GE ENERGY

Proprietary Notice
This letter forwards proprietary information in accordance with 10CFR2.390. The balance of this letter may be considered non-proprietary upon the removal of Enclosure 1.

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MFN 07-097
March 9, 2007

U.S Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: Draft Safety Evaluation for General Electric (GE) Licensing Topical Report (LTR) NEDE-33147P, Revision 1, "DSS-CD TRACG Application" (TAC No. MC1967)

By Reference 1, the NRC provided GE with the draft Safety Evaluation (SE) regarding its review of NEDC-33147P, Rev. 1 and requested a review of the SE for proprietary content and to comment on any factual errors or clarity concerns. GE has completed the review and documented its comments in the enclosure.

Revision bars identify the comments. Suggested additions are indicated by underlined text, and proposed deletions are shown by strikeout. Proprietary information is identified by a double underline inside double square brackets.

Enclosure 1 contains proprietary information of the type that GE maintains in confidence and withholds from public disclosure. The information has been handled and classified as proprietary to GE as indicated in the affidavit. The affidavit contained within NEDC-33147P is applicable to the information provided in Enclosure 1 and identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GE. GE hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. Enclosure 2 is a non-proprietary version of Enclosure 1.

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If you have any questions, please contact, Mike Lalor at (408) 925-2443 or myself.

Sincerely,

R. E. Brown

Robert E. Brown
General Manager, Regulatory Affairs

Project No. 710

Reference:

1. NRC letter, S.L. Rosenberg (NRC) to R.E. Brown (GE), MFN 07-051, " Draft Safety Evaluation for General Electric Nuclear Energy (GENE) Topical Report (TR) Revision 1 to NEDE-33147P, Revision 1, "DSS-CD TRACG Application" ", dated January 11, 2007

Enclosures:

1. Comments on Draft SE for NEDE-33174P, DSS-CD TRACG Application- Proprietary

2. Comments on Draft SE for NEDE-33174P, DSS-CD TRACG Application - Non-proprietary

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ENCLOSURE 1

MFN 07-097

Comments on Draft SE for NEDE-33174P, DSS-CD TRACG Application

GE Proprietary Information

PROPRIETARY INFORMATION NOTICE

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GE proprietary information is identified by a double underline inside double square brackets. In each case, the superscript notation{3} refers to Paragraph (3) of the affidavit provided in NEDE-33147P 3, which documents the basis for the proprietary determination. [[This sentence is an example.{3}]] Specific information that is not so marked is not GE proprietary.

ENCLOSURE 2

MFN 07-097

Comments on Draft SE for NEDE-33174P, DSS-CD TRACG Application

Non-Proprietary Version

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1 to MFN 07-097, which has the proprietary information removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]]

Non-Proprietary Version

DRAFT SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) NEDE-33147P

"DSS-CD TRACG APPLICATION"

GENERAL ELECTRIC NUCLEAR ENERGY

PROJECT NO. 710

1.0 INTRODUCTION AND BACKGROUND

By letter dated February 27, 2004, General Electric (GE) Nuclear Energy (GENE) requested U.S. Nuclear Regulatory Commission (NRC) review of licensing TR NEDE-33147P, "DSS-CD TRACG Application" (Reference 1). Revision 1 to NEDE-33147P was issued on May 23, 2006 (Reference 2). The purpose of TR NEDE-33147P is to provide an approach to confirm the minimum critical power ratio (MCPR) margin during reasonably limiting instability event simulations for Detect and Suppress Solution - Confirmation Density (DSS-CD) applications. TR NEDE-33075P (Reference 3) provides the DSS-CD generic licensing basis for GE boiling water reactor (BWR)/3-6 product lines and describes a standard procedure for plant-specific confirmations of reload designs and other design changes that may affect the DSS-CD generic licensing basis. TR NEDE-33075P was approved by NRC staff safety evaluation report, dated November 27, 2006 (Reference 4). The DSS-CD solution includes four separate algorithms for detecting stability related oscillations: Confirmation Density Algorithm (CDA), Period Based Detection Algorithm (PBDA), Amplitude Based Algorithm (ABA), and Growth Rate Algorithm (GRA). The PBDA, ABA, and GRA detection algorithms provide the protection basis for TR Option III (Reference 5). They are in DSS-CD as defense-in-depth algorithms and are not part of the licensing basis for the DSS-CD solution, which is accomplished solely by the CDA. The CDA is designed to recognize an instability and initiate control rod insertion before the power oscillations increase much above the noise level.

TRACG is a GE proprietary version of the Transient Reactor Analysis Code (TRAC). The TRACG code model description, qualification, application for anticipated operational occurrences (AOOs), and use in the DSS-CD process are documented in TRs NEDE-32176P (Reference 6), NEDE-32177P (Reference 7), NEDE-32906P-A (Reference 8), and NEDE-33075P (Reference 3). TR NEDE-33075P was approved by NRC staff safety evaluation report, dated November 27, 2006 (Reference 4). TR NEDE-33147P, Revision 1, incorporates the essential information from the above four TRs to describe and justify the use of TRACG for modeling instabilities in the DSS-CD process.

The NRC staff review includes TR NEDE-33147P and Revision 1 (References 1 and 2) and responses to the NRC staff Requests for Additional Information (Reference 9). The NRC staff was assisted in its review by its consultant, Information Systems Laboratories, Inc. (ISL), who wrote the attached technical evaluation report (TER). The details of the review are given in the attachment. The NRC staff reviewed the attached TER and adopted the findings recommended

by ISL.

2.0 REGULATORY EVALUATION

The DSS-CD design provides the capability for automatic detection and suppression of reactor instability events and minimizes reliance on the operator to suppress instability events. The CDA is designed to recognize an instability and initiate control rod insertion before the power oscillations increase much above the noise level. The DSS-CD solution and related licensing basis were developed to comply with the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," Criteria 10 and 12.

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.

The purpose of the DSS-CD TRACG analyses is to confirm the inherent MCPR margin afforded by the solution design. To ensure compliance with Criteria 10 and 12 of Appendix A to 10 CFR Part 50, the NRC staff will confirm that the licensee performed the plant-specific trip setpoint calculations using NRC-approved methodologies as prescribed in NUREG-0800, Standard Review Plan, Section 4, via onsite audits as necessary.

3.0 TECHNICAL EVALUATION

TR NEDE-33147P, Revision 1, provides the licensing basis and methodology to demonstrate the adequacy of the TRACG analyses as part of the DSS-CD solution. The DSS-CD licensing basis consists of two major components: a) an efficient oscillation detection algorithm - the CDA, providing an early trip signal upon instability inception prior to any significant oscillation amplitude growth and MCPR degradation; and b) a set of integrated TRACG event simulations for reasonably limiting anticipated events that confirm the limited effect on the MCPR performance within the stated applicability range. This evaluation only covers component b) and a separate evaluation covers component a). TR NEDE-33147P, Revision 1, describes the licensing requirements and the scope of the TRACG application to DSS-CD, the identification and ranking of BWR phenomena for stability, the applicability of TRACG models to DSS-CD, model uncertainties, the application uncertainties and biases, the combination of uncertainties, and a demonstration analysis.

3.1 TRACG Analyses Approach For Licensing Compliance

The DSS-CD solution and related licensing basis comply with the requirements of Criteria 10 and 12 of Appendix A to 10 CFR Part 50. The overall TRACG demonstration analysis approach for DSS-CD is consistent with the Code Scaling, Application and Uncertainty (CSAU) analysis methodology (NUREG/CR-5249, Reference 10) and Regulatory Guide 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance," and addresses the applicable elements of the NRC-developed CSAU evaluation methodology. As established in Reference 3, Table 2-1 of TR NEDE-33147P, Revision 1, provides a summary of 14 CSAU methodology steps for TRACG.

3.2 Phenomena Identification Ranking

TR NEDE-33075P (Reference 3) presents the phenomena identification ranking table (PIRT) for BWR/3-6 stability transients. The critical safety parameter for stability events is the MCPR. The MCPR value is determined by the governing physical phenomena. The PIRT is used to delineate the important physical phenomena. The PIRTs are ranked with respect to their impact on the critical safety parameters. The PIRT for BWR/3-6 stability transient ~~for two recirculation pump trips (2 RPT)~~ was developed to identify the physical phenomena. The stability transient events have been categorized into three distinct types of instability: 1) channel thermal-hydraulic instability; 2) core-wide instability; and 3) regional instability.

The PIRT serves a number of purposes. First, the phenomena are identified and compared to the modeling capability of the code to assess whether the code has the necessary models to simulate the phenomena. Second, the identified phenomena are cross-referenced to the qualification basis to determine what qualification data are available to assess and qualify the code models and to determine whether additional qualification is needed.

The following 28 phenomena were ranked as high importance for at least one of the instability types considered: 1) channel-bypass leakage flow, 2) core void coefficient, 3) core 3-D kinetics, 4) delayed neutron fraction, 5) subcriticality of first harmonic mode, 6) interfacial shear, 7) subcooled void model, 8) pellet heat distribution, 9) pellet heat transfer parameters, 10) gap conductance, 11) core void distribution - axially and between channels, 12) bundle-bypass leakage flow, 13) natural circulation flows, 14) boiling transition - dryout margin, 15) core pressure drop, 16) separator pressure drop, 17) initial total core flow, 18) initial total core power, 19) initial feedwater temperature, 20) core size, 21) core loading pattern, 22) core exposure, 23) core axial power distribution, 24) hot channel axial power distribution, 25) radial power distribution, 26) control rod pattern, 27) initial MCPR, and 28) mixed core effect. The dominant phenomena for a BWR instability are captured by the phenomena ranked as high importance in Reference 3. The TRACG has the capability to simulate the high importance phenomena in the list. Using the PIRT table ranking results, the uncertainties for the highly ranked PIRT phenomena are established and evaluated based on a bounding analysis to arrive at the total model uncertainty.

3.3 Scenario Specifications and MCPR Uncertainty Assessment

Based on GE's review (Reference 3) of all potential anticipated instability event initiators, anticipated instability events may be initiated as a result of: (1) normal operational maneuvers; (2) anticipated events from off-rated operating conditions; or (3) anticipated flow reduction

events from rated conditions. As indicated in Reference 3, the 2 RPT transient with regional mode oscillations for BWR/3-6 was chosen by GE as a reasonably limiting scenario for the confirmation of MCPR margin. The limiting product line was found to be the BWR/6 (i.e., regional mode instabilities increase as core size increase), operating along 120 percent of original licensed thermal power at an initial core flow of 80 percent and the 2 RPT transient down to natural circulation flow rates as the limiting scenario, which is a reasonably limiting event for investigation of the margin associated with DSS-CD.

GE has performed ~~the TRACG calculations applying a~~ [[ ]] ~~at their limits. The results demonstrate that, even for these very large~~a representative TRACG calculation with [[ ]] This results in a [[ ]] increase in the critical power ratio (CPR) oscillations relative to the nominal case results. This analysis shows that even with these very large combined uncertainties, DSS-CD provides sufficient protection before safety limits are violated.

This [[ ]] value was calculated to demonstrate the CSAU bounding value for the stability application and is not intended to establish DSS-CD CPR confirmation methodology or licensing basis.

The NRC staff has reviewed GE§s approach and found that the proposed~~limiting~~ scenario and resultant [[ ]] bounding uncertainty for ~~the~~this analysis ~~are~~is acceptable. This is acceptable because of the early detection and efficient suppression of the DSS-CD approach, and because the ~~application~~demonstration of [[ ]] relative uncertainty to the oscillation ΔCPR of the example BWR/6 case (Case number 10080RG6 of Reference 3) ~~still resulted in significant ΔCPR margin to the safety limit MCPR (SLMCPR).~~is consistent with [[ ]]

3.4 Applicability of TRACG to DSS-CD Applications

It is a two-step process to demonstrate the applicability of TRACG for the analysis of anticipated instability events in BWRs. First, the identified phenomena are compared to the modeling capability of the code to determine that the code has the necessary models to simulate the phenomena as shown in Table 4-1 of NEDE-33147P, Revision 1. Second, the capability of the TRACG models to treat the highly ranked phenomena and the qualification assessment of the TRACG code for stability application are examined as shown in Table 4-2 of TR NEDE-33147P, Revision 1.

3.4.1 TRACG Code Qualification

The TRACG code is used to simulate limiting events to confirm the DSS-CD solution early oscillation detection and suppression capability. TRACG is a multi-dimensional, two-fluid thermal-hydraulic computer code including three-dimensional transient neutronics capability to model the phenomena that are important in evaluating the operation of BWRs. Best-estimate analyses performed with TRACG have been approved by the NRC to support licensing applications in different areas, including specific thermal-hydraulic instability performance and AOO transients. TRACG has been extensively qualified against separate effects tests, component performance data, integral system effects tests, and full-scale BWR plant data. Section 5 of TR NEDE-33075P, Revision 5 (Reference 3) provides a limited ~~TRACG~~ description of the TRACG qualification. TR NEDE-33075P was approved by NRC staff safety evaluation report, dated November 27, 2006 (Reference 4).

3.4.2 Thermal-Hydraulic Modeling

The thermal-hydraulic model in TRACG is based on a multi-dimensional, two-fluid, two-phase flow model, that solves the transient governing conservation equations for the different fluid components that make up a BWR nuclear reactor system. In addition, it also includes TRACG fluid model and closure models. Assessment or qualification of these models is documented in Reference 7. The models and the assessment of these models indicate that the thermal-hydraulic models are capable of capturing the dominant phenomena expected during a BWR power instability event. The TRACG thermal-hydraulic instability modeling has been evaluated for adequacy by comparison to experimental data of the FRIGG research facility in Sweden.

The NRC staff has reviewed the subject submittal (References 1 and 2) and the responses to RAIs (Reference 9) and concluded that the thermal-hydraulic modeling is acceptable because: 1) TRACG includes models required to simulate the dominant thermal-hydraulic phenomena through the PIRT method; and 2) ~~the~~separate ~~uncertainty associated with these thermal-hydraulic models is bounded by the bounding CSAU calculation in the change for the oscillatory ΔCPR/CPR as approximately~~ [[ ]] conservative uncertainties are applied to the [[ ]] for the DSS-CD bounding uncertainty procedure. [[ ]] These combined uncertainties bound the expected results from a CSAU statistical approach.

3.4.3 Transient 3-D Neutronics Modeling

The transient three-dimensional (3-D) neutronics model is consistent with the GE 3-D BWR core simulator. The TRACG solved the 3-D transient neutron diffusion equations using one neutron energy group and up to six delayed neutron precursor groups. Feedback is provided from the thermal-hydraulics model for moderator density (i.e., void fraction), fuel temperature, boron concentration, and control rod position. For BWR instabilities, the most important feedback is due to changes in moderator density/void fraction.

Based on the evaluation of the responses to RAIs, the NRC staff concludes that the approach for the TRACG 3-D transient neutronics model is acceptable because: 1) it is capable of simulating the dominant phenomena associated with operating BWR power driven instabilities; 2) the PIRT for operating BWR power instabilities identifies the dominant 3-D neutronics

phenomena required to model power instabilities; and 3) the uncertainties associated with these models are bounded by the ~~bounding CSAU calculation in approximately~~ [[
]]

3.4.4 Coupling between Thermal-Hydraulic and Neutronics Models

The thermal-hydraulic and neutronics models in TRACG are coupled in a semi-implicit method. The amplitude and shape functions are extrapolated to the new time level to provide the power distribution required to advance the thermal-hydraulic solution to the new time level. The resulting new time level fluid conditions based on the extrapolated power are used to determine the new time nuclear parameters that are a function of fluid conditions and fuel rod temperatures. These new time nuclear parameters are used to calculate the new 3D neutronics solution.

The NRC staff concludes that the approach is acceptable because: 1) the TRACG coupling between the thermal-hydraulic and neutronics model would simulate operating BWR power oscillations; 2) time step sensitivity studies indicate no significant accumulation of transient analysis error for BWR instability calculation; and 3) the uncertainty associated with the coupling of these two models is bounded by the ~~bounding CSAU calculation in approximately~~ [[
]]

3.4.5 Bounding CSAU Total Uncertainty Demonstration

A bounding approach is based on combining the total biases and uncertainties so that a bounding result is obtained. The bounding CSAU calculation was defined by the high importance phenomena (such as power, core flow, exposure, etc.) set to reasonably bounding values. The remaining high importance model parameters, plant parameters, and initial conditions are perturbed, which results in the shortest time for the hot channel CPR to violate the SLMCPR. The total bounding uncertainty is obtained by performing a TRACG calculation with the high importance phenomena at bounding values. This bounding CSAU demonstration calculation results in an uncertainty of [[ ]] in the ΔCPR/CPR for the BWR power instability.

The NRC staff finds this approach demonstration acceptable because: 1) TRACG has capability to simulate the dominant phenomena associated with BWR power instabilities; 2) the bounding CSAU uncertainty for the ΔCPR/CPR for the BWR power instability is [[

]]

4.0 LIMITATIONS AND CONDITIONS

The NRC staff will require a submittal for review if [[ ]]a change in the process to bound the uncertainty in the MCPR is proposed ~~for TRACG is proposed~~.

5.0 CONCLUSION

The NRC staff has reviewed TR NEDE-33147P and Revision 1 (References 1 and 2), and the response to the NRC staff RAIs (Reference 9) and concluded that TR NEDE-33147P, Revision 1, is acceptable because:

1. The TRACG includes models required to simulate the dominant phenomena associated with operating BWR power oscillation.

2. The TRACG models and simulation capability have been assessed against separate effects, integral and plant data for operating BWR power oscillations, and have been shown to be accurate, and capture the dominant phenomena.

3. For BWR power oscillations the dominant phenomena and the bounding uncertainty associated with the dominant phenomena were determined for TRACG.

4. The bounding uncertainty analysis for a reasonably limiting 2 RPT event for a BWR/6 at maximum extended load line limit plus (MELLLA+)/minimum core flow with all uncertainties for the highly ranked PIRT variables [[ ]] results in an [[ ]]for ~~TRACG oscillation ΔCPR/CPR .~~ the TRACG calculated ~~5.~~ [[ ]] ~~is bounding.~~oscillation in ΔCPR/CPR.

5. [[ ]].

6.0 REFERENCES

1. NEDE-33147P, Revision 0, "DSS-CD TRACG Application," MFN 04-019, February 27, 2004 (ADAMS Package Accession No. ML040630649).

2. NEDE-33147P, Revision 1, "DSS-CD TRACG Application," MFN 06-153, May 23, 2006 (ADAMS Package Accession No. ML063410124).

3. NEDE-33075P, Revision 5, "General Electric Boiling Water Reactor Detect and Suppress Solution - Confirmation Density," MFN 05-145, December 1, 2005 (ADAMS Package Accession No. ML053420450).

4. Letter, USNRC to R. E. Brown (GE), Final Safety Evaluation for General Electric Nuclear Energy (GENE) Licensing Topical Report (LTR) NEDC-33075P, Revision 5, "General Electric Boiling Water Reactor Detect and Suppress Solution - Confirmation Density" (TAC No. MC1737), November 27, 2006 (ADAMS Accession No. ML062640346).

5. NEDO-32465-A, BWR Owners' Group Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications, August 1996 (ADAMS Legacy Library Accession No. 9609230137).

6. NEDE-32176P, Revision 2, "TRACG Model Description," December 1999.

7. NEDE-32177P, Revision 2, "TRACG Qualification," January 2000.

8. NEDE-32906P-A, Revision 1, "TRACG Application for Anticipated Operational Occurrences Transient Analysis," April 2003.

9. Letter, G. B. Stramback (GE) to USNRC, Responses to DSS-CD TRACG TR RAIs, MFN 05-133, November 11, 2005.

10. USNRC, NUREG/CR-5249, "Quantifying Reactor Safety Margins: Application of Code Scaling, Applicability, and Uncertainty Evaluation Methodology to a Large-Break, Loss-of-Coolant Accident," December 1989 (ADAMS Package Accession No. ML030380503).

Attachment: TER

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