May 18, 2007

APPLICANT: General Electric Company

PROJECT: Economic Simplified Boiling Water Reactor (ESBWR) Design Certification

SUBJECT: SUMMARY OF DECEMBER 14, 2006, MEETING WITH GENERAL ELECTRIC, REGARDING AUDIT OF ESBWR STRUCTURAL DESIGN AND ANALYSIS

On December 14, 2006, a Category 1 public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) and representatives of General Electric Company (GE) at GE Nuclear Energy, San Jose, California. The purpose of the meeting was to discuss the results of an audit of the ESBWR structural design and analysis conducted December 12 through 14, 2006. A list of attendees at the December 14, 2006 public meeting is provided as Enclosure 1.

An audit plan is provided as Enclosure 2. The audit plan was given to GE. During the audit, GE's responses to NRC requests for additional information (RAIs) in the structural area were discussed. NRC's RAIs in the structural area (RAIs 3.8-1 through 109) are available in the Agencywide Documents Access and Management System (ADAMS) under Accession Numbers ML061740210, ML062610002, and ML062830158. GE's responses are also available in ADAMS under Accession Numbers ML061940087, ML062650286, ML062490455, ML063240408, and ML063400075. GE's response to RAI 3.7-59, which was also reviewed during this audit, is included in ADAMS Accession Number ML063240408. ADAMS is the system that provides test and image files of NRC's public documents. If you do not have access to ADAMS or if there are problems in accessing the documents located in ADAMS, contact the NRC Public Document Room (PDR) reference staff at 1-800-397-4209, 301-415-4737 or by e-mail to pdr@nrc.gov.

Detailed discussions on select RAI responses are summarized in the RAI Status Summary which is provided as Enclosure 3. The responses to RAIs 3.8-3, 11, 21, 22, 45, 50, 57, 63, 68, 73, 75, 83, 89, 104, 105, 106, 108, and 109 were acceptable prior to the audit. The responses to RAIs 3.8-1, 6, 7, 43, 44, 51, 53, 54, 55, 56, 58, 59, 66, 71, 74, 77, 78, 84, 86, 97, 98, and 100 were acceptable after detailed discussions during the audit. Responses to the remaining RAIs remain open pending receipt of acceptable responses that GE agreed to provide.

During the audit, staff and GE discussed differences between the GE NASTRAN structural model and the NRC ANSYS model for confirmatory analysis. The NRC submitted to GE a sample of output files for determining differences between the two models. The files shared with GE are available in ADAMS under Accession Number ML070120374. The summary of the confirmatory analysis review is provided as Enclosure 4.

Members of the public were not in attendance, and no public meeting feedback forms or comments were received.

Please direct any inquiries to Chandu Patel at 301-415-3025.

***/RA/***

Chandu Patel, Senior Project Manager
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-0010

Enclosures:
As stated

cc w/encls: See next page

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cc w/encls: See next page

ADAMS ACCESSION NO.: ML070430420

| OFFICE | NGE1/PM | NGE1/LA | SEB2/BC | NGE1/BC |
|---|---|---|---|---|
| NAME | CPatel | SGreen | SSamaddar | MShuaibi |
| DATE | 04/ 23 /2007 | 03/ 13 /2007 | 03/ 27 /2007 | 05/ 18 /2007 |

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**ESBWR Structural Design and Analysis Audit Exit Meeting**
**December 14, 2006**
**Meeting Attendance List**

| Name | Organization |
|---|---|
| Jim Gaslevic | NRC/NRO/NGE1 |
| David Jeng | NRC/NRO/DE |
| Charles Hofmayer | Brookhaven National Laboratory, NRC consultant (BNL) |
| Joseph Braverman | BNL |
| Jinsou Nie | BNL |
| Mohammed Shuaibi (by phone) | NRC/NRO/NGE1 |
| Amy Cubbage (by phone) | NRC/NRO/NGE1 |
| David Hinds (by phone) | GE Nuclear Energy (GENE) |
| George Stramback (by phone) | GENE |
| Ai-Shen Liu | GENE |
| Hugh Upton (by phone) | GENE |
| Bob Gou | GENE |
| Tetsushi Nagahama | Shimizu Corp |
| Yoshihiro Orito | Shimizu Corp. |
| Alfredo Orden | Empresarios Agrupados, GENE contractor (EA) |
| Kathy Sedney | GENE |
| Henry Solorzano | GENE |
| Teresa Dominguez | EA |
| Miguel Diaz-Llanos | EA |
| Tadao Wadayama | Hitachi, LTD |
| Nobuo Murakami | Hitachi, LTD |
| Hideyasu Furukawa | Hitachi, LTD |
| Tetsuya Nagata | Hitachi, LTD |

**Second Audit Plan for**
**ESBWR Seismic Category 1 Structures**
**(DCD Sections 3.8.1 through 3.8.5)**
**December 12 through 14, 2006**

**NRC Audit Team**

David Jeng (NRC Team Leader), Jim Gaslevic (NRC Project Manager), Charles Hofmayer (Consultant), Joseph Braverman (Consultant), Jinsuo Nie (Consultant)

**Areas to be Audited and/or Discussed**

- Discuss GE's response to RAIs, identify those issues that are unresolved, and review additional information necessary to resolve the RAIs. (Task 1)
- Audit analysis reports and design calculations to confirm the adequacy of GE's RAI responses, as applicable. (Task 2)
- Discuss the staff's confirmatory ANSYS 3-D analysis results for the truncated RB/FB Model and comparison to GE's NASTRAN shell analysis results for the same model. (Task 3)
- Identify additional RAIs (if any) based on the results of Tasks 1, 2, and 3.
- Determine the remaining open items in need of resolution and the need for additional information from GE.

**Agenda** (Note: Several activities will be conducted concurrently.)

December 12 (Tuesday), 8:30 a.m. - 5:00 p.m.*

1. Conduct an informal "Entrance Meeting" at 8:30 a.m.
2. Initiate Task 1: Discuss GE's response to RAIs, identify those issues that are unresolved, and review additional information necessary to resolve the RAIs.
3. Initiate Task 2: Review analysis reports and design calculations, to confirm the adequacy of GE's RAI responses, as applicable.
4. Initiate Task 3: Discuss the staff's confirmatory ANSYS 3-D analysis results for the truncated RB/FB Model and comparison to GE's NASTRAN shell analysis results for the same model.
5. Discuss the staff's findings with GE, at end of day.

December 13 (Wednesday), 8:00 a.m. - 5:00 p.m.*

1. Continue Tasks 1, 2, and 3.

2. Discuss the staff's findings with GE, at end of day.

December 14 (Thursday), 8:00 a.m. - 5:00 p.m.*

1. Continue Tasks 1, 2, and 3.

2. Summarize the staff's audit findings for GE, prior to the exit meeting.

3. Conduct "Exit Meeting" at 4:00 p.m.

**Audit Report**

The audit report will include (1) the updated status/resolution table for RAIs; (2) the results and conclusions of the comparison between the staff's confirmatory analysis results and GE's results for the truncated RB/FB model; (3) any new issues identified during the audit, and their resolution if achieved during the audit; and (4) any additional information to be provided by GE, as a result of the audit.

* Review schedule may be extended beyond 5:00 p.m., if needed.

**ESBWR DCD Section 3.8**

**RAI Status Summary**
**Following**
**December 12 through 14, 2006 On-Site Audit**
**(Prepared by BNL, January 18, 2007)**

**RAI Status Categories**

Acceptable and Resolved (R)

Acceptable and will be Resolved when applicable Design Control Document revision formally submitted (A)

NRC Staff Action needed to Resolve (S)

Clarification needed to Resolve (C)

Unresolved (U)

**NOTE**: **Status Changes resulting from the On-Site Audit are indicated in parentheses.**

| RAI Number | RAI Status | Comment |
|---|---|---|
| 3.8-1 | S (A) | Hansraj G. Ashar/David C. Jeng (HGA/DCJ) review<br><br>During the audit, GE indicated they will revise the DCD to explain that during the detailed design phase, the number of inaccessible areas will be minimized in order to reduce the number of permissible exclusions cited in Section 3.8.1.7.3.2 of the DCD. Also, the first sentence in the second paragraph in DCD Section 3.8.1.7.3.1, will be revised to read "The design to perform preservice inspection is in compliance with the requirements of the ASME ..." GE will state in the DCD that the use of remote tooling for inspections will be done in high radiation areas where feasible. |
| 3.8-2 | S (C) | HGA/DCJ review<br><br>During the audit, the following were discussed corresponding to item numbers in GE responses:<br><br>(1) Acceptable because DCD Rev. 2 reflects the change to seismic Category I.<br><br>(2) Acceptable because DCD Rev. 2 reflects the change to seismic Category I/II. |

(3) GE indicated that they will revise Table 3.2-1 for the U97 - Fuel Building Structure into two parts: 1 - for the main portion of the fuel building categorized as Seismic Category I (SC I) and 2 - for the Heating, Ventilation, Air Conditioning penthouse, stair towers and elevator shafts categorized as Seismic Category II (SC II)

(4) Acceptable because DCD Rev. 2 reflects the change to Seismic Category I. GE indicated, and as shown on DCD Figure 3G.2-3, the Control Building (CB) at floor slab elevation 4650 mm and below is classified as SC I and the CB structure above this floor slab is SC II.

With regard to the intake structure and discharge structures, GE indicated that they are classified as non-safety-related, which is acceptable.

3.8-3 A GE needs to include the description and sketches/details provided with the RAI response in the DCD.

3.8-4 U

During the audit, GE explained that the loads and load combinations for the entire Reactor Building (RB) from the ACI 349 and ASME Section III, Division 2 are checked against the acceptance criteria in ASME Section III, Division 2 Code. GE indicated that they have confirmed that the acceptance criteria in the ASME, Section III, Division 2 Code are more conservative than the acceptance criteria in ACI 349. GE was requested to provide the technical basis for this conclusion. Therefore, in effect the entire RB is designed to both the ASME Section III, Division 2, Subsection CC and the ACI 349 Code. In this case, the current boundary shown in DCD Figure 3.8-1 for the ASME jurisdictional boundary for all aspects of design, construction, fabrication, and inspection is acceptable. GE will provide a supplemental response to this RAI and RAIs 3.8-67, 101, 102 and 103 to reflect the above

3.8-5 U GE identified 13 items in their comparison table where the criteria in the 2004 edition of the Code is considered to be a relaxation of the 1989 Code. For each reduction in requirements tabulated in the table, GE needs to submit its technical basis for concluding that an equivalent level of safety will be achieved. Parts a), b), and c) are Acceptable.

During the audit, GE presented an update to the Table which provides the explanation for these items. Some of the 13 items do

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | not apply to ESBWR. GE indicated that for the remaining items, they will provide additional technical information to justify these items. |
| 3.8-6 | U (A) | GE needs to confirm that the referenced administrative controls are designated as Tier 1 information, because this is critical to ensuring that there is no live load inside containment during normal operation. GE needs to either define this as Tier 1 information, or consider that live load may be present inside containment during normal operation.<br><br>During the audit, GE presented data to show that if 25 percent of the live load was considered, then it would have a negligible effect on the natural frequency of structures inside containment. Also, based on this study, GE will not need to rely on administrative controls to ensure that all live load items will be removed from inside containment during outages. GE needs to submit this information as a supplemental response to this RAI. |
| 3.8-7 | U (A) | The Leak Rate Test (LRT) pressures could not be identified in DCD Section 6.2.6.1, DCD Table 1.3-3 and DCD Table 3G.1-7 for comparison with the Structural Integrity Test (SIT). Even if the LRT loads are less than the SIT loads, the definition of $P_t$ and $T_t$ in DCD Section 3.8.1.3.2 should define these test loads as SIT and LRT. In the DCD load combinations and load definitions, no other loads are eliminated because they might be less than some other load.<br><br>During the audit, GE presented a draft supplement to this RAI which indicates that the DCD will be revised to include the subject LRT pressure loads. |
| 3.8-8 | U | a) Further review needed to confirm GE's conclusion;<br>b) Response does not address the post-flooding load combination [includes Operating Basis Earthquake (OBE)] defined by SRP 3.8.1. How has GE satisfied this load combination?<br><br>During the audit, the following items were discussed:<br>Item a) is being reviewed by the staff under the containment pressure capacity review (i.e., portions of DCD Chapters 6 and 19). Item b) GE will provide a supplemental response to this RAI to demonstrate that the accident pressure + Safe Shutdown Earthquake (SSE) + flooding during Loss-of-Coolant Accident (LOCA) (used in design) bounds the post LOCA flooding event with OBE, and therefore, the post LOCA flooding load combination with OBE does not need to be considered explicitly. |

| RAI Number | RAI Status | Comment |
|---|---|---|
| 3.8-9 | U | a) If NEDE-33261P indicates that the Safety Relief Valves (SRV) has a range of 5 to 15 Hz, why does the analysis only consider a range of 5 to 12 Hz. b) Are the values 6.06 and 8.83 the fundamental natural frequencies of the structure in the vertical and horizontal direction respectively? c) Provide a comparable description for selecting the appropriate forcing functions for the different LOCA loads (chugging, Condensation Oscillation (CO), pool swell, Annulus Pressurization (AP), vent clearing, etc.) d) Since this is done for generation of floor response spectra throughout the building (not just local containment response), are there not other structural natural frequencies that should be considered? e) GE provided a markup to 3.7 (first paragraph) where it states that the method for combining seismic and Reactor Building Vibration (RBV) loads for reinforced concrete structures varies the sign (+ or -), equivalent to Absolute Value Sum (ABS). This is acceptable for reinforced concrete structures. However, it also states that the method used [presumably for all other Structures, Systems and Components (SSCs)] is the Square Root Sum of Squares (SRSS) in accordance with NUREG-0484, Rev. 1. This is acceptable for seismic plus LOCA; however, the criteria for combining other dynamic loads (e.g., SRV and individual LOCA loads (AP, Poolsweel, CO, Chugging, etc.) are not clearly defined. According to NUREG-0484, the use of SRSS for the other loads would require demonstrating a non-exceedance probability (NEP) of 84 percent or higher is achieved. Some of this information may be implied and buried within various scattered sections of the DCD (e.g., response spectra for some of the loads in Appendix 3F; however, the criteria should be clearly specified in one location.<br><br>During the audit, GE presented a draft supplemental response to this RAI. The staff needs to review this information. The response for items a, b, c, and d are acceptable. For item e, GE needs to provide documentation which describes the use of the SRSS method based on demonstrating that the NEP criteria were met. Due to time constraints during this audit, the referenced NEDE report is subject to audit at a later date. |
| 3.8-10 | U | GE's implementation of 100/40/40 method is NOT consistent with DG-1127 (Regulatory Guide (RG) 1.92). This was identified and discussed with GE via teleconference on November 21, 2006.<br><br>This will be discussed under RAI 3.8-107. |
| 3.8-11 | R | |

| RAI Number | RAI Status | Comment |
|---|---|---|
| 3.8-12 | U | For all computer programs, identify version (and revision numbers if applicable). NASTRAN and ANSYS are widely used, commercially available computer programs, and utilized in prior nuclear power plant designs. ABAQUS/ANACAP-U has been applied to a significant number of concrete nonlinear problems both in and outside the US nuclear power industry. (The SSDP-2D validation package has been revised in response to RAI 3.8-107, which is a new RAI identified after the first NRC staff audit of DCD Section 3.8. GE's response to RAI 3.8-107 was submitted on November 7, 2006.<br><br>The remaining question on SSDP will be discussed under RAI 3.8-107. |
| 3.8-13 | U | For part a), DCD should discuss the study performed for the varying soil springs (hard vs. soft) and consideration of no tension springs, as well as the results showing higher responses than used in the design. Also, since some loadings with hard soil and with no tension springs resulted in higher loads, these should be reflected in DCD Tables summarizing results/margins, because otherwise, the current results in the DCD would be misleading. Part b) will be addressed in GE's responses to RAI 3.8-92, -90, and -94.<br><br>During the audit, GE presented a draft supplemental response to address the part a) item which states that the "DCD Tables will be updated summarizing the results of the study performed." GE should also include a description (in text form) to go along with the revised DCD Tables to summarize what was done in the study and the conclusions reached. (See above for part b) |
| 3.8-14 | U | Part a) is acceptable; for the thermal analyses discussed in part b), it is not clear to the staff that using constant thermal properties (e.g., strength and E) based on the average temperature through the thickness of the concrete material is appropriate or conservative. What is the typical linear thermal gradient across a concrete element, compared to the element's average temperature? What would the fully- constrained thermal stress be at the two surfaces and at the midpoint of a typical concrete element, based on a linear temperature gradient across the element? Provide these calculations for (1) the assumed uniform material properties based on the average temperature; and (2) a linear variation in material properties across the element, consistent with the linear temperature gradient. |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | During the audit, GE presented a draft supplemental response to address the part b) item, "Describe the type of model used for this particular study (e.g., 3-D, finite element brick elements of the RB using what computer program)." Clarification is needed for Figure 3.8-14(4) - stress or force (Ny) and Table 3.8-14(1) force and moment across entire section? |
| 3.8-15 | U | In Figure 3.8-15(1), should the curve for wet well stop or continue until 100 Hrs? Explanation should be included how the determination was made that the axisymmetric loads are more severe than the nonaxisymmetric loads, and that the nonaxisymmetric loads did not need to be considered. Where in the DCD is the requirement for the Combined Operating License (COL) Action item to confirm, in the detailed design phase, that the dynamic load factor (DLF) of 2.0 is adequate to account for variation in loading function frequencies and dynamic amplification?<br><br>During the audit, GE presented a draft supplemental response to address the first and third items discussed above. Clarification is needed for the first item since the supplemental response does not agree with information presented in discussions during the meeting. The second item will be discussed under RAI 3.8-46. |
| 3.8-16 | S | Appears to be acceptable. The staff will review one of the referenced calculations/reports at the next audit.<br><br>During the audit, there was insufficient time to audit the referenced calculations/reports. These are subject to audit at a later date. |
| 3.8-17 | U | Some information requested in the RAI was not provided: figures showing the finite element models used, a summary of the types of analyses, a summary of results of the analyses, and comparison to Code acceptance criteria. Since this is a design certification, a representative design for one or more major penetrations should have been performed, and thus this information should be available. However, Figure 3.8-17(2) has a note indicating that the amount of required reinforcements around opening will be determined in the final design calculations; please explain what this means. Also, as indicated in the RAI, a summary of the information requested in the RAI should be presented in the DCD. If the analysis and design is not completed will this be a COL Action Item, to be reviewed in the future?<br><br>Staff needs to review SER-ESB-045 Design Report for the Reinforced Concrete Containment Vessel (RCCV) Wall around the Upper Drywell Personnel Airlock Opening, Rev. 0. |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | During the audit, a draft supplemental response by GE was presented which will revise Figure 3.8-17(2). In addition, the analysis and design for the Upper Drywell Personnel Airlock was completed and available for review. Due to time constraints during this audit, the referenced report is subject to audit at a later date. |
| 3.8-18 | U | a) RAI 3.7-59 is still open. b) Only SIT considered not other loads in load combination. c) Why are principal tensile stresses calculated in the direction of principal membrane force direction and in principal bending moment direction; these may not give the maximum principal stresses? d) Is that why principal tensile stresses in Table 3.8-18(2) and (3) were lower than those in Table 3.8-18(1). e) Maximum shear stresses from worst loading combination would be useful to help resolve this (ASCE 4-98 refers to nominal shear stresses are usually kept below 100 psi; another source refers to concrete cracking under SSE with shear stresses below 150 psi NUREG/CR-5407). That is why variation in concrete properties are often used to account for potential concrete cracking (ASCE Report on Stiffness of Low Rise Reinforced Concrete Shear Walls).<br><br>During the audit, GE indicated that they will consider performing a confirmatory study which will show that with concrete cracking for a selected portion of the RB /fuel building (FB), the effect of redistribution of loads is not significant. |
| 3.8-19 | S | Review referenced calculation/report 26A6625, Rev. 1, October 2005, at next audit.<br><br>During the audit, there was insufficient time to audit the referenced calculation/report. This is subject to audit at a later date. |
| 3.8-20 | U | Review the supplemental response to RAI 3.7-59 at the next audit. RAI 3.7-59 (stick model versus finite element model) is still open. GE to compare NASTRAN dynamic time history member forces versus NASTRAN static analysis using seismic stick model results to demonstrate that DCD approach is acceptable.<br><br>During the audit: this will be addressed under the review of RAI 3.7-59 (see end of this Summary Table) submitted by GE in their letter MFN 06-416, dated December 8, 2006. |
| 3.8-21 | A | |
| 3.8-22 | R | |

| RAI Number | RAI Status | Comment |
|---|---|---|
| 3.8-23 | S | Appears to be acceptable. Review GE's revised calculation/report on the external pressure load on drywell head, at the next audit.<br><br>During the audit, GE indicated that the remaining information to address this issue is contained in GE design report DE-ES-0003, which needs to be reviewed. Due to time constraints during this audit, the referenced report is subject to audit at a later date. |
| 3.8-24 | U | Response to Item (a), related to strains associated with construction-related liner deformations is correct; however, the current DCD is not consistent with the response. The DCD states that the liner plate analysis considers deviations in geometry due to fabrication and erection tolerances, while the response indicates that strains associated with construction-related liner deformations may be excluded when calculating liner strains for the service and factored load combinations according to ASME Code Section III, Division 2, Subarticle CC-3720. GE needs to resolve this inconsistency.<br><br>Item (b) is addressed by response to Item (a) above and the responses to RAIs 3.8-25 and 26. Item (b) also indicates that the analysis results of the liner strains are summarized in DCD Tier 2 Table 3G.1-35. However, this Table does not provide the liner strains associated with construction loads, as required by Table CC-3720, which is referenced by Subarticle CC-3720.<br><br>Following response to Item (b), GE indicates that fabrication/erection tolerances are considered for the liner anchor design, with the worst case results summarized in Tables 3.8-24(1) through 3.8-24(3). This will be reviewed during the December 2006 audit.<br><br>During the audit, GE indicated that the DCD will be revised to reflect the responses provided for item (a), and liner strains associated with construction loads will be included in the next DCD revision. Staff will review the worst case results summarized in Tables 3.8-24(1) through 3.8-24(3). |
| 3.8-25 | U | Further detailed review needed to fully understand the analysis study performed and to identify specific areas of the description, figures and tables (in the Supplement No. 2 response) which require further clarification. For example, the text indicates that Case 1 is provided to simulate the DCD design technique. However, the table provided for Case 1 - a and -b calls this model "Glued." The DCD and prior discussions with GE seem to indicate that the DCD model is not glued but free to deform between attachment points (rigid links). The concerns raised under this |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | RAI are closely associated with RAI 3.8-26. Additional staff evaluation is also needed to understand the methodology used for analysis of the liner anchors. |
| 3.8-26 | U | This issue is covered by RAI 3.8-25 above. See RAI 3.8-25 for resolution. |
| 3.8-27 | C | a) Acceptable (the analysis and design is addressed separately under RAI 3.8-17). b) From Figure 3.8-27(2), the Reactor Pressure Vessel (RPV) stabilizer attachment to the shieldwall does not appear to provide free radial movement, and it is not obvious how it provides lateral (i.e., tangential direction) restraint, since springs and gaps are provided for tangential movement. Please explain. Also, include the descriptions and sketches/details provided with the RAI response for both items in the DCD.<br><br>During the audit, GE provided a draft supplemental response and revised detail for the RPV stabilizer to address the above concerns. Also, the DCD will be revised to provide a description of the RPV stabilizer to capture the information presented in the RAI response. Revised sketch showing the RPV stabilizer which provides tangential restraint while allowing free radial and vertical movement is acceptable. A description of the RPV stabilizer which captures this information for inclusion in the DCD is still needed. |
| 3.8-28 | U | The staff does not know if this is identified as a COL action item or not. The staff would like to know if any typical details are available for staff review. |
| 3.8-29 | U | Insufficient information provided. Need to know Pm, Pl, Pb and Q at critical location. Also need the comparison to allowable stress limits for Pm, Pl+Pb, and Pl+Pb+Q. Provide hand calculation of fully restrained thermal stress for deltaT from construction ambient temperature to 171 degrees C. Compare to computer results for the thermal condition. |
| 3.8-30 | U | Need additional information. When is the detailed design to be conducted? Apparently, the clad thickness has not been specified yet. Open, until detailed design is completed and assessment to ASME Code requirements is documented, and subsequently reviewed by the staff. |
| 3.8-31 | U | The staff needs more information. The purpose of brackets is explained and acceptable. However, effects on local stresses in the drywell head when subjected to accident pressure and |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | temperature is not adequately addressed. GE did not analyze this detail. |
| 3.8-32 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-33 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-34 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-35 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-36 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-37 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-38 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-39 | S | Review referenced detailed report/calculation at a future audit. (February 5 through 7, 2007, Fragility Audit) |
| 3.8-40 | U | a) RPV stabilizer is in the load path and therefore GE needs to confirm it was included in the global structural analysis. For details of the RPV stabilizer, they have now been provided under RAI 3.8-27. GE indicated in the last audit, quenchers are mechanical components, therefore, not part of 3.8 review. Anchorage for quenchers to be done in next design phase - does this mean it is a COL Action Item; where is this noted in DCD? For RPV insulation, GE states that details will be developed in the detailed design phase - does this mean it is a COL Action Item? Where is this noted in DCD? Information for connection of diaphragm floor (DF) to vent wall (VW) is acceptable. b) Some design details for RPV support bracket, vent wall, shield wall, gravity-driven cooling system (GDCS) pool wall, diaphragm floor, and platforms, are not shown in the DCD (e.g., weld sizes/lengths, anchorage, some plate thicknesses. These are considered to be local design details and will be determined in the detail design phase. If these are COL Action Items, where is this noted in the DCD? |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | During the audit, GE presented a draft supplemental response to address the above items. Under item a) of the supplemental response, GE will revise the wording to reference the anchorage design in accordance with ACI 349, Appendix B. A sketch was presented depicting the details of the quencher anchorage. This sketch will be included in a revision to the DCD. For item b) the supplemental response indicates that the details of the major structural components listed are not COL Action Items. Based on this response, the staff is requesting that the complete design details (including weld types/sizes/lengths, anchorage, all plate thicknesses) for the RPV support bracket, vent wall, shield wall, GDCS pool wall, and diaphragm floor, be provided in the DCD. |
| 3.8-41 | U | The results presented raise a concern whether 50 percent of the uncracked concrete stiffness is the appropriate assumption. If 75 percent or 100 percent of the uncracked concrete stiffness had been used, then the frequency increase would be greater. GE needs to provide its technical basis for the 50 percent assumption, for the confined unreinforced in-fill concrete.<br><br>The response only discussed seismic loading; GE needs to provide an assessment of the effect of the in-fill concrete on response spectra generated from hydrodynamic loads (SRV and LOCA).<br><br>GE also needs to confirm that all thermal loading conditions analyzed using NASTRAN (including normal operating conditions) have been adjusted to account for the presence of the concrete infill, using thermal ratios obtained from ABAQUS/ANACAP thermal stress analyses.<br><br>During the audit, GE presented a draft supplemental response to address the above items. The NRC needs to review the response when submitted. |
| 3.8-42 | C | a) The markup for DCD Section 3.7 is not quite consistent with SRP 3.7.2.II.8. The DCD states that SC II are designed such that the SSE would not cause unacceptable structural interaction or failure, Whereas, SRP 3.7.2.II.8 states that the non-Category I structures will be analyzed and designed to prevent their failure under SSE in a manner such that the margin of safety of these structures is equivalent to that of the Category I structure. Based on GE's response, the DCD should include the statement, "The methods of seismic analysis and design acceptance criteria for seismic category 11 (CC-11) SSCs are the same as C-1 SSCs." |

| RAI Number | RAI Status | Comment |
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| | | During the audit, GE indicated that they will delete the inconsistency by deleting the first criteria and leaving the second criteria which states that "The methods of seismic analysis and design acceptance criteria for Seismic Category II (C-II) SSCs are the same as C-I SSCs." |
| 3.8-43 | C (A) | In general this can be accepted on the basis that under the NRC Standard Review Plan 3.8 update work, NRC staff has confirmed that ANSI/AISC N690-1994s2 (2004) is consistent with the criteria in the 1984 N690 Standard and Appendix F to draft SRP 3.8.4 (1996) (which is also the same as Appendix G of NUREG-1503). The update to the SRP 3.8 3 and 3.8.4 will accept the ANSI/AISC N690-1994s2 (2004) and delete the proposed Appendix F to draft SRP 3.8.4 (1996). Note that a spot check revealed that GE identified an exception in the DCD to ANSI/AISC N690-1994s2 (2004), regarding ductility ratios (markup of DCD Table 3.8-6). They did this in order to satisfy a staff position on ductility ratios in Appendix A to SRP 3.5.3. Are there any other items where an exception to ANSI/AISC N690-1994s2 (2004) is needed?<br><br>During the audit, two items were identified that may need to be considered as exceptions to ANSI/AISC N690-1994s2 (2004). They are the exceptions to ductility ratios and the quality assurance requirements for the painting (or coating) of structural steel to be in accordance with ANSI N101.4 as endorsed by RG 1.54. Both of these items have been incorporated into the DCD in the proposed markups submitted in the response to the subject RAI and are included in the DCD Rev. 2. |
| 3.8-44 | C (A) | The revised DCD markup Table 3.8-6 references ANSI/ASME NQA-1-1983, while DCD Section 17.0 references ANSI/ASME NQA-1-1983 and NQA-1a-1983 Addenda, as endorsed by RG 1.128, Rev. 3. There still remains inconsistency which needs to be corrected.<br><br>During the audit, GE indicated that they will revise Table 3.8-6 to reference ANSI/ASME NQA-1-1983 and NQA-1a-1983 Addenda, as endorsed by RG 1.128, Rev. 3 |
| 3.8-45 | A | |
| 3.8-46 | U | a) Acceptable. b) Combination of dynamic responses: For RCCV - varying sign (equivalent to ABS) is Acceptable. For steel portions of containment, Table 3.8-4 indicates SRSS - technical justification not provided (see RAI 3.8-9). For steel structures inside containment - ABS method was not noted in markup of Table 3.8-7 as indicated in Item 3) of GE response to this RAI. |

| RAI Number | RAI Status | Comment |
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| | | c) A description was not provided for the analysis method and design approach to evaluate the effects of SRV and LOCA direct loads (e.g., jet loads and drag loads) on submerged structures/components and those above the suppression pool water surface. Also, the footnote that will be added to DCD Table 3.8-7 has not been included in the markup of the Table 3.8-7 provided. d) Acceptable. e) Acceptable.<br><br>During the audit, GE indicated that for item b), steel portions of containment, this question is addressed under RAI 3.8-9. For steel structures inside containment, the DCD Appendix 3G will be revised to show that the ABS method is used for design. In addition, DCD Rev. 2, Table 3.8-4 and 3.8-7 have been revised to permit the use of SRSS. This is based on demonstrating the requirements for the use of SRSS which is reviewed under RAI 3.8-9. For item c) GE indicated that the load definitions and the analysis approach is contained in the referenced GE NEDE report. The referenced NEDE report is subject to audit at a later date. |
| 3.8-47 | S | Review referenced detailed report/calculation.<br><br>During the audit, there was insufficient time to audit the referenced calculation/report cited in the prior GE response. This is subject to audit at a later date. |
| 3.8-48 | U | For part b, Supplements 1 and 2 appear to contradict each other, with respect to the treatment of asymmetric loads. Supplement 1 indicates that both the N=0 and N=1 terms are used, while Supplement 2 indicates that only the N=1 term is used. Assuming that the asymmetric pressure is an internal pressure around the circumference, then at least the N=0 and N=1 terms are needed to model the pressure distribution. One circumstance where a load can be modeled using solely the N=1 term would be horizontal seismic inertial loading on an axisymmetric containment shell.<br><br>Parts a, c, and d are acceptable, except markup of DCD Appendix F, DCD 3.8.1.4.1.1.1, and 3.8.1.4.1.1.2 could not be located. Part e is acceptable - Mechanical, and electrical equipment are addressed in DCD 3.9.2 and 3.10, where SSE loads and RBV loads are specified. Part f is acceptable.<br><br>During the audit, GE presented a draft supplemental response to this RAI to explain that for the asymmetric loads, the total response is based on the summation of the N=0 and the N=1 harmonic terms. The markup of DCD Appendix 3F, DCD 3.8.1.4.1.1.1, and 3.8.1.4.1.1.2 have already been |

| RAI Number | RAI Status | Comment |
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| | | incorporated into DCD Rev. 2. The staff needs to review DCD Appendix 3F, Rev. 2. |
| 3.8-49 | S | The staff needs the review referenced detailed report/calculation.<br><br>During the audit, there was insufficient time to audit the referenced calculation/report cited in the prior GE response. This is subject to audit at a later date. |
| 3.8-50 | A | |
| 3.8-51 | U (A) | Item a) (vi) - based on a response given to RAI 3.8-53, why does not this item include pipe break loads associated with pipe breaks other than annulus pressurization (AP)? For GE Supplement 2 response, what is the technical basis for the statement that "For the GDCS and the suppression pools, the total pressure was conservatively considered to be all impulsive. Could not the addition of the convective load (depending on the frequency of sloshing and spectral acceleration) increase the total pressure loads on the pools?<br><br>During the audit, GE indicated that the only pipe break load that needs to be considered for the evaluation of containment internal structures is the AP pipe break load (due to mainsteam, feedwater, and reactor water cleanup) which consists of pressurization in the annulus and associated jet impingement, missile load, and reaction load. The basis for this is contained in DCD Section 3.6. For the second item identified above, GE presented a draft supplemental response which compares the response acceleration values for the convective and impulsive modes. The contribution of the convective mode is very small, and so considering the entire water mass in the impulsive mode is acceptable. |
| 3.8-52 | U | References cited do not provide analysis criteria; therefore, describe in the DCD whether the analysis methods will follow those presented in 3.7 and 3.8. If cold-formed sections are used, then N690 does not apply. Are there other standards that should be referenced (e.g., SMACNA and IEEE)?<br><br>During the audit, GE indicated that Section 3.8.3 will be revised to provide criteria similar to, or reference the criteria in, Section 3.8.4.1.6 and 3.8.4.1.7 for cable trays, conduits, HVAC ducts, and their supports. In addition, the additional codes and standards presented in the draft supplemental response will be added to Tables 3.8-6 and 3.8-9. |

| RAI Number | RAI Status | Comment |
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| 3.8-53 | U | Original RAI not fully answered. As noted in the RAI, GE should describe the loads, models, analysis, and design approach for assessment of containment internal structures due to the other pipe breaks (other than AP).<br><br>During the audit, the resolution of this RAI was addressed under the first part of RAI 3.8-51. |
| 3.8-54 | C (A) | Markup of DCD 3.8.3.4 points to Table 3.8-7 (internal structures to containment), which in a footnote points to DCD 3.8.4.5.1 (other structures - not internal structures to containment) for acceptance criteria, which points to Table 3.8-16 which is applicable to other structures (not internal structures to containment). This path for acceptance criteria of internal structures should not end up in Table 3.8-16.<br><br>During the audit, GE presented a draft supplemental response which indicates that DCD Table 3.8-7 will be revised to reference DCD Sections 3.8.3.3 and 3.8.3.5 for the loads/load combinations and the acceptance criteria, respectively. |
| 3.8-55 | C | The staff needs to review revised DCD Section 3.8.3.7, which was not submitted.<br><br>During the audit, GE showed that Section 3.8.1.7.3.4 of DCD Rev. 2, has been revised to address the issue of inservice inspection of the diaphragm floor and vent wall. |
| 3.8-56 | U (A) | Further review of proposed markup of DCD Figure 3G.1-55 identified that there is insufficient information about the welded connection between the radial support beams and the diaphragm floor. The note should identify that the weld is continuous along the entire length, and that the weld is typical on both sides for all radial beams. GE needs to revise DCD Figure 3G.1-55 accordingly.<br><br>During the audit, GE presented a draft supplemental response which provides the details for the weld connections and states that the revised detail will be included in the DCD. |
| 3.8-57 | A | |
| 3.8-58 | U (A) | Response to the last part of the RAI was not provided: For the other structures, confirm that RG 1.160 and 10 CFR 50.65 “Maintenance Rule” requirements for structures monitoring and maintenance are applicable to the ESBWR design. If this is not the case, provide the technical basis. Include this information in DCD Section 3.8.3.7. |

| RAI Number | RAI Status | Comment |
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| | | During the audit, GE presented a draft supplemental response to show that other structures are monitored per 10 CFR 50.65 as clarified by RG 1.160. This will be included in a revision to the DCD. |
| 3.8-59 | C (A) | Acceptable, except that the information provided should be included in the DCD.<br><br>During the audit, GE presented a draft supplemental response to be included in the DCD to address this issue. As a result of a follow-up discussion, GE will revise the proposed wording to capture item (2) in the GE response to the RAI. |
| 3.8-60 | U | GE needs to explain what information Figure 3.8-60(1) is trying to convey. Also the DCD revision states: "Thus the RB walls of the main steam tunnel are designed to accommodate the pipe support forces and the environmental conditions during and after the postulated high-energy." GE needs to clarify the "environmental conditions" that the tunnels are being designed to. Are they saying that "the break exclusion stress and fatigue limits as per BTP EMEB 3-1 of SRP 3.6.2" eliminate postulated breaks in the tunnel area, but the tunnel still experiences environmental conditions due to pressure and temperature from pipe breaks outside the area? GE needs to explain the source of these environmental effects.<br><br>During the audit, GE presented a draft supplemental response that clarifies the above question. GE also needs to revise the DCD to be consistent with the response. |
| 3.8-61 | C | GE needs to explain the seismic design criteria for the removable shield blocks to assure that their failure does not affect any safety related structures, systems or components.<br><br>During the audit, GE presented a draft supplemental response to address this issue. A steel frame retainer structure will be designed to SC II requirements to prevent sliding or overturning under the SSE event. |
| 3.8-62 | C | See staff assessment of response to RAI 3.8-42. |
| 3.8-63 | A | |
| 3.8-64 | U | GE needs to provide the technical justification for the reference to drift limits in Table 5-2 of ASCE 43-05 or demonstrate that the magnitude of the deformations for all frame members in the ESBWR design are sufficiently small so that they have a negligible |

| RAI Number | RAI Status | Comment |
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| | | impact on the design. If they choose to keep the reference to Table 5-2 of ASCE 43-05 as the basis for their response, GE will need to demonstrate that the imposition of the drift limits in Table 5-2 will have a negligible impact on the design of all frame members in the ESBWR design.<br><br>GE needs to refer to SRP 3.5.3, as well as SRP 3.5.1.4 for the design to resist automobile missile loads. ESBWR DCD Section 3.5.3 does not reference BC-TOP-9A. If GE wants to use this topical report it should be referenced in DCD Section 3.5.3 and its use accepted by the NRC. Review GE Report SER-ESB-041 at the next audit.<br><br>Also, has the large concrete wall (approx. 18m x 48m x 1m thick) in the fuel building been checked for missile impact loads?<br><br>During the audit, GE presented a draft supplemental response to address these issues. For the first paragraph above, GE will revise the response to explain that the effect of deformations are part of the analysis and design of the frame type structures. For the second paragraph, GE will revise Section 3.5.3 of the DCD to reference BC-TOP-9A, which will be evaluated under the review of that DCD section. For the third paragraph, GE indicated that they have evaluated the large concrete wall for missile impact loads. The summary of this evaluation is contained in GE report SER-ESB-041. This report is subject to an audit at a later date. |
| 3.8-65 | U | GE response references the response to RAI 3.8-64; however, that RAI does not appear to provide the requested information; i.e., a summary (in Appendix 3G or Section 3.8.4 of the DCD) that contains a description of the EBAS Building, the loads and load combinations, reinforcement stresses, and concrete reinforcement details for the basemat, seismic walls and floors. Provide this information similar to that provided for the other Seismic Category I structures. Regarding the plan and section views provided which show the relationship of the various structures, no dimensions were provided between each structure. Therefore, provide the physical gap dimensions between the structures and confirm that they are sufficiently apart so that there will be no seismic induced impacts between each adjacent structure, assuming worst case out-of-phase motion.<br><br>During the audit, GE indicated that they will complete the design of this structure and will summarize the results in a revision to DCD Appendix 3G. This revision to the DCD will confirm that sufficient gaps are provided between the emergency breathing air system (EBAS) building and the adjacent structures. |

| RAI Number | RAI Status | Comment |
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| 3.8-66 | S/C | GE needs to discuss restriction on ductility factors. Also, GE needs to explain the significance of RG 1.54, "Service Level I, II, III Protective Coatings Applied to Nuclear Power Plants."<br><br>During the audit, GE showed that the reference to RG 1.54 and the restriction for ductility ratios are in accordance with NUREG-503, Appendix G, NRC Position on the use of ANSI/AISC N690 (also see RAI 3.8-43). These requirements are presented in Table 3.8-9 of DCD Rev. 2. |
| 3.8-67 | S (U) | Items 3 and 30 (of the DCD Table) relate to another question on the jurisdictional boundary of the use of Subsection CC. Staff needs to review this further. Response regarding item 11 is acceptable.<br><br>During the audit, it was agreed to address this item under the review of RAI 3.8-4. GE will provide a supplemental response. |
| 3.8-68 | A | |
| 3.8-69 | U | For design loading and acceptance criteria, the GE response references DCD Section 9.1. DCD Section 9.1, Rev. 2 has been revised to correctly reference SRP 3.8.4, Appendix D; however, the loading combinations specified in DCD Section 9.1 are not in agreement with those in SRP 3.8.4, Appendix D. This needs to be reconciled.<br><br>During the audit, GE agreed to revise DCD Section 9.1.2.4 to be consistent with the criteria given in SRP 3.8.4, Appendix D. There was insufficient time to audit the referenced specification during the audit. This is subject to audit at a later date. |
| 3.8-70 | C | DCD Section 3.8.4.2.5 discusses the welding and subsequent inspections of pool liners during construction. GE needs to state in the DCD that these procedures apply to all pool liners, including the spent fuel pool liner. The remainder of the response is acceptable, but should be documented in the DCD.<br><br>During the audit, GE agreed to document in the DCD, the response given to the RAI. In addition, GE agreed to state in the DCD that the welding and the subsequent inspections of pool liners apply to all pool liners, including the spent fuel pool liner. |
| 3.8-71 | U (A) | What other loads besides Pa and Ta are considered in the RB design? All loads included in the RB design need to be defined in DCD Section 3.8.4.3.1.1. Also explain why the dynamic effects of the above loads are not considered in the design of the entire RB. |

| RAI Number | RAI Status | Comment |
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| | | During the audit, GE agreed to document in the DCD that the effects of SRV and LOCA dynamic loads originated inside the containment will be considered as applicable. This will be documented by adding a footnotes in DCD Tables 3.8-15 and -16. |
| 3.8-72 | U | Unresolved. GE's implementation of 100/40/40 method is not consistent with DG-1127 (RG 1.92). This was identified and discussed with GE via teleconference on November 21, 2006.<br><br>During the audit, it was agreed to discuss this item under RAI 3.8-07. |
| 3.8-73 | A | |
| 3.8-74 | U (A) | This RAI is similar to RAI 3.8-71. What other loads besides Pa and Ta are considered in the FB design? All loads included in the fuel building (FB) design need to be defined in DCD Section 3.8.4.3.3. Also, explain why the dynamic effects of the above loads are not considered in the design of the entire Fuel Building.<br><br>During the audit, GE agreed to document in the DCD that the effects of SRV and LOCA dynamic loads originated inside the containment will be considered as applicable. This will be documented by adding a footnotes in DCD Tables 3.8-15 and -16. |
| 3.8-75 | A | |
| 3.8-76 | U | SRP 3.8.4.I.6 requires, by reference to SRP 3.8.3.I.6, that welding of reinforcing bars (splices) comply with the applicable sections of the ASME Section III, Division 2, Code. The proposed markup in DCD Section 3.8.4.6 currently proposes to meet ACI 349-01 and applicable RGs for splices. This needs to be addressed.<br><br>During the audit, GE agreed to revise the DCD to reflect the requirement of SRP 3.8.4.I.6 and 3.8.3.I.6. |
| 3.8-77 | U (A) | See staff assessment of response to RAI 3.8-52.<br><br>During the audit, GE agreed to revise Tables 3.8-6 and 3.8-9 of the DCD to include the additional codes and standards presented in the draft supplemental response. |
| 3.8-78 | S | In general, the staff now accepts ANSI/AISC N690-1994s2 (2004). Discussion on the exceptions to this standard is needed.<br><br>During the audit, it was agreed to address this issue under the review of RAI 3.8-66. |

| RAI Number | RAI Status | Comment |
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| 3.8-79 | C | For the radwaste (RW) building, the term “remote” needs to be clarified. Does this building meet the criteria in SRP 3.7.2.8.a, which states that the collapse of any non-Category I structure will not cause the non-Category I structure to strike a seismic Category I structure or component? If so, provide a description of what was done to demonstrate this, since the RB/FB and RW buildings appear to be relatively close (see DCD Figure 1.1-1).<br><br>During the audit, GE indicated that they will document that the distance between the RW building and any SC I structure, system, and component is greater than the height of the RW above grade. |
| 3.8-80 | U (S/C) | Will the design of the EBAS and RW be completed soon enough to allow the NRC staff to review it before issuing the SER? Also, DCD Section 3.8.6 is not labeled “COL applicant responsibilities”, but rather “COL Information.” For COL applicant responsibilities, are there additional items specified somewhere else in the DCD that must be satisfied? Currently there is only one item in DCD Section 3.8.6; it refers to the structural integrity test (SIT) of the ESBWR containment.<br><br>During the audit, GE indicated that the status of the EBAS design is addressed in RAI 3.8-65. GE stated that since the RW building is a non-safety-related and non SCI or SC II structure, it does not need to be designed as part of the design certification, nor will it be a COL Action Item. GE also presented a draft supplemental response to address the questions related to Section 3.8.6 - COL Information. During the meeting GE indicated that structural related COL Action Items will be included in Section 3.8.6. |
| 3.8-81 | U | The new DCD Section 3.8.4.7 (Testing and In-Service Inspection Requirements) refers to monitoring of Seismic Category I structures, in accordance with Section 1.5 of RG 1.160, for those structures listed in Table 19.2-4. However, Table 19.2-4, which is referenced for the list of structures to be monitored, cannot be located. Clarify if this is the correct table reference.<br><br>10 CFR 50.65 also needs to be referenced, along with reference to RG 1.160. ESBWR Seismic Category II structures also are subject to 10 CFR 50.65 and RG 1.160. This needs to identified and discussed in the DCD.<br><br>In addition, DCD Section 3.8.4.7 does not discuss any special post-construction testing and/or inservice surveillance programs for Other Category I Structures (identified for staff review in SRP 3.8.4.I.7). These may include items such as periodic examination of inaccessible areas, monitoring of groundwater |

| RAI Number | RAI Status | Comment |
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| | | chemistry, monitoring for degradation of reinforced concrete/porous concrete/mud mat foundations due to flowing groundwater, and monitoring of settlements and differential displacements. Describe how will these be addressed, or explain why they are not applicable.<br><br>During the audit, the issues raised by the first paragraph above, are addressed by the review performed under RAIs 3.8-58. Also, reference to Table 19.2-4 will be deleted. For the issue raised in the second paragraph, GE indicated that condition monitoring and consideration of lessons learned will be defined in the DCD as a COL Action Item (also see "Additional Topic to be Discussed" at the end of this Summary Table). |
| 3.8-82 | S | Review results and supporting calculations during the second audit.<br><br>During the audit, there was insufficient time to audit the referenced calculations. This is subject to audit at a later date. |
| 3.8-83 | A | |
| 3.8-84 | C (A) | See staff assessment of this response in RAI 3.8-44.<br><br>During the audit, GE indicated that they will revise Table 3.8-9 to reference ANSI/ASME NQA-1-1983 and NQA-1a-1983 Addenda, as endorsed by RG 1.128, Rev. 3 |
| 3.8-85 | U | The Table provided in GE's response compares the 15 NRC Regulatory Positions presented in RG 1.142 against ACI 349-97, ACI 349-01, and ESBWR. The RAI requested that GE make the comparison between the staff's current position (ACI 349-97, supplemented by RG 1.142) against the unreviewed ACI 349-01, with consideration of the qualifications identified in RG 1.142 (what the DCD states). To minimize the effort, it would be acceptable to make this comparison only for those provisions in the two sets of codes that are being used. As was done in RAI 3.8-5 for the ASME Code, it would be useful to separate those items which are more stringent in ACI 349-01 from those that are less stringent in ACI 349-01. For those provisions which are less stringent (i.e., less conservative), provide the technical basis for their acceptance, which can be shown by demonstrating that an equivalent level of safety will be achieved.<br><br>During the audit, GE indicated that they will review the above and will determine the best way to address this issue. |

| RAI Number | RAI Status | Comment |
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| 3.8-86 | C (A) | Similar to RAI 3.8-59. See staff assessment of response to RAI 3.8-59. Also, see resolution of issue associated with Table 19.2-4, which is addressed under RAI 3.8-81. |
| 3.8-87 | U | This response needs to be coordinated with BNL's Confirmatory Analysis work. GE needs to explain the basis for the statement: "Note *: Additional shear force is applied to the basemat to reproduce the maximum soil spring reaction obtained by the dynamic analysis."<br><br>During the audit, GE will revise their response to explain how the additional shear force applied to the basemat is calculated. In addition, GE will enhance the explanation given during the meeting to explain how they determined and applied the seismic stick model loads onto the NASTRAN model. |
| 3.8-88 | U | GE refers to response to RAI 3.8-96. See staff assessment of response to RAI 3.8-96.<br><br>During the audit, it was agreed to address this issue under RAI 3.8-96. |
| 3.8-89 | A | |
| 3.8-90 | U | See staff assessments of RAIs 3.8-13 and 3.8-94.<br><br>During the audit, it was agreed to address this issue under RAIs 3.8-13 and -96. |
| 3.8-91 | U | GE needs to provide a copy of the complete markup for DCD Section 3.8.5.4 (the submittal only includes page 3.8-36 and ends in an incomplete sentence). The resolution of this RAI hinges upon GE's response to RAI 3.8-107. GE should have the design calculations related to this RAI available for review at the next audit. Discussion of development length in Supplement 2 is acceptable.<br><br>During the audit, GE indicated that the complete markup has been included in DCD Rev. 2. The resolution of this RAI is dependent upon the resolution of GE's response to RAI 3.8-107. There was insufficient time to audit the referenced design calculation. This is subject to audit at a later date. |
| 3.8-92 | U | GE refers to response to RAI 3.8-93. See staff assessment of response to RAI 3.8-93. |

| RAI Number | RAI Status | Comment |
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| | | During the audit, it was agreed to address this issue under RAIs 3.8-93. |
| 3.8-93 | U | GE needs to explain why DCD Section 3.8.6.2 has been deleted and state where it will be documented in the DCD that "The COL holder will have to demonstrate that differential settlements at the site do not exceed this value by instituting a settlement monitoring program or justify in the COL why it would not be necessary." GE also needs to: (1) clarify "this value" in the previous sentence, (2) why only dead load is considered in the evaluation and clarify what loads are included in the dead load, (3) why is the pedestal area the only area considered to have a potential "hard spot," (4) explain the sentence "Assumed sequence is as follows, but this is imaginary since these portions are constructed in short time periods," (5) clarify if the two construction sequences (Case A and Case B) are a COL requirement, and if not, why not, (6) why are not hard spots considered in the construction phase, (7) in the evaluation for variation of horizontal soil springs, were the walls also reviewed in addition to the mat? and (8) regarding Figure 3.8-93(3)-c, GE needs to explain why the soft X 3 case exceeds the base case.<br><br>During the audit, GE presented a draft supplemental response to address the above.<br><br>(1) For the settlement and differential settlement criteria, GE agreed to revise DCD Section 2.5 to specify, for all SC I structures, the allowable values that must be met by the COL applicant during the life of the plant for the particular site. The SC I structures are evaluated for these displacement limits and shown to meet design requirements. Also, DCD Section 3.8.5 will identify the need to satisfy these requirements and reference DCD Section 2.5. GE indicated that the precise values given in the RAI response will be reevaluated and will probably be increased since there is more margin.<br><br>(2) GE clarified why only dead load is considered.<br><br>(3) GE will address the concern that there are other horizontal variations of the soil springs (e.g., stiffer springs around the periphery, ...) to consider.<br><br>(4) GE clarified why the assumed sequence is considered to be "imaginary." That is because a conservative assumption was considered in the analysis. |

| RAI Number | RAI Status | Comment |
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| | | (5) Regarding the need to specify general construction sequences in the DCD, which were the basis of the design, GE indicated that they will perform additional calculations to consider the effects of the construction sequence of the concrete mat pour and the effects on design. These evaluations will include consideration of the governing soil properties. GE expects that these bounding type calculations will show that the resulting forces and deformations are small. If so, GE will revise the DCD to indicate that the requirements for construction of the mat (based on these evaluations) will be specified in the construction specifications. If not, then a more detailed description of the construction requirements will be provided in the revised DCD.<br><br>(6) GE indicated that the hard spots were not considered for the construction phase analyses because the deformations and resulting loads were small and also, these construction related conditions are short term. The staff needs to review this position.<br><br>(7) GE indicated that they will review the results for the walls as well and provide their evaluation.<br><br>(8) GE indicated that they will review the results and provide their explanation. |
| 3.8-94 | C | GE's response refers to Table 3G.1-58 which provides the maximum soil bearing stress involving SSE. GE needs to clarify that the values in Table 3G.1-58 represent the maximum soil bearing stress for all load combinations. GE also needs to explain whether the comparisons to the bearing pressures in Table 3.8-94(1) are for the same load combinations.<br><br>During the audit, GE presented a draft supplemental response to address the above. Regarding the first question, GE presented an acceptable response. GE needs to clarify the RAI response and the draft supplemental response regarding the comparison of the maximum bearing pressures reported in Table 3.8-94(1) to Table 3.G.1-58. GE also needs to explain why the toe pressures reported in Table 3G.1-58 are conservative when considering the variation of horizontal soil springs as discussed in RAI 3.8-93. |
| 3.8-95 | C | The response does not address correcting the circuitous referencing in DCD 3.7.5.1 and Appendix 3G. Has the bearing capacity information been accepted in the staff review of DCD 3.7? |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | During the audit, GE presented a draft supplemental response which states that they will collect COL actions for site related parameters in DCD Chapter 2. GE will revise DCD Section 3.8.5 to reference the appropriate section in Chapter 2 for site related parameters, including site specific soil bearing capacity requirements. |
| 3.8-96 | U | GE needs to clarify the response to this RAI and revise Section 3.8.5.5 to be consistent with their response. Does GE calculate the safety factor (SF) against sliding by only considering the basemat shear friction? If not, GE needs to better explain the method used in light of the question asked. GE also needs to explain (1) Do the exterior walls need to be designed for passive pressures as implied in the last sentence of item (a) of the response? (2) Are both base shear and passive pressures being relied upon for lateral restraint? (3) the friction coefficient used in the analysis and its technical bases, (4) how lift-off effects are captured in the sliding analysis, (5) the capacity of the mud mat to resist applied loads, and (6) what effect the use of chemical crystalline powder in the mud mat has on the assumed structural properties. Potential leaching of the mud mat due to groundwater is being reviewed under RAI 3.8-81.<br><br>During the audit, GE indicated the following:<br><br>(1) and (2) GE explained the answer to both is yes. The seismic stick model did not consider embedment effects while the stability calculations (soil sliding), using this shear force, did consider soil friction and soil passive pressure. However, the SASSI did consider soil embedment and it was shown that the resulting shear loads are smaller than those calculated by the seismic stick model. GE indicated that they will determine an appropriate method to consider the seismic shear force from the seismic stick model and/or SASSI analysis in their calculation of sliding stability calculation. The method used will ensure consistency of the deformation in developing the frictional soil resistance and soil passive pressure. Also, the design of the foundation walls will consider the appropriate pressures from the SASSI analysis and passive soil pressures used in the sliding stability calculations.<br><br>(3) GE will provide the reference for the static and dynamic coefficient of friction values. This would be needed if GE is not able to show that the soil frictional resistance alone can resist the seismic shear force.<br><br>(4) GE will provide additional justification to demonstrate that the effects of uplift are not significant. |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | (5) GE will expand on the description of the mud mat and provide the minimum applicable requirements (e.g., ACI Code).<br><br>(6) GE explained that this material has no deleterious effect on the concrete and has been used and approved at other nuclear power plants. |
| 3.8-97 | C (A) | GE needs to clarify how the dead load was defined for the buoyancy calculations and what effect the stored volume of the water in the pools has on the factor of safety for floatation.<br><br>During the audit, GE presented a draft supplemental response which addresses this RAI. |
| 3.8-98 | U (A) | Response to RAI 3.7-48 has been revised, based on the June 2006, 3.7 audit; one issue remains, based on the October through November 2006, 3.7 audit. GE is addressing this. GE needs to ensure consistency between DCD 3.7.2.14 and DCD 3.8.5.5.<br><br>During the audit, it was agreed that this issue is being addressed under RAI 3.7-48 and resolution of this issue will not require a change to DCD Section 3.8.5.5. |
| 3.8-99 | U | The resolution of this RAI needs to be consistent with the outcome of the review performed for RAI 3.8-81.<br><br>During the audit, it was agreed that the resolution for RAI 3.8-81 will address this RAI. The revised wording in the DCD will address structures covered by DCD Sections 3.8.4 and 3.8.5. |
| 3.8-100 | U (A) | GE shows that the bending moments increase almost 30 percent at the center due to the larger basemat thickness at the center. Since GE's primary reinforcement design is based on a 4 m depth as shown in Figure 3.8-100 (1), the effective height of the section for reinforcement design does not increase, therefore the amount of reinforcing steel required should increase. GE needs to clarify the bases for the reinforcement design in the light of their study. Also, GE needs to explain the technical bases for determining the size of the reinforcing bars in the top surface of the thickened portion to prevent the development of concrete cracking.<br><br>During the audit, GE presented a draft supplemental response which adequately addressed both questions. |
| 3.8-101 | C | GE's response to RAI 3.8-101does not adequately address RAIs 3.8-101, -102, and -103. There is no discussion of how jurisdictional boundaries have been evaluated. How are loads |

| RAI Number | RAI Status | Comment |
|---|---|---|
| | | and load combinations that cover both codes considered for the whole basemat? Were the code-specific acceptance criteria applied to the whole basemat, for the code-specific load combinations? Was there redundancy of evaluation, to effectively qualify the whole basemat in accordance with both codes?<br><br>During the audit, it was agreed that this issue is being addressed under RAI 3.8-4. |
| 3.8-102 | C | GE refers to response to RAI 3.8-101. See staff assessment of response to RAI 3.8-101.<br><br>During the audit, it was agreed that this issue is being addressed under RAI 3.8-4. |
| 3.8-103 | C | GE refers to response to RAI 3.8-101. See staff assessment of response to RAI 3.8-101.<br><br>During the audit, it was agreed that this issue is being addressed under RAI 3.8-4. |
| 3.8-104 | R | |
| 3.8-105 | R | |
| 3.8-106 | R | |
| 3.8-107 | U | Detailed staff review is needed to resolve. How would the evaluation procedure be affected by a change in the methodology to combine 3 directions of seismic response? GE's implementation of the 100/40/40 method does not comply with RG 1.92, as noted in a recent teleconference on November 21, 2006.<br><br>During the audit, GE presented a draft supplemental response to address this issue. Although a more thorough review could be performed if/when the formal supplemental response is submitted, based on a quick review of the write-up, it is unlikely that the supporting calculation would be acceptable. This is because GE indicated that in "most cases" their approach for implementing the 100/40/40 is conservative. Staff review of the SSDP-2D validation package and GE's supplemental RAI response (when received) is needed. |
| 3.8-108 | A | |
| 3.8-109 | A | |

| | | |
|---|---|---|
| 3.7-59 | U | During the audit, GE indicated that the study described in Section 6 of the report that was submitted in response to RAI 3.7-59 compares the results from the seismic time history analysis of the NASTRAN finite element model to the current design basis NASTRAN analysis, which uses the seismic stick model loads applied statically. Additional detailed staff review is needed. |

**Additional Topic to be Discussed**

Importance of condition monitoring for a 60 year design life; consideration of lessons learned from license renewal:

- Periodic groundwater monitoring to assess the aggressiveness of the below-grade environment; accessibility of below-grade concrete for periodic inspection, if groundwater is aggressive; standard design considerations vs. COL applicant action items.

- Accessibility and periodic inspection of buried tanks, piping and components; standard design considerations vs. COL applicant action items.

- Ensuring the leak-tight integrity of inaccessible, embedded portions of steel liners for concrete containments; standard design considerations vs. COL applicant action items.

During the audit, GE indicated that condition monitoring and consideration of lessons learned will be defined in the DCD as a COL Action Item.

ESBWR DCD Section 3.8
Second On-Site Audit
December 12 through 14, 2006
Discussion of Confirmatory Analysis Conducted by the Staff

During the on-site audit, two breakout meetings on confirmatory analysis review were held between the NRC staff and GE/SHIMIZU staff. In addition, there were several informal exchanges of ideas on how to minimize the modeling differences between GE's NASTRAN model and the staff's ANSYS model. The subjects covered included (1) comparison of results; (2) modeling differences; and (3) future actions to resolve differences in results.

Based on an agreement between the staff and GE, 7 major walls and 3 basemat sections were selected for the purpose of results comparison in the confirmatory analysis. During the audit, the staff discussed with GE/SHIMIZU staff the detailed comparison of the internal forces and moments for 2 representative walls and 1 basemat section. Because of time constraints, the comparisons were made by reading results from the plots submitted by GE and the plots produced by the staff, without overlapping the two sets of data on one set of plots. Displacements were only roughly compared, because there was no agreement between the staff and GE on where and how the comparison of displacement would be made. Some of the comparisons between the truncated ANSYS solid model and the truncated NASTRAN shell model were acceptable, but in some cases the differences were significant. Some were easily explained by the modeling differences. The staff described the ANSYS solid model and the application of the 6 load cases. While there were differences in how the loads were applied in the two models, the loads for both models were judged to be equivalent.

The major differences in the modeling and post-processing between the truncated NASTRAN and ANSYS models, and the corresponding post-audit actions, are summarized below:

(1) There is a gate in wall IW-F10 in the structural drawing, which SHIMIZU modeled as a zero-width gap between adjacent shell elements, but had been closed until SER-ESB-038, Rev. 4. As indicated in this report, this modeling error has been corrected. However, the staff's ANSYS confirmatory model does not have this gap, because it was not identified during the review of the modified truncated NASTRAN model. GE agreed to close the gap in the modified truncated NASTRAN model in order to be consistent with the ANSYS model, because it is difficult to add this gap to the ANSYS model.

(2) An apparent discrepancy between the SER-ESB-038 Rev. 3 and 4 results is that the critical seismic combination has changed. The only modeling change was the gap condition, as discussed above. Since this modeling change would not be expected to have such an effect, the change in the critical seismic combination needs further review. GE/SHIMIZU agreed to investigate this.

(3) GE provided displacement plots at the top of the walls in SER-ESB-038, Rev. 4, while the staff did not have corresponding plots for comparison. The staff will prepare the displacement plots as schedule permits. Otherwise, as a minimum, the staff will locate the maximum displacements from the GE's displacement plots and provide comparison at the selected locations.

(4) The total number of internal forces and moments is 7, namely N, Qx, Qy, Mx (group 1 – in section) and Qz, Nz, and Mz (group 2 – in perpendicular section). GE provided 6 of the 7 quantities for each location in the NASTRAN element coordinate system, and with the in-plane shear missing from SER-ESB-038, Rev. 4. The in-plane shear is very important for lateral seismic loadings. GE will provide a table showing for each location the correlation between the NASTRAN quantities and the sectional forces and moments as illustrated during the meeting. The data provided by GE will be in Excel files, in addition to the plots in SER-ESB-038. The Excel files will include the coordinate and the 7 internal forces and moments. The staff will make comparisons using the data in these Excel files.

(5) Some of the internal forces and moments reported in SER-ESB-038 Rev. 4 are opposite in sign to ANSYS solution, with no apparent consistency from location to location. An agreement on the positive directions of all sections was reached during the audit. GE and the staff will present the internal force and moment results consistent with the agreement, to facilitate comparison.

(6) GE's internal forces and moments in the walls were taken at the center of the first row of shell elements in the walls (-11.0 m). The staff's corresponding results were taken from the bottom of the wall (-11.5 m). The staff will move the cut plane from an elevation of -11.5 m up to -11.0 m.

(7) The shell elements for sections of varying thickness should have the correct offset. The basemat under spent fuel pool has correct offset in the shell elements, while the thickened portion of wall F3 does not. GE will change the modified truncated NASTRAN model for correct offset for these elements. However, GE indicated in the meeting it will not adjust the offset in wall F3 in the full model.

(8) Sections AA and CC in the basemat are not straight sections in the NASTRAN model. GE/SHIMIZU will check whether the internal forces and moments can be taken along straight sections.

(9) The basemat within the boundary of the RPV pedestal has been changed to 5.1 m in the full NASTRAN model, but its reinforcements are proportioned using a thickness of 4 m. A thickness of 4 m was used in the modified truncated NASTRAN model. GE will increase the thickness to 5.1 m in the truncated model with correct offset.

(10) The soil springs in the NASTRAN model are applied at the center of the basemat; while they are applied at the bottom of the basemat in the ANSYS model. However, GE/SHIMIZU performed a sensitivity study on the location of the soil springs, and found the resultant change in the responses was minimal.

(11) Hydrostatic load in the truncated and full NASTRAN models is applied at the centers of the surrounding walls and basemat. This approach results in a larger area for the hydrostatic pressure load. GE/SHIMIZU will update the model appropriately considering the true area for hydrostatic pressure, possibly in a way similar to that for the pressure load application in the RPV. The final implementation of this action will be documented in the report.

(12) GE will try to identify the possible reasons why some of plots show sharp knuckles or large gradients, which do not exist in the results of the ANSYS model. The staff and GE will try to identify possible reasons for some of significant differences in the responses between the modified truncated NASTRAN and ANSYS models, which were not immediately obvious during the audit. In particular, GE will check if a sufficient number of in-plane integration points in the wall elements to establish an adequate constraint to the basemat.

Meeting Summary dated May 18, 2007

SUBJECT: SUMMARY OF DECEMBER 14, 2006, MEETING WITH GENERAL ELECTRIC, REGARDING AUDIT OF ESBWR STRUCTURAL DESIGN AND ANALYSIS

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