GE Nuclear Energy

175 Curtner Avenue
San Jose, CA 95125

NEDO-23785-A
Supplement 1 Revision 1
DRF 0000-0000-1822
Class I
April 2002

GESTR-LOCA and SAFER Models for Evaluation of Loss-of-Coolant Accident Volume III, Supplement 1

Additional Information for Upper Bound PCT Calculation

D.C. Pappone

Approved: J.F. Klapproth

J.F. Klapproth, Manager
Engineering and Technology

DISCLAIMER OF RESPONSIBILITY

Neither GE nor any of the contributors to this document:

- Makes any representation or warranty (express or implied) as to the completeness, accuracy or usefulness of the information contained in this document or that such use of any information may not infringe privately owned rights; or

- Assumes any responsibility for liability or damage of any kind that may result from any use of such information.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 1, 2002

MFN:02-009

Mr. James F. Klapproth, Manager
Engineering & Technology
GE Nuclear Energy
175 Curtner Ave
San Jose, CA 95125

SUBJECT: REVIEW OF NEDE-23785P, VOL. III, SUPPLEMENT 1, REVISION 1, "GESTR-LOCA AND SAFER MODELS FOR EVALUATION OF LOSS-OF-COOLANT ACCIDENT VOLUME III, SUPPLEMENT 1, ADDITIONAL INFORMATION FOR UPPER BOUND PCT CALCULATION" (TAC NO. MB2774)

Dear Mr. Klapproth:

By letter dated August 21, 2001, and revised October 16, 2001, GE Nuclear Energy (GENE) provided the subject licensing topical report to support their request for elimination of the limit imposed on the upper bound peak cladding temperature (PCT) related to the use of the SAFER/GESTR-LOCA analysis methodology. The NRC staff's review found that the upper bound PCT limit of 1600°F was no longer necessary when using the SAFER/GESTR-LOCA methodology. The NRC staff also found that means other than conducting plant-specific upper bound PCT calculations were acceptable for demonstrating the conservatism of licensing-basis analyses with respect to the reference emergency core cooling system configuration.

The staff finds that the subject topical report is acceptable for referencing in licensing applications to the extent specified under the limitations delineated in the report and in the associated NRC safety evaluation. The enclosed safety evaluation defines the basis for acceptance of the topical report.

The NRC requests that GENE publish an accepted version of the revised Topical Report NEDE-23785P within 3 months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed safety evaluation between the title page and the abstract, and add a "-A" (designating accepted) following the report identification number (i.e., NEDE-23785P-A).

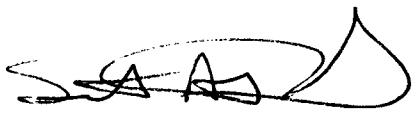
If the NRC's criteria or regulations change so that its conclusion in this letter that the topical report is acceptable is invalidated, GENE and/or the applicant referencing the topical report will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Pursuant to 10 CFR 2.790, we have determined that the enclosed safety evaluation does not contain proprietary information. However, we will delay placing the safety evaluation in the public document room for a period of ten (10) working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that

any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

If you have any questions, please contact Joseph Donoghue, GENE Project Manager, at (301) 415-1131.

Sincerely,



Stuart A. Richards, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 710

Enclosure: Safety Evaluation

cc w/encl: See next page

cc:
Mr. George B. Stramback
Regulatory Services Project Manager
GE Nuclear Energy
175 Curtner Avenue
San Jose, CA 95125

Mr. Charles M. Vaughan, Manager
Facility Licensing
Global Nuclear Fuel
P.O. Box 780
Wilmington, NC 28402

Mr. Glen A. Watford, Manager
Nuclear Fuel Engineering
Global Nuclear Fuel
P.O. Box 780
Wilmington, NC 28402

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

GE NUCLEAR ENERGY TOPICAL REPORT

NEDE-23785P, VOL. III, SUPPLEMENT 1, REVISION 1, "GESTR-LOCA AND SAFER MODELS FOR EVALUATION OF LOSS-OF-COOLANT ACCIDENT VOLUME III, SUPPLEMENT 1, ADDITIONAL INFORMATION FOR UPPER BOUND PCT CALCULATION"

PROJECT NO. 710

1.0 BACKGROUND

By letter dated August 21, 2001 (Reference 1), and revised October 16, 2001 (Reference 2), GE Nuclear Energy (GENE) provided information supporting their request for elimination of the upper bound peak cladding temperature (PCT) limit on use of the SAFER/GESTR LOCA analysis code. The SAFER/GESTR methodology is documented in a previous GENE submittal (Reference 3). In their review of the SAFER/GESTR methodology documented in Reference 4, the staff determined that there was not sufficient support to use the methodology in cases where calculated cladding temperatures exceeded 1600°F. Thus, the safety evaluation limited the use of the methodology for cases where the calculated PCT did not exceed 1600°F. If applicants wish to use the methodology for calculated PCTs in excess of the limit, additional supporting information is needed to assure that the upper bound PCT is sufficiently conservative.

GENE stated that the original intent of the SAFER/GESTR-LOCA methodology was to use a one-time generic upper bound PCT calculation to demonstrate that the process used to calculate the licensing basis PCT was sufficiently conservative. Due to the limitation placed on the methodology, licensees have conducted plant-specific calculations of the upper bound PCT. The GENE request in this submittal seeks to eliminate the need for licensees to conduct these calculations.

2.0 STAFF EVALUATION

In Reference 4, the staff imposed an upper bound temperature limit of 1600°F on PCT calculations using the SAFER/GESTR methodology in large part because of a lack of data for cladding temperatures above that point. In its safety evaluation the staff determined that:

> The application methodology is acceptable therefore for cases where the calculated upper bound PCT is less than 1600°F. Above this value, additional supporting information is needed to provide assurance that the upper bound PCT prediction is sufficiently conservative.

The staff has since reviewed another methodology proposed by GENE, SAFER/CORECOOL (Reference 5), for use with both jet pump and non-jet pump plants. SAFER is used in this methodology to provide the boundary conditions for the clad heatup calculation performed by CORECOOL. The NRC approved the SAFER/CORECOOL methodology for both jet pump and non-jet pump plants (References 6 and 7).

The CORECOOL methodology was assessed versus clad temperature data approaching the 10 CFR 50.46 limit of 2200°F. Assessment calculations provided by GENE demonstrate that the CORECOOL methodology is conservative in prediction of rod temperatures for the entire temperature range, including those in excess of 1600°F. Comparison calculations have been performed for SAFER and CORECOOL for both jet pump and non-jet pump plants. The non-jet pump plant comparison indicates that SAFER calculates a higher PCT than does CORECOOL for the entire time of the transient. In the case of the jet pump plant comparison, SAFER calculates a higher cladding temperature than does CORECOOL for the heatup phase, PCT, and most of the quenching phase of the transient.

GENE has performed additional comparison calculations using the TRACG thermal-hydraulic analysis code. While TRACG has not been reviewed and approved by the staff for this purpose, the code performs in a similar fashion to the staff's TRAC-B code. Also as documented in Reference 8, the staff reviewed and approved TRACG for anticipated operational occurrence analysis. In all cases analyzed for a typical BWR/4 design, SAFER predicts a higher second cladding temperature peak than does TRACG.

In addition, the use of the SAFER/GESTR LOCA methodology is for an upper bound PCT calculation. The proposed change does not affect the requirement for licensees to demonstrate that the limits set forth in 10 CFR 50.46 will be met based on the results of licensing basis calculations. That is, the PCT shall not exceed 2200°F, the cladding oxidation shall not exceed 0.17 times the total cladding thickness before oxidation, the total amount of hydrogen generated from chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding were to react, and that changes in the core shall be such that the core remains amenable to cooling.

On the basis of code-to-code computational comparisons, the staff finds removal of the upper bound PCT limit of 1600°F for the SAFER/GESTR-LOCA methodology to be acceptable.

In Reference 4, to apply SAFER/GESTR, the staff required confirmation that plant-specific operating parameters have been conservatively bounded by the models and inputs used in the generic analyses. In addition, the staff required confirmation that the plant-specific emergency core cooling system (ECCS) configuration is consistent with the reference plant class ECCS configuration. In these cases, GENE has satisfied these requirements by performing plant-specific upper bound PCT calculations to demonstrate that the licensing basis analysis is sufficiently conservative. GENE has further stated that because a large number of such calculations have now been performed for the entire GE boiling water reactor (BWR) product line, that it is appropriate to eliminate further calculations of plant-specific upper bound PCTs. The staff notes that GENE determined that plant-specific upper bound PCT calculations would be the basis for meeting the staff's requirements in Reference 4.

The staff also notes that GENE has performed the plant-specific upper bound PCT calculations for its entire product line. Unless there are significant changes to a plant's configuration that would invalidate the existing calculations, other means, such as demonstrating the magnitude of a change in PCT for a change in fuel design, may be used to satisfy the staff's safety evaluation limitation.

3.0 CONCLUSIONS

After review of the GENE submittal regarding calculation of upper bound PCT using the SAFER/GESTR-LOCA methodology, the staff concludes that sufficient information has been provided via code-to-code comparisons to eliminate the 1600°F limit on calculated upper bound PCT. The staff also concludes that the existing limitation on plant-specific application of the upper bound PCT methodology can be satisfied by means other than recalculation of a plant-specific upper bound PCT.

4.0 REFERENCES

1. Letter J. F. Klapproth, GE, to NRC, "Transmittal of GE Proprietary Licensing Topical Report NEDE-23785P, Vol. III, Supplement 1, Revision 1, 'GESTR-LOCA and SAFER Models for Evaluation of Loss-of-Coolant Accident Volume III, Supplement 1, Additional Information for Upper Bound PCT Calculation'," dated August 21, 2001.

2. Letter J. F. Klapproth, GE, to NRC, Same subject, dated October 16, 2001.

3. NEDE-23785-1-PA, Rev. 1, "The GESTR-LOCA and SAFER Models for Evaluation of the Loss-of-Coolant Accident (Volume III), SAFER/GESTR Application Methodology," October 1984.

4. C. O. Thomas, NRC, to J. F. Quirk, GE, "Acceptance for Referencing of Licensing Topical Report NEDE-23785 Revision 1, Volume III(P), 'The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident'," June 1, 1984.

5. NEDE-30966P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volume I, SAFER - Long Term Inventory Model for BWR Loss-of-Coolant Analysis," October 1987.

6. G. C. Lainas, NRC, to H. C. Pfefferlen, GE, "Review of NEDE-30996(P), 'SAFER Models for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volumes I and II'," February 19, 1987.

7. NEDE-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volume II, SAFER Application Methodology," October 1987.

8. Safety Evaluation by the Office of Nuclear Reactor Regulation for NEDE-32906P, "TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses," July 2001.

Principal Contributor: R. Landry

Date: February 1, 2002

There is no written Request for Additional Information (RAI) associated with this approved GE document.

TABLE OF CONTENTS

LIST OF FIGURES

ADDITIONAL INFORMATION FOR UPPER BOUND PCT CALCULATION

In the SAFER/GESTR-LOCA application methodology, both a licensing basis peak cladding temperature (PCT) and an upper bound PCT are calculated. The purpose of the licensing basis PCT is to demonstrate compliance with the acceptance criteria of 10CFR50.46. The purpose of the upper bound PCT calculation is to demonstrate that the licensing basis PCT is sufficiently conservative. The NRC Safety Evaluation Report (SER) approving the SAFER/GESTR-LOCA application methodology imposed a restriction of 1600°F on the upper bound PCT. The SER required additional supporting information be provided to assure that the upper bound PCT calculation is sufficiently conservative at temperatures above 1600°F. This supplement provides additional supporting information to justify that the licensing basis and upper bound PCTs are sufficiently conservative even though the upper bound PCT may exceed 1600°F and that an explicit limit on the upper bound PCT is not needed.

The original intent of the SAFER/GESTR-LOCA application methodology was to use a one-time generic upper bound PCT calculation to demonstrate that the process used to calculate the licensing basis PCT was sufficiently conservative. In practice, the upper bound PCT has been calculated on a plant-specific basis in order to address the SER conditions on the applicability of the generic upper bound PCT calculation. This supplement provides justification for the elimination of the plant-specific upper bound PCT calculation.

1. BACKGROUND

The SAFER application methodology (Reference 1) was developed to meet the requirements of SECY 83-472 (Reference 2), which presented an interim approach whereby more realistic evaluation models could be used for LOCA calculations and still meet the requirements of 10CFR50 Appendix K. Approval of the SAFER application methodology is documented in Reference 3. The current version of the SAFER code and further details for the application methodology are described in Reference 4. In Reference 5, the NRC documented that no further review of the changes described in Reference 4 was required. The limiting LOCA, defined by the combination of break size, location, and worst single failure which results in the highest calculated PCT, is determined based on nominal models and assumptions. A licensing basis PCT is then calculated for the limiting LOCA using the nominal model augmented only with the required models of Appendix K. This licensing basis PCT is used to demonstrate compliance with the acceptance criteria of 10CFR50.46. A 95 percent probability upper bound PCT is also calculated for the limiting LOCA to demonstrate that the licensing basis PCT calculated using the Appendix K models is sufficiently conservative.

The NRC SER approving the SAFER/GESTR-LOCA application methodology restricted the upper bound PCT to 1600°F (Reference 3). This restriction was imposed because: (a) the range of test data submitted as part of the code qualification extended only to 1600°F, and (b) the Monte Carlo simulation presented in the SAFER Licensing Topical Report (LTR) was performed over a temperature range where effects such as metal-water reaction are negligible. The SER states that

> "The application methodology is acceptable therefore for cases where the calculated upper bound PCT is less than 1600°F. Above this value, additional supporting information is needed to provide assurance that the upper bound PCT prediction is sufficiently conservative."

This additional supporting information is provided in the following sections.

The original intent of the SAFER application methodology as described in Section 1 of Reference 1 was to perform the nominal break spectrum calculations and licensing basis PCT calculation on a plant-specific basis. No plant-specific upper bound PCT calculations were planned. The upper bound PCT calculations presented in Appendix A of Reference 1 represented a one-time generic calculation of the 95 percent probability upper bound PCT for different BWR product lines to provide assurance that the application procedure results in calculated licensing basis PCTs that are sufficiently conservative. The NRC SER approving the SAFER/GESTR-LOCA application methodology (Reference 3) placed conditions on the use of the generic upper bound PCTs in plant-specific applications. Because of the range of plant specific operating parameters and ECCS performance parameters within the BWR product lines, the practice has been to calculate the upper bound PCT on a plant-specific basis rather than rely on the generic upper bound PCT calculations in order to demonstrate that the licensing basis PCT is sufficiently conservative. The SAFER/GESTR-LOCA model has been applied to all GE BWRs and the relationship between the licensing basis PCT and upper bound PCT has been well established. Justification for the elimination of the plant-specific upper bound PCT calculation is provided in Section 4.

2. CODE QUALIFICATION AT PCTS GREATER THAN 1600ºF

The NRC SER approving the SAFER/GESTR-LOCA application methodology (Reference 3) restricted the upper bound PCT to 1600°F based in part on the range of test data submitted as part of the code qualification. Subsequent to the SAFER submittal, GE submitted the SAFER/CORECOOL model (Reference 6) to extend the range of applicability of the SAFER model to non-jet pump plants and to higher temperatures. In the SAFER/CORECOOL methodology, the SAFER code provides boundary conditions for the CORECOOL bundle heatup calculation. The NRC has approved the SAFER/CORECOOL model for use in both jet pump and non-jet pump plant applications

(Reference 7). The approved SAFER/CORECOOL application methodology used for non-jet pump plant analyses has no restriction on the upper bound PCT (Reference 8).

[[

]]

Figure 1. Predicted vs. Measured PCT

[[

.]]

Figure 2. SAFER vs. CORECOOL PCT for a Non-Jet Pump Plant

[[

]]

Figure 3. SAFER vs. CORECOOL PCT for a Jet Pump Plant

3. UPPER BOUND PCT CALCULATION

[[

]]

3.1 SAFER Plant Modeling Uncertainty Term (Δ4)

[[

]]

Figure 4. Comparison of SAFER and TRACG PCTs

[[

]]

3.2 SAFER Mean-Nominal Bias Term ($\overline{\Delta 3}$)

[[

]]

3.3 Monte Carlo Simulation (2sΔ3)

[[

]]

Figure 5. Comparison of Upper Bound and Licensing Basis PCT

4. ELIMINATION OF PLANT-SPECIFIC UPPER BOUND PCT CALCULATION

[[

]]

5. CONCLUSIONS

The purpose of the upper bound PCT calculation in the SAFER/GESTR-LOCA methodology is to demonstrate that the licensing basis PCT calculated using the required models of Appendix K is sufficiently conservative. The NRC SER approving the SAFER/GESTR-LOCA application methodology required additional supporting information to assure that the upper bound PCT calculation is sufficiently conservative at temperatures above 1600°F. The reasons given in the SER for the 1600°F limit have been addressed in this supplement. The code qualification against test data has been supplemented at higher temperatures. [[

]]

The SAFER PCT calculation is inherently conservative at higher temperatures due to simplifications in the modeling. This conservatism is demonstrated by comparisons to the PCT results calculated using the more detailed SAFER/CORECOOL and TRACG models. Differences in the methods used to calculate the licensing basis PCT and upper bound PCT ensure that, at higher temperatures, the licensing basis PCT will always be higher than the upper bound PCT. The licensing basis PCT will be restricted by the 2200°F limit in 10CFR50.46 before the upper bound PCT reaches temperature ranges where the metal-water reaction becomes a significant factor. [[

]] Based on the above discussions, both the licensing basis PCT and upper bound PCT calculations will be sufficiently conservative when the upper bound temperatures are calculated to be above 1600°F. Since the licensing basis PCT will always be sufficiently conservative at higher temperatures, there is no need to calculate a plant-specific upper bound PCT. [[

]]

The discussions above demonstrate that at higher temperatures, the licensing basis PCT will always be higher than the upper bound PCT and the plant-specific upper bound PCT calculation is no longer necessary for the purpose of qualifying the licensing basis PCT. [[

]] It is no longer necessary to calculate a plant-specific upper bound PCT for the purpose of qualifying the licensing basis PCT. Therefore, the plant-specific upper bound PCT calculation can be eliminated.

6. REFERENCES

1. NEDE-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for Evaluation of the Loss-of-Coolant Accident (Volume III), SAFER/GESTR Application Methodology," October 1984.

2. SECY-83-472, "Emergency Core Cooling System Analysis Methods," November 17, 1983.

3. Cecil O. Thomas (NRC) to J.F. Quirk (GE), "Acceptance for Referencing of Licensing Topical Report NEDE-23785 Revision 1, Volume III (P), 'The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident,'" June 1, 1984.

4. NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000.

5. Stuart A. Richards (NRC) to Mr. James F. Klapproth (GENE), "General Electric Nuclear Energy (GENE) Topical Reports GENE-32950P and GENE-32084P Acceptability Review," dated May 24, 2000.

6. NEDE-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volume I, SAFER – Long Term Inventory Model for BWR Loss-of-Coolant Analysis," October 1987.

7. Gus C. Lainas (NRC) to H.C. Pfefferlen (GE), "Review of NEDE-30996(P), 'SAFER Models for Evaluation of Loss-of-Coolant Accident for Jet Pump and Non-Jet Pump Plants, Volumes I and II,'" February 19, 1987.

8. NEDE-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volume II, SAFER Application Methodology," October 1987.

9. FLN-2001-13, G.A. Watford (GNF) to J.L Wermiel (NRC), "Summary of Changes and Errors in ECCS Evaluation Models," August 10, 2001.