June 29, 2007

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

SUBJECT: ECONOMIC SIMPLIFIED BOILING WATER REACTOR (ESBWR) CHAPTER 21 OPEN ITEMS

Dear Mr. Brown:

As you are aware, the U. S. Nuclear Regulatory Commission staff is preparing the safety evaluation report (SER) for the ESBWR design certification application submitted by GE-Hitachi Nuclear Energy Americas LLC (GHNEA) on August 24, 2005. The staff has identified 34 open items for SER Chapter 21, "Testing and Computer Code Evaluation," which are enclosed for your information. The staff is prepared to review your responses to the open items and have conference calls and meetings with your staff, as appropriate, to resolve these open items to support issuance of the SER.

Please provide a response date for any late or unscheduled open items discussed in the enclosure.

This open item letter is based on the staff's review of the ESBWR Design Control Document (DCD) Revision 3, Request for Additional Information (RAI) responses and other submittals received to date. The staff will continue its review as additional RAI responses and other deliverables are submitted, including future DCD Revisions. The staff will inform cognizant GHNEA staff of any resulting changes to the status of Chapter 21. If you have any questions, please contact Amy Cubbage at (301) 415-2875 or aec@nrc.gov or Shawn Williams at (301) 415-3207 or saw8@nrc.gov.

Sincerely,

***/RA/***

Mohammed A. Shuaibi, Chief
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Docket No. 052-010

Enclosure:
As stated

cc: See next page

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ADAMS Accession No. ML071770469

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| OFFICE | PM:NGE1 | BC:DE:SBCV | BC:DSRA:SRSB | |
| NAME | SWilliams | MSnodderly | GThomas for JDonohue | |
| DATE | 6/26/07 | 6/28/07 | 6/28/07 | |
| OFFICE | SPM:NGE1 | BC:NGE1 | | |
| NAME | ACubbage | MShuaibi | | |
| DATE | 6/28/07 | 6/29/07 | | |

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**GE-Hitachi Nuclear Energy Americas LLC (GHNEA) ESBWR**
**Preliminary Open Items**
**Chapter 21**
**Testing and Computer Code Evaluation**

RAI 21.6-4, Supplement No.1, 3/12/07, ML070810043

This request asked General Electric (GE) to provide additional information on the depressurization operations during an Anticipated Transient Without Scram (ATWS). The staff finds the information that GE submitted in relation to Phenomena Identification and Ranking Table (PIRT) ranking and models contained within TRACG for simulating depressurization during an ATWS complete for review. However, GE has not submitted any demonstration calculations of this event. Before the staff approves TRACG's capability of performing this calculation, it would need for GE to submit some demonstration calculations. GE indicated that Emergency Operating Procedures (EOPs) have not been established at this time to instruct an operator to depressurize during an ATWS event. Therefore the staff does not find it necessary to approve this function of TRACG to support the ESBWR design certification. Should EOPs be established that instruct the operators to depressurize during an ATWS event, the staff would like to evaluate TRACG demonstration calculations at that time to ensure TRACG's capability of simulating the event. If GE requests approval of this capability of TRACG at this time, GE will need to submit demonstration calculations of this event.

*Status: GHNEA committed to provide a response by 8/5/07.*

RAI 21.6-12, Supplement No.1, 3/12/07, ML070810043

In this request, the staff asked GE to explain how the time dependent FILL table was created for the TRACG model of the Standby Liquid Control System (SLCS) injection during an ATWS. GE gave the equations for which the table was developed. The staff has identified a possible error in the equation for Vj+1. The term inside of the second square root is a difference in pressures (i.e. between accumulator gas space pressure and RPV pressure) and includes the difference in gravity head between the RPV and the accumulator. If the units for the term h0*ρ/144 are correct, then units for Hj/144 are in error. h0 is an elevation usually measured in feet and Hj is a Reactor Pressure Vessel (RPV) water level which is probably in feet. However, in order for these two terms to be consistent there must be a density included with Hj term (i.e. Hj*ρj/144 ). Does Hj already include a density? According to the RAI response it's a water level which is typically in units of length. The staff would like for GE to address this possible error. In addition, the staff requests that GE justify their selection for the effective k loss in this equation. What is the uncertainty in the effective k loss for the accumulator line and nozzles? Given that uncertainty, what is the uncertainty in SLCS injection velocity? A perturbation of 10 percent in the SLCS injection velocity does not impact the suppression pool temperature; however does a perturbation of 10 percent bound the uncertainty associated with this model?

*Status: GHNEA committed to provide a response by 8/5/07.*

Enclosure

RAI 21.6-39, Supplement No.1, 3/12/07, ML070810043

The staff is concerned about GE's methodology as applied to non-isolation ATWS events since it appears that many of GE's design and modeling choices, and assumptions were based on the a failure to scram during an isolation event. GE predicts that during an isolation ATWS event, such as MSIV closure ATWS, the natural circulation patterns will develop such that the periphery of the core will be in down-flow and the center of the core will be in up-flow. Hence, GE selected the injection of the SLCS to be in the periphery core bypass. It would follow that the boron would flow down through the periphery bypass and then up through the channels as it moves to the center of the core. However during a non-isolation ATWS, these natural circulation patterns may not develop. There may be up-flow in the core periphery bypass causing the boron to flow up, in which case its mixing and transport time to get into the center channels is not as well established. The staff requests GE provide a discussion on how boron enters the core during a non-isolation ATWS. GE should describe the flow paths. GE should also discuss the nodalization and flow blocking selected, and justify that it has been demonstrated to be conservative during non-isolation ATWS events, including depressurization (if needed, see comment on RAI response 21.6-4).

*Status: GHNEA committed to provide a response by 8/5/07.*

RAI 21.6-44, Supplement No.1, 3/12/07, ML070810043

This RAI is related to qualification of the boron mixing model in TRACG. The staff needs additional information to determine that the test cited is applicable to ESBWR conditions. The staff is concerned that there is no test data to verify the mixing behavior of the SLCS system as injected into the core bypass. The tests cited to be applicable to the ESBWR are those where the boron is injected through the HPCS sparger for a scaled BWR/5 and 6. The justification used is predicated on knowing the ESBWR boron flow path and that it is similar to that of the HPCS sparger location. However this leads to a circular reasoning since the data is supposed to be used to inform the TRACG model that it is adequately calculating the boron mixing and flow paths in the core. Do you have any test data that verifies that injection of boron into the core bypass periphery will have mixing and flow paths similar to that of the HPCS sparger? In the RAI response, the scaling was only performed for the radial and axial directions and not as rigorous as that was done for the SBWR where you scaled such parameters as boron injection concentration, temperatures, loss coefficients, etc. Please provide a more rigorous scaling analysis. In addition, comparing the mixing tests to the ESBWR MSIV closure ATWS event seems awkward. The ESBWR MSIV closure ATWS event is so dissimilar to the experiment that a direct comparison would be difficult. Are there any comparisons using a TRACG04 input deck of the same experiment? The staff would like additional information about the test conditions. Please provide the following reference used in the RAI response: "Test Report Three-Dimensional Boron Mixing Model," General Electric Co., Proprietary Information, NEDE-22267, Class III, October 1982 (RAI response reference 21.6-44-3).

*Status: GHNEA committed to provide a response by 8/5/07.*

<u>RAI 21.6-51, 10/11/06, ML062830003</u>

Evaluate whether or not instability is likely to occur during the following ATWS events:

a) Loss of Feedwater Flow and
b) Turbine trip with full bypass and feedwater available.

Do not model any operator actions, but include the automated actions (e.g., feedwater runback on high pressure scram) if setpoints are reached. Using your approved methodology NEDE-33083P, Supplement 1 "TRACG Application for ESBWR Stability Analysis,"determine a decay ratio beyond the scram setpoint, when power is raised beyond reactor scram setpoint for the turbine trip event and level lowered beyond reactor scram setpoint for the Loss of Feedwater Flow event. Power and level should be justified for each of the events. Alternatively, add margin to your calculations by increasing the void reactivity coefficient by 30 percent.

*Status: GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

<u>RAI 21.6-55, Supplement No. 1, 5/7/07, Non-Proprietary Version, ML071420046</u>

1. Appendix B in the RAI response (Reference 2) shows [ ] vessel source connections. Explain why there are [ ] vessel connections. Did you model separate IC (isolation condenser) loops for each IC?

2. When describing the applicability of the PANTHERS IC tests to the SBWR in Section 4.2.3.1 of NEDC-32725P, Rev. 1 (Reference 1) you state that "The IC inlet pressures tested and analyzed by TRACG (Table 4.2-2) span the entire operating range of the SBWR. The SBWR range is bounded by the SRV setpoints…" Table 5.2-2 of Revision 3 of the ESBWR DCD shows the SRV setpoint (8.618 MPa) to be above the tested pressures at PANTHERS [[ ]]. Justify that the PANTHERS IC test is applicable to ESBWR conditions. Are there other higher pressure tests performed at PANTHERS that can be used for comparison with the TRACG?

3. Provide the applicability range of the [[ ]]. Section 6.6.11.3 of NEDE-32176P (Ref. 4) suggests pressure conditions that are substantially lower than would be seen during an ESBWR AOO or ATWS. Justify that this correlation is adequate for the pressure conditions seen in an ESBWR AOO/ATWS. Justify that the range of the data used to determine the [[ ]] uncertainty cited in Table 4.4-1 in NEDC-33083-P-A (Ref. 3) is applicable to ESBWR conditions.

4. Justify that the modeling of the IC pools as a [[ ]] in the AOO/ATWS IC model is adequate and/or conservative. Explain how the heat transfer to the pools [[ ]] as compared to the PANTHERS modeling and justify that it is adequately modeled. NEDC-33083P-A (Ref. 3) indicates that you are using the [[ ]] correlation. Justify the use of this correlation. Provide comparisons to PANTHERS if available. What model is being used for the IC model for ESBWR LOCA simulations? Justify its use.

5. Provide justification that the nodalization changes from that of the PANTHERS IC modeling summarized in Table 1 of RAI response 21.6-55 (Ref. 2) will adequately represent the

ESBWR IC system. For the condenser tube modeling performed for the PANTHERS IC facility, Section 4.2.4.1.3 of NEDC-32725P (Ref. 1) states that a sensitivity study confirmed the adequacy of the [[ ]] cell nodalization. Justify that the [[ ]] cell nodalization used in the AOO/ATWS TRACG model is adequate.

6. The TRACG nodalization for the LOCA event in Appendix A of the RAI response (Reference 2) does not show the IC drain tank. Update the diagram to show the IC drain tank.

7. The staff is aware that the heat removal capability of the ICS is credited in the simulations of an ESBWR LOCA event in which there are non-condensible gases present due to radiolysis. The comparison of the TRACG results to PANTHERS data in References 1 and 5 show that TRACG does not adequately model the timing of the noncondensible gas transport in the IC. You state that the test conditions are not representative of the conditions seen in the plant. Justify that the modeling of the IC heat removal capacity in the ESBWR LOCA events is conservative given the presence of non-condensible gases. Provide comparisons to test data that are representative of conditions seen in the ESBWR if available.

<u>References</u>

1. NEDC-32725P, Revision 1, TRACG Qualification for SBWR, August 30, 2002 (ADAMS Accession Nos. ML022560558 and ML022560559)

2. Letter from D.H. Hinds (GE) to NRC, MFN 07-168, Response to Portion of NRC Request for Additional Information Letter No. 66 Related to ESBWR Design Certification Application – TRACG Application – RAI Number 21.6-55, March 29, 2007. (ADAMS Accession No. ML071010556)

3. NEDC-33083P-A, MFN 05-017, TRACG Application for ESBWR, March 2005 (ADAMS Accession No. ML051390265)

4. NEDE-32176P, Rev. 3, TRACG Model Description, April 2006. (ADAMS Accession No. ML061160238)

5. Update of ESBWR TRACG Qualification for NEDC-32725P and NEDC- 33080P Using the 9-Apr-2004 Program Library Version of TRACG04, MFN 04-059, June 6, 2004 (ADAMS Accession No. ML041610037)

*Status:* *GHNEA has not committed to a response date.*

<u>RAI 21.6-57, Supplement No. 1, 6/12/07, ML071630437</u>

In response to Part B of this question, GE states that: the analysis delay time envelopes the control rod scram time requirements criteria that this duration (the maximum delay time between deenergizing of scram solenoids to start control rod motion) be less than or equal to. Justify the amount of time established for the control rod scram time requirements criteria.

*Status:* *GHNEA has not committed to a response date.*

RAI 21.6-63, 10/10/06, ML062790238

Provide a description of all of the differences in the analyses performed in Chapter 4 of NEDE-33083P (MFN 05-017 and MFN 04-109) and Chapter 15 of ESBWR DCD Tier 2, Revision 1.

*Status:* *GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

RAI 21.6-64, 10/10/06, ML062790238

In topical reports NEDC-33083P Supplement 1 (Methodology to calculate stability margins for ESBWR using TRACG) and NEDE-32906P-A Rev. 2 (Methodology to perform transient analysis for BWR/2-6 using TRACG) both high and medium importance PIRT parameters were included in the uncertainty analysis. However, for the TRACG application for ESBWR AOOs, it appears that only high importance PIRT parameters are to be included in the uncertainty analysis with the exception of a few medium ranked parameters.

A. Provide a basis explaining the exclusion of the medium ranked parameters from the uncertainty analysis.

B. Why were some medium importance parameters included in the ESBWR transient uncertainty analysis and other PIRT parameters of medium importance not included? Explain the method for selecting the parameters included in the uncertainty analysis.

C. Page 4-21 in Section 4.4 of NEDC-33083P-A states, "For some phenomena that have little impact on the calculated results, it is appropriate to simply use a nominal value or to conservatively estimate the bias and uncertainty." Is a nominal value used for the medium ranked phenomena? If so, explain why bounding values were not used. Provide a discussion of how medium ranked phenomena are treated in terms of model uncertainty and bias.

*Status:* *GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

RAI 21.6-65, 10/10/06, ML062790238

Page 4-32 in Section 4.4.2 of NEDC-33083P-A states "The adequacy of the nodalizations has been demonstrated and is supported by sensitivity studies. Standard nodalizations for modeling of ESBWR reactor vessels and other components have been presented in the *TRACG Qualification for SBWR* [24]."

A. The staff was unable to locate any sensitivity studies in your reference pertaining to the radial channel grouping and azimuthal nodalization of the VESSEL component for the transient analysis. It appears that this nodalization is the same as that presented in NEDC-33083P Supplement 1 *TRACG Application for ESBWR Stability Analysis*. Confirm if this is true. Provide additional information discussing that this nodalization scheme is adequate for the transient analysis. Discuss how it is adequate to model the various transients.

B. The staff understands that you are not using the CHAN nodalization described in your reference 24 (*TRACG Qualification for SBWR*). The staff understands that the nodalization that you are using appears to be the same as that described in NEDC-33083P Supplement 1, *TRACG Application for ESBWR Stability Analysis.* Confirm if this is true. Provide a basis explaining that this nodalization is adequate for performing the transient analysis.

C. Provide diagrams illustrating the VESSEL axial, radial and azimuthal noding and channel grouping. Provide diagrams with nodalizations of all of the components connected to the VESSEL (such as the ICS, CHAN and steamlines) and show how (which nodes) these are connected to the VESSEL.

D. Update your documentation to identify and describe in the same manor any other components that are nodalized differently than what is described in the *TRACG Qualification for SBWR* report.

*Status:* *GHNEA responded on 6/21/07, MFN 07-347.*
*GHNEA's response is under staff review.*

<u>RAI 21.6-69, 10/10/06, ML062790238</u>

On page 6-142 of NEDE-32176P, Rev. 3, the sensitivity to steam condensation in containment makes reference to studies performed for a main steam line break (MSLB) where the peak pressures and temperatures in containment occur very late in the accident.

(a) Does this conclusion hold true for cases, such as the feedwater line break (FWLB), when the peaks occur early in the accident?

(b) How is the phenomena identification and ranking table (PIRT) multiplier determined for use in a licensing analysis - is the value event specific?

*Status:* *GHNEA committed to provide a response by 7/20/07.*

<u>RAI 21.6-71, 10/10/06, ML062790238</u>

In Section 7.11.1.2 of NEDE-32176P, Rev. 3, reference is made to the bounding model used to address uncertainties in the amount and location of noncondensable gases in containment. The model as shown in Figure 7-43 does not include the features referenced to for the MSLB case. How does the current model address these uncertainties for each type of accident (MSLB, FWLB, etc.)

*Status:* *GHNEA committed to provide a response by 7/20/07.*

RAI 21.6-72, 10/10/06, ML062790238

In Section 7.11.2.1 of NEDE-32176P, Rev. 3, the text describes two axial levels while the reference figure shows three. How does the selection of the number of axial levels effect the natural circulation in this region, the amount of mixing which influence the wetwell gas temperature and pressure?

*Status: GHNEA committed to provide a response by 7/20/07.*

RAI 21.6-75, 10/10/06, ML062790238

Ref [7]: *TRACG Qualification*, NEDE-32177P Rev 3, is to be published June 2006. Please submit this reference.

*Status: GHNEA committed to provide a response by 7/20/07.*

RAI 21.6-78, 10/10/06, ML062790238

On page 7-47 of NEDE-32176P, Rev. 3 you state: "Two options exist for the calculation of the critical power ratio (CPR) for transient conditions." Why do you have two options for calculation of transient CPR? Is one method more accurate than the other? What are your guidelines for when to use which method for transient CPR calculations? Which method is used during an AOO calculation and during an ATWS calculation? On page 7-48 of the same document you state: "The assessment of the critical power calculation can be found in Section 3.6 of the *TRACG Qualification LTR*." The staff does not have Reference 6 (Rev. 3 of the *TRACG Qualification LTR*) which you state is to be published in June 2006. Provide the information from this document that may answer the above questions on the CPR calculation options for transient conditions.

*Status: GHNEA committed to provide a response by 7/20/07.*

RAI 21.6-79, 10/10/06, ML062790238

In Section 6.6.7 of NEDE-32176P, Rev. 3, you describe the correlation in TRACG for calculating minimum stable film boiling temperature. You have three different options. Describe the conditions under which each of the three options is selected. On page 6-117, you state "The Shumway correlation, however, has a larger data base and captures the flow and pressure dependence better than the Iloeje correlation." The TRACG input decks submitted to the staff show that you have selected the Iloeje model for the ESBWR events. Explain the choice of this model.

*Status: GHNEA responded on 5/17/07, MFN 07-256.*
*GHNEA's response is under staff review.*

RAI 21.6-81, 10/10/06, ML062790238

Please address the following questions related to distribution of channel power:

A. Eq. 9.4-11 in NEDE-32176P, Rev. 3, includes Fco, which is the fraction of direct moderator heating that appears in the coolant in the bypass, water rod, and bundle coolant. In TRACG, the water rod coolant, the core bypass coolant, and the bundle coolant are simulated as separate flow paths. How is the direct moderator heating associated with Fco split up for these three different coolant regions within the BWR core? Please describe the basis of the model.

B. Page 62 of NEDC-32965P, Rev. 0 (UM-0149, Rev. 0), describes the user input fractions for fission power and decay heat for direct moderator heating, fuel clad gamma heating and water rod(s) clad gamma heating as described in NEDC-32176, Rev. 3, page 9-35. The description for FDMN2 (direct moderator heating fraction for decay heat power) states "The prior practice of setting FDMH2=FDMH1 is discouraged since it is non-conservative with respect to post-scram evaluations of peak clad temperature." Where FDMH1 is the direct moderator heating fraction for fission power. Please explain why you have set FDMH1=FDMH2 for all of the CHANs in the ESBWR TRACG decks for LOCA, AOO, ATWS and Stability given this statement in the user's guide.

C. You state that $c_0$ in Eq. 9.4-14 of NEDC-32176P, Rev. 3, is calculated based on MCNP analysis, and page 63 of NEDC-32965P, Rev. 0 (UM-0149, Rev. 0), provides a default value of this parameter (DMHZERO in TRACG) for GE11 fuel design. TRACG models for LOCA, AOO, ATWS and stability use a different value for GE14 fuel. Is this number based on MCNP calculations for GE14 fuel? If not, provide the basis for assuming that $c_0$ does not change for the GE14 fuel design.

D. How does the direct moderator heating model change based on the control fraction for a given CHAN component? How specifically is the user input for BPAPC (bypass area per channel) used in the direct moderator heating model?

E. The fission power distribution model presented in section 9.4 in NEDE-32176P, Rev. 3, appears to assume no gamma heat of the pressure vessel walls. Explain how gamma heating of the pressure vessel walls is considered.

F. a and b in Eq. 9.4-13 in NEDE-32176P, Rev. 3, are assumed constant for calculating the fractional deposition of fission power in the fuel clad, water rod clad, control blades, and channel wall. For the case of direct moderator heating you make the correction in Eq. 9.4-14 in NEDE-32176P, Rev. 3. Please provide justification that a and b are independent of the moderator density for fuel clad, water rod clad, control blades, and channel wall deposition, or that the correction made by Eq. 9.4-14 in NEDE-32176P, Rev. 3, adequately characterizes the moderator density dependence of a and b for the above.

G. What is the normalization formula used to normalize Eq. 9.4-11 in NEDE-32176P, Rev. 3? If the energy distribution fraction Fco is decreasing because the moderator density is decreasing, how are the other fractions in Eq. 9.4-11 in NEDE-32176P, Rev. 3, adjusted to ensure that they sum to one?

H. Does TRACG uncertainty analysis include uncertainty associated with a and b for c, f, w, bl, ch, and co?

*Status: GHNEA committed to provide a response by 7/20/07.*

<u>RAI 21.6-82, 10/10/06, ML062790238</u>

Section 9.1.3 in NEDE-32176P, Rev. 3, indicates that at the beginning of the calculation with the PANCEA wrapup, that the TRACG cross sections include the presence of Xenon. However, the transient calculation procedure does not indicate that the Xenon concentration is updated. The staff is aware that TRACG is capable of simulating transients with transient Xenon conditions, but is unable to locate any details about your models and calculation procedures. Please provide these details. Are transient Xenon conditions used in the simulation of any AOO and ATWS events? Include information on how the treatment of Xenon is conservative for these events.

*Status: GHNEA responded on 6/8/07, MFN 07-352.*
*GHNEA's response is under staff review.*

<u>RAI 21.6-83, 10/10/06, ML062790238</u>

Provide nodalization studies justifying your axial nodalization described in NEDC-33083P, Supplement 2, of the vessel bypass in relation to boron transport and mixing for the ESBWR ATWS event.

*Status: GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

<u>RAI 21.6-84, 10/10/06, ML062790238</u>

In discussing the biases and uncertainties for the void coefficient in NEDE-32906P "TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses" in response to Staff RAI 12 (MFN-06-046, dated 2/14/2006, ML0605305750) you state "When the PANAC11 model is implemented in TRACG it will be necessary to make a similar assessment TGBLA06 and MCNP and change the TRACG void coefficient model accordingly." Please state if this has been done and provide the staff with the documentation that includes the details of the new evaluation.

*Status: GHNEA responded on 6/8/07, MFN 07-352.*
*GHNEA's response is under staff review.*

<u>RAI 21.6-85, 10/10/06, ML062790238</u>

Describe the computational procedure used to generate a PANACEA Wrap up file for use with TRACG as applied in NEDC-33239P. Specifically explain what calculations are performed with PANAC11 and how these results are captured numerically in the PANACEA Wrap up file.

*Status: GHNEA responded on 6/21/07, MFN 07-347.*
*GHNEA's response is under staff review.*

RAI 21.6-88, Supplement No. 2, 3/20/07, non-proprietary version, ML070790226

1. Comments on Supplement 1 to RAI 21.6-88 response Supplement 1 to MFN-06-467 states that the pressure drop iteration accounts for the bypass flow fraction using [[ ]]. Please explain how the elements of the [[ ]] are determined. Explain any differences in the determination of the bypass flow rate using [[ ]] as in the ESBWR calculation and the method used in the outer loop iteration described in NEDO- 20953-A to converge the in-channel and bypass flow rates. If the approaches are consistent (as would be indicated by the statements in Section 1.5.5 of NEDC-33239P (LTR)) clarify the description of the [[ ]] in the revised LTR and provide, as a supplemental response, the parameters calculated by [[ ]] that are used as [[ ]]. Alternatively provide as a supplemental response a detailed description of the means by which [[ ]] in terms of the information already provided in Supplement 1 to MFN-06-467.

If the elements of the [[ ]] are calculated in a manner that is not consistent with Section 1.5.5 for the specific application to the ESBWR, update the NEDC-33239P LTR to also include a description of the method by which this calculation is performed. If the elements are derived from the iterative [[ ]] calculations, provide the number of elements and the ranges of applicable power and flow rates as an RAI response. If another means is or was used to determine the elements, provide the [[ ]] and a description of the origin of the elements as an RAI response. In the mathematical expression for the axial power shape parameter (the fraction of bundle power below the core midplane) explain why [[ ]] in the update to the LTR.

Describe the basis for the [[ ]] given that the [[ ]] is based on calculated [[ ]] for [[ ]] as an RAI response. Are there any flow regime transitions for the high power ESBWR bundles (i.e., above [[ ]]) specifically that may result in channel flow errors as a result of the extrapolation between [[ ]]? If so, are they of sufficient magnitude to perturb the nodal power distribution beyond the established uncertainties? Provide the answer as an RAI response.

Verify in an RAI response that the bypass voiding is calculated according to the method in PANAC11AE8. Alternatively, if the response to RAI 4.4-39 request for supplemental information contains a [[ ]] verify that the bypass region is predominantly liquid (i.e. <5 percent void above the LPRM D detector).

*Status: GHNEA responded on 6/13/07, MFN 06-467 Supplement 2.*
*GHNEA's response is under staff review.*

RAI 21.6-90, 10/10/06, ML062790238

In an ATWS event, the presence of control blades in the lower bypass will affect the boron distribution. Provide the height of the control blades above the top of the core plate when blades are in the full out position. Discuss how the presence of control blades in the lower bypass affects the boron distribution. If this is not accounted for in the TRACG analyses of an ATWS event, demonstrate that the presence of the control blades does not affect the ATWS analyses.

*Status: GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

RAI 21.6-91, 10/10/06, ML062790238

Provide the most recent version of all of your TRACG input decks with the next revision of the DCD. This should include input decks used for LOCA,AOOs, ATWS and stability.

*Status: GHNEA responded on 5/17/07, MFN 07-256.*
*GHNEA's response is under staff review.*

RAI 21.6-92, 10/11/06, ML062830003

For each analysis performed in Chapters 4, 6 and 15, update the DCD Tier 2 to include the specific codes used including exact version, revision, and modification designations. In instances where a suite of codes is used (i.e., TRACG with a PANACEA wrap up file and GSTRM gap conductance model), include this information for each code used as part of the suite. Identify the software test report number associated with each production code.

*Status: GHNEA responded on 5/7/07, MFN 07-257.*
*GHNEA's response is under staff review.*

RAI 21.6-94, Supplement No. 1, 5/3/07, non-proprietary version, ML071240125

1. Comments on RAI 21.6-94 response:

The staff does not require additional information regarding [[ ]] to complete review of the DCD Section 4.3, however, per the requirements of 10 CFR 74.13 the COL holder will be required to produce a material balance report. Update the DCD to include a COL applicant action item for the COL applicant to inform the staff of this means or method for producing such a report.

*Status: GHNEA has not committed to a response date.*

RAI 21.6-95, 1/19/07, ML070080448

During the NRC staff audit of TRACG as applied to ESBWR loss-of-coolant accident on December 11-15, and 19-20, the audit team did not locate any documented changes from TRACG04 versions 42 to 45. Verify that there were no substantial changes to TRACG04 for these versions.

*Status: GHNEA committed to provide a response by 6/20/07.*
*No response has been submitted as of the date of this letter.*

RAI 21.6-96, 1/19/07, ML070080448

During the NRC staff audit of TRACG as applied to ESBWR loss-of-coolant accident (LOCA) on December 11-15, and 19-20, GE stated that GE is using the PC version of TRACG04 for ESBWR LOCA analyses. The audit team viewed a document on the comparison of TRACG04A (Alpha VMS version) to the TRACG04P (PC) version. ("Comparison of TRACG Results for ESBWR ECCS & CONT Cases - PC versus ALPHA versions," DRF 0000-0054-3548 Section 0000-0055-6820, July 19, 2006)

Please address the following:

A. State what version of TRACG04 (A or P) is being used for all ESBWR analyses using TRACG in DCD Chapters 4, 6 and 15.

B. The TRACG04A and P comparison that the staff viewed during the audit was for the limiting breaks in DCD Rev. 1, show the differences between TRACG04A and P for the limiting breaks in the most recent version of the DCD using the updated nodalizations.

C. The comparison between TRACG04A and P shows that TRACG04P predicts a long-term drywell containment pressure lower by roughly 20kPa (or 3psi). For the DCD, Rev. 1 analyses the peak pressure was reached in the short term. For that calculation you stated that the long-term differences were not important for the peak pressure calculation. Rev. 2 of the DCD shows that peak pressure is reached in the long-term. Address the possible non-conservatism between TRACG04A and P for the long term peak pressure analysis in the latest revision of the DCD.

D. In your comparison between TRACG04A and P, you state that the reason for the difference in wetwell and drywell pressures was due to roundoff errors in non-condensible gas concentrations. The NRC staff is concerned that roundoff errors can have a substantial (roughly 7 percent) effect on calculated peak pressures. Address the concern that the TRACG04 and/or the ESBWR LOCA model may be hyper-sensitive to non-condensible gas concentrations.

*Status: GHNEA responded on 6/21/07, MFN 07-348.*
*GHNEA's response is under staff review.*

<u>RAI 21.6-98, 1/19/07, ML070080448</u>

The staff noted in its acceptance review of ESBWR (Reference 1) that GE did not address all of the confirmatory items that were to be performed at the design certification stage as stated in the staff's SER on TRACG for ESBWR loss-of-coolant accident (LOCA) analyses (Reference 2). In response to the staff's acceptance review of ESBWR, GE submitted some information (Reference 3) to address the confirmatory items in Reference 2, but this information is still incomplete.

Please address the following confirmatory items:

2. Submit the long-term core cooling analyses.

13. Analyze standard problems and submit to the NRC.

14. Provide all nodalization changes including diagrams since the approval of TRACG for ESBWR LOCA Analyses in Reference 2, include most recent changes incorporated into Rev. 2 of the DCD; Explain the statement in Reference 3 that a "Total of 5 chimneys to calculate the minimum water level." In the TRACG input decks submitted to the staff and in Figures 6.2-6 and 6.2-7, the core/chimney section is divided into only 3 rings.

15. GE needs to submit additional information on the passive containment cooling system (PCCS) vent system demonstrating that it will perform as expected.

20. Describe all design changes since the approval of TRACG for ESBWR LOCA analyses in Reference 2 and demonstrate that the staff's conclusions would not be altered as a result of these changes.

References:

1. Letter to S.A. Hucik (GE) from W.D. Beckner (NRC), "Results of Acceptance Review for ESBWR Design Certification Application (TAC No. MC8168)," September 23, 2005

2. Letter to L.M. Quintana (GE) from W.D. Beckner (NRC), "Reissuance of Safety Evaluation Report Regarding the Application of General Electric Nuclear Energy's TRACG Code to ESBWR Loss-of-Coolant Accident (LOCA) Analyses (TAC NOS. MB6279, MB6280, MB6281, MB6282, MB6283, MB6801 and MB7255)," October 28, 2004

3. Letter from D.H. Hinds (GE) to NRC, MFN 05-096, "Summary of September 9, 2005 NRC/GE Conference Call on TRACG LOCA SER Confirmatory Items," September 20, 2005

*Status: GHNEA committed to provide a response by 7/22/07.*

<u>RAI 21.6-99, 1/19/07, ML070080448</u>

During the NRC staff's audit of TRACG as applied to ESBWR LOCA, the staff reviewed a document (Reference 1) that contained a GE internal review of the TRACG qualification, as part of GE QA processes. This document stated that the TRACG application statement should document that the boron mixing model is not qualified and its use is not recommended. GE confirmed that this was added to the application statement in the TRACG04 User's Manual. Please explain this statement and GE's subsequent use of the boron mixing model in ESBWR ATWS applications (Reference 2).

References:

1. "TRACG04A Qualification Design Review Closure Items," DRF 0000-0041-0817

2. NEDE-33083P Supplement 2, "TRACG Application for ESBWR Anticipated Transient Without Scram Analyses," January 2006

*Status: GHNEA responded on 6/21/07, MFN 07-348.*
*GHNEA's response is under staff review.*

RAI 21.6-100, 1/19/07, ML070080448

Please answer the following questions regarding the CHAN leakage model:

A. Are you using the “GE Design Leakage Flow correlations” derived from Reference 1 to calculate leakage flow in the ESBWR anticipated transients without scram (ATWS) calculations? Since this correlation was derived for loss-of-coolant accident (LOCA) conditions, is it applicable for high pressure conditions, such as those seen in an ESBWR ATWS event? Provide the correlation’s applicability range.

B. The TRACG04 ESBWR ATWS input decks indicate that GE may be overlaying the default values of coefficients for the GE Design Leakage Flow correlations via specification of CWF and CWB. If so, justify the selection of these coefficients.

C. The CHAN leakage model described in Section 7.5.1 in Reference 2 is based on a driving pressure for each of the leakage paths. Provide a discussion on how TRACG04 selects the reference pressures where the leakage flow is calculated. Include details such as the cells used for calculating these pressures.

References:

1. B.S. Shiralkar and J. R. Ireland, “Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR Appendix K, Amendment No. 5, Backflow Leakage from the Bypass Region for ECCS Calculations,” NEDE-20566-5P, GE Proprietary Report, June 1978.

2. NEDE-32176P, Revision 3, “TRACG Model Description,” April 20, 2006

*Status: GHNEA responded on 6/21/07, MFN 07-348.*
*GHNEA’s response is under staff review.*

RAI 21.6-101, 1/29/07, ML070230300

During the audit of TRACG04 for ESBWR loss-of-coolant accident analyses, the staff viewed comparisons between data and TRACG04 for the GIRAFFE GS1 test from the TRACG04 Software Test Report (eECPER 0000-0009-7157-00). The results show significant differences between TRACG02 and TRACG04. TRACG04 under predicts the dry well annulus temperature by approximately 60K for long durations. The staff was unable to locate information on this comparison in the TRACG04 ESBWR qualification that has been submitted to the NRC (“Update of ESBWR TRACG Qualification for NEDC-32725P and NEDC-33080P Using the 9-Apr-2004 Program Library Version of TRACG04,” MFN 04-059, June 6, 2004). Please explain these differences.

*Status: GHNEA committed to provide a response by 7/22/07.*

RAI 21.6-103, 5/30/07, ML071490166

Section 4.0 of the staff safety evaluation on NEDC-33083P, “TRACG Application for ESBWR,” gives several items that the staff identified as needing confirmation at the design certification stage. Please identify where in the DCD or in a supplement to NEDC-33083P the following items are addressed:

Item 10. The assumption of the loss of feedwater flow used by GENE is not conservative. Therefore the existing GENE MSLB model and the current analysis approach underestimates the maximum containment pressure and temperature. At the design certification phase, this should be resolved.

Item 13. During the staff’s earlier review of the SBWR, work that GENE relies on for the ESBWR, the staff noted that GENE had not evaluated more traditional integral containment tests such as the Marviken tests, the Carolinas Virginia Tube Reactor test 3 without sprays, and the Battelle- Frankfurt Model Containment tests C-13 and C-15, for MSLBs. The staff also requested that GENE provide a plan and schedule to assess the ability of TRACG to model containment performance against additional separate effects tests. Separate effects tests that should be considered include the Wisconsin Flat Plate condensation tests.

*Status:* *Staff requested a response date of 7/12/07 in RAI Letter No. 100.*
*GHNEA has not committed to a response date.*

RAI 21.6-104, 6/21/07, ML071590313

Figure 4.4-31 S01-2 in MFN 06-297 Supplement 7 shows that the time to boiling transition as calculated by TRACG could be non-conservative. Provide additional information demonstrating that this calculation is accurate or conservative. Explain how the uncertainty of the calculation is accounted for in all TRACG04 analyses for the ESBWR design certification (as shown in DCD Chapters 4, 6, and 15).

Reference: Letter from J.C. Kinsey (GE) to NRC, MFN 06-297 Supplement 7, “Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application - DCD Chapter 4 and GNF Topical Reports - RAI Number 4.4-2S01, 4.4-27S01, 4.4-31S01 and 4.4-54S01,” April 10, 2007.

*Status:* *Staff requested a response date of 7/30/07 in RAI Letter No. 101.*
*GHNEA has not committed to a response date.*

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