ENCLOSURE 2

MFN 14-038

Comment Summary Table and Draft SE Markup

Non-Proprietary Information – Class I (Public)

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1, which has the proprietary information removed. Portions of the document that have been removed are indicated by white space with an open and closed bracket as shown here [[ ]].

Comment Summary for Draft Safety Evaluation for NEDO-32465 Supplement 1,

"Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications"

Note: Page numbers shown in this table reflect the page numbers in this enclosure. Due to suggested changes in the Safety Evaluation (SE) and the addition of a change summary table, these page numbers differ from the page numbers in the draft SE sent to GEH for review.

Location	Comment
Section 1.0 Introduction	Page 6: Last Paragraph: Please replace "DSS-CD" with "DIVOM calculations". Suggested changes shown in the markup.
Section 2.2 DIVOM Methodology	Page 8: 1st paragraph: GEH suggests the following changes: "This potential for a non conservative DIVOM curve made Solutions I-D, II, and III invalid as a viable…" Suggested changes shown in the markup.
Section 2.2 DIVOM Methodology	Page 8: 3rd paragraph: GEH suggests the following changes: "To calculate the cycle-specific DIVOM curve, a licensed three-dimensional (3-D) core simulator (e.g., TRACG04/PANAC11) is used to simulate core-wide and regional oscillations at the limiting power/flow state point ~~several state points throughout that cycle~~ a minimum of three cycle exposures." *This clarifies the way in which DIVOM is calculated.* Suggested changes shown in the markup.

Location	Comment
Section 2.2 DIVOM Methodology	Page 8: 4th paragraph: GEH suggests replacing the last three sentences with the following text: "The original BWROG methodology described in NEDO-32465-A (Reference 2) uses a single DIVOM slope over the expected range of oscillation magnitudes (the Hot Channel Oscillation Magnitude (HCOM) range). However, the BWROG DIVOM methodology allows for a more generic DIVOM curve, where the slope varies with oscillation amplitude**.** The GEH DIVOM methodology is consistent with the BWROG DIVOM methodology. ~~The GEH DIVOM methodology application procedure is described in detail in NEDO-32465-A (Reference 2). It uses a single DIVOM slope over the expected range of oscillation magnitudes (the Hot Channel Oscillation Magnitude (HCOM) range).~~" *NEDO-32465-A is a BWROG document. The text was reorganized in order to reflect that NEDO-32465-A is the original basis and the plant-specific DIVOM guidelines updated the method in order to calculate DIVOM on a cycle-specific basis and to make it clear that the GEH methodology is consistent with the BWROG methodology.* Suggested changes shown in the markup.
Section 2.3 TRACG04 Use For Divom Calculations	Page 11: GEH suggests the following change to the section title: "TRACG04 Use For ~~Divom~~ DIVOM Calculations" Suggested changes shown in the markup.
Section 2.4 TRACG04 Modifications from TRACG02	Page 12: GEH suggests replacing Reference 11 in this section with Reference 9 and deleting Reference 11. "Appendix A of NEDO-32465, Supplement 1 (Reference 1) documents the 15 main changes made to TRACG02 in the upgrade to TRACG04. Most of these changes affect loss-of-coolant accident calculations (Reference 9)." *Reference 11 does not discuss TRACG04.* Suggested changes shown in the markup.
Section 4.0 Technical Evaluation	Page 16: Paragraph directly below Figure 8: Change 'Section 7' to 'Sections 3 and 7'. *This clarification reflects that FRIGG stability tests are discussed in Section 3 of Reference 7.* Suggested changes shown in the markup.

Location	Comment
Section 6.0 Conclusion	Page 19: Item 3: GEH suggests the following change: "Therefore, the use of TRACG04 for DIVOM stability calculations is acceptable for ~~BWR/3-6 plants~~ BWRs employing ~~any approved D&S stability solution like Solutions ID, II or III~~ the long term stability solutions Option I-D, Option II, or Option III." *This change is recommended because DIVOM is part of three long-term stability solutions. The applicability of a long-term stability solution to a particular BWR type is dependent on the assessment of that BWR and the long-term stability solution selected. Application of DIVOM with TRACG04/PANAC11 does not impact the assessment of a long-term stability solution to a particular BWR type.* Suggested changes shown in the markup.
Section 7.0 References	Page 20: GEH suggests deleting Reference 11 and replacing it with 'Not Used' since it is not used in the SE and a later version of the same LTR is used elsewhere in the SE. Suggested changes shown in the markup.

Markup of Draft Safety Evaluation for
NEDO-32465 Supplement 1,

"Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications"

The following markup illustrates the GEH proprietary content and suggestions per the comment summary table.

DRAFT SAFETY EVALUATION BY THE OFFICE NUCLEAR REACTOR REGULATION

TOPICAL REPORT NEDO-32465, SUPPLEMENT 1

“MIGRATION TO TRACG04/PANAC11 FROM TRACG02/PANAC10 FOR REACTOR STABILITY DETECT AND SUPPRESS SOLUTIONS LICENSING BASIS METHODOLOGY FOR RELOAD APPLICATIONS”

GE-HITACHI NUCLEAR ENERGY AMERICAS, LLC

PROJECT NO. 710

1.0 INTRODUCTION

By letter dated September 9, 2011 (Agencywide Documents Access and Management System Accession No. ML112550358), GE Hitachi Nuclear Energy Americas, LLC (GEH) submitted Topical Report (TR) NEDO-32465, Supplement 1, “Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications,” to the U.S. Nuclear Regulatory Commission (NRC) staff for review (Reference 1). NEDO-32465, Supplement 1, provides the licensing basis and methodology for Delta Critical Power Ratio (CPR) over Initial Minimum CPR (MCPR) Versus Oscillation Magnitude (DIVOM) calculations using the TRACG04 code [TRACG is the designation for the GEH proprietary version of the Transient Reactor Analysis Code (TRAC)]. The DIVOM methodology was reviewed and approved by the NRC staff as documented in TR NEDO-32465-A (Reference 2). Supplement 1 to NEDO-32465 addresses a code migration from TRACG02/PANAC10 to TRACG04/PANAC11, which had previously been implemented following a GEH evaluation in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.59 (Reference 3).

Two related submittals have been recently approved by the NRC staff: Revision 8 of the DSS-CD Methodology TR, NEDC-33075P-A (Reference 4), and Revision 4 of TR NEDE-33147P-A (Reference 5). These TR revisions are based on the use of TRACG04 in the DSS-CD process and document the applicability of TRACG04/PANAC11 for DSS-CD calculations.

The GEH TRACG04 code model description, qualification, and application for anticipated operational occurrences are documented in TRs NEDE-32176P, NEDE-32177P, NEDE-32906P-A, and NEDE-32906P-A, Supplement 3, respectively (References 6 thru 9). References 8 and 9 have been reviewed and approved by the NRC staff (References 6 and 7 are included for information).

In NEDO-32465, Supplement 1 (Reference 1), GEH requests NRC staff review and approval of this supplement to the licensing basis for the Detect and Suppress Solutions Licensing Basis Methodology (Reference 2) to use TRACG04/PANAC11 for applications to the Option 1-D, Option II, and Option III Stability Long Term Stability Solutions (LTS).

The NRC staff was assisted in this review by staff from Oak Ridge National Laboratory. The NRC staff's review is based on the submitted TR supplement, requests for additional information (RAI) questions, and information obtained during meetings with GEH to clarify and supplement the RAI questions. The main conclusion from this review is that the proposed code migration from TRACG02/PANAC10 to TRACG04/PANAC11 is acceptable for DIVOM calculations

The NRC staff is currently evaluating the TRACG04 models for post-critical heat flux (CHF) heat transfer, dryout, and rewet, including the correlations for stable film boiling temperature (Tmin) and the quench front model (Reference 10). This safety evaluation covers the application of TRACG04/PANAC11 for ~~DSS-CD~~DIVOM calculations, where calculations are not analyzed past the point of CHF; therefore the approval of TRACG04 for ~~DSS-CD~~DIVOM calculations does not imply the approval of the TRACG04 post-CHF models.

2.0 BACKGROUND

2.1. Long Term Solutions

Following the March 1988 instability event at a LaSalle County Station boiling water reactor (BWR), the BWR Owners Group (BWROG) initiated a task to investigate actions that industry should take to resolve the stability issue as an operational concern. Through analysis, the BWROG found that the existing plant protection system, which was based on a scram on high average power range monitor (APRM) signal, may not provide enough protection against out-of-phase modes of instability; thus, the BWROG decided that a new automatic instability suppression function was required as a long-term solution and that this function should have a rapid and automatic response which does not rely on operator action.

The BWROG submitted and the NRC staff approved three different long-term stability options (References 16 and 17). It is up to the individual licensees to choose which solution will be implemented in their reactor. These options can be summarized as follows:

I. Exclusion Region. A region outside which instabilities are very unlikely is calculated for each representative plant type using well-defined procedures. If the reactor is operated inside this exclusion region, an automatic protective action is initiated to exit the region. This action is based exclusively on power and flow measurements, and the presence of oscillations is not required for its initiation. Two concepts of Solution I were submitted by the BWROG and approved by the NRC staff:

I-A Immediate protection action (either scram or select rod insert) upon entrance to the exclusion region.

I-D Some small-core plants with tight inlet orifices have a reduced likelihood of out-of-phase instabilities. For these plants, the existing flow-biased high APRM scram provides a detect and suppress function to avoid safety limits violation for the expected instability mode. In addition, administrative controls are proposed to maintain the reactor outside the exclusion region.

II. Quadrant-Based APRM Scram. In a BWR/2, the quadrant-based APRM is capable of detecting both in-phase and out-of-phase oscillations with sufficient sensitivity to initiate automatic protective action to suppress the oscillations before safety margins are compromised.

III. LPRM-Based Detect and Suppress. Local power range monitor (LPRM) signals or combinations of a small number of LPRMs are analyzed on-line by using three diverse algorithms. If any of the algorithms detects an instability, automatic protective action is taken to suppress the oscillations before safety margins are compromised.

All of the above solutions have been implemented in commercial nuclear power plants in the United States (U.S.). Nevertheless there are three significant areas of consideration, which merit a revisit of these long-term solutions. These areas are: (a) deficiencies identified in the CPR versus oscillation amplitude correlation used for detect and suppress solutions (i.e., the DIVOM correlation,) which resulted in a 10 CFR Part 21 notification, (b) proposed increases in power density, and (c) lessons learned from instability events that occurred at Nine Mile Point Nuclear Station, Unit 2 (hereafter, “Nine Mile Point 2”) in July 2003 and Perry Nuclear Power Plant, Unit 1 (hereafter, “Perry”) in December 2004.

In recent years, the industry has been moving to reactor operation at higher and higher power densities and power-to-flow ratios. This operation is, in principle, detrimental to the stability characteristics of the reactor and results in two consequences: (a) it increases the probability of instability events, and (b) it increases the severity of the event should it occur (e.g., larger amplitude oscillations). Indeed, simulations of two recirculation pump trip (2RPT) transients initiated at MELLLA+ conditions (80 percent flow and 120 percent original licensed thermal power) indicate that instabilities of sufficiently large amplitude to compromise the safety limit MCPR (SLMCPR) in a short time are not only possible, but very likely.

Since implementation of the long-term solutions, instability events have occurred at two U.S. plants: Nine Mile Point 2 in July 2003 and Perry in December 2004. Both events occurred in Solution III plants. Some deficiencies were identified in the performance of Solution III for the Nine Mile Point 2 event, resulting in a 10 CFR Part 21 notification. The deficiencies were related to the adjustable parameters for period-based detection, which are now recommended to be placed at their most sensitive settings. Most parameter settings for the long-term solutions are evaluated on a plant-specific basis by collecting noise data over a relatively long period of time. The parameters are adjusted during this trial period until normal plant transients do not trigger the stability detection algorithms. In the Nine Mile Point 2 event, the adjustable parameters had been set to the least sensitive value to avoid spurious actuations. The event had a very small oscillation amplitude and, because of the settings chosen, the confirmation count value kept on resetting and tripped the reactor later than expected. In spite of stability solution deficiencies that were identified after careful analysis of the event data, Solution III automatically initiated a scram of the reactor and the SLMCPR was never compromised in the Nine Mile Point 2 event. The Perry event resulted from a malfunctioning valve, which triggered scram actuation by Solution III without compromising the SLMCPR.

2.2. DIVOM Methodology

The DIVOM methodology is described in detail in NEDO-32465-A (Reference 2). The DIVOM correlation is used to estimate the delta CPR as a function of oscillation amplitude, and it is required to select the scram set point for detect and suppress solutions. The DIVOM correlation was approved on the basis that it would be bounding for all reasonable circumstances; however, later analysis demonstrated that some plant-specific calculations result in larger loss of CPR margin than the DIVOM prediction. Therefore, the generic DIVOM curve may be non-conservative for some plant applications. A non-conservative DIVOM curve would then result in stability-related setpoints that would not guarantee that specified acceptable fuel design limits would be maintained if a limiting instability event were to occur. This potential for a non-conservative DIVOM curve made Solutions I-D, II, and III invalid as a viable long-term solution, unless cycle-specific DIVOM correlations were used, which is the approach used by most plants today.

In principle, two DIVOM correlations are calculated for each reactor condition: the core-wide mode DIVOM and the regional-mode DIVOM. Under all credible circumstances, the regional-mode DIVOM correlation has a larger slope (i.e., more conservative) than the core-wide mode DIVOM. This is because regional-mode oscillations are always accompanied by larger swings in hot channel flow, which reduce the CPR performance.

To calculate the cycle-specific DIVOM curve, a licensed three-dimensional (3-D) core simulator (e.g., TRACG04/PANAC11) is used to simulate core-wide and regional oscillations at the limiting power/flow state point ~~several state points throughout that cycle~~ for a minimum of three cycle exposures. For each exposure time, a growing power oscillation is calculated as illustrated in Figure 1 through 3.

The TRACG output is parsed to determine the maximum swings in power and CPR in each bundle. The power and CPR amplitudes for each oscillation are plotted against each other, and a piece-wise linear function is plotted to define a region that statistically bounds all oscillations as illustrated in Figure 4. For most applications, this piece-wise linear function is a single straight line that defines a single slope, which is known as the DIVOM slope. The original BWROG methodology described in NEDO-32465-A (Reference 2) uses a single DIVOM slope over the expected range of oscillation magnitudes (the Hot Channel Oscillation Magnitude (HCOM) range). However, the BWROG DIVOM methodology allows for a more generic DIVOM curve, where the slope varies with oscillation amplitude. The GEH DIVOM methodology is consistent with the BWROG DIVOM methodology. ~~The GEH DIVOM methodology application procedure is described in detail in NEDO-32465-A (Reference 2). It uses a single DIVOM slope~~

~~over the expected range of oscillation magnitudes (the Hot Channel Oscillation Magnitude (HCOM) range)~~.

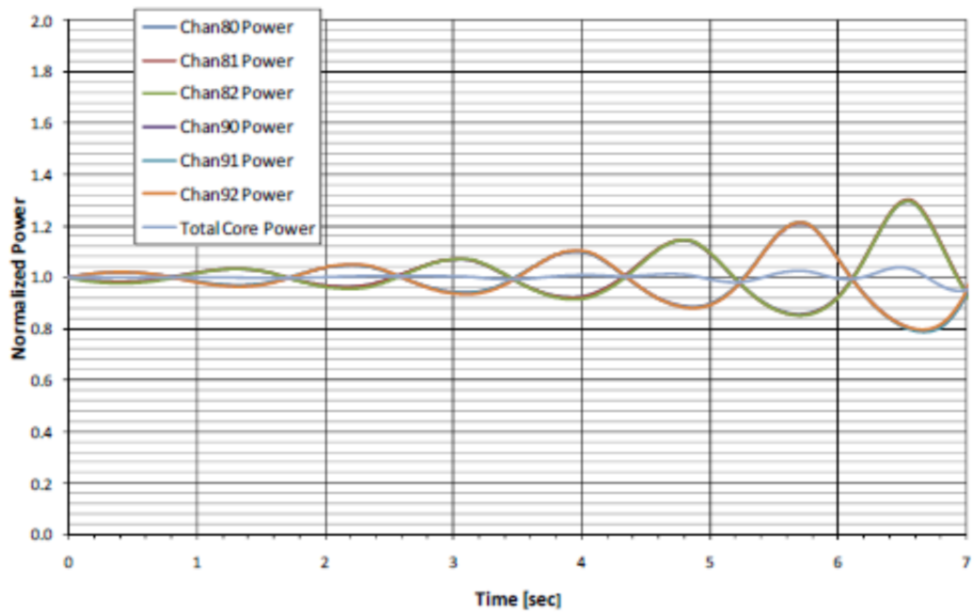

Figure 1. Typical regional-mode power oscillation calculated by TRACG04/PANAC11

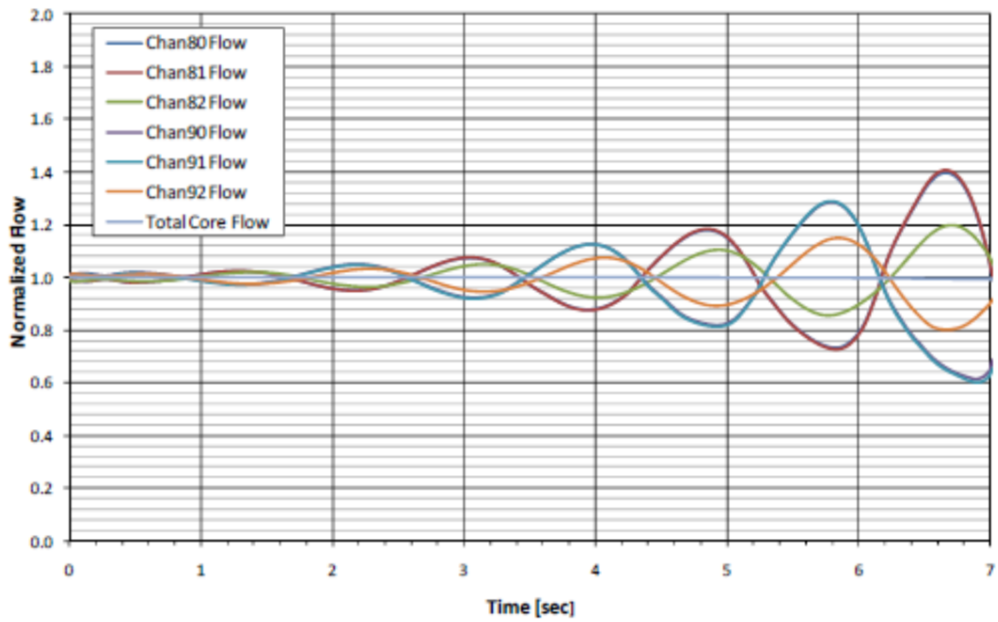

Figure 2. Typical regional-mode flow oscillation calculated by TRACG04/PANAC11

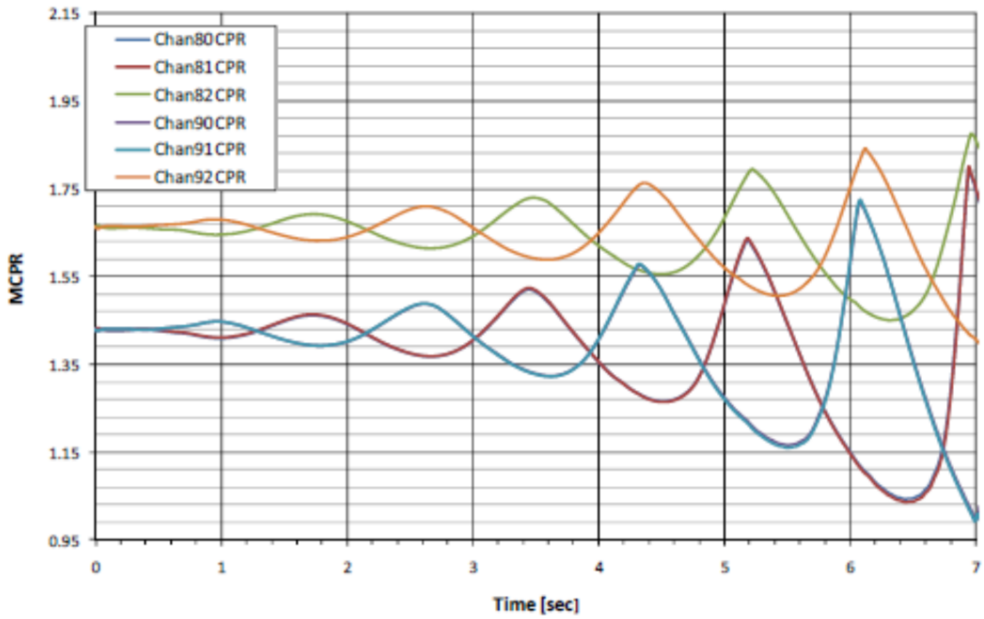

Figure 3. Typical regional-mode MCPR oscillation calculated by TRACG04/PANAC11

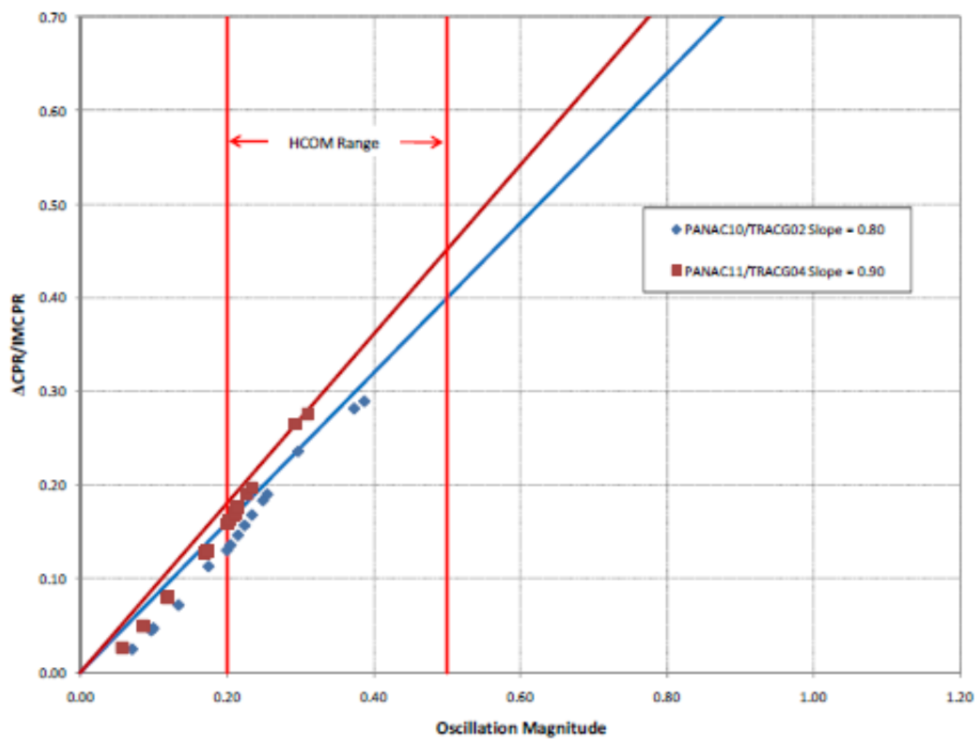

Figure 4. Typical regional DIVOM slope (TRACG04 vs TRACG02)

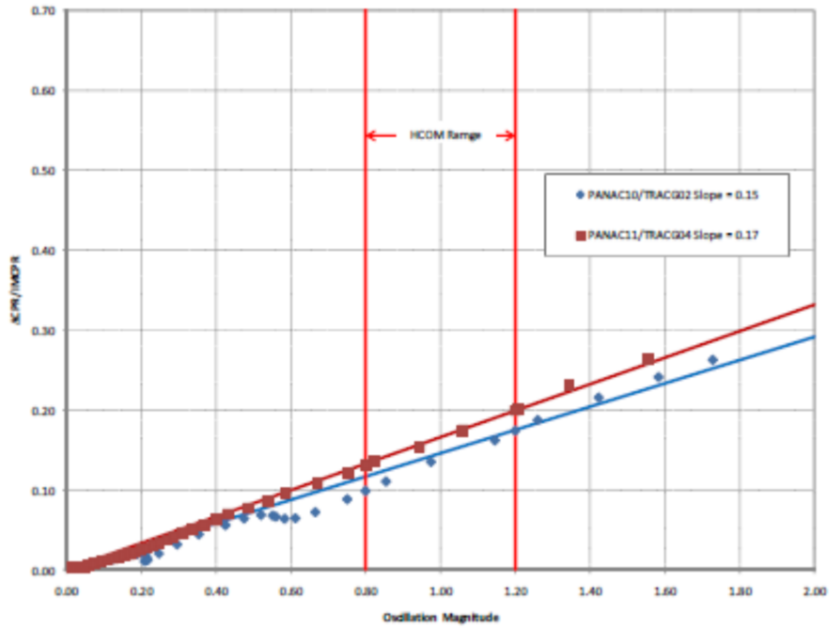

Figure 5. Typical core-wide DIVOM slope (TRACG04 vs TRACG02)

2.3. TRACG04 Use For ~~Divom~~ DIVOM Calculations

The generic DIVOM analysis performed in NEDO-32465-A (Reference 2) used TRACG02 coupled with PANAC10 (P10). However, most plants have now adopted the PANAC11 (P11) BWR core simulator methodology coupled with TRACG04 to perform DIVOM analyses. The use of the TRACG04/P11 methodology was originally supported by a 10 CFR 50.59 evaluation. NEDO-32465, Supplement 1 (Reference 1) documents this methodology upgrade. Only the detect and suppress (D&S) part of the Option 1-D, Option II, and Option III Stability LTSs are based on the DIVOM methodology. There are no other changes requested for any of these stability solutions.

2.4. TRACG04 Modifications from TRACG02

Appendix A of NEDO-32465, Supplement 1 (Reference 1) documents the 15 main changes made to TRACG02 in the upgrade to TRACG04. Most of these changes affect loss-of-coolant accident calculations (Reference ~~11~~9). The changes that are most relevant to DIVOM calculations are:

1. Upgrade to the PANAC11 kinetics model and cross sections generated with the P11/TGBLA06 methodology.

2. Fuel rod thermal conductivity models are now consistent with the PRIME fuel rod thermal-mechanical code/methodology.

3. Update of pump homologous curves with data representative of large pumps.

3.0 REGULATORY EVALUATION

The DIVOM correlation is used to estimate the delta CPR as a function of oscillation amplitude, and it is required to select the scram set point for D&S solutions. Supplement 1 to NEDO-32465 addresses a code migration from TRACG02/PANAC10 to TRACG04/PANAC11, which had previously been implemented following a GEH evaluation in accordance with 10 CFR 50.59.

The DIVOM correlation and its related licensing basis were developed to comply with the requirements of General Design Criteria 10 and 12 in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants."

Criterion 10, "Reactor design," requires that: "The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences."

Criterion 12, "Suppression of reactor power oscillations," requires that: "The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed."

To ensure compliance with Criteria 10 and 12, Appendix A, 10 CFR Part 50, the NRC staff will confirm that the licensee performs the plant-specific trip setpoint calculations using NRC-approved methodologies as prescribed in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Chapter 4. The subject TR provides the licensee's application to support its TS license amendment changes.

Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," establishes the minimum quality requirements for the design, fabrication, construction, and testing of structures, systems, and components of nuclear power plants and fuel reprocessing facilities. Nuclear power plants include the structures, systems, and components that prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. These requirements establish the criteria by which the NRC staff review the development of safety system hardware and software for use in nuclear power plants.

The GEH safety system development process has been approved by the NRC staff as a process that is consistent with the requirements of 10 CFR Part 50, Appendix B. The DIVOM correlation and its scram set point for D&S solutions were developed for use in GE-design BWRs using the GEH safety system development process, thereby addressing the requirements of 10 CFR Part 50, Appendix B.

4.0 TECHNICAL EVALUATION

In NEDO-32465, Supplement 1 (Reference 1), GEH requests NRC staff review and approval of the Detect and Suppress Solutions Licensing Basis Methodology to use TRACG04/P11 for applications to the Option 1-D, Option II, and Option III Stability LTS.

The supplement (Reference 1) presents a series of comparisons of DIVOM calculations using the old TRACG02/P10 and the new TRACG04/P11 methodologies. Because P10 and P11 use different cross section methodologies, extreme care must be taken to develop the two cross section sets so that both represent the same reactor condition. Nevertheless, small differences are to be expected.

The main results of this benchmark indicate that the DIVOM slopes calculated by both methodologies are essentially identical, with the new TRACG04/P11 methodology being slightly more conservative (larger DIVOM slope) than TRACG02/P10. These benchmarks are reproduced here as Figure 4 and 5. The NRC staff notes that in these figures the red line (TRACG04/P11) is slightly higher than the blue line (TRACG02/P10), which results in lower values of the scram setpoint and is more conservative.

As stated previously, the changes in TRACG04 relevant to DIVOM calculations are: (1) upgrade from P10 to P11, (2) the use of PRIME for fuel thermal conductivity models, and (3) upgrade of the pump characteristics. These changes are acceptable and do not significantly affect the quality of the DIVOM slope calculation, as demonstrated by the previous benchmarks.

In the response to RAI 14 in Reference 15, GEH provided the results of a benchmark of the TRACG04 code against recent periodic dryout tests for modern fuel bundles. The onset of boiling transition is predicted using the GEXL correlation, developed for each fuel product type using full-scale critical power test data. As part of this full-scale test data, the fuel bundle is subjected to oscillatory flow conditions that result in periodic dryout and rewet. The resulting temperature oscillations on the heated fuel rods were modeled with TRACG04 and the GEXL correlation and compared with the measured temperature transients. Complete details are provided in the response to RAI 14 (Reference 15). Figure 6 thru Figure 8 show some examples for the most recent tests with GE14 and GNF2 type fuel. [[

]], and the CPR margin is

calculated using the GEXL correlation. Reasonable agreement is observed between the calculated and measured rod temperatures, [[ ]].

Additional oscillatory dryout tests are documented in Section 3.6.1 of the TRACG Qualification Report (Reference 7). Based on this experimental data, the NRC staff concludes that the GEXL correlation implemented in TRACG can predict oscillatory conditions of the kind considered in DIVOM calculations.

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Figure 6. Test flow oscillations, imposed to TRACG as boundary condition

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Figure 7. Fuel temperature oscillation predicted by TRACG compared to measurements

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Figure 8. Fuel temperature oscillation predicted by TRACG compared to measurements

In Sections 3 and 7 of the TRACG Qualification Report (Reference 7), GEH has documented a number of successful TRACG benchmarks against plant stability tests and events, including

1. LaSalle Instability Event
2. Leibstadt Stability Tests
3. Nine Mile Point 2 Instability Event
4. Peach Bottom 2 Stability Tests
5. FRIGG Stability Tests

5.0 RAI RESOLUTION

The NRC staff requested additional information from GEH about a number of topics. Most of these RAI questions were for clarifications to the statements in the TR, or requests to define more specifically the methodology for future applications. The detailed responses are documented in (Reference 14). The staff reviewed the responses to the RAI questions and found them acceptable. No open issues remain following this evaluation. Below is a summary of the RAI responses.

5.1. RAI-1 - TRACG04 Configuration Options:

Please specify the required TRACG04 configuration options (where TRACG represents the Transient Reactor Analysis Code – GEH proprietary version) for DIVOM [Delta CPR over Initial MCPR Versus Oscillation Magnitude] calculations (e.g., full-core channel mapping, axial nodalization, semi-implicit method, etc.).

The RAI question response provides the configuration options for TRACG04 DIVOM calculations, including the channel mapping, axial nodalization, and the requirement to use the [[ ]].

5.2. RAI-2 – Approved Code Versions:

NEDO-32465, Supplement 1, Revision 0 states that "The NRC has examined the capability and qualification of P11/TGBLA06 through numerous applications" (where P11 represents PANAC11, a boiling water reactor core simulator methodology, coupled with TGBLA06, a fuel lattice physics methodology used to provide lattice input to nuclear design and analysis methods). Please provide a list of references of approved ("-A") licensing topical reports (LTRs) that use the P11/TGBLA06 methodology.

The references were provided. Previously approved applications of TRACG04 with the P11/TGBLA06 neutronic models include anticipated operation occurrence (AOO) and anticipated transient without scram (ATWS) overpressure analyses, Economic Simplified BWR (ESBWR) transients, ESBWR stability analyses (Reference 13), and ESBWR ATWS. In addition, TRACG04/P11 was used extensively in the preparation of the TR NEDC-33173, "Applicability of GE Methods to Expanded Operating Domains" (Reference 18).

5.3. RAI-3 – Applicability To New Fuels:

Please describe the applicability of the DIVOM methodology with TRACG04/P11 (TRACG04 coupled with PANAC11) in NEDO-32465, Supplement 1 to new fuels and fuels from other vendors. Is a review process required for new fuels before application of P11/TGBLA06?

In the response to the RAI question, GEH clarifies that the DIVOM methodology is plant- and cycle-specific. As such, the TRACG04/P11 analysis includes the detailed bundle design, whether it is from GEH/Global Nuclear Fuel – Americas, LLC (GNF) or from other fuel vendors. Therefore, the TRACG04/P11 DIVOM methodology is applicable to current and new fuel designs from GEH/GNF and/or other fuel vendors. The qualification of P11/TGBLA06 to new fuel designs involves a comparison of key parameters such as the eigenvalue, void coefficient and control rod worth to the corresponding parameters produced with MCNP [Monte Carlo N-Particle code]. The NRC staff finds GEH's evaluation acceptable.

5.4. RAI-4 – Fuel Properties:

As part of the TRACG04 upgrade, PRIME (a fuel rod thermal mechanical code) is used to calculate fuel properties. What codes or methodologies were used to calculate the fuel properties in the sample cases in Figures 4-18 to 4-23?

In the RAI question response, GEH clarifies that consistent fuel properties have been used for all calculations. When a calculation is marked as TRACG02/P10, the GESTR thermal mechanical code was used to derive the fuel properties. For calculations marked TRACG04/P11, PRIME was used.

5.5. RAI-5 – Channel Grouping:

As part of the new TRACG04 methodology, stability calculations are performed with full one-to-one channel mapping; however, old TRACG02/P10 applications used channel grouping (typically approximately 30 thermal-hydraulic channels). What channel grouping was used for the sample cases in Figures 4-18 to 4-23? Please describe any impact on DIVOM slopes of the new channel grouping strategy.

In the RAI question response, GEH clarifies that the new TRACG04 methodology that uses one-to-one channel mapping only applies to DSS-CD, as described in Reference 9. For Solution III DIVOM calculations, the channel grouping strategy documented in the response to RAI question 1 above is used.

5.6. RAI-6 – Natural Circulation HCOM:

Section 4.2 of NEDO-32465, Supplement 1 states that HCOM values at natural circulation are typically between 0.8 and 1.0. In Figure 5-4, a single HCOM value of approximately 1.05 is marked in the figure. How can a bounding DIVOM slope be defined with only one HCOM value instead of a range? Please explain the example of Figure 5-4.

In the RAI question response, GEH clarifies that for normal Solution III applications, a HCOM range would be used. However, for Solution ID applications, a single HCOM value specified by the methodology is used. In the particular case of Figure 5-4 of the TR, the purpose of that calculation was to compare the performance of TRACG02/P10 with TRACG04/P11; for purposes of this comparison, a single known HCOM value was used.

6.0 CONCLUSION

Based on its review of the subject TR, as stated above, the NRC staff has reached the following conclusions:

1. The TRACG04/P11 code suite is qualified to model the growing unstable power oscillations that are required for the DIVOM calculation procedures.

2. TRACG04/P11 can correctly predict the onset of dryout conditions during power oscillations representative of instabilities.

3. Therefore, the use of TRACG04 for DIVOM stability calculations is acceptable for ~~BWR/3-6 plants~~BWRs employing ~~any approved D&S stability solution like Solutions ID, II or III~~the long term stability solutions Option I-D, Option II, or Option III.

4. The TRACG04 DIVOM application may include all power/flow domains and all licensed operational enhancements where the Long Term Solution is applicable.

5. Key fuel parameters are explicitly input to the TRACG04 model. Therefore the applicability of TRACG04 for DIVOM applications is not limited to the fuels demonstrated in NEDO-32465 Supplement 1 (Reference 1). The methodology may be applied to future fuels types, including fuel designs from other vendors.

7.0 REFERENCES

1. NEDO-32465 Supplement 1. “Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications,” GE Hitachi Nuclear Energy. September 2011.

2. NEDO-32465-A. “Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications,” GE Nuclear Energy. August 1996.

3. 0000-0115-7421-R0. “TRACG04P DIVOM 10 CFR 50.59 Evaluation Basis,” GE Hitachi Nuclear Energy. April 2010.

4. NEDC-33075P-A, Revision 8. “GE Hitachi Boiling Water Reactor Detect and Suppress Solution – Confirmation Density,” GE Hitachi Nuclear Energy, November 19, 2013.

5. NEDE-33147P-A, Revision 4, “DSS-CD TRACG Application,” GE Hitachi, August 12, 2013.

6. NEDE-32176P, Revision 4. "TRACG Model Description," GE Hitachi Nuclear Energy. January 2008.

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