August 16, 2006

Mr. David H. Hinds, Manager, ESBWR
General Electric Company
P.O. Box 780, M/C L60
Wilmington, NC 28402-0780

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 53 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION

Dear Mr. Hinds:

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

The NRC staff has identified that additional information is needed to continue portions of the review. The staff's request for additional information (RAI) is contained in the enclosures to this letter. Enclosure 1 includes Proprietary information which is indicated in brackets and underlines. We have prepared a Non-Proprietary version of the RAI (Enclosure 2) that does not contain Proprietary information.

The RAI questions are related to the ESBWR design control document (DCD) Chapter 4, "Reactor", Sections 4.2, 4.3, and 4.4 and topical reports NEDC-33237P,"GE14 for ESBWR - Critical Power Correlation, Uncertainty, and OLMCPR Development," NEDC-33239P, "GE 14 for ESBWR Nuclear Design Report," NEDC-33240P, "GE14E Fuel Assembly Mechanical Design Report," and NEDC-33241P, "GE14 Fuel Rod Thermal-Mechanical Design Report," and NEDC-33242P, "GE14 for ESBWR Fuel Rod Thermal Mechanical Design Report."

RAI Questions 4.2-2 through 4.2-7, and 4.8-1 through 4.8-16 were sent to you in draft form via electronic mail on May 24, June 9, and July 17, 2006. These questions were discussed with your staff at the closed meeting that was held at the GE facility in Wilmington, NC on June 19-22, 2006.

RAI Questions 4.3-2 through 4.3-5, and 4.4-2 through 4.4-6, and 4.4-15 through 4.4.-56 were sent to you in draft form via electronic mail on June 5, and July 20, 2006. These questions were discussed with your staff during telecons on June 28, June 30, and July 5, 2006. These questions were also discussed with your staff at the closed meeting that was held at the GE facility in Wilmington, NC on June 19-22, 2006.

RAI 4.4-1 was sent to you in draft form via electronic mail on April 26 and July 20, 2006. This question was discussed with your staff during telecons on May 11, June 28 and July 5, 2006. This question was also discussed with your staff at the closed meeting that was held at the GE

facility in Wilmington, NC on June 19-22, 2006. You agreed to respond to the RAI on the following schedule:

August 23, 2006: 4.2-2 through 4.2-7, 4.3-1, 4.3-3, 4.3-4, 4.4-2, 4.4-5, 4.4-6, 4.4-14 through 4.4-17, 4.4-19, 4.4-24, 4.4-27, 4.4-31 through 4.4-34, 4.4-37, 4.4-44 through 4.4-50, 4.4-53 through 4.4-56, 4.8-1 through 4.8-16;

September 29, 2006: 4.3-2, 4.3-5, 4.4-25, 4.4-26, 4.4-28-30, 4.4-35, 4.4-36, 4.4-38, 4.4-39, 4.4-42, 4.4-43, 4.4-51, 4.4-52;

October 13, 2006:4.4-1,4.4-10 through 4.4-13, 4.4-3, 4.4-4,4.4-18, 4.4-20 through 4.4-23, 4.4-40, 4.4-41.

If you have any questions or comments concerning this matter, you may contact me at (301) 415-4115 or mcb@nrc.gov or you may contact Amy Cubbage at (301) 415-2875 or aec@nrc.gov.

Sincerely,

/RA/

Martha Barillas, Project Manager
ESBWR/ABWR Projects Branch
Division of New Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 52-010

Enclosures: 1. Request for Additional Information (Proprietary)
2. Request for Additional Information (Non-Proprietary)

cc: See next page (w/o encl. 1)

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September 29, 2006: 4.3-2, 4.3-5, 4.4-25, 4.4-26, 4.4-28-30, 4.4-35, 4.4-36, 4.4-38, 4.4-39, 4.4-42, 4.4-43, 4.4-51, 4.4-52;

October 13, 2006:4.4-1,4.4-10 through 4.4-13, 4.4-3, 4.4-4,4.4-18, 4.4-20 through 4.4-23, 4.4-40, 4.4-41.

If you have any questions or comments concerning this matter, you may contact me at (301) 415-4115 or mcb@nrc.gov or you may contact Amy Cubbage at (301) 415-2875 or aec@nrc.gov.

Sincerely,

/RA/

Martha Barillas, Project Manager
ESBWR/ABWR Projects Branch
Division of New Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 52-010

Enclosures: 1. Request for Additional Information (Proprietary)
2. Request for Additional Information (Non-Proprietary)

cc: See next page (w/o encl. 1)

ACCESSION NO. ML062260145

OFFICE	NESB/PM	NESB/BC(A)
NAME	MBarillas	JColaccino
DATE	08/15/2006	08/16/2006

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Distribution for DCD RAI Letter No. 53 dated August 16, 2006

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Request for Additional Information (RAI)
ESBWR Design Control Docuemnt (DCD) Tier 1 Section 2.8, Tier 2 Section 4.2 and Appendix 4B

RAI Number	Reviewer	Question Summary	Full Text
4.2-2	Clifford P	Describe mechanical database supporting oxide thickness.	DCD Tier 2, Section 4.2.1.1.4 states, “The oxide thickness itself is not separately limiting and no design limit on cladding oxide thickness is therefore specified.” (Similar statement for hydrogen content in Section 4.2.1.1.5.) (a) Describe the extent of the irradiated and unirradiated mechanical testing database for both fuel rods and assembly components (including channels) with respect to oxide and hydride concentrations and orientations used to support the thermal-mechanical design analyses. (b) Demonstrate that the cladding is capable of achieving 1 percent permanent deformation up to expected oxide/hydride concentrations at end-of-life.
4.2-3	Clifford P	Verify the pedigree of GSTRM.	DCD Tier 2, Section 4.2.1.1.4 refers to the GSTRM topical report NEDC-31959P (April 1991). Describe the licensing history of GSTRM, including the staff's review and any subsequent changes to the various fuel performance models (e.g., tuning/calibration) within GSTRM, and the pedigree of this unapproved document.
4.2-4	Clifford P	Provide the mechanical test database.	DCD Tier 2, Section 4.2.1.1.5 states, “Mechanical properties testing demonstrates that the cladding mechanical properties are negligibly affected for hydrogen contents far in excess of that experienced during normal operation.” Provide the mechanical properties testing database, along with pool-side corrosion measurements, to support this statement.
4.2-5	Clifford P	Provide the fuel design requirements in Appendix 4B.2.	DCD Tier 2, Appendix 4B.2 should define the specific Tier 2 and Tier 2* thermal-mechanical fuel design requirements. These requirements would then be addressed within a separate fuel assembly mechanical design topical report to demonstrate, using approved models and methods, the acceptability of a proposed fuel assembly design to the ESBWR. The specific thermal-mechanical design requirements may be patterned after the standard review plan. The current text appears to be an overview of a fuel design change process and should be removed.

RAI Number	Reviewer	Question Summary	Full Text
4.2-6	Clifford P	Provide supporting empirical database, especially test results on irradiated fuel rods.	DCD Tier 2, Appendix 4B.2 states, "For local AOOs such as rod withdrawal error, a small amount of calculated fuel pellet centerline melting may occur, but is limited by the 1 percent cladding circumferential plastic strain criterion." The staff has concerns with the ability to accurately model fuel volumetric expansion as fuel enthalpy approached incipient melt temperatures, and the ability to accurately model the evolved fuel pellets in future operation. (a) Demonstrate that the fuel thermal expansion/swelling model is capable of accurately predicting volumetric expansion during rapid power changes and at temperatures (1) approaching T_{melt} and (2) exceeding T_{melt}. Include a discussion of the models ability to predict fission-product-induced swelling. Provide supporting empirical database, especially test results on irradiated fuel rods. (b) Demonstrate that all of the fuel performance models (e.g., conductivity, expansion, relocation, FGR, grain growth, etc.) remain valid and within their original accuracy for simulating evolved fuel (having undergone partial melt) during future operation including AOOs. Provide supporting empirical database, especially test results on irradiated fuel rods.
4.2-7	Clifford P	Identify the core-wide AOOs and the criteria to evaluate each.	DCD Tier 2, Appendix 4B.5 states, "99.9 percent of the rods in the core must be expected to avoid boiling transition for core-wide incidents of moderate frequency..." This criteria differs from GESTAR-II which states, "Ninety-nine point nine percent (99.9 percent) of the rods in the core must be expected to avoid boiling transition." (a) Discuss the basis for this change. (b) Identify AOOs not characterized as "core-wide" and the criteria used to evaluate each. (c) Distinguish between events classified as moderate frequency and those classified as less frequent.

Request for Additional Information (RAI) on ESBWR
NEDC-33240P, GE14E Fuel Assembly Mechanical Design Report &
NEDC-33242P, GE14E Fuel Rod Thermal-Mechanical Design Report

RAI Number	Reviewer	Question Summary	Full Text
4.8-1	Clifford P	Identify GE14E debris filter components.	The GE14E fuel assembly description in Section 2 of NEDC-33240P does not identify any debris filtration components. Provide a description and drawing of any debris filtration components, if applicable. Include a discussion of the effectiveness of the design in trapping debris.
4.8-2	Clifford P	Explain fuel manufacturing quality and change process.	The Zircaloy-2 processing described in Section 2.2 of NEDC-33240P includes the sentence: "If more significant process changes are made, the applicability and adequacy of the properties will be confirmed." As indicated in this section, changes in material composition and manufacturing process have the potential to impact the material properties of the finished Zircaloy-2. (a) Describe the manufacturing quality control procedures which will be in place to ensure that future lots of fuel assembly components exhibit the same performance characteristics as provided in NEDC-33240P. (b) Describe the manufacturing change process which will be in place to ensure that future lots of fuel assembly components (manufactured with changes in the fabrication process) exhibit the same performance characteristics as provided in NEDC-33240P.
4.8-3	Clifford P	Address part-length fuel rod differential growth.	Section 3.1 of NEDC-33240P addresses dimensional changes of assembly components. This section does not address part-length fuel rod growth and design margin to accommodate differential growth relative to the spacer-positioning water rod. Please address this issue.

RAI Number	Reviewer	Question Summary	Full Text
4.8-4	Clifford P	Address differential assembly growth and spring engagement.	Section 3.1 of NEDC-33240P addresses dimensional changes of assembly components. This section does not address differential assembly growth and design margin to ensure channel fastener spring engagement within a control cell. Please address this issue.
4.8-5	Clifford P	Discuss the applicability of previous measurements to the GE14E design.	Figures 3-3, 3-6, and 3-9 of NEDC-33240P provide measured irradiation-induced growth data taken from current and past GE fuel designs. (a) Discuss the applicability of these previous measurements to the GE14E design. Identify the material composition and manufacturing process for each of the data sets. (b) Discuss the linearity of the data.
4.8-6	Clifford P	Describe the steps taken (e.g., irradiated material testing) to ensure that the beginning-of-life evaluations are most limiting.	Section 3.3.1 of NEDC-33240P states, "The limits are typically applied to unirradiated material conditions because irradiation increases the material strength properties." While it is true that irradiation hardening increases the material yield strength, it may not increase the overall strength of a component such as a spacer. Describe the steps taken (e.g., irradiated material testing) to ensure that the beginning-of-life evaluations are most limiting.

RAI Number	Reviewer	Question Summary	Full Text
4.8-7	Clifford P	Provide test data to support fretting wear evaluation.	Section 3.3.3 of NEDC-33240P states, “Testing is performed to assure that the mechanical features of the design do not result in significant vibration and consequent fretting wear.” (a) Provide the flow induced vibration (FIV) test results for the GE14E assembly design. (b) Discuss the impact of in-reactor dimensional changes (e.g., fuel rod growth, grid spring relaxation, etc.) on the adequacy of laboratory testing of unirradiated samples. (c) If specific GE14E FIV test results have not been conducted, demonstrate the applicability of previous FIV test results to the GE14E design. Describe any differences in assembly design (e.g.,, part-length rods, grid springs, grid elevations, materials, etc.) which may potentially impact the FIV test results.
4.8-8	Clifford P	Provide a quantitative assessment of seismic/dynamic loading	Section 3.4.1.11 of NEDC-33240P describes the seismic and dynamic loads, including hold down margin, acting on the fuel assembly during normal and accident conditions. Conclusions are qualitative and lack the necessary information for the staff to make a determination. Provide a quantitative assessment of seismic and dynamic loads for the GE14E fuel assembly design including supporting mechanical test data and the resulting fuel design requirements.
4.8-9	Clifford P	Describe how channel deformation and control blade interference will be handled in the GE14E fuel assembly.	Section 4.2 of NEDC-33240P states, “Tests have been performed which show that significant interference between control blade and channels can be tolerated without causing a failure of the control blade to settle and without significantly affecting scram times.” (a) Provide the details of these tests. (b) Recently, channel bow, most likely due to shadow corrosion effects, has been a significant issue. Describe how channel bow and control blade interference will be managed for the GE14E fuel assembly design.

RAI Number	Reviewer	Question Summary	Full Text
4.8-10	Clifford P	Identify any deviations from approved methodology.	Identify any deviations from NRC-approved fuel mechanical design methodology (e.g., treatment of model uncertainties and manufacturing tolerances, rod power history, etc.) being employed in the evaluation of the GE14E fuel rod and fuel assembly design for ESBWR. Also, identify where the statistical methodology presented in Appendix A of NEDC-33242P has been previously reviewed and approved by the staff.
4.8-11	Clifford P	Demonstrate that the currently approved fuel performance models are applicable to GE14E.	Demonstrate that the currently approved fuel performance models (e.g., models within GSTRM) are applicable to the GE14E design and ESBWR operating conditions (e.g., assembly average and nodal peak linear heat rate, power-to-flow ratio, etc.).
4.8-12	Clifford P	Provide PCI/SCC clad failure details.	Section 3.3.1 of NEDC-33242P states, “The barrier concept has been demonstrated by experimental irradiation testing and extensive commercial reactor operation to be an effective preventive measure for PCI/SCC failure without imposing reactor operating restrictions.” Provide the details of these power ramp tests including fuel rod design, fuel rod burnup, corrosion levels, and power history.
4.8-13	Clifford P	Provide Zircaloy fatigue data.	Section 3.4 of NEDC-33242P states, “The Zircaloy fatigue curve employed represents a statistical lower bound to the existing fatigue experimental measurements.” (a) Provide details on the supporting experimental data. (b) Discuss the relative conservatism of GNF’s fatigue data and methodology relative to the fatigue safety factors in SRP 4.2.II.A.1(b).

RAI Number	Reviewer	Question Summary	Full Text
4.8-14	Clifford P	Describe treatment of natural zirconium liner.	Describe the treatment of the natural zirconium liner in each of the fuel rod analyses (e.g., assumed Zry-2, ignored, specific zirconium properties).
4.8-15	Clifford P	Describe treatment of GSTRM model uncertainties in cladding strain analysis.	Table 4-1 of NEDC-33242P lists the parameters biased to their worst tolerance for the cladding strain analysis. Describe how the GSTRM model uncertainties (e.g., pellet thermal expansion, etc.) are accounted for in this evaluation.
4.8-16	Clifford P	Discuss validation of GSTRM fuel conductivity.	FRAPCON-3 benchmark cases appear to identify a difference in calculated fuel temperature relative to GSTRM. Please review the material presented in NUREG/CR-6534 Vol.4, Section 2 on burnup degradation of fuel thermal conductivity and the revised FRAPCON-3 fuel conductivity model (ML051440720) and discuss the current conservatism within the GSTRM fuel thermal conductivity.

RAI number	Reviewer	Summary	Full text
4.3-2	Attard A	Provide the experience database in tabulated form, pertinent to expected operation of the ESBWR, and operation with high exit void fractions.	In DCD Tier 2, Section 4.3.2, titled Nuclear Design Analytical Methods, the staff noted that most of the references **do not reflect recent BWR operating experience.** Please provide the experience database in tabulated form, (including as much detail as possible), pertinent to expected operation of the ESBWR, and operation with high exit void fractions. Specifically: (a) Demonstrate quantitatively and qualitatively that the current lattice and simulator (depletion) code suite have been validated in regions characteristic of ESBWR operation, such as low mass flows and of high void fractions. (b) Demonstrate quantitatively and qualitatively, that the Lattice/Depletion code systems and associated uncertainties and biases established for these codes (especially for reactivity coefficients, including void coefficients) remain valid for the neutronic and thermal-hydraulic conditions predicted for the ESBWR operation. (c) Demonstrate quantitatively and qualitatively, that the fuel isotopic validations and testing performed in the Lattice/Depletion code systems remain applicable for prolonged operation under high void conditions for the fuel lattice designs that would be used for the expected ESBWR. (d) Provide any validation data in support of the GE neutronic methodology prediction capability by comparison to gamma scans and TIP data. Specifically, the staff is looking for core follow benchmarking based on present fuel designs, operating strategies, and core conditions, similar to those strategies and core conditions expected for ESBWR operation. This request pertains to any recent fuel, such as the GE-14, in particular for first cycle and second cycle fuel operation.

RAI number	Reviewer	Summary	Full text
4.3-3	Attard A	Submit the modified version of TGBLA06 so the staff can review the changes to the code as part of the ESBWR DCD.	In DCD Tier 2, page 4.3-3, reference is made to the lattice code TGBLA06, which has recently been modified to accommodate a minor correction in the programming of analytical formulation in the code. Please submit the modification(s) to TGBLA06. The submittal should include the changes made to the code and validation of the code as it pertains to recent application(s) since the modification of the code, and any natural circulation database, as it pertains to the analysis of the ESBWR steady-state neutronic performance. The contents of the submittal should include before and after calculational results with technical justification(s) in support of the changed results. **Also provide a comparison between the modified TGBLA06 and MCNP results in Section 1.3 of NEDC-33239P, “GE14 for ESBWR Nuclear Design Report.”**
4.3-4	Attard A	Discuss any recent changes made to PANACEA since the staff’s last approval.	Discuss any recent changes made to PANACEA since the staff’s last approval. Provide similar information to that requested in RAI 4.3-3. It is presumed that this version of the code is the NRC-approved version of record.
4.3-5	Attard A	Provide additional discussion for MTC curves.	DCD Tier 2, Figure 4.3-3 on page 4.3-14, shows that the Moderator Temperature Coefficient (MTC) is slightly positive at lower temperature towards end of cycle (EOC). Provide additional discussion for each MTC curve in this figure.

Request for Additional Information (RAI)
ESBWR Design Control Document (DCD) Tier 2, Chapter 4.4, Thermal and Hydraulic Design

RAI number	Reviewer	Summary	Full Text
4.4-1	Attard A Gilmer J	Additional detail should be provided in DCD Section 4.4	Some sections of DCD Tier 2, Section 4.4 do not contain sufficient detail for the reviewer to make a determination of acceptability. Provide additional detailed information as follows: (a) If analyses or tests are necessary to demonstrate compliance with regulations, provide a discussion of the theoretical or experimental basis, the method used, the assumptions and boundary conditions, the limitations, and the results as applied to the ESBWR design. (b) Discuss the means by which the design addresses the regulatory guidance outlined in NUREG-0800, Standard Review Plan, Section 4.4, Thermal and Hydraulic Design, Revision 1, including General Design Criteria, Regulatory Guides, and other referenced documents. (c) If traditional computational methods are used (i.e., those which have already been accepted for conventional BWR's), provide the technical justification (qualitatively and quantitatively) as to why these computational methods remain appropriate for the ESBWR evaluation. That is, why do current computational methods apply to the ESBWR core design? (d) If new methods are used, identify the differences from conventional computational methods and the justification for their use. When thermal hydraulic limits are presented, such as the operating limit minimum critical power ratio (OLMCPR) and any other relevant Safety Limits, please provide a discussion of any differences from conventional methods for determining these limits. A top level guide to the appropriate sections would be beneficial. The DCD sections which are considered to require additional discussion are identified in subsequent RAI's. Other sections which did not have an associated question identified, but which could be enhanced by additional discussion, include: 4.4.1.3, 4.4.1.4, 4.4.1.5, 4.4.1.6, 4.4.1.7, 4.4.2.1.1, 4.4.2.1.3, 4.4.2.2, 4.4.2.3, 4.4.2.5, 4.4.2.6, 4.4.3.1.1.1, 4.4.3.1.1.2, 4.4.3.1.1.3, 4.4.3.3., 4.4.3.4, 4.4.3.5, and 4.4.3.6

RAI number	Reviewer	Summary	Full Text
4.4-2	Gilmer J	Provide test data used to develop the empirical void fraction correlation.	DCD Tier 2, Section 4.4.1.2 refers to "empirical correlations based on the characteristic dimensions of the fuel bundle and hydraulic properties of the two-phase flow in the fuel bundle" in regard to the void fraction distribution bases. **Provide test data used to develop the empirical correlations and address its applicability to the ESBWR operating range. Is this the same void fraction qualification database referred to in Section 4.4.3.2 of DCD Tier 2?**
4.4-3	Gilmer J	Provide more detail on heat transfer modeling.	DCD Tier 2, Section 4.4.1.5 discusses the fuel heat transfer bases. Provide additional detailed description of the heat transfer between the coolant and the fuel rod surface. **Address why GE's current (conventional) heat transfer model remains valid for the ESBWR.**
4.4-4	Gilmer J	Discuss steady-state MCPR and MLHGR limits for AOOs.	DCD Tier 2, Section 4.4.1.7 provides a summary of the design bases. Discuss the evaluation of steady-state MCPR and MLHGR limits for the most severe AOO, including assumptions, methods, and results.
4.4-5	Gilmer J	Describe applicability of Bundle Critical Power Performance Method to the ESBWR design.	DCD Tier 2, Section 4.4.2.1.1 refers to topical report NEDO-10958-A for discussion. Address conditions and limitations applicable to its use for the ESBWR design.
4.4-6	Gilmer J	Provide applicability of two-phase pressure drop in natural circulation modeling to the ESBWR design.	The friction pressure drop correlation provided in Section 4.4.2.3.1 of DCD Tier 2, is the same as that used for forced flow in conventional BWRs. Since the ESBWR is a natural circulation reactor with differences in fuel length, spacer separation distance, and partial length rod height, why are there no differences in the friction pressure drop correlation, particularly the two-phase multiplier, which is based on data for conventional BWR fuel bundles?

RAI number	Reviewer	Summary	Full Text
4.4-15	Gilmer J	Describe applicability of the local pressure drop two-phase local multiplier to ESBWR design.	The local pressure drop correlation discussed in Section 4.4.2.3.2 of DCD Tier 2, is the same as that used for forced flow in conventional BWRs. (a) What empirical constants were used (and from what source) to fit the results to ESBWR fuel design? (b) How is the single-phase data correlated to two-phase for the fuel assembly components?
4.4-16	Gilmer J	Provide local pressure drop new test data.	DCD Tier 2, Section 4.4.2.3.2 states that new test data are obtained whenever there is a significant design change. Discuss the data available for the ESBWR design and how it is used in the evaluation.
4.4-17	Gilmer J	State qualification of test data range.	What range of test data discussed in Section 4.4.2.4.of DCD Tier 2 has the pressure drop methodology been qualified to?
4.4-18	Gilmer J	Discuss applicability of referenced Topical Report to ESBWR design.	DCD Tier 2, Section 4.4.2.5 references a topical report which has not yet received NRC approval. Discuss the applicability of the topical report to the ESBWR design.
4.4-19	Gilmer J	Describe uncertainties specific to the ESBWR design	DCD Tier 2, Section 4.4.3.1.1.2 refers to uncertainties specific to the ESBWR. Describe these uncertainties and also list conventional BWR uncertainties which are included in the ESBWR design evaluation.

RAI number	Reviewer	Summary	Full Text
4.4-20	Gilmer J	Provide a discussion of the calculation of the reactor internals pressure drop and associated loads for normal and transient operation.	DCD Tier 2, Sections 4.4.1.3, 4.4.2.3, and 4.4.3.3 discuss the bases, methods, and evaluation of the core pressure drop and hydraulic loads but do not provide sufficient detail for staff review. Provide a discussion of the calculation of the reactor internals pressure drop and associated loads for normal and transient operation, including the model, input data, assumptions, and results. Discuss the applicability of the referenced TRACG topical report to the ESBWR design.
4.4-21	Gilmer J	Provide sections of DCD where ICC monitoring system hardware is discussed.	NUREG-0800, Standard Review Plan, Section 4.4 (Draft Rev. 2 - April 1996), Item I (Areas of Review) includes a review of the functional performance and requirements for the Inadequate Core Cooling (ICC) monitoring system hardware. Provide a reference in Section 4.4 to the appropriate section(s) of the DCD which address the ICC system.
4.4-22	Gilmer J	Provide TS and Bases applicable to Section 4.4.	NUREG-0800, Standard Review Plan, Section 4.4 (Draft Rev. 2 - April 1996), Item I (Areas of Review) includes a review of the technical specifications (TS) regarding safety limits and limiting safety system settings. Provide a reference in Section 4.4 to the applicable core thermal-hydraulic technical specifications and bases.
4.4-23	Gilmer J	Discuss pressure drop and flow comparison to conventional BWRs.	DCD Tier 2, Section 4.4.1.4 discusses the pressure drops and flow distributions in the fuel channels and core bypass regions. (a) Provide a quantitative comparison to those of conventional BWRs for both fuel channels and core bypass regions. (b) What is the impact on the MCPR limit as flow is reduced, or what reduction in flow would result in impacting the MCPR limit and by how much?

RAI number	Reviewer	Summary	Full Text
4.4-24	Gilmer J	Explain applicability of total pressure drop qualification test data to the GE14E fuel design.	Explain why the test data discussed in Section 4.4.2.3.5 of DCD Tier 2, is applicable to the ESBWR natural circulation flow design with GE14E fuel, considering the differences in active fuel length, spacer separation, and part-length rod height from the tested GE14 fuel.

RAI Number	Reviewer	Question Summary	Full Text
4.4-25	Attard A	Provide description of procedures and biases used.	Section 1.0 of NEDC-33237P, states that "appropriate procedures are used and biases are applied". Describe these procedures and biases.
4.4-26	Attard A Gilmer J Lurie D	Revise NEDC-33237P to include test data and other technical information to support the development of the CHF correlation for GE14E fuel.	During the closed meeting at the GE facility in Wilmington, NC (6/19-22/06), the staff informed GE that the qualitative information GE provided in Topical Report NEDC-33237P, regarding the development of the CHF correlation for the GE14E fuel design, does not contain sufficient quantitative technical data to justify the uncertainties provided in the topical report. As a result, GE agreed to re-write NEDC-33237P, to include additional qualitative and quantitative technical information in support of all the uncertainties provided in the report. GE suggested that they will rewrite the topical report to further address the following major areas:: A. GE will provide additional qualitative and quantitative technical data in the report to be revised pertaining to the application of GE14 12-foot fuel data to GE14E 10-foot fuel. B. GE will provide additional qualitative and quantitative technical data (including data from the ATLAS test facility) in support of the spacer sensitivity studies, and in support of the part-length rod sensitivity studies. This data is used by GE in the COBRAG computer code to perform spacer sensitivity studies. The NRC staff and GE have agreed that the code COBRAG does not need to be reviewed at this time, but the staff reserves the right to review the code at a later date, if necessary. C. Chapter 5,Table 5-1 of NEDC-33237P, will include detailed quantitative technical basis for three of the uncertainty values. The three uncertainty values alluded to are those uncertainties that pertain to the parameters that are unique to the ESBWR. Additional qualitative technical basis should be provided for the remainder of the uncertainties listed in Table 5-1, stating

RAI Number	Reviewer	Question Summary	Full Text
			why these uncertainties are still valid for ESBWR application. D. Each determined uncertainty in the text and the tables, including the total correlation uncertainty, such as those in Table 4.2, must be determined via a 95/95 methodology, where applicable.
4.4-27	Gilmer J Attard A	Discuss R-factor determination for GE14E fuel design.	The first paragraph on page 3-1 of NEDC-33237P discusses the evolution of the GEXL correlation and references an approved topical report for the R-factor determination. This report addresses GE11, GE12, and GE13 fuel. **Explain in detail the changes** required for the GE14 fuel design and any GE14E fuel design differences that affect the R-factor determination.
4.4-28	Gilmer J Attard A	Discuss ATLAS test data applicability for ESBWR design.	The second paragraph on page 3-1 of NEDC-33237P discusses the use of the ATLAS facility to develop correlation data. It states that BWR flows, pressures, and temperatures were used. (a) Address the range of test conditions and configuration in relation to the ESBWR design considering the natural circulation cooling and higher output thermal power of the ESBWR. (b) Was any adjustment made to the test data to account for magnetic biasing attributed to the electrically-heated rods of the ATLAS facility? **If no adjustment is made, how is the use of the data justified?**
4.4-29	Gilmer J Attard A	Discuss applicability of operating parameter ranges for ESBWR fuel.	Section 4.1 of NEDC-33237P shows the expected operating parameter range (including transients) for the ESBWR (i.e., pressure, mass flux, inlet subcooling, and R-factor). For any parameter which is outside the tested range, provide justification for use of existing GE14 data.

RAI Number	Reviewer	Question Summary	Full Text
4.4-30	Gilmer J Attard A	Explain conservatism of ECPR value for mass flux.	Table 4-2 of NEDC-33237P, gives Average ECPR values greater than 1.0. The preceding paragraph states that ECPRs less than 1.0 represent points for which the correlation is [[ ]], and those greater than 1.0 represent points where the correlation is [[ ]]. Explain why the data with mass flux less than or equal to [[ ]] is [[ ]] for use for the GE14E design.
4.4-31	Gilmer J Attard A	Explain conservatism of mean ECPR value.	On page 4-9 of NEDC-33237P, the Mean ECPR value provided [ ]]. Explain why this is [[ ]] for use in GE14E Operating Limit calculations.
4.4-32	Gilmer J Attard A	Provide additional information on OLMCPR determination.	On page 5-1, Section 5.1 of NEDC-33237P, the determination of the Operating Limit Minimum Critical Power Ratio (OLMCPR) is discussed. Provide additional discussion of the applicability of the GETAB program (Reference 1) to the ESBWR design.
4.4-33	Gilmer J Attard A	Discuss the critical power uncertainties referenced for the ESBWR design.	Section 5.1, page 5-2, of NEDC-33237P, refers to Tables 4.1 and 4.2 of Reference 8, an approved topical report for Power Distribution Uncertainties for Safety Limit MCPR Evaluations. Provide a discussion, qualitative and quantitative, and technical justification for the applicability of this reference to the ESBWR design. **Also discuss the applicability of Reference 6 to the ESBWR design.**

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RAI Number	Reviewer	Question Summary	Full Text
4.4-34	Attard A	Discuss the core physics model in the ESBWR design.	Section 1.1 of NEDC-33239P discusses the core physics evaluation model. In the ESBWR evaluation, are all fuel bundles modeled separately, or are individual fuel bundles modeled with an adjustment to account for the effect of adjacent fuel bundles?
4.4-35	Attard A	Provide qualitative and quantitative justification for [[ ]].	Section 1.3.1 of NEDC-33239P, Monte Carlo Benchmark Comparison, refers to [[ ]]. What is [[ ]]? Provide qualitative and quantitative justification.
4.4-36	Attard A	Provide [[ ]].	Section 1.3 of NEDC-33239P mentions [[ ]]. What [[ ]] are being referred to? Were TGBLA06 results ever compared directly to the [[ ]]?
4.4-37	Gilmer J Attard A	Demonstrate adequacy of assumption of linear variation of thermal hydraulic variables.	Section 1.5 of NEDC-33239P, states that all thermal hydraulic variables are assumed to vary linearly between nodes. Discuss any sensitivity studies performed to demonstrate the appropriateness of this assumption.
4.4-38	Gilmer J Attard A	Discuss the effect of crud buildup on flow rate, pressure drop, heat transfer and nodal power distribution.	Section 1.5 of NEDC-33239P briefly discusses crud buildup. Provide details of the evaluation of crud buildup, including the assumptions, modeling, and resulting influence on channel flow rates, pressure drop, rod heat transfer, and nodal power distribution.

RAI Number	Reviewer	Question Summary	Full Text
4.4-39	Gilmer J Attard A	Discuss core pressure drop assumption.	Section 1.5 of NEDC-33239P states it is assumed that [[ ]]. **Provide additional clarification regarding this assumption, that is, considering the chimney arrangement.**
4.4-40	Gilmer J Attard A	Discuss conservatism of bypass region assumptions.	Section 1.5.4 of NEDC-33239P discusses the bypass region calculation. The temperature of water in the vessel annulus (downcomer) region is assumed equal to the core inlet temperature. Discuss the conservatism of this assumption considering the variation in downcomer temperature with height.
4.4-41	Gilmer J Attard A	Explain why energy contribution from heat generation in the core shroud and upper and lower core structures is ignored.	Section 1.5 of NEDC-33239P states that the energy contribution from heat generation in the core shroud and upper and lower core structures is ignored. Explain why this is conservative, considering the neutron and gamma absorption heating in these structures.
4.4-42	Gilmer J Attard A	Provide values of friction empirical correlation.	What are the values used for the friction correlation constants a, b, and c in Equation 1.5.3 of NEDC-33239P? What is the reference source? What effect does each constant have on coolant flow and boiling height?
4.4-43	Gilmer J Attard A	Provide assumed surface roughness and source of assumed friction factor correlation constants.	What is the assumed value of the surface roughness, ε, in Equation 1.5.3 of NEDC-33239P? Also, what is the source of the friction factor correlation constants in Equation 1.5.3? If surfaces are not smooth, what is the impact on boiling height?
4.4-44	Attard A	Clarify if there was adjustment of PANAC11 results.	Section 1.6.3 of NEDC-33239P, provides the procedure for performing gamma scanning and highlighting the performance of PANAC11 against TIP data. Are the results of PANAC11 adjusted results?

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4.4-45	Attard A	Explain Eigenvalue trends with burnup shown in Figure 1-26.	Section 1.6 of NEDC-33239P, Figure 1-26, provides insight into the eigenvalue trend with burnup. Explain the [[ ]]. Also, explain the [[ ]].
4.4-46	Attard A	Explain how negative trend is accounted for in the design process.	Section 1.6.5 of NEDC-33239P, Cold Critical Measurements, states that the negative trend alluded to in Figures 1-26 and 1-27 is accounted for in the design process. Provide additional supportive information to this effect.
4.4-47	Attard A	Clarify how RMS results were obtained.	Are the RMS results provided in Table 1-17 using TIP-adjusted PANAC11 predictions?
4.4-48	Attard A	State the lattice physics code used.	Section 1.7 of NEDC-33239P, Reactivity Coefficient Methods, references an NRC-approved lattice physics code. State the code referenced.
4.4-49	Attard A	Provide additional details on void fraction values and standard hot depletion points.	Section 1.7 of NEDC-33239P states that all the calculations were performed as a function of void fraction and at various standard hot uncontrolled exposure depletion points. Provide specific details, in tabular form, including the void fraction values and explanation of standard hot depletion points. **Discuss any sensitivity studies which have been performed to assess the effect of perturbations of pressure and core flow.**

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4.4-50	Attard A	State correct bundle designation in Figure titles.	Section 3.0 of NEDC-33239P, Figures 3-1 through 3-6, indicate a bundle designation [[ ]] in the title. a) It is assumed by the staff that the fuel type used in the analysis of the referenced core (alluded to in section 3.1 of NEDC-33239P), is the GE14E and not the [[ ]]? If so, shouldn't the designation in Figures 3-1 through 3-6 be GE14E? Also, is the "referenced core" the same as an initial core, or an equilibrium core? b) If this is the GE14E, provide a description of the final fuel design used in the analysis. c) The designation in the titles of these same figures also suggest that these computer runs were conducted using PANACEA 10. Is that correct? Please clarify.
4.4-51	Attard A	Provide bundle peaking values for GE14E fuel.	Section 3.1.2.1 of NEDC-33239P discusses bundle peaking. Are the bundle peaking values (both fuel pin and bundle) lower for the GE14E bundles? How do these compare to ABWR and BWR/6 values?
4.4-52	Attard A	Provide additional explanation of Figures 3-7 through 3-21.	Explain Figures 3-7 through 3-21 in section 3.0 of NEDC-33239P and why there are no figures representing the higher void fraction conditions. How does the linear fit of void fraction data compare to TGBLA at 90 percentvoid conditions?
4.4-53	Attard A	Provide additional discussion of Figure 3-33,Cold Shutdown Margin vs.Cycle Exposure.	Figure 3-33 of NEDC-33239P represents the shutdown margin with exposure. Is this for all rods in, or just the shutdown banks? Provide additional discussion of the physics behind the shape of the curve in the figure.

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4.4-54	Attard A	Clarify limit reference.	**In Figures 3-37 through 3-41 of NEDC-33239P, reference is made to comparison with a limit. Clarify what limit is being referred to.** **On page 3-8 of NEDC-33239P, the MCPR is discussed briefly. The staff requests clarification of figures 3.41 through 3.44, with supporting discussion regarding what rod patterns are being referred to, what exactly is being ratioed, and what parameter is being defined as 1?.**
4.4-55	Attard A	Explain Figures 3-55 through 3-60.	Provide an explanation of Figures 3-55 through 3-60.
4.4-56	Gilmer J	Provide additional discussion of ÎCPR/ICPR and uncertainties.	In reference to Section 4.4.2.1.2, provide additional quantitative discussion of the transient ÎCPR/ICPR and statistical uncertainty associated with the critical power correlations. Also provide values for manufacturing tolerances, parameter measurement, and calculation uncertainties. Discuss any conditions and limitations of the referenced approved Topical Reports which are applicable to the ESBWR design.

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