ADDENDUM TO THE SAFETY EVALUATION
BY THE OFFICE OF NEW REACTORS
APPLICATION OF THE TRACG COMPUTER CODE TO
THERMAL-HYDRAULIC STABILITY ANALYSIS FOR THE ESBWR DESIGN
NEDE-33083P, SUPPLEMENT 1

In support of the preapplication review for the economic simplified boiling-water reactor (ESBWR), General Electric Hitachi Nuclear America, LLC (GEH), submitted Supplement 1 to NEDE-33083P, "TRACG Application for ESBWR Stability," dated December 9, 2004. In the corresponding safety evaluation report (SER) dated August 29, 2007 (Ref. 1) the U.S. Nuclear Regulatory Commission (NRC) staff accepted TRACG for use in the design certification application to calculate stability margins for the ESBWR. However, Section 5.0 of the staff's SER contained several confirmatory items that were dependent on final design information for resolution. Subsequent to the issuance of the original staff SER, the applicant submitted Revision 6 of the ESBWR Design Control Document (DCD) (Ref. 2) and responses to a number of staff requests for additional information (RAIs) (Refs. 3-5). The NRC staff found the information necessary to disposition the confirmatory items for NEDE-33083P, Supplement 1 in DCD Revision 7 and the RAI responses discussed herein. This addendum contains the staff's evaluation and closure of these confirmatory items.

The regulatory criteria related to this review are identified in the staff evaluation (Ref. 1).

1.0 ITEM 1: PHYSICS PARAMETERS

1.1 Confirmatory Item #1

Confirmatory Item #1 states the following:

> The staff notes that the uncertainties in the physics parameters will be addressed in the design certification review of the ESBWR. The methods employed for generating cross sections for TRACG were not considered part of the scope of the current review in which the void coefficient is a primary factor in determining core stability. Any potential changes in the uncertainties in nuclear parameters as a result of this subsequent review should be included in decay ratio acceptance criteria.

1.2 Staff Evaluation of Confirmatory Item #1

The staff reviewed the PANAC11/ Toshiba-General Electric Boling Lattice Analysis Code (TGBLA) physics methods used to generate nuclear parameters and cross-sections for the ESBWR as part of the ESBWR design certification. The staff also determined that the method for generating cross-sections is acceptable for use in transient analyses in general, and for use in ESBWR stability calculations in particular. The staff's evaluation of the application of TRACG for ESBWR transient analysis (Ref. 6) and the staff's evaluation (Ref. 7) of NEDC-33239P, "GE14 for ESBWR Nuclear Design Report," Revision 4, issued April 2010 (Ref. 8), both discuss the interface between PANAC11/TGBLA and TRACG.

The SER for the application of TRACG to ESBWR transient analysis (Ref. 6) describes the staff's review of the adequacy of the PANAC11/TGBLA06 code as applied to the ESBWR. That SER specifically reviewed the adequacy of these codes for generating cross-sections for ESBWR stability analyses. The SER's main conclusion is that the methodology for generating cross-sections is acceptable for ESBWR stability analysis. However, the staff noted that the conditions and limitations of the staff evaluation for the GE14 topical report, NEDC-33239P (Ref. 7), must be met. These conditions and limitations apply to GE14E fuel and ESBWR applications.

The staff evaluation for NEDC-33239P (Ref. 7) noted that the NRC staff performed sensitivity studies using Monte Carlo N-Particle (MCNP) and MONTEBURNS to evaluate the GEH void reactivity coefficient uncertainty methodology and the uncertainty in the GEH isotopic concentrations. During its review of the methodology to calculate the void coefficient uncertainty for extended power uprates, the staff determined that there is a larger bias than the bias GEH is calculating at higher void fractions. Therefore—

> Use of PANAC11 generated nuclear data for ESBWR reload transient analyses (AOO, stability, or ATWS) requires that TRACG utilize the void reactivity coefficient correction model described in NEDE-32906P, Supplement 3. The fuel lattices input to the model must be representative of the cycle specific fuel loading. (Ref. 9)

Since the use of PANAC11/TGBLA06 for generating ESBWR cross sections has been approved in the staff SER for NEDC-33239P (Ref. 7, see also Ref. 17 and 18). Confirmatory Item #1 is closed. Note that condition 4.15 from the staff SER to NEDC-33239P applies to the use of TRACG04 for ESBWR stability analyses. Accordingly, the staff found the PANAC11/TGBLA methods for representing the ESBWR as described in the ESBWR DCD to be acceptable.

2.0 ITEM 2: FUEL

2.1 Confirmatory Item #2

Confirmatory Item #2 states the following:

> The staff also notes that GE [General Electric] will be submitting its fuel design for review by the staff as part of design certification. The staff expects GE to justify continued applicability of its methodology for evaluating stability by evaluating input parameters and uncertainties related to the fuel design to ensure that the methodology for evaluating stability is not affected. Should there be an effect such that conclusions about the acceptability of the stability methodology are invalidated, the staff expects GE to revise and resubmit its respective documentation.

2.2 Staff Evaluation of Confirmatory Item #2

The staff completed its evaluation of the GE14E fuel design for use in the ESBWR as part of its review of NEDC-33239P (Ref. 7). In addition, all of the stability analyses presented by the applicant in Appendix 4D of the DCD (Ref.2), NEDO-33337, “ESBWR Initial Core Transient Analyses,” Revision 1, issued April 2009 (Ref. 10), and NEDO-33338, “ESBWR Feedwater Temperature Operating Domain Transient and Accident Analysis,” Revision 1, issued May 2009 (Ref. 11), have used the GE14E-specific parameters. During the pre-application stage, fuel design was not finalized. The applicant submitted the stability analyses for the GE14E fuel for the design certification. The issue which led to the confirmatory item was whether the ESBWR fuel, GE14E, would have fuel parameters that were so different than those of GE14 fuel that the stability methodology would not be applicable. This is not the case, and as stated in the evaluation, the stability calculations are done with the correct fuel.

Therefore, Confirmatory Item #2 is closed.

3.0 ITEM 3: CRITICAL POWER RATIO CALCULATIONS

3.1 Confirmatory Item #3

Confirmatory Item #3 states the following:

> The staff also notes that GE demonstrated that there were large CPR margins associated with the conditions used for evaluating stability, and, therefore, phenomena associated with the prediction of dryout and film boiling, cladding deformation, etc., is considered to be of low importance in GE's stability PIRT. GE will be submitting its CPR correlation as part of design certification. At that time, the staff expects GE to reanalyze the CPR margins for this application, and should there be significantly less margin than previously predicted, the staff expects GE to update its PIRT accordingly.

3.2 Staff Evaluation of Confirmatory Item #3

The staff has reviewed NEDC-33237P, "GE14 for ESBWR—Critical Power Correlation, Uncertainty, and OLMCPR Development," Revision 4, issued July 2008 (Ref. 12). In NEDC-33237P, GEH proposed that the GEXL14 correlation remains applicable for GE14E fuel because the shorter part-length rod length in GE14E and the difference in grid spacing both affect critical power ratio (CPR) on the order of 1 percent, but in opposite directions. COBRAG calculations compared to GE14 ATLAS test data, adjusted for these fuel differences, support this conclusion. In addition, GE14E CPR test data were collected to validate the use of the GEXL14 correlation for that fuel. The staff concluded in the SER for NEDC-33237P (Reference 19) that the approach taken by GEH in NEDC-33237P is acceptable. Therefore, it can be concluded that the CPR margin will not change significantly from the CPR values predicted using the GE14 CPR correlation, and the use of the GE14 CPR correlation is acceptable.

The ESBWR stability acceptance criteria require that the reactor be stable at all possible operating conditions, including anticipated operational occurrences (AOOs). The ESBWR licensing basis uses an "Option I" stability solution to satisfy General Design Criterion (GDC) 12, "Suppression of Reactor Power Oscillations," in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." Point SP1M and the associated lines in the simulated thermal power scram and rod blocks define an exclusion region (as shown in Ref. 11), and the ESBWR stability outside of the SP1M exclusion region is demonstrated by analysis. DCD Section 4D includes the "Stability Evaluation" for ESBWR and the staff evaluation of Thermal–Hydraulic Stability is evaluated in Section 4A of the Safety Evaluation Report for ESBWR (Ref. 20).

The applicant submitted the GE14E CPR test results and the staff concluded that there is sufficient CPR margin (Ref. 19). Because there is sufficient CPR margin staff concludes that there is no need to update the PIRT, and hence Confirmatory Item # 3 is closed.

Specifically, the stability acceptance criteria require that the decay ratio (DR) calculated by TRACG be less than 0.8 for all three density-wave stability modes. NEDO-33338 (Ref. 11) determined the limiting AOO with respect to stability to be a loss of feedwater heating with SCRII functional from operating point SP1M. The minimum allowed feedwater temperature of point SP1M is set in the core operating limit report on a cycle-specific basis to ensure that the ESBWR will not be unstable under the limiting AOO. Stability during startup transients is also demonstrated by analysis. Therefore, CPR performance is not a direct concern with respect to stability because oscillations that could challenge a specified acceptable design limit are precluded by operating at feedwater temperatures greater than point SP1M.

Confirmatory Item #3 is closed.

4.0 ITEM 4: STABILITY DURING ANTICIPATED TRANSIENT WITHOUT SCRAM

4.1 Confirmatory Item #4

Confirmatory Item #4 states the following:

> GE has not provided any information on ATWS in support of this application. Therefore, stability during ATWS was not considered as part of this review, and approval of the TRACG code for stability analysis during startup and normal operation does not imply acceptance of TRACG for ATWS stability analysis.

4.2 Staff Evaluation of Confirmatory Item #4

GEH discussed the modeling of stability during an anticipated transient without scram (ATWS) in Section 15.5.4.3.6 of the DCD (Ref. 2). GEH stated that it introduced regional perturbations in channel inlet liquid flow at different times during the transient. In addition, to demonstrate margin, the void reactivity coefficient is increased by 30 percent.

The TRACG calculation proposed by the applicant, where perturbations are imposed at different times during the transient, is able to demonstrate that the calculated DR is strictly less than 1.0, but it cannot quantify the available margin.

The staff has performed a simple confirmatory calculation to determine the effect of increasing the void reactivity coefficient by 30 percent for typical ESBWR conditions (point SP0) using the LAPUR code (Ref. 13). Using nominal ESBWR SP0 end-of-cycle conditions, the LAPUR calculation shows a corewide DR of 0.21. Increasing the void coefficient by 30 percent results in an increase in the corewide DR to 0.36, which is a 0.15 (70 percent) increase in DR. Thus, the staff concluded that a 30 percent increase in void reactivity coefficient is sufficient to demonstrate margin to stability during ATWS events.

As a further conservatism, the applicant assumed that, following failure to scram, the automated feedwater runback was delayed approximately 80 seconds, even though the control system should initiate it in approximately 7 seconds. This is a very significant conservatism, because if the control system was assumed to initiate the runback within approximately 7 seconds, the feedwater temperature transient would not occur and the power level would remain at or below nominal conditions, which are known to be stable.

The results of the conservative ATWS/stability analysis show that the ESBWR can become unstable under these extreme ATWS conditions. Figure A.2.4.1-1 of NEDO-33338 (Ref. 11) shows a small-amplitude but self-sustained regional-mode oscillation (i.e., limit cycle) of approximately 0.5 megawatts peak to peak. When the water level starts to drop (approximately 85 seconds), the oscillation mode switches from regional to corewide and the oscillation decays, indicating that the reactor has become stable once more. The applicant stated that the change in oscillation mode and the rapid stabilization result from uncovering the steam separators as the water level drops. The TRACG04 calculations indicate that all applicable fuel limits are satisfied during this relatively small oscillation.

Based on the above data, the staff concludes that the automated ATWS mitigation features (i.e., feedwater flow runback) are adequate to mitigate the ATWS/stability oscillations. The calculations indicate that ATWS acceptance criteria are satisfied even in the presence of unstable power oscillations. Therefore, the staff concludes that the criteria for ESBWR stability during ATWS events are satisfied. Confirmatory Item #4 is closed.

5.0 ITEM 5: DETECT AND SUPPRESS FUNCTION

5.1 Confirmatory Item #5

Confirmatory Item #5 states the following:

> The proposed TRACG procedures for calculation of ESBWR stability margins are best estimate for the expected conditions during the cycle. The most likely mode of instability is expected to be regional (out-of-phase). Therefore, to ensure compliance with GDC 10, the ESBWR reactor protection system must incorporate an approved detect and suppress function. The review and approval of this function will be the subject of a separate submittal.

5.2 Staff Evaluation of Confirmatory Item #5

In its response to RAI 4.3-7 S01 (Ref. 4), the applicant committed to implementing a long-term stability solution that will be based on the NRC-approved Detect and Suppress Solution—Confirmation Density (DSS/CD) and will be provided in the Core Operating Limits Report (COLR) (cycle-specific calculated) per Subsections 5.6.3.b and 5.6.3.c of DCD Tier 2, Chapter 16 (Technical Specifications). Revision 7 of the DCD, Appendix 4D (Ref. 2) provides the details of this implementation. This solution is referred to as ESBWR defense in depth (DID), and it has the following main features:

- The licensing basis as specified in (Ref. 1) for the ESBWR is to avoid instabilities by defining an exclusion region at feedwater temperatures lower than point SP1M. The licensing calculation is performed on a cycle-specific basis and defines the minimum feedwater temperature allowed. Instabilities outside of the exclusion region are highly unlikely as demonstrated by cycle-specific calculations. Therefore, DSS/CD is a DID measure.

- The primary difference between the standard DSS/CD and the ESBWR DID solution is that a licensing calculation is not necessary to demonstrate that the DID will prevent the violation of specified acceptable fuel design limits (SAFDLs). It is expected that, in the unlikely case that the ESBWR becomes unstable, such instability would be caused by a slow transient (e.g., loss of feedwater heating), so DSS/CD will scram the reactor with a DR very close to 1.0, and thus, a challenge to SAFDLs will be highly unlikely.

- The hardware will not be declared as safety grade since it is not required for a nonlicensing-basis calculation. Therefore, high-quality software and hardware will be used without unnecessarily compromising plant availability.

The staff and its contractors reviewed with GEH personnel the applicability of the DSS/CD parameter settings that are fixed in the DSS/CD SER (Ref. 14). Since the ESBWR is a different design (especially in terms of the short core height), some of these parameters are not applicable. In the ESBWR, the expected oscillation frequency is approximately twice the expected frequency in operating reactors. Thus, some DSS/CD parameters (e.g., Tmin, Tmax, corner frequency) require adjustment by a factor of approximately two. Table 4D-5 of Revision 6 of the DCD (Ref. 2) documents these changes in parameters. DCD Section 4D includes the “Stability Evaluation” for ESBWR and the staff evaluation of Thermal –Hydraulic Stability is evaluated in Section 4A of the Safety Evaluation Report for ESBWR (Ref. 19).

In summary, the applicant proposed a new long-term solution, the ESBWR DID, which is based on the approved DSS/CD. This solution uses all of the approved algorithms from DSS/CD, with parameter settings adjusted to the special ESBWR characteristics. Since the solution provides DID, a licensing-basis calculation is not required to demonstrate the effectiveness of the DID solution in preventing SAFDLs. The licensing basis is an “Option 1” stability solution, which defines and enforces an exclusion region based on the minimum allowable feedwater temperature of point SP1M. The core operating-limit report defines this minimum allowable feedwater temperature on a cycle-specific basis. Confirmatory Item #5 therefore is closed.

6.0 ITEM 6: ASCENSION TO FULL-POWER PHASE OF STARTUP

6.1 Confirmatory Item #6

Confirmatory Item #6 states the following:

> The use of TRACG is acceptable to predict the ESBWR trajectory during the initial phases of startup up to the ascension to full-power phase. During this transient, a stability margin can be determined by increasing the heat up rate until the onset of instability. TRACG is not acceptable for predicting the startup transient during the ascension to full-power phase as xenon is not considered and insufficient information is provided in regard to the impact of the balance of plant. The staff is aware that PANACEA has an option for predicting transient xenon and that this option can be invoked for a startup calculation. The staff expects this to be done for the initial startup of the ESBWR to properly predict the margins during the ascension to full-power phase. The ascension to full-power phase of the startup will be the subject of a subsequent review by the staff during design certification.

6.2 Staff Evaluation of Confirmatory Item #6

The evaluation of this issue has two parts:

(1) evaluation of the margin to stability during low-pressure startup, which the applicant provided in its response to RAI 4.4-59 (Ref. 5)

(2) evaluation of the impact of xenon (Xe) on startup, which the applicant provided in its response to RAI 4.4-60 (Ref. 5)

In its response to RAI 4.4-59 (Ref. 5), the applicant performed a detailed analysis of the ESBWR startup with a wide range of parameter variations in order to bound the expected startup conditions. All of these variations simulated neutronic feedback, as the NRC requested. The study concludes that startup heatup rates as high as 110 degrees Celsius (C) per hour (198 degrees Fahrenheit (F) per hour) are safe and free from instabilities that could challenge SAFDLs. This demonstrated safe value is twice the maximum heatup rate allowed by the thermal-stress limit of 55 degrees C per hour (99 degrees F per hour), and approximately four times the expected ESBWR heatup rate of 27.5 degrees C per hour (49.5 degrees F per hour).

The applicant's response to RAI 4.4-59 discusses the progression of the startup event and details of the calculations. GEH listed two separate regimes during startup where flow oscillations are observed:

(1) At very low pressure (less than 0.25 megapascals (MPa); 36 pounds per square inch (psi)) subcooled boiling occurs first at the outlet of the hot channels. This results in significant flow oscillations as bubbles are created and then collapse.

(2) Later in the transient, a second range of flow oscillation is observed when boiling starts on the separators by flashing. This oscillation regime also occurs at relatively low pressure (approximately 1 MPa (150 psi)).

The staff believes that both of these regimes result in seemingly chaotic flow oscillations, which could be characterized as instabilities. GDC 12 requires that unstable oscillations "which can result in conditions exceeding SAFDLs are not possible." Therefore, the acceptability of these two oscillation regimes during startup depends on the possibility of exceeding SAFDLs.

In its analysis, the applicant calculated the CPR during startup. The analysis concludes that CPR limits will not be exceeded at the analyzed heatup rates. The nominal ESBWR startup rate of 27.5 degrees C per hour (49.5 degrees F per hour) was not calculated, but a heatup rate of 38 degrees C per hour (68.4 degrees F per hour) results in a minimum CPR of 7.2, which the staff considers to be a significant margin. For all of the conditions analyzed, the minimum CPR value calculated was 2.6, and it corresponded to a heatup rate of 81 degrees C per hour (145.8 degrees F per hour) with a high radial peaking factor (RPF). This calculation indicates that CPR limits are not likely to be exceeded even if the heatup rate is 300 percent of that recommended.

Since the applicant's calculations are technically sound and reasonable, the staff concludes that SAFDLs are not likely to be exceeded by the maximum allowed startup heatup rate of 55 degrees C per hour (99 degrees F per hour). Therefore, the flow oscillations observed during startup are acceptable and satisfy the GDC 12 requirements.

In its response to RAI 4.4-60 (Ref. 5), the applicant provided a series of TRACG calculations that varied the "PIRT46" parameter. These calculations were used to simulate the Xe effect via the impact on local power peaking.

The applicant presented the following physical arguments to explain why the constant-Xe calculation is acceptable:

- Xe concentration is controlled mostly by the power distribution and power level before scram.
- Xe burnup occurs at significant levels only when the power is greater than 10 percent. At low powers (e.g., 1 percent), the Xe burnup rate is negligible.
- ESBWR startup is of concern during the low-pressure stage. After full pressure is reached, the ESBWR startup procedures are similar to those of operating reactors.

- Full pressure (i.e., the turbine roll pressure) is achieved with reactor power less than 2 percent; therefore, the Xe concentration is not expected to differ significantly from the shutdown pressure.

- Operating reactor experience has shown that full pressure is achieved approximately 5 hours after startup. Xenon burnup has been found to be insignificant at less than 2 percent power during this time.

In its response, the applicant stated that TRACG uses a constant cross-section set generated by PANAC11 for a given Xe condition. TRACG is not capable of calculating time-varying Xe transients. However, the PIRT46 parameter provides the capability to simulate Xe effects by increasing or decreasing local power peaking.

PANACEA is a series of steady-state calculations for the startup path that can model the Xe burnup. GEH performed a PANACEA study for the ESBWR initial core, MOC. Based on this PANACEA study, GEH concluded that an RPF of 8 conservatively bounds the expected radial peaking when accounting for Xe burnup (the nominal RPF value is approximately 5). The TRACG calculations used RPF values as high as 11.

The nominal case used an RPF value of 5, which corresponds to a hot channel power of 479 kilowatts (for a heating rate of 91 megawatts for the core) and a minimum CPR of 7.2. The Xe-burnup bounding simulation increased the RPF to 11 (hot channel power 1,440 kilowatts) and decreased the minimum CPR to 5.3. A CPR of 5.3 maintains very significant margin.

Since the applicant's responses are technically sound and reasonable, the staff finds that Xe burnup effects will not invalidate the conclusion that SAFDLs will be met during startup. Thus, the GDC 12 requirements will be satisfied even when accounting for Xe burnup. Based on the applicant's responses, RAIs 4.4-59 and 4.4-60 are resolved. Confirmatory Item #6 is closed.

7.0 ITEM 7: GAP CONDUCTANCE

7.1 Confirmatory Item #7

Confirmatory Item #7 states the following:

> The staff did not review the dynamic gap conductance input during the initial review of Reference 16

7.2 Staff Evaluation of Confirmatory Item #7

The default fuel thermal conductivity modeling in TRACG04 is based on the PRIME03 code, which the NRC has not reviewed and approved for the ESBWR. Staff requested in RAI 6.3-54 that GEH justify use of the PRIME03-based thermal conductivity model in TRACG04, since PRIME03 has not been reviewed and approved by the NRC for ESBWR. In RAI 6.3-55, staff requested that GEH justify the use of gap conductance and fuel thermal conductivity from different models (GSTRM and PRIME03-based TRACG04, respectively).

The GEH response to RAI 6.3-55 included a description of the TRACG04 calculations, as requested and discussed in the following paragraphs for RAI 6.3-54 but did not provide sufficient justification for combining models. However, the response to RAI 6.3-54 S01, discussed below, addresses the impact of using gap conductance and fuel thermal conductivity from different models (GSTRM and PRIME03-based TRACG04, respectively) on TRACG04 calculations. Since this issue was addressed in the supplements to RAI 6.3-54, the staff concluded that RAI 6.3-55 could be closed.

The GEH response to RAI 6.3-54 states that the fuel files generated using the GSTRM code are being used as input to TRACG04 and that the TRACG04 thermal conductivity model is used. The TRACG04 thermal conductivity model is based on the thermal conductivity model in the PRIME03 code, and accounts for the degradation of thermal conductivity due to the presence of gadolinium and for the degradation of thermal conductivity as exposure increases. Since the TRACG04 thermal conductivity model has not been approved in previous versions of TRACG and since the thermal conductivity model has not been approved as part of a PRIME03 review for ESBWR, the NRC staff requested that GEH provide experimental data and benchmarks as well as TRACG02 (GSTRM) versus TRACG04 (PRIME03-based) thermal conductivity sensitivity study results in RAI 6.3-54 S01.

In response to RAI 6.3-54 S01 (MFN 08-713), GEH provided the results from sensitivity studies comparing representative AOO, ATWS, and Stability cases analyzed with the GSTRM model and the TRACG04 (PRIME03-based) model to the base cases using GSTRM gap conductance and TRACG04 (PRIME03-based) thermal conductivity. GEH did not submit experimental data and benchmarks to support use of the PRIME03 code or the TRACG04 thermal conductivity model for ESBWR.

The Loss of Feedwater Heating (LOFWH) regional stability evaluation at Middle of Cycle (MOC) exposure from ESBWR DCD Section 4D.1.5 was chosen for the stability sensitivity study because it is the limiting stability event. A comparison of the decay ratio results from the base case and two sensitivity cases shows a negligible change in decay ratio between the base case (with GSTRM gap conductance and PRIME03-based thermal conductivity) and the PRIME03-based sensitivity case. However, the GSTRM sensitivity case resulted in a relatively limiting decay ratio (0.71 for GSTRM case vs. 0.66 for base case and PRIME03-based case).

The results of the LOFWH regional stability sensitivity studies give the staff reasonable assurance that the ESBWR TRACG 0.8 decay ratio limit is not exceeded by the stability results shown in the ESBWR DCD and in the TRACG for ESBWR Stability topical report. In addition, the stability analysis will be analyzed on a cycle specific basis, so these results will be updated. Staff accepts the use of GSTRM model for both gap conductance and thermal conductivity in the ESBWR design certification. The conclusions and limitations for ESBWR TRACG AOO and ATWS analyses (including the 2413 kPa ((350 psi)) critical pressure penalty) contained in the NRC staff evaluation of GEH's Part 21 report (Appendix F to the SE for NEDC-33173P, (Ref. 21) are applicable to this SE. Use of other methods or analysis strategies for ESBWR must be approved by the NRC. Based on the applicant's response, RAI 6.3-54 S01 was resolved.

8.0 CONCLUSIONS

The staff reviewed the additional data provided by the applicant to address the open items in the original SER to NEDE-33083, Supplement 1 (Ref. 1). The staff found that the confirmatory items have been adequately addressed and therefore can be closed.

The staff concluded that the TRACG code and methodology described in Reference 1 and associated RAI responses are applicable to the calculation of ESBWR stability margins as described in Chapter 4D of the DCD (Ref. 2).

However, since the use of PANAC11/TGBLA for generating ESBWR cross sections has been approved in the staff SER for NEDC-33239P, the following condition identified from the staff SER for NEDC-33239P (Ref. 7) applies to the use of TRAG04 for the ESBWR Stability analyses.

> The regional mode stability analysis must be performed using a radial nodalization in TRACG04 based on the PANAC11-generated first harmonic mode. The harmonic calculation performed by PANAC11 must use a full-core representation.

The following condition is identified from the staff SER for NEDE-32906P, Supplement 3.

> Use of PANAC11 generated nuclear data for ESBWR reload stability analyses require that TRACG utilize the void reactivity coefficient correction model described in NEDE-32906P, Supplement 3 (Ref. 17). The fuel lattices input to the model must be representative of the cycle specific fuel loading.

9.0 REFERENCES

1. Letter from D.B. Matthews (NRC) to R.E. Brown (GEH), “Reissuance of Safety Evaluation Regarding the Application of the GE-Hitachi Nuclear Americas LLC (GEH) Licensing Topical Report ‘TRACG Application for ESBWR Stability Analysis,’ NEDE-33083P, Supplement 1,” August 29, 2007. (ADAMS Accession No. ML072270138)

2. “General Electric Company—ESBWR Standard Plant Design—Revision 6 to Design Control Document Tier 2,” September 2009 (ADAMS Accession No. ML092680561)

3. Letter from J.C. Kinsey (GEH) to NRC, MFN 07-309, “Response to Portion of NRC Request for Additional Information Letter No. 66—Related to ESBWR Design Certification Application—RAI Numbers 21.6-66 through 68, 21.6-80, 21.6-82, 21.6-84,” June 8, 2007. (ADAMS Accession No. ML071920098)

4. Letter from J.C. Kinsey (GEH) to NRC, MFN-08-226, “Response to Portion of NRC Request for Additional Information Letter No. 156—Related to ESBWR Design Certification Application—RAI Number 4.3-7 Supplement 1,” April 11, 2008 (ADAMS Accession No. ML081070307)

5. Letter from J.C. Kinsey (GEH) to NRC, MFN-08-438, “Response to Portion of NRC Request for Additional Information Letter No. 98—Related to ESBWR Design Certification Application— RAI Numbers 4.4-59 and 4.4-60,” May 2, 2008 (ADAMS Accession No. ML081280461)

6. Safety Evaluation Report for Licensing Topical Reports (LTR) NEDE-33083P, Supplement 3, “Application of the TRACG Computer Code to the Transient Analysis for the ESBWR Design” DATE – TBD (Proprietary Version - ADAMS Accession No. ML100150979)

7. Combined Safety Evaluation Report for Licensing Topical Reports (LTRs) NEDC-33239P, Revision 4, “GE14 for ESBWR Nuclear Design Report and NEDE-33197P, Revision 4, ‘Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring” July 2010. (ADAMS Accession Nos. ML101670068, ML101720671, ML101670050)

8. NEDC-33239P, “GE14 for ESBWR Nuclear Design Report,” Revision 4, March 2009. (ADAMS Accession No. ML090970169)

9. GE Hitachi Nuclear Energy, NEDO-32906, Revision 2, “TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses,” February 2006 (ADAMS Accession No. ML060530566)

10. GE-Hitachi Nuclear Energy, NEDO-33337, Revision 1, “ESBWR Initial Core Transient Analyses,” April 2009 (ADAMS Accession No. ML091130628)

11. NEDO-33338, Revision 1, “ESBWR Feedwater Temperature Operating Domain Transient and Accident Analysis,” May 2009. (ADAMS Accession No. ML091380173)

12. NEDC-33237P, “GE14 for ESBWR—Critical Power Correlation, Uncertainty, and OLMCPR Development,” Revision 4, July 2008. (ADAMS Accession No. ML081990206)

13. U.S. Nuclear Regulatory Commission, NUREG/CR-6958, ORNL/TM-2007/233, “LAPUR 6.0 R.0 Users Manual,” October 2008 (ADAMS Accession No. ML083030200)

14. GE Hitachi Nuclear Energy, NEDO-33075-A, Revision 6, “General Electric Boiling Water Reactor Detect and Suppress Solution—Confirmation Density,” January 2008. (ADAMS Accession No. ML080310396)

15. Letter from J.C. Kinsey (GEH) to NRC, MFN-08-713, “Response to Portion of NRC Request for Additional Information Letter No. 156—Related to ESBWR Design Certification Application—RAI Number 6.3-54 S01,” September 22, 2008 (ADAMS Accession No. ML082680145)

16. NEDE-33083P, Supplement 1, “TRACG Application for ESBWR Stability,” December 9, 2004. (Agencywide Documents Access and Management System (ADAMS) Accession No. ML050060158)

17. Final Safety Evaluation Report By the Office of NRR, Licensing Topical Report NEDE-32906P, Supplement 3, “Migration To TRACG04/PANAC11 From TRACG02/PANAC10 For TRACG AOO And ATWS Overpressure Transients General Electric Hitachi Nuclear Energy Americas, LLC, July 10, 2009 (ADAMS Accession No. ML0917511021).

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