for areas containing safety-related equipment. The component inside a panel located in harsh environment may be exposed to higher temperature than the ambient room temperature due to internally generated heat. Clarify that the temperatures listed in the Tables 3H-2 through 3H-4 represent the maximum temperature seen by a component inside a panel.

cc:

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