GE-Hitachi Nuclear Energy Americas LLC
ESBWR Preliminary Open Items
Chapter 3
Design of Structures, Components, Equipment, and Systems

RAI 3.2-6 Supplement No. 1 (E-mail Amy May 20, 2007)

The response to RAI 3.2-6 indicates that quality assurance (QA) Requirement E is appropriate for all nonsafety-related SSCs regardless of their seismic classification. Note (5) to Table 3.2-1 identifies Quality Class E as QA requirements commensurate with the importance of the item's function. Note (4) to Table 3.2-2 also states that elements of 10 CFR 50 Appendix B are generally applied to nonsafety-related equipment commensurate with the importance of the equipment's function. Due to the general nature of this Quality Assurance E (QA-E) definition, it is not clear what specific QA requirements are applicable to various components that are classified as QA E. For example, the DCD does not identify what supplemental requirements, if any, are applicable to nonsafety-related SSCs such as the steam dryer, RPV insulation and high energy piping whose failure may adversely affect safety related SSCs. Also, Section 17.4 on Quality/Reliability Assurance or Section 19.6, on RTNSS do not appear to address graded supplemental requirements applicable to QA Class E for important non-safety systems such as the standby AC power system and the plant service water system that have a defense-in-depth function. Please clarify what graded requirements are applied to Quality Assurance Class E for each component in Table 3.2-1 so classified. If not sufficiently defined at this time, this will be subject to further review at a later time when design requirements and a design-specific focused PRA are complete.

Status: GEH responded to this RAI by letter dated April 24, 2008. The staff is reviewing the response.

RAI 3.2-19 Supplement No. 4, April 25, 2008, ML081090436

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.

Status: GEH has not responded to this RAI

RAI 3.2-63, Supplement 1, 5/24/07, ML0716200230

In response to NRC RAI 3.2-63 regarding medium voltage distribution system and low voltage distribution system (needed for recharging batteries) being classified as non-safety and non-seismic, GEH indicated that the equipment is located in the electrical building and that the electrical building and the components within it that are needed to recharge the safety-related batteries will be designed to withstand seismic effects using methods permitted by the International Building Code (IBC), without formally classifying these components as Seismic Category I. However, the NRC staff notes that the method of seismic analysis referenced in Section 16.2.3 of the IBC is only applicable to building structures and not the electrical equipment. In view of the above, please identify the standards or codes that will be used to qualify the electrical equipment (switchgear) that will be used to recharge the safety-related batteries (after 72 hours) in the event of a seismic event to ensure their availability when required.

Status: GEH responded to this RAI on August 1, 2007, MFN 07-052, Supplement 1. However, resolution of this RAI will depend on the resolution of RAI 22.5-7. GEH has responded to RAI 22.5-7 S01 by letter dated April 28, 2008. The staff is reviewing the response.

RAI 3.2-66 Supplement No.1, May 9, 2008, ML081290237

The response to RAI 3.2-66 does not include an adequate basis for re-classification of the Turbine Building as non-seismic (NS). The applicant is requested to identify each of the criteria considered and explain how the reclassification and building design methodology meets these criteria. RG 1.29 provides the necessary guidance on criteria selection. If the applicant's evaluation concludes that reclassification of the Turbine Building as NS does not represent an exception to RG 1.29, the applicant will need to provide specific information to justify that this exception does not adversely affect the functionality of SSCs important to safety within and adjacent to the building, by interaction with the Turbine Building when subjected to safe shutdown earthquake loadings. Fail safe is not an adequate justification, unless all failure modes resulting from a seismic event have been considered and evaluated.

Status: GEH has not responded to this RAI.

RAI 3.6-6 Supplement No. 2, April 25, 2008, ML081090436

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? 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.

Status: GEH has not responded to this RAI.

RAI 3.6-7, Supplement 2, 2/19/2008, ML080320174

In response to RAI 3.6-7 S01, Item (e), GEH indicated that both PDA and ANSYS computer programs are controlled by GEH internal procedures. However, GEH is using another computer code or file "REDEP" to define the pipe whip restraint (PWR) force and deflection relationship based on its design parameters. In accordance with DCD Subsection 3J.3.1, REDEP is a file containing a large database and is used to supply the force/deflection data for the design of GEH U-Bar whip restraint. GEH must control the quality of REDEP by internal procedures, similar to that of PDA and ANSYS.

Therefore, the staff requests GEH to revise DCD, Tier 2 to indicate that all of the above programs will have proper quality control procedures in place.

Status: GEH responded to this RAI by letter dated April 24, 2008. The staff is reviewing the response.

RAI 3.6-11, Supplement 1 4/25/2008, ML081090436

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).

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.

Status: GEH has not responded to this RAI.

RAI 3.6-12 Supplement No. 1, April 25, 2008, ML081090436

(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.

(b) In its response to part (b) of RAI 3.6-12, GEH provides a table of maximum piping and postulated break dimensions and compares 25 diameters to its maximum impingement distance of 9.1 meters. 25 diameter distances from 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 jet 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 to 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.

Status: GEH has not responded to this RAI.

RAI 3.6-13 Supplement No. 1, April 25, 2008, ML081090436

(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 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).

Status: GEH has not responded to this RAI.

RAI 3.6-14 Supplement No. 1, April 25, 2008, ML081090436

.(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 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 plans to use. GEH is requested to provide the 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.

Status: GEH has not responded to this RAI.

RAI 3.6-15 Supplement No. 1, April 25, 2008, ML081090436

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.
Status: GEH has not responded to this RAI.

<u>RAI 3.6-16 Supplement No.1, April 25, 2008, ML081090436</u>

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 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.

Status: GEH has not responded to this RAI.

<u>RAI 3.6-17 Supplement No. 1, April 25, 2008, ML081090436</u>

In its response to RAI 3.6-17, GEH explains that it plans 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.

Status: GEH has not responded to this RAI.

<u>RAI 3.6-19 Supplement No. 1, April 25, 2008, ML081090436</u>

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.

Status: GEH has not responded to this RAI.

<u>RAI 3.7-52 Supplement No. 3, April 10, 2008, ML080950374</u>

The staff reviewed the GEH response to RAI 3.7-52, Supplement 2, dated February 5, 2008. Based on its review of the response and the proposed revision to DCD Tier 2, Subsection 3.7.3.13, the staff identified the following issues that remain to be addressed:

(a) A clear statement of the seismic classification and the applicable seismic analysis/design methodology needs to be included in the DCD revision, for each concrete tunnel and trench; considering that the trenches protect and support Category 1 piping and conduit/duct banks, the trenches should be Seismic Category I; DCD Tier 2, Table 3.2-1 should identify all the trenches and tunnels, and their seismic classification.

(b) The DCD revision should include a description of the seismic analysis methodology for Category I FPS yard piping, Category I electrical conduits/duct banks, and Safety Class RW-IIa radwaste piping that are supported in the tunnels and trenches.

(c) The DCD revision should include a definition of the seismic input motion at the surface, consistent with the single envelope design spectrum defined at the bottom of the RB/FB foundation.

(d) The first sentence of the proposed revision to 3.7.3.13 states "There are no Seismic Category I (C-I) utilities i.e. piping, conduits, or auxiliary system components that are directly buried underground." However, a subsequent sentence in the proposed revision states "For seismic Category I (C-I) buried conduits, tunnels, and auxiliary systems, the following items are considered in the analysis and design in accordance with SRP 3.7.3 (Rev. 3, March 2007):" Explain why conduits and auxiliary systems are listed, but not piping. Should any of the three be listed? Should only "buried tunnels and trenches" be listed? The wording in the DCD revision needs to be corrected.

(e) The statement "..., the following items are considered…" needs to be clarified. Are all of these items evaluated for each tunnel and trench? If not, list and explain any exceptions. Are any of the items applicable to analysis of piping, conduit/duct banks, and auxiliary system components protected by and/or supported in the trenches and tunnels? This information should be included in the DCD revision.

Status: GEH has not responded to this RAI.

<u>RAI 3.7-63 Supplement No. 1, May 9, 2008, ML081290237</u>

The staff reviewed the GEH response to RAI 3.7-63, and concluded that additional information is needed before it can complete its assessment of the two technical issues covered by this RAI.

Part (1) - GEH needs to submit a comparison of the surface spectra derived by placing the input motion at the bottom of the RB/FB foundation to the surface spectra derived by placing the input motion at the bottom of the CB foundation, for each of the 4 SASSI layered soil cases. In deriving the surface spectra from the foundation motions, the method identified as the NRC method in GEH's response to RAI 3.7-16 must be used. Submit four (4) figures, similar to Figure 3.7-63(1).

In reviewing Figure 3.7-63(1), the staff noted that the surface spectra corresponding to placing the input motion at the bottom of the CB foundation (dashed line) does not appear to be correct. It resembles the spectrum of the input motion at the foundation level. The dashed line would be expected to exhibit the same pattern of peaks and valleys as the solid line. GEH needs to confirm that the dashed line is correct, and provide an explanation for the unexpected shape.

Part (2) - The staff notes that GEH can define any surface spectrum it chooses to for design certification of the fire water service complex (FWSC). COL applicants will need to demonstrate that the site-specific surface spectrum is enveloped by the spectrum GEH has used for design certification of the FWSC. If this is not the case, then a site-specific analysis of the FWSC will be required at the COL stage. This will be in addition to the required comparisons at the RB/FB and CB foundation levels. SRP 3.7.1 specifies a check at the foundation level for each structure.

The staff believes that the surface spectra used for seismic analysis of the FWSC should envelop the 8 surface spectral plots that the staff has asked GEH to derive under Part (1) above. This would ensure consistency between the input at the RB/FB and CB foundation levels and the input at the surface for the FWSC. GEH's proposed 1.35 factor on the input motion at the bottom of the RB/FB foundation may or may not produce a suitable envelope. Based on comparing Figure 3.7-63(1) to Figure 3.7-63(2), it appears to the staff that a 1.35 factor may not be sufficient over the entire frequency range.

The staff requests GEH to reassess its methodology for selecting the surface spectra for seismic design of the FWSC; provide the technical basis for its selection; and identify the necessary COL applicant action items to ensure the seismic adequacy of the FWSC at each site.

Status: GEH has not responded to this RAI.

RAI 3.8-4 Supplement No. 3, February 19, 2008, ML080320174

The staff reviewed the Supplement 2 response to this RAI, transmitted in GEH letter dated November 6, 2007, and finds that the design of the entire RB to the more limiting acceptance criteria of ASME Section III, Division 2, Subsection CC and ACI 349-01 is acceptable. This includes enveloping the loading combinations and the allowable stresses in the concrete and steel reinforcement from both Codes. This approach for the design of the reactor building needs to be described in the appropriate subsections and tables of Sections 3.8.4 and 3.8.5, and Appendix 3G of the DCD.

Based on the above discussion, the ASME Code jurisdictional boundary for design, construction, fabrication, and inspection of the containment discussed in DCD Section 3.8.1 and as shown in DCD Figure 3.8-1 would also need to be revised. As noted in the Supplement 1 response to this RAI, Interpretation No. 12 (III-2-83-01) of ASME Code Section III states that when the containment mat is integral with other building foundations, only the portion of the containment foundation mat directly beneath the containment vessel including any additional peripheral volume for anchoring of the containment shell reinforcement shall be considered within the code jurisdictional boundary and constructed in accordance with the rules of ASME Code Section III, Division 2. Based on this interpretation, Section 3.8.1 of the DCD including Figure 3.8-1 also needs to be revised to indicate that where integral connections from the reactor building exist (i.e., base mat beyond the containment foundation mat directly beneath the containment vessel as well as floor and walls integrally connected to the containment) the additional peripheral volume for anchoring the containment shell reinforcement shall be within the Code jurisdictional boundary, and thus are subject to all of the rules in ASME Code Section III, Division 2.

Status: GEH responded to this RAI on April 16, 2008. The staff is reviewing the response.

RAI 3.8-9 Supplement No. 4, April 10, 2008, ML080950374

In the Supplement 3 response dated March 13, 2008, GEH identified a number of GEH reports, two NUREG reports, and an NRC letter which relate to the SRSS method for combining dynamic loads. Simply listing such documents does not provide the technical basis for acceptance of the use of the SRSS method for combining seismic and hydrodynamic loadings. As stated in the response, NUREG-0484, Rev. 1 does use information from several of the GEH referenced reports. Based on the use of this information, the staff notes that NUREG-0484 concludes that the use of the SRSS method is acceptable for SSE plus LOCA, but the NUREG report indicates that the use of SRSS for combination of dynamic responses, for loads other than SSE plus LOCA, requires satisfying specific criteria provided in the NUREG. Therefore, GEH is requested again to specifically provide the technical basis for combining dynamic responses for loads other than SSE plus LOCA. If a technical basis is specifically given in any of the referenced documents, then the specific section(s) or page(s) should be identified and the documents should be provided, since often they are not readily available as in this case.

Status: GEH has not responded to this RAI.

<u>RAI 3.8-17 S02, May 24, 2007, ML071620023</u>

A review of the figures provided in GEH's response, which present the element forces and moments in the local finite element model, show in some cases a sudden change in response. As an example, the plot of moment versus elevation in Section A-A, presented in Figure 3.8-17(12), shows sudden changes in magnitude from approximately -8 to -10 and then +5 MNm/m over a change in elevation from about 16.5 to 17 and then 17.5 m. GEH needs to explain this sudden change in element forces and whether this indicates that there may not be sufficient discretization (refinement) in the finite element model. In addition, as requested in the original RAI, a description summarizing the analysis, a figure showing the local finite element model, and figure(s) showing the reinforcement details provided in the GEH response for this representative containment penetration should be included in the DCD.

Status: GEH responded to this RAI by letter dated April 30, 2008. The staff is reviewing the response.

<u>RAI 3.8-25 Supplement No. 5, March 28, 2008, ML080810240</u>

(1) The response, transmitted in GEH letter dated December 12, 2007, provided some information regarding the analysis of the containment liner plate in the full DCD NASTRAN building model. The information provided in the analytical study of a small portion of the containment wall however, did not address the major concerns raised in the RAI. The small “DCD model” was analyzed and compared to the “contact model” which showed the same strains and reaction forces at the liner anchors. However, under pressure loads the two models are essentially identical and so the strains and anchor loads are expected to be the same. This is similarly true for the thermal loading case. Therefore, it does not appear that the study addresses the concerns raised in the RAI.

It was expected that GEH would configure the small DCD model to be identical to the actual full DCD model configuration; that is, it would match the presumed <u>coarser spacing of finite elements with rigid links</u> used in the full DCD model regardless of the actual liner anchor locations. The contact model should then confirm the accuracy of the small DCD model configuration by using a finer discretization (i.e., more finite elements) spaced between the <u>actual locations of the liner anchors.</u> For this contact model, the use of rigid links at the actual anchor locations in both horizontal and vertical directions and the use of contact elements at all other node locations would be acceptable. These two models would not match each other as they do in the current study submitted in the supplemental response.

Based on the above, GEH is requested to revise the analytical models or explain how the current study in the RAI response addresses the potential differences between the current liner model in the full DCD model (which does not match the actual liner anchor spacing and has a presumably coarser distribution) and the true liner configuration with actual anchor spacings.

(2) As part of this RAI, GEH is also requested to provide the following information:

a. How are the strains tabulated in DCD Table 3G.1-35 determined? Are they obtained directly from the individual finite elements of the full DCD NASTRAN model and are they the maximum membrane and maximum membrane plus bending strain acting in any direction throughout the thickness of the liner plate?

b. Since the NASTRAN analysis does not consider potential buckling of the liner plate, GEH is requested to explain if buckling of the liner can occur under the maximum calculated strains for the most critical anchor spacing configuration. If buckling can occur, then describe the calculation performed to obtain the strains in the buckled configuration and demonstrate that they still meet the allowable strain limits in the ASME Code. This should include consideration of the liner strains under thermal local effects on the containment liner due to design basis accident condition. Considering the time-dependent nature of the load, pressure loading may not be present to mitigate the buckling of the liner.

Status: GEH has not responded to this RAI.

RAI 3.8-26 Supplement 1

This RAI depends on the resolution of RAI 3.8-25 above. No response required.

RAI 3.8-28 Supplement No. 3, March 6, 2008, ML080630254

In its response to RAI 3.8-28, Supplement 2, dated November 28, 2007, GEH stated that the mechanical and electrical penetrations are part of the containment boundary, for which design commitment is an ITAAC, as delineated in DCD Tier 1, Revision 4, Table 2.15.1-2, Item 2. Therefore, no COL action item is required.

The staff reviewed DCD Tier 1, Revision 4, Table 2.15.1-2, Item 2, and the referenced Tier 1, Table 2.15.1-1, to determine if there is sufficient information to address the staff's concern. The staff concluded that with some additional clarification in Tier 1, Table 2.15.1-1 and correction of a typographical error in Tier 1, Table 2.15.1-2, Item 2, the information will be sufficient to address the staff's concern. The staff requests GEH to address the following in the next revision of DCD Tier 1:

a) DCD Tier 1, Table 2.15.1-1 lists 11 pages of containment penetrations, including the mechanical and electrical penetrations for which only typical design details currently exist. This table is referenced by DCD Tier 1, Table 2.15.1-2, Item 2, apparently defining a commitment that all applicable provisions of ASME Code Section III will be met, and will be documented in the Code Stress Report. However, the information included in Tier 1, Table 2.15.1-1, related to ASME Code Section III, Seismic Category I, and Safety-Related classifications is not consistently identified for all rows of the table. Revise DCD Tier 1, Table 2.15.1-1 to specifically identify the ASME Code Section III, Seismic Category I, and

Safety-Related classifications for each row of the table, and add a note that the evaluation of all penetrations designated ASME Code Section III will be documented in the Code Stress Report.

b) Correct the typographical error in Tier 1, Table 2.15.1-2, Item 2. In the “Acceptance Criteria” column, “Table 2.1.51-1" should be “Table 2.1.15-1".

Status: GEH has not responded to this RAI.

RAI 3.8-41 Supplement No. 5, March 6, 2008, ML080630254

GEH response dated December 12, 2007, provided information requested for four items related to the effects of the infill concrete within the vent wall and diaphragm floor structures located inside containment. The staff has two concerns as described below.

(1) Based on the prior analytical results, consideration of 50 percent of the (unreinforced) infill concrete stiffness had a pronounced effect on the structural responses from seismic loadings and so GEH has indicated that it would envelop these results with those from the original seismic design case of 0 percent concrete stiffness. From the information provided in the current response it is still not evident that if 100 percent of the concrete stiffness was considered then the increase in member forces and response spectra would be negligible. The basis provided in the response for the small effect on frequency caused by increasing the concrete stiffness from 50 percent to 100 percent is still questionable, as well as the effect of this frequency shift on the member forces and response spectra. GEH needs to either consider the entire range of concrete stiffness in its analysis and design of the ESBWR or clearly demonstrate that the member forces and response spectra are not affected. Also, the current description in the DCD, including Sections 3A.8.4 and 3A.8.5 do not clearly state what percentage of concrete stiffness is considered for the vent wall and diaphragm floor, and it does not clearly state that member forces and response spectra from this set of analyses are enveloped with the results without the infill concrete in the vent wall and diaphragm floor.

(2) This item covers the effect of the infill concrete stiffness for hydrodynamic loadings such as Annulus Pressurization, Safety Relief Valve Discharge, chugging, and condensation oscillation. Since the figures provided in this response show that the hydrodynamic spectra are greater in some locations, GEH needs to consider the entire range of concrete stiffness in its analysis and design of the ESBWR for hydrodynamic loads as well.

Status: GEH has not responded to this RAI.

RAI 3.8-79 Supplement No. 3, April 10, 2008, ML080950374

(1) The response, transmitted in GEH letter dated November 20, 2007, relies on the analysis and design of the radwaste building (RW), which will be performed in accordance with RG 1.143 in the future, as the basis for demonstrating that the RW building meets the interaction criteria of non-category I structures and seismic Category I structures. The information provided does not demonstrate that the RW building has been analyzed and designed to withstand an SSE.

GEH DCD Tier 2 Rev. 4, Section 3.7.2.8, provides three options for addressing the interaction of non-Category I structures and seismic Category I structures. For the RW building, it appears from the GEH response that Option (3) has been selected. Option (3) indicates that non-Category I structures are analyzed and designed to prevent their failure under SSE conditions in a manner such that the margin of safety of these structures is equivalent to that of seismic Category I structures. SSCs in this category are classified as C-II. According to DCD Section 3.7, the methods of seismic analysis and the design acceptance criteria for C-II SSCs are the same as C-I. The staff has approved Option (3) as a means of demonstrating the adequacy of potential interaction between non-category I and seismic Category I structures. The analysis and design to satisfy this option should be separate from the criteria in RG 1.143 which is intended to demonstrate the design adequacy of the RW building under the OBE or ½ SSE (not the SSE).

Based on the above discussion, the staff requests that GEH provide the analysis and design of the RW building in accordance with DCD Section 3.7.2.8, Option (3); which indicates that they are performed in accordance with the same criteria as seismic Category I structures. This should include the seismic SSI analysis, definition of SSE spectra used as input, site interface parameters, and design adequacy of critical sections as was performed for the other C-I structures.

(2) Since the service building (SB) is classified as a Seismic C-II structure, the same information requested above for the RW building is also needed for the SB to address the interaction of non-Category I structures and Seismic C-I structures.

(3) The GEH response to the original RAI indicated that the turbine building (TB) is classified as a Seismic C-II structure. The staff notes that Table 3.2-1 in DCD Tier 2 Rev. 4 now indicates that the seismic classification of the TB is non-seismic (NS). Since the TB is also in close proximity to the reactor building/fuel building, what is the technical basis for this change in classification? If GEH has selected Option (2) of DCD Section 3.7.2.8 to address the interaction criteria, provide a description of the calculations that were performed to demonstrate that the collapse of the TB does not impair the integrity of the seismic C-I structures. This description should be included in the DCD to demonstrate the integrity of the seismic C-I structures. If Option (3) is selected, then the TB should be classified as seismic C-II, and the same information as described above for the SB and RW building is needed.

Status: GEH has not responded to this RAI.

<u>RAI 3.8-80, Supplement 3, 4/10/2008, ML080950374</u>

The response transmitted in GEH letter dated November 20, 2007, explained that the radwaste building (RW) is identified as part of the ESBWR standard plant in DCD Tier 2 Subsection 1.1.2.1, and is therefore a part of the design certification scope. The staff accepts the response which indicates that the RW building is part of the design certification scope. However, the referenced Subsection 1.1.2.1 does not clearly state this; it indicates that “The following main buildings (see Figure 1.1-1) are within the scope for the ESBWR” This should be revised to clearly indicate that the following buildings are within the <u>design certification</u> scope for the ESBWR.

The DCD indicates that the analysis and design of the RW building is in accordance with NRC RG 1.143, Rev. 2, 2001. This RG provides information and criteria that will provide reasonable assurance that SSCs used in the radioactive waste management and steam generator blowdown systems are designed, constructed, installed, and tested on a level commensurate with the need to protect the health and safety of the public and plant operating personnel. Since the RW building is within the design certification scope, the information needed to develop the reasonable assurance that the health and safety of the public and plant operating personnel is achieved, should be provided. Therefore, the staff requests that GEH provide in the DCD the description of the analysis and design as well as a summary of the results for the RW building, similar to Category I structures, which demonstrate compliance with RG 1.143.

Status: GEH has not responded to this RAI

RAI 3.8-91 Supplement No. 4, May 24, 2007, ML071620023

The applicant's supplemental response addressed the questions raised by the staff during the audit. However, to eliminate any uncertainty in the staff's interpretation of the tabulated load data in combining the individual loads, and in applying the combined loads to selected critical elements, the staff requests the applicant to provide the following additional information for the most critical basemat element and the most critical wall element (i.e., whose stress ratios for concrete and steel reinforcement are the highest, recognizing that a different element and different load combination may govern for the concrete versus the steel):

The individual loads, combined loads, and a hand calculation performed in accordance with the design code for the concrete and steel reinforcement (for flexure and membrane forces, and for the corresponding shear forces).

Please also provide the results of the SSDP analysis for the same two elements, which will allow a direct comparison to the hand calculation results.

Status: GEH responded to this RAI by letter dated December 12, 2007. The staff is reviewing the response.

RAI 3.8-93 Supplement No. 3, March 28, 2008, ML080810240

The RAI Supplement 2 response, transmitted in GEH letter dated November 28, 2007, provided information to address five items related to the foundation and soil settlement, seismic soil shear wave velocity requirement, construction sequences, and soil stiffness studies. To address Item (5) in the supplemental response, the staff requests GEH to clarify whether the COL applicant or someone else will determine if the construction sequence is substantially different from the sequences considered in the design, and if substantially different, who will ensure that they will not adversely impact the basemat design. The commitment regarding the construction sequence, with this additional clarification, should also be included in DCD Tier 2, Subsection 2.

Status: The applicant has not responded to this RAI.

RAI 3.8-94, Supplement 3, 3/28/2008, ML080810240

The RAI Supplement 2 response, transmitted in GEH letter dated November 28, 2007, provided information to address five items related to the soil bearing capacities. GEH is requested to addresses the following items:

(1) The staff agrees with the statement made in the GEH response that confirmation of the bearing capacity is a COL item. However, the development of the required bearing capacities is part of the DCD review and if the values are extremely large compared to known soil and rock capacities, the staff needs to have a reasonable assurance that these bearing capacities can be met. Therefore, GEH is requested to explain why these extremely large bearing capacities are considered to be reasonable values which can be met at various potential plant sites.

(2) GEH is requested to explain why it is acceptable to use a linearly interpolated value for the soil bearing capacities between the three sets of values (soft, medium, and hard). Using the information presented in Figure 3.8-94(1)(c) of the response (as an example), this would underpredict the required bearing capacity.

(3) Footnotes are still missing in the revised Table 5.1-1 in DCD Tier 1 Revision 4.

Status: GEH has not responded to this RAI.

RAI 3.8-96 Supplement No. 3, March 28, 2008, ML080810240

The RAI Supplement 2 response, transmitted in GEH letter dated November 28, 2007, provided information to address nine items related to the stability analyses performed for the ESBWR foundations. The staff requests GEH to address the items discussed below which are still unresolved. The item numbers match the prior RAI Supplement 2 item numbers except for item number 10 which is a follow-up item from RAI 3.8-96, Supplement 1. Note that some of the items discussed below, in the context of sliding stability, are also applicable to overturning stability.

(1) In the equation given for passive soil pressure, why was the water pressure considered in resisting sliding, since there would be an equal and opposite water pressure on the other side of the building? Why wasn't the active soil pressure, on the entire foundation wall and basemat vertical edge, due to static and seismic loads considered on the other side of the building acting in the opposite direction to the passive pressures? Clearly define what surcharge loads (q) were utilized in the equation, because only known permanent surcharge loads (e.g., from other buildings) which would never be removed are appropriate.

(2)

a. GEH states that the shear strength of the soil, i.e., the resistance at the basemat bottom, is composed of friction and cohesion. However, the procedure described by GEH would only apply to a sliding capacity calculation where failure occurs within the soil medium; it would not apply to a sliding capacity calculation at the concrete to soil interface. Therefore, GEH also needs to consider the sliding capacity caused by sliding resistance between the concrete and soil interface (alone). Typically this consists of the bottom friction resistance term given in Tables 3.8-96(3) and 3.8-96(4) of the RAI response which is identified as "Fub: Bottom Friction Force." If any additional sliding resistance due to cohesion between the soil and concrete at the foundation bottom is used, then describe this approach and explain how it compares to other industry analytical methods such as the Navy Design Manual DM7-02 (available from various websites). Such an approach would require having a cohesive soil which would then become a site interface parameter. This will then need to be placed in DCD Tier 1 and Tier 2, and will need to be satisfied by the COL applicant. Note that whatever approach is used for all soil stability calculations, the evaluations must cover all soil types/conditions that the design certification is intended to cover (e.g., soft, medium, and hard soils; cohesive soils and granular (cohesionless) soils; varying soil friction angle; etc.).

b. For the case of sliding frictional resistance capacity between the foundation mat and soil, the staff does not agree that the use of the static coefficient of friction is conservative. The shear force required to initiate sliding between two surfaces is usually greater than the force required to maintain motion, and therefore it is not conservative to use the higher value to resist sliding. Furthermore, the use of the static frictional resistance at the bottom of the basemat is not consistent with the use of the passive soil resistance at the vertical edge of the basemat. This is because to mobilize the full passive resistance at the vertical edge of the basemat requires some movement of the basemat, in which case, the dynamic sliding friction would be more applicable. Based on the above, GEH is requested to revise their approach to ensure that all of the resisting forces utilized to prevent sliding are developed using a consistent set of assumptions or provide justification for any alternative methods.

(3) No additional information needed.

(4) The equation provided for the calculation of cohesion (c') for use in sliding evaluations does not appear to be appropriate for its intended use. That is because of the following items: (a) It appears that this equation which determines the cohesion value c' is only applicable for cohesive soils, not granular (cohesionless) soils; (b) The use of the cohesion value is applicable for soil shear capacity calculations where failure may occur within the soil medium; it would not be applicable for a sliding capacity calculation at the concrete to soil interface; (c) The relationship between q_u and cohesion c' and the recommended use of 0.5 to 0.7 of c' for sliding stability evaluations could not be located in Reference 1, which was referred to in the RAI response; (d) The magnitudes of the bearing capacities tabulated in Table 3.8-96(2), which are used to determine c' seem to be unrealistically high. They would require, for the RB/FB medium soil case for example, a soil bearing pressure capacity of 7.3MPa (153ksf) which are extremely large compared to known soil and rock capacities (also identified under RAI 3.8-94). Therefore, GEH is requested to provide the technical basis for application of their approach for all soil types/conditions (e.g., soft, medium, and stiff; cohesive soils and granular (cohesionless) soils; varying soil friction angle; etc.) that the design certification is intended to cover or utilize other accepted analytical methods typically used for sliding evaluations as discussed under item (2) above.

(5) and (6) Please revise the response to these items based on any revision to Item (4).

(7) The reduction in contact area between the foundation basemat and the soil, due to some overturning uplift from seismic loads, needs to be considered in the calculations, especially since the margins currently shown in the tables will change and may be reduced when the sliding calculations are revised to address the other items in this RAI.

(8)

a. Confirm whether the response given means that the analysis and design of the SSCs in the ESBWR plant including development of the floor response spectra were all based on the enveloped responses for the lumped mass models and the SASSI models. If the analysis and design of the SSCs were based only on the lumped mass models, then did all of the building responses (i.e., member forces, nodal accelerations, nodal displacements, and floor response spectra) from the lumped mass models bound the responses from the SASSI models?

b. From the response to this item, it appears that the shear wave velocity of the backfill material does not have to match the surrounding undisturbed soil. Since the properties of the backfill material will likely be different, GEH is requested to identify the extent of excavation of the soil during the construction of the plant structures and identify what will be the requirements for the soil properties of the backfill material. If these are different than what were assumed in any of the seismic analyses and designs, then GEH is also requested to provide the technical basis for accepting the differences or confirm that the design basis building responses (including floor response spectra) bound the expected values of the backfill soil properties (including reduced shear wave velocities). In the case of the foundation walls, GEH is also requested to explain why the elastically calculated wall pressures from seismic and other loads are still appropriate in view of the soil properties (including reduced shear wave velocity) of the backfill material. Unless the analyses and design cover the entire range of possible backfill soil properties, the assumed soil properties for the backfill materials should be considered a requirement, and therefore, clearly stated in the DCD as a site requirement.

(9) As noted in the staff's prior assessment of GEH RAI 3.8-96, Supplement 2, response, the traditional method for evaluating the stability (sliding and overturning) of nuclear plant structures in accordance with SRP 3.8 is to perform two separate 2-D evaluations, one for the N-S direction and one for the E-W direction. The minimum vertical downward load (deadweight minus upward buoyancy force minus upward vertical seismic force) is considered separately with the N-S horizontal seismic force and with the E-W horizontal seismic force.

In calculating the total upward vertical seismic force, the total N-S horizontal seismic force, and the total E-W horizontal seismic force at the soil/foundation interface, it is acceptable to use either SRSS or 100-40-40 (as defined in RG 1.92, Rev. 2) to combine the individual responses from response spectrum analyses for the 3 directions of seismic loading. Thus, the SRSS or the 100-40-40 methods are used only to determine the individual total structural response in a given direction (e.g., total shear force in N-S direction) from the individual collinear responses due to each of the three perpendicular seismic excitations (i.e., N-S shear force due to N-S earthquake, N-S shear force due to E-W earthquake, and N-S shear force due to vertical earthquake). The approach GEH is using does not follow this method, but instead combines non-collinear structural responses (i.e., N-S shear force, E-W shear force, and vertical force) following the 100-40-40 method, which is unacceptable.

In lieu of this, the results from a 3-D time history analysis using statistically independent inputs can be used, to search the time history response for the worst case combination of vertical and horizontal seismic responses, which minimize the sliding and overturning factors of safety when combined with deadweight and upward buoyancy force.

GEH proposed application of the 100-40-40 method in this case is not consistent with the staff's acceptance of the method, which as stated in RG 1.92, Rev. 2, applies to combination of individual response components when RSA is used. On this basis, it is not acceptable to the staff. The two approaches described above are acceptable. If GEH chooses to apply an alternate method, then it will need to submit a comparison to results that would be achieved by either one of the two methods described above.

(10) The crystalline powder which is proposed by GEH for use in the mud mat concrete below the basemat and which is intended to provide waterproofing to prevent water infiltration or ex-filtration still raises some questions. It appears that the concrete mud mat is unreinforced and therefore, cracking of the mud mat is very likely to occur and the crystalline powder may not be effective in preventing water infiltration or ex-filtration. GEH is requested to provide technical information that demonstrates the effectiveness of the crystalline additive in concrete foundations. This information should include: the requirements necessary for proper use of this product, data which demonstrates its effectiveness under similar conditions (e.g., reinforced or unreinforced concrete, effect on concrete compressive strength, minimum thickness required for the concrete section, water pressure/head capacity and permeability versus water pressure/head, etc.), and what performance testing requirements will need to be satisfied during construction. In addition, specific information needs to be provided in the DCD regarding: the compressive strength of the concrete mud mat, if any reinforcement is needed, the acceptable range of thickness for the concrete mud mat, the inclusion of a statement (which was made in the Supplement 1 response) that "The mud mat construction is performed in accordance with the same standards and requirements as the basemat," and inclusion of performance testing requirements that will be needed during construction of the mud mat (e.g., permeability testing, compressive strength testing, etc.). GEH is also requested to explain what waterproofing system is relied upon to prevent infiltration of ground water through the walls below grade.

Status: GEH has not responded to this RAI.

<u>RAI 3.8-101 Supplement No. 3, February 19, 2008, ML080320174</u>

The response transmitted in GEH letter dated November 28, 2007, refers to RAI 3.8-4, Supplement 2 for resolution of this RAI. While significant progress has been made in resolving RAI 3.8-4, it still remains open; therefore, RAI 3.8-101 must also remain open. When RAI 3.8-4 is fully resolved, then the existing text in DCD Section 3.8.5.2 and other related sections (e.g., Appendix 3G) need to be revised to properly describe the applicable codes, standards and specifications for the foundations of the reactor building and the other Seismic Category I structures. The revised text should not simply refer to Section 3.8.1.2 and 3.8.4.2 as it does now unless the referenced sections clearly explain which specific codes, standards and specifications apply to each foundation covered in DCD Section 3.8.5.

Status: GEH responded to this RAI on April 16, 2008. The staff is reviewing the response.

<u>RAI 3.8-102 Supplement No. 3, February 19, 2008, ML080320174</u>

The response, transmitted in GEH letter dated November 28, 2007, refers to RAI 3.8-4, Supplement 2 for resolution of this RAI. While significant progress has been made in resolving RAI 3.8-4, it still remains open; therefore, RAI 3.8-102 must also remain open. When RAI 3.8-4 is fully resolved, then the existing text in DCD Section 3.8.5.3 and other related sections (e.g., Appendix 3G) need to be revised to properly describe the loads and load combinations for the foundations of the reactor building and the other Seismic Category I structures. The revised text should not simply refer to Section 3.8.1.3 and 3.8.4.3 as it does now unless the referenced sections clearly explain which loads and load combinations apply to each foundation covered in DCD Section 3.8.5.

Status: GEH responded to this RAI on April 16, 2008. The staff is reviewing the response.

<u>RAI 3.8-103 Supplement No. 3, February 19, 2008, ML080320174</u>

The response transmitted in GEH letter dated November 28, 2007, refers to RAI 3.8-4, Supplement 2 for resolution of this RAI. While significant progress has been made in resolving RAI 3.8-4, it still remains open; therefore, this RAI 3.8-103 must also remain open. When RAI 3.8-4 is fully resolved, then the existing text in DCD Section 3.8.5.5 and other related sections (e.g., Appendix 3G) need to be revised to properly describe the structural acceptance criteria for the foundations of the reactor building and the other seismic Category I structures. The revised text should not simply refer to Section 3.8.1.5 and 3.8.4.5 as it does now unless the referenced sections clearly explain which acceptance criteria apply to each foundation covered in DCD Section 3.8.5.

Status: GEH responded to this RAI on April 16, 2008. The staff is reviewing the response.

<u>RAI 3.8-107 Supplement No. 2, May 24, 2007, ML0716200230</u>

(a) The staff reviewed the numerical data provided in the supplemental response to RAI 3.8-107, and did not reach the same general conclusion as the applicant, concerning the conservatism of the DCD results, compared to the SRSS and the RG 1.92 100/40/40 methods for combining responses from 3 directions of motion. The applicant is requested to address the following questions:

(1) From review of the Fot values in Tables 3.8-107(2) and 3.8-107(7), both listed as element 1824, it appears that the calculation for combined loading uses different values for the DCD method and for the SRSS/RG1.92 100/40/40 methods. Of particular note is Nx, listed as 4.096 in Table 3.8-107(2) and 0.946 in Table 3.8-107(7). Please explain this apparent discrepancy, which would tend to show the DCD method is conservative. If this is an error, re-calculate the combined loading results using the correct Fot loads, and provide the revised comparison results.

(2) All comparisons presented in Figures 3.8-107(1) thru (12) show that the predicted stress does not exceed the allowable stress limit, for all 3 methods of spatial combination. The data presented is based on a limited subset of locations and two (2) load combinations that include SSE. Please identify any locations and load combinations where the allowable stress limit is exceeded by any of the 3 spatial combination methods. Quantify the degree of exceedance.

(3) Figures 3.8-107(6)(b) and (10)(b) show one point where the SRSS and RG1.92 100/40/40 methods of spatial combination produce results significantly higher (factor of 2.5 to 3) than the DCD method. Please explain this large difference, and provide the technical basis for considering this large difference to be acceptable.

(4) The RG 1.92, Rev.2, acceptable procedure for implementation of the 100/40/40 rule was intended to produce the most conservative estimates of response components due to 3 directions of seismic loading. Since the calculated response components are absolute values and seismic response is oscillatory, both the positive and negative sign must be considered when combining with response components due to other loads. This is completely analogous to implementation of the SRSS combination method. Studies conducted by the staff demonstrated the conservatism of this approach, compared to SRSS. The staff requires clarification why, for combined loading cases, the DCD method of combination (ASCE 4-98 implementation of the100/40/40 rule) produces higher results than the RG 1.92 implementation procedure for the 100/40/40 rule at approximately 50 percent of the locations in the comparison tables.

(b) The staff also reviewed the revised validation report for SSDP-2D, provided in the applicant's initial response to RAI 3.8-107. Based on this review, the staff requests the following clarifications:

(1) Table 7 and Table 8 present the transverse shear analysis and code check for ASME 2004 and ACI349-01, respectively. Table 7 lists the stress units as "MPa". Table 8 lists some units as "MPa" and some units as "psi". Please revise these tables as appropriate, to identify the correct units.

(2) The results presented in Tables 7 and 8 each show excellent correlation with hand calculations. However, comparing the results in Table 7 to the results in Table 8, row 1 and row 5 show differences between the 2 codes, while the remaining rows show consistency. Please explain the basis for the differences in rows 1 and 5.

(3) The applicant is requested to provide a copy of the journal article utilized for the membrane section force calculation in Section 4.1 of the validation report. For Section 4.2 of the validation report, the applicant is requested to identify the source of the equations utilized for the axial force and bending moment calculation, and provide a copy of the applicable pages. In addition, explain whether the hand calculations solve the same set of equations utilized in the SSDP computer code, or whether the hand calculations use an independent approach. If the hand calculations use an independent approach, please describe the method used in the SSDP computer code.

(c) The staff noted that the calculation of F_{OT}, used in demonstrating the combined loading comparisons, uses a unique "thermal ratio" for each individual internal force and moment resultant calculated by linear elastic thermal stress analysis using NASTRAN. For element 1824 used in the demonstration calculation, the "thermal ratio" varies as follows:

1.69 for Nx (1.981 goes to 3.348)
0.14 for Ny (-2.824 goes to -0.395)
1.0 for Nxy (0.082)
0.16 for Mx (-4.322 goes to -0.692)
0.29 for My (-7.438 goes to -2.157)
1.0 for Mxy (0.022)
-0.15 for Qx (-0.082 goes to 0.012)
0.24 for Qy (-1.354 goes to -0.325)

It is the staff's understanding that these ratios were obtained based on the results of two (2) ABAQUS/ANACAP analyses. The first was a linear elastic thermal stress analysis, and the second was a nonlinear thermal stress analysis that considered internal force and moment redistribution due to concrete cracking and inelastic material behavior. The wide variation in the thermal ratios, and the significant reduction in the maximum elastically calculated results indicates that nonlinear behavior and re-distribution of internal forces and moments is very significant.

The staff has a concern that combining the nonlinear thermal stress analysis results with the elastically calculated results for other loads may not be appropriate. The correct approach, because of the significant nonlinear behavior evident in the ABAQUS/ANACAP thermal analysis, would be to apply all simultaneously occurring loads at the same time using the ABAQUS/ANACAP nonlinear model. In the presence of significant nonlinear behavior, linear superposition of results due to different applied load sets may lead to significant errors in the final combined loading response.

The staff requests the applicant to provide a detailed technical basis for the acceptability of its approach. Example comparisons for element 1824 and several other representative locations should be included in the response.

Status: GEH responded to this RAI by letter dated May 1, 2008. The staff is reviewing the response.

<u>RAI 3.8-110 Supplement No. 2, April 10, 2008, ML080950374</u>

In the Supplement 1 response dated February 26, 2008, GEH stated that the ESBWR design certification meets the regulatory positions stated in Regulatory Guide 1.57, Revision 1, which endorses the ASME Section III, Division 1, Subsection NE, 2001 Edition through the 2003 Addenda; and DCD Tier 2 Table 1.9-21 and Subsection 3.8.2.2 will be revised to show Regulatory Guide 1.57, Revision 1, as being applicable to the ESBWR design certification. The staff reviewed the proposed revision and finds it acceptable.

(a) In the response, GEH also identified that DCD Tier 2 Table 3.8-4 will be revised to agree with the load combinations in Regulatory Guide 1.57, Revision 1. The staff reviewed the proposed revision; compared it to RG 1.57, Rev. 1; and noted that DCD Table 3.8-4 does not address Service Level A load combinations (5) and (6) and Service Level C load combinations (4) and (5), which originate from 10 CFR 50.34 and 10 CFR 50.44, and include P_{g1}, P_{g2}, and/or P_{g3}.

    In order to be consistent with RG 1.57, Rev. 1, please describe in DCD Section 3.8.2 how GEH has addressed the cited load combinations. Similarly, the staff notes that for the concrete portion of containment, DCD Tier 2, Table 3.8-2 does not address the load combinations 5.B.(1), (2), and (3) in RG 1.136, Rev. 3, which originate from 10 CFR 50.34/ 10 CFR 50.44. In order to be consistent with RG 1.136, Rev. 3, describe in DCD Section 3.8.1 how GEH has addressed the cited load combinations.

(b) In the last part of the response, GEH indicated that the materials listed in DCD Tier 2 Subsection 3.8.2.6 have been made consistent with the materials listed in ASME Section III, Division 1, Subsection NE, Article NE-2121. Materials previously listed in DCD Tier 2 Subsection 3.8.2.6 that are applicable to ASME Section III, Division 1, Subsection NF, or to ASME Section III, Division 2, Subsection CC, or any materials not shown on DCD Tier 2

Appendix 3G drawings of the steel components of the RCCV, have been removed. The staff reviewed the proposed revision to Subsection 3.8.2.6, and finds it acceptable, except for “Clad (SA-240, type 304L)”. The staff confirmed that Figure 3G.1-51 specifies 2.5 mm cladding on the exterior surface of the drywell head, and references SA-240, type 304L. However, the staff notes that SA-240 is a plate material designation. Therefore, please either confirm the applicability of SA-240 to cladding material, or revise the referenced material specification accordingly, in both DCD Subsection 3.8.2.6 and Figure 3G.1-51.

(c) The DCD Tier 2 Chapter 3 Revision 3 to Revision 4 Change List, item 46, identified the following change to Subsection 3.8.2.6, 1st paragraph, 4th bullet:

> Inserted “or SA-540 Gr. B24 Class 3” as bolting material and “or SA-479 Type 304” as nut material to be in accordance with F3G.1-51 through F3G.1-53.

The staff confirmed that DCD Rev. 4 Figures 3G.1-51 through 3G.1-53 reference SA-540 Gr. B24 Class 3 bolting material. There is no reference to a nut material. However, the staff noted in its review of GEH Supplement 1 response to RAI 3.8-110, that these bolt and nut materials have been deleted in the proposed revision to Subsection 3.8.2.6. This is appropriate because neither the bolt material nor the nut material is listed in ASME Section III, Division 1, Subsection NE, Article NE-2121.

Please revise Figures 3G.1-51 through 3G.1-53, to reference a bolting material that is listed in ASME Section III, Division 1, Subsection NE, Article NE-2121, and also describe any corresponding design modifications to the bolted closures that may be needed as a result of the material change. In lieu of this, GEH may submit its technical basis for the acceptability of SA-540 Gr. B24 Class 3 bolting material and SA-479 Type 304 nut material for this containment pressure boundary application. If the second alternative is pursued, then DCD Subsection 3.8.2.6 must be revised, to discuss the use of the non-NE materials for this application.

Status: GEH has not responded to this RAI.

RAI 3.8-113, May 29, 2007, ML071450138

Provide the technical details about how temperature effects were considered in the design of Spent Fuel Pool structure, to account for boiling of the pool water for up to 72 hours at 212 degrees F. Identify which load category (e.g., T_a or T_o) and load combinations in DCD, Tier 2, Table 3.8-15 include consideration of this thermal condition for the reinforced concrete walls. This information needs to be documented in the DCD.

Status: GEH responded to this RAI by letter dated May 1, 2008. The staff is reviewing the response.

RAI 3.8-117, January 14, 2008, ML080020219

DCD Revision 4, Section 3.8.2.1 has been revised to add the PCCS condensers as steel components of the concrete containment vessel. DCD Revision 4, Section 3.8.2.4.1.5 has also been added, to provide a description of the PCCS condensers. The fourth paragraph states “The PCCS condenser parts conform to the design requirements of Subarticles NE-3200 and NE-3300 of ASME Code, Section III, Subsection NE (Class MC). The PCCS condenser support is evaluated in accordance with the ASME Code, Section III, Subsection NF.”

In order to complete its review, the staff requests the applicant to address the following:

a. ASME Code Section III, Subsection NE (Class MC), Subarticle NE-1120 states "Only containment vessels and their appurtenances shall be classified as Class MC. Piping, pumps, and valves which are part of the containment system (NE-1130) or which penetrate or are attached to the containment vessel shall be classified as Class 1 or 2 by the Design Specification and meet the requirements of the applicable Subsection." It appears to the staff that the PCCS condensers and the piping between the condensers and the drywell would be more appropriately classified as Class 1 or Class 2. These sections of the ASME Code (NB- 3200 and 3300 or NC-3200 and 3300) provide design and analysis procedures that the staff considers more applicable to piping and components. Explain the exact meaning of the statement "The PCCS condenser parts conform to the design requirements of Subarticles NE-3200 and NE-3300 of ASME Code, Section III, Subsection NE (Class MC)." Were the condensers and piping initially designed to NE, NB, or NC? If NB or NC, were any design modifications necessary to conform with NE? If NE, would any design modifications be necessary to conform with NB or NC?

b. The PCCS condensers are designated as part of the containment pressure boundary. This appears to be a unique application of condensers. In order to develop reasonable assurance that the containment has been adequately designed, the staff requests the applicant to provide a comprehensive description of the condenser and connecting piping. The description should include details and figures showing the individual parts of the condenser and how they are connected; dimensions; materials; the piping and pipe supports between the containment top slab and condenser; and the supporting elements from the condenser to the top slab and lateral supports to the pool walls.

c. Since the PCCS condensers and piping are part of the containment pressure boundary, include in the DCD a description of the analysis and design evaluation (including results) comparable to the information provided for other steel components of containment.

d. Provide a detailed description of how the preoperational pressure tests will be performed for the PCCS condenser and associated piping in accordance with the requirements of the applicable subsection of ASME Code Section III, including discussion of the provisions of the Code where it is not obvious the Code provisions can be met. As an example, how is examination for leakage accomplished after application of test pressure?

Provide a detailed description of how the preservice and inservice inspection requirements of ASME Code Section XI, Subsection IWE, will be effectively implemented for the PCCS condensers and associated piping. The staff notes that the IWE requirements are applicable primarily to accessible shell type structures.

Status: GEH responded to this RAI by letter dated April 29, 2008. The staff is reviewing the response.

RAI 3.8-119, January 14, 2008, ML080020219

Appendix 3B of DCD Revision 4 has deleted significant portions of information for the containment hydrodynamic load definitions which were utilized in the structural evaluations for the containment and containment internal structures. In addition to deleting some important text information, all of the figures in the previous DCD Revision 3, Appendix 3B (Figures 3B-1 through 3B-11), have been removed. The current text in Appendix 3B now refers to

Reference 3B-1, GEH Energy report "ESBWR Containment Load Definition," (NEDE-33261P and 33261) for the deleted information. The descriptive information of the hydrodynamic loadings applied to the structural models needs to be included in the DCD, just as seismic loading descriptions are included in the DCD. This description should include some pressure distribution diagrams on the containment and containment internal structures, representative pressure time histories, and sequencing of loading events comparable to the figures deleted from DCD Revision 3.

Status: GEH responded to this RAI by letter dated March 13, 2008. The staff is reviewing the response.

RAI 3.8-120 Supplement No. 1, May 27, 2008, ML081440404

Part (b):

1. In Part (b) of the RAI response, dated April 3, 2008, GEH revised the applicable sections of DCD 3.8.2 and 3.8.3 to identify the material grade for the various steel materials used so that they will be consistent with the material properties assumed in design. However, for all locations in DCD 3.8.3 where the material A-709 HPS 70W is given, a footnote was added which refers to ASME Code Case N-763. Since DCD 3.8.3 applies to the containment internal structures, which are designed using the ANSI/AISC N690 specification, please explain the reason for referencing ASME Code Case.

2. The GEH response to RAI 5.2-50 indicates that A-709 HPS 70W is being added to the DCD as an option for the containment liner. Use of A-709 HPS 70W material for containment liner is currently under review by the ASME Standards Committee under a new code case (ASME Code Case N-763). As such, this needs to be approved by the ASME Code before it can be used for containment liner. The staff requests GEH to explain why an option is being given for use of the A-709 HPS 70W material. Also, based on the proposed revisions to the DCD, it is not clear as to what portions of the containment liner and appurtenances will use the currently specified ASME SA-516 Gr.-70 or the newly proposed material of ASTM A-709 HPS 70W. These should be clearly explained.

3. If the A-709 HPS 70W material will also be used for the containment liner and appurtenances, then GEH is requested to explain how the change in material (including the much higher yield strength) affects the analysis and design of the containment. This should include the effects of this new material on the overall finite element analysis of the entire containment structure for mechanical and thermal loads as well as the localized design of the liner and liner anchorages.

Part (c):

In Part (c) of the RAI response, dated April 3, 2008, GEH indicated that the portion of the reactor shield wall using ASTM A709 HPS 70W with thicknesses exceeding 4 inches may be fabricated using one of the multiple layer construction techniques identified in ASME Code, Section VIII, Division 1. The staff notes that the reactor shield wall is not a pressure vessel, and if it was a pressure vessel for use in nuclear power plants, it would be subject to the rules of ASME Section III not Section VIII. 10 CFR 50.55a which is the basis for endorsing applicable sections of the ASME Code does not endorse ASME Section VIII. If GEH still wants to use some other method (such as the ASME Code, Section VIII, Division 1) rather than a conventional engineering design approach for treating multiple layers of cylindrical structures, then GEH is requested to fully describe the specific analytical approach that will be used and to demonstrate the technical adequacy of the approach. Simply referring to some Code and stating that using the construction techniques of that Code allows the multiple layer shells to act as a solid wall is not sufficient.

Status: GEH has not responded to this RAI.

RAI 3.8-121 Supplement No. 1, May 27, 2008, ML081440404

The RAI response dated April 3, 2008, provided additional information related to the analysis and design of the composite floor slabs. This was needed because the analysis and design method being used is a unique approach to design composite floor slabs. The following parts (a) through (e), noted in the GEH's response require further information:

(a) As requested in the original RAI, the technical basis (justification) for treating the steel plates as two orthogonal rebars and also designing the composite floor slabs using ASME Code Section III, Division 2, Subsection CC criteria was not provided. GEH is requested to provide this information. Also, how does this approach compare to other more conventional methods for design of composite floor slabs such as Section Q1.11 – Composite Construction of ANSI/AISC N690 or the International Building Code (IBC) which references ANSI/AISC 341?

(b) How are the forces developed at the studs for design? What are the allowable values? Is the material and design of the studs performed in accordance with ANSI/AISC N690; If so, what sections of N690? If not, explain why.

(c) If the design code of record for the composite floor slabs is ANSI/AISC N690, then why are the allowable values for the concrete, rebar, and steel plate of the ASME Code utilized. How do these compare to a design done in accordance with N690 for steel and ACI-349 for concrete?

(d) If temporary shoring is not used, why is the statement made that the steel plates are not affected by the initial stress during construction (e.g., concrete pour). How is this initial stress addressed in design of the composite floor steel plates.

(e) The series of tests listed as references for composite floor slabs tested in Japan, as noted in the response, are in Japanese which is not useful. The other papers that are listed in the response as references are for composite walls (not floors), have plates on both sides (not one side as in the ESBWR design), and it is not evident if they include out of plane loading test results. Thus, it is not clear that there is any useful information in these papers to support the design approach being used. As requested in the original RAI, provide any test data and/or peer reviewed articles that could support the design approach being used. To expedite the review, the actual paper should be provided (not just a reference) and an explanation should be provided to show that the configuration of the specimens (e.g., wall thickness, plate thickness, anchorage type), material properties, and loading (bending, membrane, and shear) used for testing or the article are similar to or in the range of the design condition used for the ESBWR.

Status: GEH has not responded to this RAI

RAI 3.9-75 Supplement No. 1, May 15, 2007, ML071580015

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.

Status: GEH replied to this RAI by letter dated August 7, 2007. However GEH is planning to provide further clarification on this RAI.

RAI 3.9-77 Supplement No. 2, March 28, 2008, ML080810240

Provide the justification for extrapolating the stresses in the ESBWR top guide from stresses calculated in the ABWR, based on the guide plate lateral load results from the beam model analyses. In particular, comment on any differences in stress concentrations and stress patterns in the ABWR and ESBWR top guides, all of which would have to be the same or very similar in the ABWR and the ESBWR for the extrapolation to provide a reasonable estimate of the stress in the ESBWR top guide.

Status: GEH has not responded to this RAI.

RAI 3.9-81, October 10, 2006, ML 062760404

It is stated in DCD Tier 2, Section 3.9.2.5 that the reactor internal pressure differentials due to an assumed break in main steam or feedwater line are determined by analysis as described in DCD Tier 2, Section 3.9.5.3. In order to assure that no significant dynamic amplification of load occurs as a result of the oscillatory nature of the blowdown forces during an accident, a comparison is made of the periods of the applied forces and the natural periods of the core support structures being acted upon by the applied forces. These periods are determined from a comprehensive vertical dynamic model of the reactor pressure vessel (RPV) and internals. Provide a summary of the analytical results that demonstrate no significant dynamic amplification of the loads on the reactor internals core support structures as a result of the postulated break in main steam or feedwater lines.

Status: GEH has not responded to this RAI.

RAI 3.9-96, Supplement 1, 5/15/2007, ML071580015

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.

Status: GEH responded to this RAI by letter dated February 4, 2008. The staff is reviewing the response.

<u>RAI 3.9-133 Supplement No. 1, May 10, 2007, ML073050301</u>

In its response to RAI 3.9-133, the applicant committed to instrumenting the prototype ESBWR steam dryer per DCD Tier 2, Subsection 3.9.2.4 and Subsection 3L.4.6 of DCD, Tier 2, Appendix 3L, and the prototype ESBWR chimney partitions, per Section 3L.5 of DCD, Tier 2, Appendix 3L. The applicant clarifies Item 5 in DCD, Tier 2, Section 3L.2.1 (page 3L-4), stating that the statement, “FIV will not be an issue,” does not apply to the steam dryer or chimney partition assembly. The applicant has also clarified that vibration data for all equipment listed in DCD Tier 2, Table 3L.4 will be acquired during initial startup and power ascension testing. Pressure data, however, while recorded during startup testing, will not be evaluated in detail unless the primary vibration measurements indicate the need for further assessment. The staff finds the applicant’s response acceptable, however, the applicant is requested to revise the DCD, Tier 2, Section 3.9.5 to include the above clarifications.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

<u>RAI 3.9-134 Supplement No. 1, July 10, 2007, ML072000077</u>

GEH is requested to provide the following information after the ESBWR main steam line layout and standpipe designs are completed and the acoustic resonance conditions are characterized. Please describe the design of the ESBWR safety relief valve (SRV) standpipes summarizing (1) dimensions of the SRVs, standpipes, and the main steam lines (MSLs); (2) expected steam flow speeds near the SRV standpipes; (3) plant power levels at which acoustic resonances in the standpipes might be strongly excited, along with the frequencies of the resonances and their expected amplitudes; and (4) the proximity of various SRVs to each other on individual MSLs.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

<u>RAI 3.9-135 Supplement No. 1, May 10, 2007, ML073050301</u>

In its response to RAI 3.9-135, the applicant refers to the following three additional documents that are yet to be submitted:

Reference 3L-5: General Electric Company, “Steam Dryer - Acoustic Load Definition,” NEDC-33312P, Class III (Proprietary)
Reference 3L-6: General Electric Company, “Steam Dryer - Structural Evaluation,” NEDC-33313P, Class III (Proprietary)

Reference 3L-7: General Electric Company, “Steam Dryer - Instrumentation and Power Ascension Monitoring,” NEDC-33314P, Class III (Proprietary).

The applicant is requested to submit these documents so that its response to RAI 3.9-135 can be evaluated.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

RAI 3.9-136 Supplement No. 1, May 10, 2007, ML073050301

In its response to RAI 3.9-136, the applicant refers to a future report - Reference 3L-5: General Electric Company, “Steam Dryer-Acoustic Load Definition,” NEDC-33312P, Class III (Proprietary) - to address parts (a) and (b) of this RAI. The applicant is requested to submit Reference 3L-5 (NEDC-33312P) so that the staff can evaluate its response to RAI 3.9-136.

Status: GEH submitted the above report by letter dated November 16, 2007. The staff is reviewing the report.

RAI 3.9-138 Supplement No. 1, May 10, 2007, ML073050301

In its response to parts (a), (b) and (c) of the RAI 3.9-138 in a letter (MFN 07-194) from J.C. Kinsey of GEH to USNRC, dated April 2, 2007, the applicant refers to a report – Reference 3L-7: General Electric Company, “Steam Dryer-Instrumentation and Power Ascension Monitoring,” NEDC-33314P, Class III (Proprietary), which is not yet available for review. Even though the applicant provides some insight on planned dryer instrumentation [parts (a)-(c)], which will be placed near regions where the highest fluctuating stresses are expected, the information provided to date is not sufficient to address fully the RAI. Please provide the remaining information requested in original RAI 3.9-138.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

RAI 3.9-143 Supplement No. 2, April 10, 2008, ML080950374

The GEH response to RAI 3.9-143 S01, dated December 7, 2007, is not acceptable. It did not address specifically the four questions raised in the RAI. In GEH’s response to RAI 3.9-143 S01, GEH stated that:

> ….In the unlikely event of a gross weld rupture the radial clearance between the RPV tube stub and the CRD housing is very small (nominally 1/8 mm) which would minimize any transverse movement of a CRD housing. “Frequency” (should be “flow”) induced vibrations, stress, and flow are discussed in ESBWR Licensing Topical Report NEDE-33259P, “Reactor Internals Flow Induced Vibration Program – Part I,” (transmitted via MFN 06-012).
>
> The adequacy of CR Guide Tube, CR Housing, and natural frequency and stress of the system configuration discussed in NEDE-33259P was based on the fixed end boundary condition at the penetration nozzle weld, not based on the assumed complete weld failure. Therefore, if GEH continues to conclude that the flow induced vibration during this hypothetical condition would produce stress in the CRD Guide Tube that is within the endurance limit as defined using the fatique curve for austeinitic steel, Figure I-9.2.1 of ASME Code, Section III, GEH is requested to provide detailed response to the four questions raised in RAI 3.9-143 S01.

Status: GEH responded to this RAI by letter dated May 5, 2008. The staff is reviewing the response.

RAI 3.9-144 Supplement No. 1, October 12, 2007, ML072690003

1) In reference to RAI 3.9-144A(e), the limited instrumentation locations do not appear sufficient to identify potential adverse flow effects on the main steam, feedwater, condensate, and isolation condenser systems, and its components such as main steam isolation valve and safety relief valve during plant startup and power ascension. Discuss your plans to provide sufficient instrumentation and locations to demonstrate that potential adverse flow effects, such as the effects resulting from acoustic resonance, are not causing the qualification limits for the steam, feedwater, and condensate lines, and their components, to be exceeded during operation of the ESBWR.

2) Revise the ESBWR DCD Tier 2, Appendix 3L, to include sufficient information as provided in letter dated June 11, 2007, (MFN 07-325) in response to RAI 3.9-144B(b-h) to support design certification.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

RAI 3.9-148 Supplement No. 1, April 10, 2008, ML080950374

The staff finds that the GEH response to RAI 3.9-148, dated December 14, 2007, is partially complete. The staff needs the following additional information related to DCD Tier 2, Table 3.9-5:

(1) Identify the specific paragraphs of Subsection NG for Requirement (d) as applied to Service Condition Levels A and B.

(2) For Service Condition Level C, Requirement (d) provides General Limit of 0.6 ultimate strength (US), whereas Fig. NG-3224-1 provides a smaller limit of 0.5 US. Please explain this difference.

The footnote (*) to equations e, f, g needs to be changed to read: “Equations e, f, g will not be used unless supporting data are provided to the NRC for review and approval.”

Status: GEH responded to this RAI by letter dated May 20, 2008. The staff is reviewing the response.

RAI 3.9-151 Supplement No. 1, May 10, 2007, ML073050301

In its response to the NRC RAI 3.9-151, dated November 22, 2006, the applicant states:

> “The program that GE[H] intends to complete pertaining to FIV of reactor internal components is explained in Licensing Topical Report NEDE-33259P. This plan includes the completion of analysis for the remaining reactor internal components, and the details of the measurement and inspection program to be implemented at the startup of the first ESBWR plant. GE[H]’s plan is to complete this work in 2007 prior to submittal of the first COL submittal. Regarding the steam dryer FIV program, GE[H] is

planning to implement design features that will reduce the FIV susceptibility of the steam dryer, and commitments related to testing at subsequent ESBWR plants is not appropriate until all the evaluation work is complete."

The applicant's response to the first part of the RAI 3.9-151[RAI 3.9-151(a)] regarding the program pertaining to FIV of reactor internal components is addressed in LTR NEDE-33259P and the applicant plans to complete the program before the submittal of the first COL application. This information should be included in the DCD, Tier 2, Section 3.9.5, so that the COL applicant would be aware of it. The applicant is requested to revise the DCD to incorporate this information.

The applicant's response to the second part of RAI 3.9-151[RAI 3.9-151(b)] regarding steam dryer instrumentation is incomplete. The applicant does commit to instrument the steam dryer bank hoods, end plates, skirt, drain channels, and support ring in its response to RAI 3.9-73. The applicant is requested to incorporate this information in DCD, Tier 2, Section 3.9.5. In addition, the applicant is requested to include commitments related to testing of steam dryer at second and subsequent ESBWR plants in DCD.

Status: GEH responded to this RAI by letter dated April 7, 2008. The staff is reviewing the response.

RAI 3.9-168 Supplement No. 2, March 28, 2008, ML080810240

GEH is requested to justify the testing frequencies that have been extended in the revised table beyond refueling outage intervals, such as safety-relief valve (SRV) F006, safety valve F003, SRV discharge line inboard vacuum breaker F007, SRV discharge line outboard vacuum breaker F008, rupture disk F028, and drywell wetwell vacuum breaker valve F002. This information is needed to confirm that the proposed testing frequencies satisfy the NRC regulations that incorporate by reference the ASME Code inservice testing (IST) provisions.

In response to RAI 3.9-159, Supplement 1, in MFN 08-109 (dated February 11, 2008), GEH states that Table 3.9-8, "In-Service Testing," in ESBWR DCD Tier 2 was revised to provide more detailed justifications for deferring quarterly IST testing. A justification for extending the testing frequencies identified above was not provided.

Status: GEH responded to this RAI by letter dated May 14, 2008. The staff is reviewing the response.

RAI 3.9-177, December 6, 2007, ML073381170

In DCD,Tier 2, Revision 3, there is a COL Information Item 3.9.9.4, which states that COL holders shall make available to the NRC staff design specification and design reports required by the Code for vessels, pumps, valves and piping systems for the purpose of audit. In Revision 4, this item is no longer listed under Subsection 3.9.9, COL Information. GEH is requested to reinstate this COL item in the DCD as an applicant item or to address the item through ITAAC. To allow addressing the item through an ITAAC, thereby moving completion of the design to after licensing, design acceptance criteria will need to be requested similar to piping. If the COL item is reinstated and Piping DAC requested, piping should be separated out from COL Information Item 3.9.9.4 so that it is fully addressed through the DAC.

Status: GEH responded to this RAI on January 29, 2008. The staff is reviewing the response.

RAI 3.11-18, January 14, 2008, ML0800020219

Tables 3H-3, 3H-4, 3H-9, and 3H-10 for the reactor building and control building provide maximum room temperatures for normal and accident conditions used in the establishment of equipment qualification. Please provide an analysis that shows that these temperatures will not be exceeded. The analysis should consider all heat loads affecting the room such as equipment loads, HVAC operation if it is not isolated, heat loads from adjoining rooms, solar loads, personnel loads, lighting, and external environmental conditions for both winter and summer design conditions to the extent they impact room temperatures. If passive measures are used to remove heat loads, please clearly identify these passive measures, the conditions under which they operate, and any surveillance activities that would be required. This analysis should be referenced and summarized in the DCD to support a finding of acceptability.

Status: GEH responded to this RAI by letter dated May 30, 2008. The staff is reviewing the response.

RAI 3.11-20 Supplement No. 1, April 10, 2008, ML080950374

In GEH response to RAI 3.11-20 in MFN 08-296 dated March 27, 2008, GEH stated that Tables 3H-6 and 3H7 as “Environment for Normal Operating Conditions,” were mislabeled and that these tables now provide radiation environmental conditions under reactor accidents.

1. Please provide reactor accident source term used to calculate integrated gamma doses inside the Reactor Building and Control Building as shown in the ESBWR DCD Revision 4, Tables 3H-6 and 3H-7.

2. Please provide a sample calculation GEH performed to calculate integrated gamma doses inside the Reactor Building and Control Building as shown in Tables 3H-6 and 3H-7.

If GEH used a computer code(s), please state name(s) of the code and provide its input and output files.

Status: GEH has not responded to this RAI.

RAI 3.11-23, March 6, 2008, ML080630254

In Table 3H-11, “Radiation Environment Conditions Inside Containment Vessel for Accident Conditions,” of DCD, Tier 2, Revision 4, GEH provided (1) operating dose rates using NUREG-1465, and (2) six month integrated doses, in upper and lower areas of drywell as well as wetwell and suppression pool gas space. Please provide the following information.

1. State fission product release phase(s) in NUREG-1465 used for developing the dose rates and integrated doses in the table.

2. State how GEH converted fission product release fractions in NUREG-1465 to calculate the dose rates and integrated doses in the table.

3. Provide a sample calculation GEH performed to calculate the dose rates and integrated doses in the table.

If GEH used a computer code(s), please state name(s) of the code and provide its input and output files.

Status: GEH has not responded to this RAI.

RAI 3.11-24, March 6, 2008, ML080630254

In DCD Tier 2, Revision 4, Table 3H-5 lists the operating dose rates for the various portions of the containment vessel. The listed operating dose rates for the upper drywell and upper area of the lower drywell are given as 26.1 R/hr and for the lower area of the lower drywell as 19.8 R/hr. On the basis of the different operating dose rates in different rooms in the containment vessel as shown in Figures 12.3, show how you arrived at the operating dose rate values for the drywell listed in Table 3H-5. Verify that the listed operating dose rates for the upper and lower drywell of 26.1 and 19.8 R/hr, respectively, in Table 3H-5, are conservative and bounding.

Status: GEH has not responded to this RAI.

RAI 3.11-25, March 6, 2008, ML080630254

The following apply to DCD Tier 2, Revision 4, Table 3H-6;

a) using the average operating dose rates shown in Figures 12.3-1 through 12.3-8 for each of the areas listed in Table 3H-6, the 60-year integrated doses calculated by the staff appear to be well below the integrated doses listed in Table 3H-6 for most of these areas. Show how the integrated gamma dose values listed in the second column of Table 3H-6 were calculated and, for one of the plant zones listed in Table 3H-6, provide a sample calculation showing how the zone area dose rate and integrated dose were calculated.

b) explain why Table 3H-6 lists two different integrated doses for some areas and only a single integrated dose value for other areas,

c) on the basis of the normal operation dose rates shown in Figures 12.3-1 through 12.3-8, the 60-year integrated doses for some of the areas listed in Table 3H-6 exceed the 10^4 rad qualification criteria for electronic equipment stated in the footnote for Table 3H-6. For each of these areas (those areas where the plant radiation zone designation is Zone D (25 mRem/hr) or greater), describe what plant design features (e.g. shielding, equipment location) will be used to ensure that the electronic equipment in these areas will not be exposed to integrated radiation doses that will exceed the equipment qualification for radiation,

d) the integrated gamma dose listed in Table 3H-6 for the Main Steam Tunnel is listed as less than 10^7 rads. Since this value exceeds the equipment qualification values for both electronic equipment (10^4 rads) and other equipment (10^6 rads) as stated in the footnote for this table, describe the plant design features which will be used in the Main Steam Tunnel to ensure that the radiation qualification limits of the equipment in this area will not be exceeded.

Status: GEH has not responded to this RAI.

RAI 3.11-26, March 28, 2008, ML080810240

In DCD Tier 2, Rev. 4, Table 3H-5 lists the operating dose rate and the 60-year integrated dose for various zones within the containment vessel.

a) The 60-year integrated dose of 1.7 E+2 R listed for the Wetwell appears to be in error since it is not a factor of 7.4 E+5 (number of hours in 60 years) greater than the operating dose of <1.4 R/hr listed in this table for the Wetwell. Revise this table to provide the correct integrated dose value in the Wetwell.

b) The 60-year integrated gamma doses listed in Table 3H-5 for the upper and lower drywell areas (plant zones b-1 through b-3) exceed the equipment qualification values for both electronic equipment (10^4 rads) and other equipment (10^6 rads) as stated in the footnote for Table 3H-6. Describe the plant design features which will be used in these drywell areas to ensure that the radiation qualification limits of the equipment in these areas will not be exceeded.

Status: GEH has not responded to this RAI.

RAI 3.11-27, March 28, 2008, ML080810240

The following apply to DCD Tier 2, Rev. 4, Table 3H-11.

a) The last two columns of Table 3H-11 list the integrated gamma and beta doses for zones b-1 through b-4 in the containment vessel. Footnote (3) of this table states that these doses are integrated over a 6 month period (i.e., the hourly gamma and beta dose rate values given in the first two columns of Table 3H-11 should be multiplied by a factor of 4380 (4380 hours in a 6 month period) to obtain the integrated values in the last two columns). Explain why the integrated doses in the last two columns in this table are only a factor of 10 larger than the hourly doses shown (except for the integrated beta dose for the Wetwell, which is a factor of 12.4 higher).

b) Table 3.11-1 states that the equipment listed must remain available or operational for 72 hours. On the basis of the operating dose rates listed in Table 3H-11, the equipment located in various plant zones inside the containment vessel would receive an integrated dose of 1.9 E+9 rads for a 72-hour period. This integrated dose value exceeds the equipment qualification values for both electronic equipment (10^4 rads) and other equipment (10^6 rads) as stated in the footnote for Table 3H-6. Describe the plant design features which will be used inside the containment vessel to ensure that the radiation qualification limits of the equipment in these areas will not be exceeded.

   Status: GEH has not responded to this RAI.

RAI 3.12-17 Supplement No. 1, May 3, 2007, ML070930014

Justification for the use of SRSS in load combination tables for all load cases should be demonstrated by showing that the non-exceedance probability (NEP) of 84 percent or higher is satisfied as required in NUREG-0484.

Status: GEH has not responded to this RAI.

RAI 3.12-27 Supplement No. 1, May 3, 2007, ML070930014

SRSS combination of the inertial and SAM responses for USM method of analysis is not consistent with the staff position in the Standard Review Plan (SRP). GEH should provide additional technical justification for this position.

Status: GEH has responded to this RAI by letter dated May 20, 2008. The staff is reviewing the response.