ENCLOSURE 2

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GE Nuclear Energy

3901 Castle Haynes Rd, Wilmington, NC 28401

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COMPILATION OF IMPROVEMENTS TO GENE'S SAFER ECCS-LOCA EVALUATION MODEL

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Revision History

Revision 0

Initial Issue

Revision 1

1. Revised Section 6.1 to summarize the historical practice.

2. Revised Section 6.2 to reflect the model improvements.

3. Updated the conclusions in Section 6.3.

4. Added Section 8 to address the application of the correlation in the counter current flow limiting model to address an NRC request.

5. Added additional References 11 through 14 in Section 9.

6. Added Section 10 to address NRC questions regarding CCFL

7. Added additional reporting letters (see pages 63 through 106).

1. INTRODUCTION

This report provides a compilation of the corrections and improvements made to GE's SAFER ECCS-LOCA evaluation model since the model was last reviewed and approved by the NRC. This report provides an addendum to the SAFER model description in 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." This report also provides an addendum to the application methodology description in NEDE-23785-1-PA, "The GESTR-LOCA and SAFER Models for Evaluation of the Loss-of-Coolant Accident, Volume III, SAFER/GESTR Application Methodology."

The General Electric LOCA evaluation models based on SAFER/GESTR are shown in Table 1. The models in the second column labeled "Original Approved Method" and their associated application methodology have been approved[3, 4] by the U.S. Nuclear Regulatory Commission (NRC) for application to jet pump plants, i.e., BWR/3 through BWR/6. Reference 3 contains an extensive description of the SAFER models and their qualification for jet pump plant application. An enhanced version of the SAFER model (column 3 labeled "Enhanced Approved Method" of Table 1), which extends its applicability to the non-jet pump, external loop, BWR/2 plants has also been approved[1, 2] by the NRC. This improved version of SAFER incorporates models for more accurate heat transfer analysis at high temperatures and extends the qualification and application of SAFER well beyond the range of temperatures encountered in the previous jet pump plant analysis.

The current set of GE LOCA evaluation models is shown in column 4 labeled "Current Refined Method" of Table 1. Sections 2 through 4 of this document describe refinements made to the SAFER code subsequent to the documentation provided in Reference 1. These models were discussed with the NRC staff in July 1988[5]. The SAFER modifications described in this report have also been documented as part of reporting changes and errors in the Emergency Core Cooling System evaluation methodology under 10CFR50.46. A summary of the reported changes to the SAFER code is provided in Table 2. Changes reflecting more than the simple correction of an implementation coding error for consistency with existing documentation are described in detail in Sections 2 and 3. A complete set of 10CFR50.46 reporting documentation, including the associated impact on the licensing basis PCT, is included as an attachment to this document.

The current set of LOCA analysis methods includes the TASC code as a replacement for the SCAT short-term hot channel model. The use of TASC for LOCA analysis is required to model the axially variable parameters associated with part length fuel rods[6] and is consistent with current transient analysis methods. Reference 7 provides a complete description of the TASC models and qualification for bundles with part-length fuel rods and earlier fully rodded bundle designs. As indicated in Table 1, there have been no changes to the LAMB, CORCOOL or GESTR methods.

Section 5 of this document describes the evaluation of the generic uncertainties used to determine the SAFER Upper Bound PCT. The evaluation addresses current fuel designs and uses the current SAFER version (SAFER04V). The approach used in this evaluation follows the process documented in Reference 4.

Section 6 of this document provides the basis for GENE's approach for evaluating expanded/alternate operating modes in the SAFER/GESTR-LOCA analyses. Neither the SAFER/GESTR-LOCA application methodology LTR[4] nor the NRC SER approving the methodology have specific requirements for how expanded/alternate operating modes are to be evaluated. The practice of evaluating these modes as sensitivity studies has been used consistently for all plant SAFER evaluations. The NRC has reviewed and accepted plant-specific SAFER evaluations and operating mode licensing submittals that use this practice.

Section 7 of this document provides a discussion of the time varying axial power shape due to the control rod insertion during the scram. The time varying axial power shape during the scram does not have a significant effect on the LOCA analysis results. GENE's LOCA application methodology does not explicitly model the effect of time varying axial power shape.

Table 1. SAFER-GESTR BASED LOCA ANALYSIS METHODS

Application	Original Approved Method	Enhanced Approved Method	Current Refined Method
Short-Term System Blowdown	LAMB	LAMB	LAMB
Short-Term Hot Channel Heat Transfer	SCAT	SCAT	TASC
Long-Term System Inventory(Refill)	SAFER02 (1984)	SAFER03 (1987)	SAFER04V (1988)
Fuel Rod Heatup	CHASTE	CORECOOL (If Needed)	CORECOOL (If Needed)
Fuel Rod Model	GESTR	GESTR	GESTR

Table 2. SAFER Code Changes

	Description of Change	Date Reported
1.	Jet Pump Entrainment enhancement	1988, 1991
2.	Two-Phase Leakage enhancement	1988, 1991
3.	Computer Platform (VAX) conversion	1988, 1991
4.	Energy Balance Error correction in bottom unheated node of the core	1990
5.	Modeling Correction for LPCI Quenching in Lower Plenum	1990
6.	Bypass Void Profile Error correction	1990
7.	Energy Balance Error correction in isolation condenser	1990
8.	Upper Plenum Flow Initialization Error correction	1993
9.	Hot Bundle Pressure Drop Error correction	1993

2. MODEL REFINEMENTS

The SAFER modifications fall into two categories:

1. Model refinements made to improve calculations under degraded ECCS conditions.
2. Alterations to the code to adapt it to the VAX computer system and to improve the numerical reliability of the calculations.

Section 2 describes the model improvements made to SAFER from category 1. The need for these model refinements was identified when SAFER results were compared with the corresponding TRACG predictions for plants with low ECCS capacity. These model changes are important only for LOCA transients with low ECCS flows, such as one core spray, that reflood the vessel slowly. Code modifications that fall into category 2 are described in Section 3. The impact of the model changes is discussed in Section 4.

2.1 Jet Pump Entrainment

During the blowdown of a large break LOCA transient, vapor is generated in the lower plenum region as a result of rapid depressurization and sensible heat released from the reactor vessel wall and internal structures. Consequently, some of the lower plenum inventory can be lost by entrainment through the jet pumps if the lower plenum level approaches the bottom of the jet pumps during the blowdown phase, depending on the vapor velocities. [[

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This change was reported to the NRC in References 5 and 10.

2.2 Two-Phase Leakage Flow

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This change was reported to the NRC in References 5 and 10.

3. NUMERICAL IMPROVEMENTS

This section describes the numerical improvements made to SAFER to improve reliability.

3.1 Double Precision Computation

In adapting the code to the VAX system with its smaller word length, the calculations were converted to double precision.

This change was reported to the NRC in References 5 and 10.

3.2 Vapor Availability Check

The jet pump break flow quality calculation in SAFER is discussed in Section 2.1. [[

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This change was reported to the NRC in References 5 and 10.

3.3 External Loop Time Step

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This change was reported to the NRC in References 5 and 10.

3.4 LPCI Quenching in Lower Plenum

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This change was reported to the NRC in Reference 9.

4. IMPACT OF CHANGES

The impact of the SAFER modifications described in this report has been documented as part of reporting changes and errors in the Emergency Core Cooling System evaluation methodology under 10CFR50.46. Reference 9 describes several errors in the SAFER02 and SAFER03 code versions. The correction of these errors was made using the SAFER04V code version. The impact reported in Reference 9 was determined by comparing original SAFER02 and SAFER03 calculations with corrected SAFER04V calculations for an extensive set of plant specific cases including all plants previously evaluated with SAFER02. Therefore, the reported impact includes the impact of the SAFER04V model changes as well as the error corrections. The impact reported in Reference 9 supercedes the SAFER04V impact documented in Reference 5 and was determined to be -100°F to +20°F. The impact of the modifications on the Upper Bound PCT is discussed in Section 5.

SAFER04V has been used to establish the licensing basis for almost all plants. For the few remaining plants whose licensing basis was established with SAFER02, application of the -100°F to +20°F assessment reported in Reference 9 brings these plants to the equivalent of a SAFER04V basis for the purposes of evaluating the changes and errors reported under 10CFR50.46.

The 1988 revision to 10CFR50 Appendix K placed a restriction on the use of the Dougall-Rohsenow flow film boiling correlation. This restriction allowed the continued use of the Dougall-Rohsenow correlation in evaluation models that were approved prior to the 1988 revision until such time that a change or error correction was made in the evaluation model that resulted in a significant reduction in the overall conservatism in the evaluation model. SAFER02, which was approved by the NRC in 1984, used the Dougall-Rohsenow flow film boiling correlation. The Dougall-Rohsenow correlation was replaced with the modified Dittus-Boelter correlation in SAFER03 and has not been used in later versions of the SAFER code. The NRC specifically reviewed and approved the model change that implemented the modified Dittus-Boelter correlation in their SER for SAFER03. For almost all plants, the licensing basis has been established using SAFER04V and therefore, uses the approved modified Dittus-Boelter correlation. For the few remaining plants whose licensing basis was established with SAFER02, the impact of the change from the Dougall-Rohsenow correlation to the modified Dittus-Boelter correlation is included in the -100°F to +20°F assessment reported in Reference 9.

5. SAFER UPPER BOUND PCT EVALUATION

The SAFER/GESTR-LOCA application methodology was approved under SECY-83-472 which requires the calculation of both a 95th percentile "upper bound" PCT and a licensing basis PCT that incorporates the required features of Appendix K. Sufficient conservatism in the analysis results is then demonstrated by showing that the licensing basis PCT is higher than the upper bound PCT.

The process used for establishing the upper bound PCT is documented in Reference 4. This process uses a combination of plant-specific calculations and uncertainty terms for which the values have been determined generically. The plant-specific calculations use the current version of the SAFER code, SAFER04V, and are performed on a fuel-specific basis. The generic uncertainty terms were determined in Reference 4 using SAFER02 and the GE6 fuel design. An evaluation was performed in order to assess the applicability of the generic uncertainty values determined in Reference 4 given the code changes between SAFER02 and SAFER04V and the fuel design changes between GE6 and the various 8x8, 9x9, and 10x10 fuel designs in use today. This evaluation concluded that use of the generic uncertainty values determined in Reference 4 will result in a conservative upper bound PCT calculation with SAFER04V and for the fuel designs in use today.

5.1 Upper Bound PCT Calculation

The upper bound PCT is calculated using an equation of the form:

$$PCT_{\text{Upper Bound}} = PCT_{\text{Nominal}} + \Delta 4\text{-max}_{\text{generic}} + (\overline{\Delta 3} + 2s_{\Delta 3})$$

where:

PCT_{Nominal} = Peak cladding temperature assuming nominal input values for the plant parameters.

$\Delta 4\text{-max}_{\text{generic}}$ = Modeling Bias. This term accounts for errors in modeling processes for which experimental data is available for comparison. These are primarily the LOCA thermal-hydraulic processes.

$(\overline{\Delta 3} + 2s_{\Delta 3})$ = Plant Variable Uncertainties. This term accounts for the uncertainties due to inputs to the model. These are typical plant parameters with associated uncertainties in their measured values.

$\overline{\Delta 3}$ = Generic "mean-nominal bias" adder. This term adjusts the nominal results to achieve the "mean" PCT.

$2s_{\Delta 3}$ = Plant-specific 2 sigma plant variable uncertainty. This term provides the 95th percentile upper bound.

Plant-specific calculations are performed for the $PCT_{Nominal}$ and $2s_{\Delta 3}$ terms for each fuel type in the core. The current version of SAFER04V is used for these calculations; therefore, the values for the $PCT_{Nominal}$ and $2s_{\Delta 3}$ terms include the effects of the code changes between SAFER02 and SAFER04V and the new fuel designs. Generic values from Reference 4 are used for the $\Delta 4\text{-max}_{generic}$ and the $\overline{\Delta 3}$ terms. Justification for the use of the generic values for the $\Delta 4\text{-max}_{generic}$ and the $\overline{\Delta 3}$ terms is provided in the following sections.

5.2 Modeling Bias Term ($\Delta 4\text{-max}_{generic}$)

The modeling bias term, $\Delta 4\text{-max}_{generic}$, is made up from the following terms:

$$\Delta 4\text{-max}_{generic} = \Delta 7 + \Delta 2 + \Delta 5$$

Where:

$\Delta 7$ = Term to estimate the error between TRAC modeling of experiments and actual experimental results

$\Delta 2$ = Term to estimate the error between TRAC and SAFER PCT predictions for BWR large break-LOCAs

$\Delta 5$ = Term to estimate the incremental error due to scaling when modeling a plant with TRAC as opposed to modeling an experiment.

In order to determine the impact of the code changes between SAFER02 and SAFER04V and the new fuel designs, the $\Delta 4\text{-max}_{generic}$ term was recalculated in accordance with the methodology described in Reference 4. The current versions of TRACG and SAFER04V were used in these calculations. The qualification basis for the version of TRACG used in these calculations is consistent with the version of TRAC used in the original generic uncertainty evaluations.

The $\Delta 7$ term was reevaluated using the current version of TRACG to predict the experimental results. These $\Delta 7$ evaluations used the same suite of experiments as the original $\Delta 7$ calculations. The $\Delta 7$ term was evaluated for both the first peak PCT and the second peak PCT. The results of this evaluation showed that the original $\Delta 7$ values for both the first peak PCT and second peak

PCT from Reference 4 are bounding. Therefore, use of the original Δ7 values will result in a conservative upper bound PCT calculation.

The Δ2 term was reevaluated for the BWR/4 and BWR/6 plant types using the current version of TRACG and the latest version of SAFER04V. These calculations were performed for the 8x8, 9x9, and 10x10 fuel designs in use today. The results of the BWR/6 evaluation showed that the original Δ2 values for both the first peak PCT and second peak PCT from Reference 4 are bounding for all fuel types. The results of the BWR/4 evaluation showed that the original BWR/4 Δ2 values for the first peak PCT were not bounded for all fuel types; however, these terms are not used in plant-specific calculations because all BWR/3-4 plants are second peak PCT limited. The original BWR/4 Δ2 values for the second peak PCT from Reference 4 are bounding for all fuel types. Based on the results of this evaluation, use of the original Δ2 values will result in a conservative upper bound PCT calculation.

The value determined in Reference 4 for the Δ5 term was originally based on engineering judgement and an assessment of the nodalization used in the TRAC model. The basis for the value used for the Δ5 term is not affected by the changes in TRACG or by changes in fuel design. Therefore, the original value determined in Reference 4 for the Δ5 term remains applicable for use in SAFER04V evaluations.

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

The $\overline{\Delta 3}$ term, the "Mean-Nominal Bias," accounts for fact that the nominal analysis PCT and the true statistical mean PCT are not exactly the same. In Reference 4, a complex multi-step process was used to determine the $\overline{\Delta 3}$ term. First, a 28-85 SAFER run experiment was performed statistically combining the five significant upper bound parameters (decay heat, peak linear heat generation rate, stored energy, initial minimum critical power ratio (first peak PCT) or transition boiling temperature (second peak PCT), and break flow). Then a response surface was fitted to the experiment results. This response surface was then used in a 10,000 trial Monte Carlo analysis to determine the true "mean" PCT. This process was used to calculate the $\overline{\Delta 3}$ term for the BWR/6 first peak PCT and the BWR/4 second peak PCT for both fuel types analyzed in Reference 4. The $\overline{\Delta 3}$ term is a minor contributor to the upper bound PCT calculation; the range of $\overline{\Delta 3}$ values calculated in Reference 4 are –24°F to 31°F (0°F – 31°F used in plant-specific analyses).

In order to determine the impact of the code changes between SAFER02 and SAFER04V and the new fuel designs, the $\overline{\Delta 3}$ term was evaluated using SAFER04V and the current 8x8, 9x9, and 10x10 fuel types. A simplified approach was used in these evaluations. SAFER04V sensitivity studies were performed where the five significant upper bound parameters were individually varied by ±2σ. These sensitivity studies were performed for each of the basic fuel designs for both the BWR/6 first peak and the BWR/4 second peak. The response surface equations

developed in Reference 4 were then used to calculate the sensitivity to the $\pm 2\sigma$ variations for the five upper bound parameters. The results of the SAFER04V sensitivity studies were then statistically compared to the sensitivity study results obtained using the Reference 4 response surface equations. The results of this comparison showed that the SAFER04V results were not statistically different than those shown by the response surface equation. Because the SAFER04V sensitivities are similar to the original sensitivities, it is expected that a detailed calculation of the $\overline{\Delta 3}$ term would not result in a significant change in the values for this term. Also, the variations shown between the SAFER04V results and the response surface results are small with respect to the conservatisms shown in the evaluations for the $\Delta 7$ and $\Delta 2$ terms. The overall upper bound PCT calculation would remain conservative even if these variations were included. Based on the results of this evaluation, use of the original $\overline{\Delta 3}$ values in the upper bound PCT calculations is acceptable for SAFER04V and the current fuel designs.

5.4 Conclusions

The generic upper bound uncertainty values determined in Reference 4 were reviewed to determine the impact of the code changes between SAFER02 and SAFER04V and the fuel design changes between GE6 and the various 8x8, 9x9, and 10x10 fuel designs in use today. The results of the generic upper bound uncertainty evaluation show that the original $\Delta 4\text{-max}_{generic}$ terms are conservative, the original generic $\overline{\Delta 3}$ terms remain acceptable, and that the combined generic $\Delta 4\text{-max}_{generic}$ and $\overline{\Delta 3}$ terms are conservative with respect to the values obtained using the current versions of TRACG and SAFER04V and for the current fuel designs. Therefore, use of the generic uncertainty values determined in Reference 4 will result in a conservative upper bound PCT calculation with SAFER04V and for the fuel designs in use today.

6. EXPANDED OPERATING DOMAINS AND ALTERNATE OPERATING MODE APPLICATIONS FOR JET PUMP PLANT ANALYSES

This section addresses how the SAFER/GESTR-LOCA application methodology for jet-pump plants has been applied to expanded operating domains, such as Maximum Extended Load Line Limit Analysis (MELLLA) and Increased Core Flow (ICF), and alternate operating modes such as Feedwater Temperature Reduction and Feedwater Heater out of Service.

6.1 Application Methodology Background and Historical Practice

The SAFER/GESTR-LOCA application methodology for jet pump plants is described in Reference 4. The SAFER/GESTR-LOCA application methodology is based on a best-estimate approach where best-estimate modeling and nominal input values and assumptions are used to evaluate the LOCA response. No attempt is made to introduce conservatism into either the modeling or the input values and assumptions with the exception of those parameters for which the SAFER analysis defines the analytical limit value (e.g., ECCS system performance characteristics). The reported licensing basis PCT results are demonstrated to be sufficiently conservative by comparison with the results of a 95th percentile upper bound PCT evaluation.

10CFR50.46 (a)(1)(i) and (ii) requires a level of conservatism in an ECCS LOCA analysis. The NRC stated in both SECY-83-472, and the statements of consideration supporting the 1988 revision to 10CFR50.46 that the 95th percentile of the uncertainty evaluation probability distribution was considered adequate to meet the "high level of probability" required by 10CFR50.46. The SAFER/GESTR-LOCA application methodology was approved under SECY-83-472. This gave rise to calculation of both a 95th percentile "upper bound" PCT and a licensing basis PCT, incorporating required features of Appendix K. Analysis conservatism is demonstrated by showing the licensing basis PCT is higher than the upper bound PCT.

The NRC SER for the SAFER/GESTR-LOCA application methodology further restricted the upper bound PCT to temperatures less than 1600°F, based on the PCT range of the experimental and analytical qualification bases submitted in support of the methodology. The 1600°F restriction on SAFER's upper bound PCT resulted in every domestic jet-pump plant SAFER/GESTR-LOCA analysis having at least 600°F of margin beyond that required by 10CFR50.46.

Consistent with this basis, the licensing basis PCT has been based historically on normal operating conditions at rated core flow. The expanded operating domains and alternate operating modes were then analyzed as sensitivity studies from the base SAFER analysis at rated conditions. The sensitivity studies demonstrate that the PCT impact of these expanded operating

domains and alternate operating modes is usually small in comparison to the margin available to the 2200°F limit.

Neither the SAFER/GESTR-LOCA application methodology LTR (Reference 4) nor the NRC SER approving the methodology have specific requirements for how expanded operating domains and alternate operating modes are to be evaluated. The practice of evaluating these modes as sensitivity studies has been used consistently for all plant SAFER evaluations. The NRC has reviewed and accepted plant-specific SAFER evaluations that used this approach.

This analysis approach that evaluates expanded operating domains and alternate operating modes as sensitivity studies was justified for a number of reasons:

1. The regulatory acceptance of peak cladding temperature changes resulting from expanded operating domains and alternate operating modes:

   The licensing basis PCT and the sensitivity study results constitute a family of PCTs that cover all licensed operating modes for the plant. The plant-specific 10CFR50.46 documentation requirements for these expanded/alternate operating modes have been met by inclusion of the evaluations in either the plant-specific SAFER LTR or in the safety analysis LTR for the operating mode. NRC approval of the SAFER LTR or the licensing amendment for the operating mode incorporates the operating mode into the plant licensing basis and no further reporting is required when the mode is exercised. The licensing basis PCT is the reference temperature used for tracking the impact due to changes and errors in the plant-specific analysis basis.

2. Basis for model and application methodology development:

   Rated operating conditions were assumed in both the experiments used to develop the SAFER code and in the application methodology basis approved in the SAFER LTR. When changes are made or errors are corrected in SAFER, the code is re-qualified against this basis. Calculating the licensing basis PCT at rated operating conditions makes the plant-specific analysis consistent with the code and methodology development basis. This provides a consistent basis for the assessment of the PCT impact due to code changes or error corrections reported under 10CFR50.46.

3. Consistent Plant to Plant Comparisons:

   Not all plants have elected to implement all the features of the various operating improvement programs. Also, the extent of the implementation varies from one plant to another. For example, the core flow at the MELLLA point ranges from 75% to 90% of rated, the core flow at the ICF point ranges from 105% to 110%, and the temperature reduction for FFWTR ranges from about 50 to 100°F. Calculating the plant licensing basis PCT at rated conditions provides a common reference point for all plants for the assessment and reporting of PCT impacts due to code or input changes.

6.2 Methodology Improvement

The treatment of expanded operating domains and alternate operating modes continues to be considered in light of the ongoing increase in plant operating domain options as well as changes in the regulatory environment.

The range of extended operating domains has been expanded to consider Extended Power Uprate (EPU) and MELLLA+. The SAFER/GESTR-LOCA application is used for ECCS-LOCA analysis across a wider range of power and flow options available to the plant.

The SAFER/GESTR-LOCA application methodology will continue to be based on a best-estimate approach where best-estimate modeling and nominal input values and assumptions are used to evaluate the LOCA response. The reported licensing basis PCT results will be demonstrated to be sufficiently conservative by comparison with the results of a 95th percentile upper bound PCT evaluation.

The status of the SAFER/GESTR-LOCA application approval with the NRC has also been updated. As noted in Section 6.1, the NRC, in the SER approving the SAFER/GESTR-LOCA methodology, imposed a restriction of 1600°F on the upper bound PCT based on the range of experimental and analytical qualification bases submitted (Reference 4). Subsequent activity was completed to extend the range of the qualification bases (Reference 11). NRC review of the supplemental information resulted in the removal of this PCT restriction (Reference 12).

Given these changes, the SAFER/GESTR-LOCA application has been adapted to present a conservative, yet realistic, calculation of licensing basis PCT across the span of operating domains licensed for a plant. Flexibility has been included in the process to assure compliance to the acceptance criterion across all power and flow combinations and determination of a single, bounding licensing basis PCT.

For the reasons noted in the previous section (Section 6.1), a base analysis is still confirmed or performed for the rated flow, rated power case. This approach preserves the ability to compare results between plant classes and across the same plant class to confirm reasonable outcomes. It is also faithful to the operating conditions that form the basis for the model and methodology development.

The extended operating domains and alternate operating modes are analyzed as sensitivity studies to the analysis performed at rated conditions, consistent with current practice. Extended operating domain and alternate operating mode cases are defined by inputting state points into calculations which span the range of allowable power and flow combinations for the plant, according to the various operating improvement programs for which it may be licensed.

If the results of the off-rated sensitivity studies show that the Appendix K PCT at an off-rated operating point is higher than the Appendix K PCT at rated core flow and power conditions, then the most limiting power and flow point (highest PCT) becomes the basis for assessing the remaining factors which enter into the PCT determination. A spectrum of cases to identify the

limiting single failure, fuel type (if different fuel designs are resident), break size, axial power shape and break location are then performed assuming the limiting power and flow condition. This is a change from previous practice.

The upper bound and licensing basis PCT are to be calculated on the basis of the most limiting operating point, rated or off-rated, as it may be identified. [[

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For a standard SAFER/GESTR-LOCA analysis, a table comparing the off-rated PCT results with the rated PCT results is reported. By calculating the licensing basis PCT from the most limiting PCT from among all the allowed, rated and off-rated, power and flow conditions, considering break size, fuel type, power distribution and single failure, compliance to the 2200°F 10CFR50.46 PCT limit is demonstrated.

6.3 Conclusions

The SAFER/GESTR-LOCA methodology is supported by a substantial base of LOCA technology that has shown that realistic PCTs are about 900-1100°F for the limiting break. The SAFER/GESTR-LOCA methodology takes advantage of this technology basis resulting in a substantial reduction in the licensing basis PCT results compared to the previous LOCA evaluation models. As the SAFER/GESTR-LOCA application has been extended to a wider range of operating conditions, adaptations have been made so that it continues to calculate realistic consequences of the LOCA event. A change in the NRC approval status, eliminating the imposed 1600°F limit on upper bound PCT, has been incorporated. The methodology has been updated so that the sensitivity to expanded operating domains and alternate operating modes can be identified. Licensing basis PCT results, now calculated on the basis of the most limiting of allowed operating state points, continue to provide a sufficiently conservative confirmation of compliance to licensing acceptance criteria.

7. USE OF TVAPS IN EARLY BOILING TRANSITION DETERMINATION FOR LOCA ANALYSES

This section provides a discussion of the Time Varying Axial Power Shape (TVAPS) in the early boiling transition determination for LOCA analyses. The axial power shape in the fuel bundle changes due to the control rod insertion during the scram. GENE's LOCA application methodology does not model the effect of TVAPS in the determination of early boiling transition during a LOCA.

The time varying axial power shape during the scram does not have a significant effect on the LOCA analysis results. TVAPS is significant for evaluating the critical power ratio (CPR) during pressurization transients which result in a reactivity insertion due to the void collapse. The void collapse, combined with the effect of the control rod insertion, shift the power towards the top of the bundle. The core response during first few seconds of a LOCA, however, is dominated by the rapid flow reduction resulting from the break of one recirculation line and a recirculation pump trip in the other line. This effect is captured in the current hot channel early boiling transition (EBT) evaluation. The impact on axial power shape from the rapid flow reduction will be a shift in power to the bottom of the core following the shift in axial void fraction. This secondary effect will have two impacts. Testing the TVAPS impact for rapid flow reduction (ABWR all pump trip) has shown that TVAPS reduces the ΔCPR for this case which would tend to delay BT allowing more stored heat removal. This is consistent with critical power tests that show a higher CPR for bottom peaked power distributions. The second impact is the moving of the higher power planes lower down in the bundle (below the lowest point where boiling transition occurs) would allow more stored heat removal. The control rod insertion is expected to have no impact during the first second when EBT is calculated, since the LOCA analysis assumes start of control rod motion at 0.9 seconds into the event.

The use of a constant axial profile will therefore increase the likelihood of BT for the high power node and provide earlier BT times relative to a TVAPS evaluation. This will minimize stored energy removal and lead to higher PCTs. The average core does not experience EBT and therefore would not be impacted by TVAPS as nucleate boiling would be maintained during the period. Similarly, the response for small breaks would not be impacted by TVAPS because there is sufficient core flow coastdown to maintain nucleate boiling until the core uncovers.

After the first few seconds, fission power will be reduced to very low levels leaving only decay heat. The distribution of decay heat is consistent with the initial power distribution and will not be impacted by TVAPS. The use of a constant axial profile provides a conservative evaluation of hot channel EBT response during the first few seconds of a LOCA and provides a correct calculation of the decay heat distribution.

8. APPLICATION OF CORRELATION IN THE COUNTER CURRENT FLOW LIMITING MODEL

Counter Current Flow Limiting (CCFL) can occur where there is a geometrically restricted area and is characterized by a limitation of downward flow of liquid through the area by an upward flow of vapor. In general, within the BWR fuel bundle, several "candidate" locations are potentially vulnerable to CCFL such as the upper/lower tie plate, inlet orifice, spacer locations, and at the end of partial length fuel rods. In the SAFER/GESTR methodology for ECCS-LOCA, CCFL is modeled at two locations: the top of the core at the fuel upper tie plates and the bottom of the core at the side entry orifices. The effect of CCFL at the top of the fuel bundle is to delay the downflow of injected core spray water down through the core. At the bottom location, the effect is to decrease the draining from the bundles and hold up inventory in the core, a positive effect for PCT determination. If the region becomes subcooled above the restriction, subcooled water will enter through the restriction. A condensation of vapor below the restriction is initiated and the CCFL phenomenon will break down, allowing liquid to flow through the restriction bounded only by hydraulic resistance.

In the ECCS-LOCA SAFER/GESTR evaluation model, the modified Wallis correlation is used to account for the CCFL phenomenon (Reference 3.) This application has been accepted by the NRC as documented in the Safety Evaluation Review approving the model. It is noted there that the approved evaluation model uses a conservative bound. Documentation of the bounding nature of the Wallis correlation modification has been provided to the NRC (Reference 13) by presentation of a test database, judged to be acceptable, and a linear least squares fit proposed for the correlation coefficient. The NRC, in accepting the test data and the form of the modification, did not accept the least squares fit coefficient, but declared a one-sided bound would be acceptable which covered 90% of the data population with a 95% confidence. This was the bounding form of the correlation alluded to, which is used in the GE ECCS evaluation model.

A question on CCFL modeling was posed in Reference 14 following a review of GE methods regarding power uprates. The subject of the review was an early GE internal document presenting a technical summary of development activities performed within GE to define model correlations and features, but not in context of a licensing topical report. Details were presented therein on the Findley-Dix correlation for void fraction determination. An appendix to the report suggested a possible extension of the Findley-Dix correlation could be used as a method for calculating CCFL behavior. The conclusion of the internal report was that additional verification and data would be required to support such implementation. Subsequently, this approach was rejected in favor of applying the modified Wallis correlation as described above. Concerns expressed in Reference 14 corroborate the prior decision to apply a more robust CCFL treatment in GE's evaluation model. The Findley-Dix correlation is not applied to CCFL, consistent with the discussion of CCFL provided in the SAFER/GESTR topical reports submitted to the NRC (References 3 and 13).

9. REFERENCES

1. "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," NEDE-30996P-A, October 1987.

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

3. "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accidents, Volume II, SAFER - Long Term Inventory Model for BWR loss-of-Coolant Analysis," NEDE-23785-1-PA, October 1984.

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

5. Letter, H.C. Pfefferlen, GE to J.A. Norberg, NRC, "ECCS Evaluation Model Improvement," July 14, 1988.

6. "GE11Compliance With Amendment 22 of NEDE-24011-P-A (GESTAR II)," NEDE-31917P, April 1991.

7. "TASC03 A Computer Program for Transient Analysis of a Single Channel," NEDC-32084P, January 2000.

8. "BWR Large Break Simulation Tests – BWR Blowdown/Emergency Core Cooling Program," GEAP-24962, March 1981.

9. Letter, R.C. Mitchell to the Director of Nuclear Reactor Regulation, "Reporting of Changes and Errors in ECCS Evaluation Models," June 13, 1990.

10. Letter, P.W. Marriott to the Director of Nuclear Reactor Regulation, "Reporting of Changes and Errors in ECCS Evaluation Models," March 12, 1991.

11. NEDE-23785PA, Vol. III, Supplement 1, Revision I, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident, Volume III, Supplement 1, Additional Information for Upper Bound PCT Calculation," March 2002.

12. Stuart A. Richard (NRC) to James F. Klapproth (GENE), "Review of NEDE-23785, 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) February 1, 2002.

13. NEDE 20566-P-A, Vol. III, "Analytical Model for Loss-of-Coolant analysis in accordance with 10CFR50 Appendix K – Volume 3," September 1986.

14. Letter, M. C. Honcharik, (NRC) Office of Nuclear Reactor Regulation, to R. E. Brown, (GE) Manager, Regulatory Affairs, "TOPICS TO BE ADDRESSED IN UPDATED GENERAL ELECTRIC NUCLEAR ENERGY (GENE) TOPICAL REPORT (TR) NEDC-32096P, 'COMPILATION OF IMPROVEMENTS TO GENE'S SAFER ECCS [EMERGENCY CORE COOLING SYSTEM]-LOCA [LOSS-OF-COOLANT] EVALUATION MODEL," May 23, 2007.

10. ATTACHMENT 1

Response to NRC's Questions Regarding CCFL

NRC RAI 1

Appendix E of NEDE-21565, illustrates the performance of the Findlay-Dix correlation in predicting the counter-current flows in the pressure range 14.7 to 1000 psia. It appears that although the source document is referenced and the correlation is employed in ECCS evaluations, the staff did not directly review or approve the source document. As such, the following RAIs relate to the application of Findlay-Dix correlation for LOCA analyses of BWRs operating at the proposed EPU/MELLLA+ conditions.

1-1 Figure E-3 shows that the drift flux model prediction for the counter-current flow lies within the flooding limit line curve. Above 14.7 psia, Figures E-4 and E-5 show an unacceptable counter-current flow behavior (P= 500 and P=1000 psia), where the flooding curve is violated. Since bundle cooling and PCT will ultimately rely on the down flow of liquid into the core from the core spray, please correct the model behavior so that CCFL is not invalidated over the full range of pressures.

1-2 Show the comparisons of the model predictions against counter-current flow data through perforated plates and heated bundles over the ranges of liquid subcooling and steam flow rates that reflect the LOCA conditions.

GEH Response

Section 8 of NEDC-32950, Revision 1 discusses that the Modified Wallis Correlation was used in the ECCS evaluation, and not the Findlay-Dix correlation.

NRC RAI 2

Please explain how the CCFL model accounts for the subcooling of the liquid spray?

GEH Response

Section 8 of NEDC-32950, Revision 1 explains that the CCFL model is described in NEDC-23785-P. In Section 3.4.2, NEDC-23785-P states:

> "If the upper region is subcooled, the vapor flow that can be condensed by the liquid downflow is subtracted from the vapor upflow. The allowable downflow is then updated from the CCFL correlation with the reduced value of vapor upflow as the independent parameter."

Liquid spray is accounted to the inventory of the upper region (shown in figure 3-3 as that above the CCFL plane).

NRC RAI 3

Page 3-17 of NEDC-23785-1-PA, dated July 26, 1988 presents the CCFL limit equation.

3-1 Please describe how the drift flux model is formulated to assure the flooding limit is not violated (i.e. please show the final form of the drift velocity, Vgj, expression modified to assure the limits are maintained).

3-2 How is the flooding limit implemented in the code?

GEH Response

Response to 3-1

Section 8 of NEDC-32950P, Revision 1 references NEDC-20566-P-A, which provides a discussion of the application of the CCFL calculation in the evaluation model (See NEDC-20566-P-A, Volume II, Section II.A.2, compliance paragraph 3.2). The Modified Wallis Correlation is used to define a maximum amount of subcooled water that can be allowed through the restricting CCFL plane. (This may be inferred as a "limit", but is variable by conditions and is the dependent variable of the calculation, not a standard for comparison purposes.) The model is set by the nature of the coefficient of the correlation to take this as a minimum amount of downflow. Then, this amount is subtracted off from the inventory of the upper region inventory (from core spray and upper vessel sources) and the rest is directed to core bypass, not effective for cooling. The applicable Modified Wallis correlation is not expressed in terms of Vgj.

Response to 3-2

A flooding limit is not explicitly defined. It does not exist, per se, in the evaluation model as described in salient LTR documents, other than in terms of the allowed possible downflow calculated to pass through against the vapor upflow.

NRC RAI 4

What is done in the licensing calculation when the liquid down flow exceeds the flooding limit? Please explain.

GEH Response

As stated in the response to RAI 3 above, NEDC-20566-P-A describes that excess down flow is removed to bypass and not effective for cooling. Further, NEDC-20566-P-A describes the cooling of vapor which leads to break down of CCFL when flow is then limited by hydraulic constraints.

11. ATTACHMENT 2

Compilation of 10CFR50.46 Reporting

GE Nuclear Energy

June 13, 1990
MFN 023-90
PWM 90-24

Director of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Mail Station PI-137
Washington, DC 20555

Attention: Document Control Desk

Subject: **REPORTING OF CHANGES AND ERRORS IN ECCS EVALUATION MODELS**

The purpose of this letter is to report, in accordance with 10CFR5O.46, (a)(3)(i), the impact of changes and errors in the Emergency Core Cooling System (ECCS) evaluation methodology used by GE. This report covers the period from October 17, 1988 to the present. It is noted that peak clad temperature (PCT) variations resulting from plant specific system or fuel changes are not believed to be part of the 10CFR50.46 reporting requirements and are not considered in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566P, "Analytical Model for Loss-of-Coolant analysis in accordance with 10CFR50 Appendix K."

Minor coding errors were recently found in both the jet pump and non-jet pump plant versions of the SAFER evaluation model described in NEDE23785, "The GESTR-LOCA and SAFER models for the Evaluation of the Loss-of-Coolant Accident," and NEDE 30996, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants." These are described in Attachment 1. Corrections have been made and it has been determined that there is no impact on any plant technical specification. For the jet pump plants, the only effect is on calculated PCTs which have substantial margin and therefore do not establish operating limits. In the case of the non-jet pump plants, the effect is a slight reduction in the calculated PCTs which does not require a change in operating limit. An assessment of this effect has been made, and it is estimated that application of the corrected code version on a plant-specific basis could result in PCT changes which range from an increase of less than 20°F to a decrease of as much as 100°F. Given the absence of any potential technical specification impact, this does not represent a change which would require reanalysis.

By copy of this letter, licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the

HCP90005

Robert C. Jones, Jr.
Page 2
June 13, 1990

evaluation methodology. Since the specified changes do not result in a need for reanalysis or Technical Specification modifications, this submittal is believed to satisfy 10CFR50.46(a)(3)(ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions or comments, please call me or H. C. Pfefferlen at (408) 925-3392.

Sincerely,

R. C. Mitchell, Acting Manager
Regulatory & Analysis Services
Mail Code 382, Phone (408) 925-6948

rmw

cc L. S. Gifford (GE Rockville)
H. C. Pfefferlen
R. C. Jones, Jr. (NRC)

HCP90005

Attachment 1

CHANGES TO THE GE ECCS EVALUATION MODEL (SAFER)

The following corrections were made to the SAFER ECCS evaluation model described in NEDE 30996 and NEDE 23785.

SAFER MODEL FOR JET PUMP PLANT APPLICATIONS

1) The effect of system depressurization on the energy balance in the unheated bottom node of the core region was found to be incorrectly modeled. This treatment of depressurization could result in early Counter Current Flow Limitation (CCFL) breakdown at the side entry orifice when the bypass region becomes subcooled. The early breakdown could result in high calculated peak clad temperatures.

   The SAFER model was corrected to account for depressurization in this node as intended and described in the original SAFER report (NEDE 23785).

2) Steam quenching by the Low Pressure Coolant Injection (LPCI) system (BWR/3, 4) was found to be incorrectly modeled. The model allowed all of the steam in the lower plenum to be directly quenched rather than limiting the quenching to the steam available through the jet pumps. In addition, it was assumed that sufficient steam was available due to flashing to saturate the LPCI water as long as the jet pumps were not full. This assumption is not appropriate, after the reactor vessel has depressurized to the ambient pressure. The impact of these errors is conservative in most cases.

   The SAFER model was corrected to more rigorously account for the condensation of steam by the LPCI water in the reactor vessel. These changes are consistent with the intent of the original model.

3) The calculation of the bypass void profile set to zero the void fraction at the bottom of the bypass region. This error results in an overestimate of bypass mass and leakage flow from the bypass to the core. This error was corrected in the expanded jet pump and non-jet pump code version (NEDE 30996) by using a calculation of void fraction at this location. However, this correction was not explicitly discussed in NEDE 30996, as the formulation in the original report (NEDE 23785) is correct.

   The NEDE 23785 version of the SAFER code was corrected to be consistent with the later NEDE 30996 version, which included the effect of the change in the qualification basis.

SAFER MODEL FOR NON-JET PUMP PLANT APPLICATIONS

1) A coding error (typographical) in the isolation condenser routine was found which resulted in a significant underestimation of the

energy added to the recirculation loop. This led to a delay in filling of the recirculation loop and initiation of flow to the downcomer and core for small breaks and resulted in an excessively high predicted PCT.

The typographical error was corrected to make the code consistent with the description in NEDE 30996.

HCP9OOO5

GE Nuclear Energy

March 12, 1991
MFN 025-91

Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Mail Station PI-137
Washington. DC 20555

ATTENTION: Document Control Desk

SUBJECT: **REPORTING OF CHANGES AND ERRORS IN ECCS EVALUATION MODELS**

REFERENCE:

1. Letter. RC Mitchell to the Director of Nuclear Reactor Regulation. "Reporting of Changes and Errors in ECCS Evaluation Models", June 13, 1990.
2. Letter. RH Buchholz to PS Check "Description of Coding Changes to the GE Appendix K LOCA Evaluation Model" November 5, 1980.
3. Letter. HC Pfefferlen to HN Berkow "SAFER Model for Application to Both Jet Pump and Non-Jet Pump Boiling Water Reactors". September, 23, 1986.
4. Letter. HC Pfefferlen to JA Norberg. "ECCS Evaluation Model improvements". July 14. 1988
5. Letter. JS Charnley to MW Hodges. "Application of Approved Methods to a New GE Fuel Design", August 7, 1989

The purpose of this letter is to report, in accordance with 10CFR50.46(a)(3)(ii). the impact of changes and errors in the Emergency Core Cooling System (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference 1) to the present. It is noted that peak cladding temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate. on a plant specific basis in accordance with other sections of 10CFR50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566-P-A, Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K" during this reporting period. However, in the past, as part of the ECCS reverification program. some changes had been made to the SAFE methodology. These changes were discussed with the NRC and documented in Reference 2. At that time the impact of these changes was estimated to be less than $\pm$ 40°F. The updated code version was to be incorporated into the plant analysis when a complete ECCS reanalysis is required. Until that time, the plant ECCS analysis is updated to account for the heatup characteristics of the reload fuel but the system response is based on the previous code version. While most ECCS analyses are now based on the updated code version, from time to time additional reanalysis and updating does occur. Since the NRC has. accepted the updated model. we do not believe such changes in model application requires reporting under 10CFR50.46(a)(3)(ii) and such conversions will not be included in future reports.

Page Two

There have been no changes or errors identified in the SAFER/GESTR methodology described in NEDE 23785-l-P-A. The GESTR-LOCA and SAFER Models for the Evaluation of Loss-of-Coolant Accidents", and NEDE 30996-P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants". As discussed in Reference 3, the models described in NEDE-23785-1-P-A and NEDE-30996-P-A (as supplemented by Reference 4) represent the two controlled versions of the SAFER/GESTR code. The difference in these code versions (reference 3) is estimated to be less than ± 50° in the limiting PCT and both have been accepted by the NRC. Because of this, a change in the code versions used on a given plant application is not believed to require reporting under 50.5*6(a)(3)(ii) and will not be included in future reports.

It shou!d be noted that GE is adapting the models of the SAFE/REFLOOD methodology and the SAFER/GESTR methodology to accommodate the geometric configuration of the GE 11 fuel design as described in Reference 5. A summary description of these modifications will be included in the information report describing GE 11 compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II) and are not considered reportable under 10 CFR 50.46 (a) (3) (ii).

By copy of this letter, licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no reanalysis or technical specification modifications are required, this submittal is believed to satisfy 10CFR50.46(a)(3)(ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions or comments, please call me or HC Pfefferlen at (408) 925-3392.

Sincerely

P.W. Marriott, Manager
Regulatory & Analysis Services
Mail Code 382 Phone (408) 92o-6948

jz:PWMNRC

* sic, this is a typo in the original

GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

MFN-040-88
HCP88040

July 14, 1988

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulations
Washington, D.C. 20555

Attention: J. A. Norberg, Special Assistant
Division of Engineering and System Technology

Subject: **ECCS Evaluation Model Improvements**

References:
1) Letter, H. C. Pfefferlen to H. N. Berkow, "SAFER Model for Application to both Jet Pump and Non-Jet Pump Boiling Water Reactors", September 23, 1986.
2) Letter, C. O. Thomas to J. F. Quirk, "Acceptance for Referencing of Licensing Topical Report NEDE-23785 Revision 1, Volume III (p), "The GESTR-LOCA and SAFER Models for Evaluation of the Loss-of-Coolant Accident", June 1, 1984.

Gentlemen:

This is to inform you of planned modifications to the approved SAFER ECCS evaluation model described in NEDE 30996, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants". These modifications will enhance the high temperature predictive capability of SAFER for jet pump plant applications by improving the modeling of certain LOCA phenomena which have been found to have a noticeable affect under some LOCA conditions. Also, alteration of the code is necessary to accommodate a planned change in the main frame computer central processor at GE. These changes have negligible affect on the non-jet pump version of SAFER.

The need for additional modeling improvements beyond those already incorporated in the NEDE 30996 version of SAFER (Reference 1) was identified during SAFER application to a foreign jet pump plant. In this case, the plant licensing basis resulted in peak clad temperatures (PCT) approaching 2200°F. It was found that under these conditions the jet pump entrainment and two phase leakage flow models were introducing excessive conservatisms. Improvements were made and accepted for application to this foreign plant. These same changes are now planned for incorporation into the domestic version of SAFER.

NRC
Page 2
July 14, 1988

An extensive evaluation has been performed of the impact of these model changes. It has been demonstrated that there is a negligible impact on the model qualification basis, BWR 2 (non-jet pump plant) applications, and generic BWR 3/4 and 5/6 results. Furthermore, a comparison of this latest model with the model approved in NEDE 30996 shows that the PCT results are within 50°F for a full spectrum of current jet pump plant applications (see enclosure).

We do not believe these changes warrant additional NRC review since they have minimal impact on the qualification basis reported in NEDE 30996. Further, should future jet pump applications result in upper bound temperatures above 1600°F, additional information is required (reference 2) to "provide assurance that the upper bound PCT prediction is sufficiently reliable". It is our conclusion that there are no unaddressed operational or safety questions associated with the planned code changes. Accordingly, we plan to immediately update the controlled version of SAFER and make it available for plant specific applications. In order to record these changes, a revision of NEDE 30996 will be issued by the end of the year.

This matter has been discussed with M. W. Hodges and he has indicated his concurrence.

Regards,

H. C. Pfefferlen, Manager
BWR Licensing Issues
(408) 925-3392

SG/HCP:md
cc: L. S. Gifford (GE Rockville)
M. W. Hodges (NRC)

IMPACT OF IMPROVED SAFER MODEL ON PLANT CALCULATIONS

CASE	IMPACT (°F)
BWR/2 DBA	
- Nominal assumptions	-11
- Appendix K assumptions	-22
BWR/2 SMALL BREAK (0.1 ft 2)	
- Appendix K assumptions	+16
BWR/4 DBA	
- Nominal assumptions	-18
BWR/6 DBA	
- Nominal assumptions	+9
RANGE FOR U.S. PLANT SPECIFIC LICENSING CASES	-44 to +50
BWR w/o LPCI (1 LPCS ONLY) (2 foreign plants)	÷300

bcc: R. Mitchell
J. Gay
B. Shiralkar
G. Sozzi

GE Nuclear Energy

June 26, 1992
MFN 058-92
PWM 92-051

Office of Nuclear Reactor Regulation
US Nuclear Regulator Commission
Mail Station P1-137
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: REPORTING OF CHANGES AND ERRORS IN ECCS EVALUATION MODELS

REFERENCE: 1. Letter, PW Marriott to the Director of Nuclear Reactor Regulation, "Reporting of Changes and Errors in ECCS Evaluation Models", March 12, 1991.

The purpose of this letter is to report, in accordance with 10CFR50.46(a)(3)(ii), the impact of changes and errors in the Emergency Core Cooling System (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference 1) to the present. It is noted that peak cladding temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

There has been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566-P-A, "Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K" or the SAFER/GESTR methodology described in NEDE 23785-1-P-A, "The GESTRA-LOCA and SAFER Models for the Evaluation of Loss-of-Coolant Accidents", and NEDE 30996-P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants".

It has been observed that ECCS evaluation model results can be sensitive to changes in the computer operating system or small changes in input parameters. Test cases have been run for a change in the operating system and procedure for defining jet-pump loss coefficients for SAFER/GESTR. The range of impact of these changes on the predicted PCT was found for the cases analyzed to be less than $\pm$ 50° F. Similarly, a change in the computer system for part of the SAFE/REFLOOD package (CHASTE) resulted in an estimated range of impact on predicted PCT of + 10° F and -25° F. Potential PCT variations of this magnitude should be anticipated when future ECCS analyses are performed on the new computer system; however, existing PCT predictions are valid and no change to any plant specific evaluation is required.

By copy of this letter, licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no reanalyzes or technical specification modifications are required, this submittal is believed to satisfy 10CFR50.46(a)(3)(ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions or comments, please call me or HC Pfefferlen at (408)925-3392.

Sincerely,

S.J. Stark

S.J. Stark, Acting Manager
Regulatory & Analysis Services
Mail Code 482 Phone (408)925-6948

PWM:jz

bcc: DG Albertson
RA Hanvelt*
JF Klapproth
LE Miller
RC Mitchell
LD Noble
HC Pfefferlen
DC Serrell
BS Shiralkar
GL Sozzi
JE Wood

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

June 30, 1993
MFN #090-93

Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555

ATTN: Document Control Desk

SUBJECT: REPORTING OF CHANGES AND ERRORS IN ECCS EVALUATION MODELS

REFERENCE: 1) Letter, SJ Stark to the Office of Nuclear Reactor Regulation, "Reporting of Changes and Errors in ECCS Evaluation Models" dated June 26, 1992 (MFN # 058-92)

The purpose of this letter is to report, in accordance with 10CFR50.46 (a) (3) (ii), the impact of changes and errors in the Emergency Core Cooling Systems (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference 1) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566-P-A "Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K".

Two minor coding errors were corrected in the SAFER Code. The SAFER/GESTR methodology is described in NEDE 23785-1-P-A, "The GESTR-LOCA and SAFER Models for the Evaluation of Loss-of-Coolant Accidents", and NEDE 30996-P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants"...The first error corrected was improper upper plenum flow initialization. This error caused a flow discontinuity at the beginning of the transient. A second error was corrected that impacts the latter part of a small break LOCA. A sign error in the pressure drop balance caused the top of the hot channel to remain uncovered even after the upper plenum and bypass were full. The impact of these errors on predicted pct is ± 5°F.

The observation that ECCS evaluation models can be sensitive to small input parameter changes under some circumstances was reported in Reference 1. Based on the SAFER cases analyzed at the time, the range of impact on the predicted PCT was reported as ± 50°F. Recent studies have indicated that the impact could be slightly larger than ± 50°F for some BWR/4 plants with LPCI injection into the lower plenum using the SAFER model. These studies indicated a total variation of less than 85° F for most cases but with one case showing a range of 102° F (i.e., greater than ± 50°F).

The identified sensitivity is related to the explicit numerical treatment in SAFER combined with rapid and simultaneous variations of multiple parameters. Work is underway to limit this sensitivity through better control of time steps in the computation. This will provide assurance that such sensitivities are well within the previously stated ± 50° F. Any changes resulting from this activity will be reviewed with the NRC at the appropriate time. It should be noted that existing PCT predictions are valid (i.e., within the stated uncertainty band) and no change to any plant specific evaluation is required.

By copy of this letter, Licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no reanalysis or technical specification modifications are required, this submittal is believed to satisfy 10CFR50.46 (a) (3) (ii) for evaluation model changes without further reporting on the part of the individual utilities.

If you have any questions, please call me or HC Pfefferlen at (408) 925-3392.

Sincerely,

R.C. Mitchell

RC Mitchell, Manager
Safety & Communications
(408) 925-2755 M/C 487

CC: HC Pfefferlen

BCC: DG Albertson
RA Hanvelt*
JF Klapproth
LE Miller
LD Noble
HC Pfefferlen
DC Serrell
BS Shiralkar
GL Sozzi
JE Wood

*Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

July 1, 1994

MFN # 088-94

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, D.C. 20555

Attention: Document Control Desk

Subject: REPORTING OF CHANGES AND ERRORS IN ECCS EVALUATION MODELS

Reference: Letter, R. C. Mitchell to the Office of Nuclear Reactor Regulation, "Reporting of Changes and errors in ECCS Evaluation Models", dated June 30, 1994 (MFN # 090-93)

The purpose of this letter is to report, in accordance with 10CFR50.46 (a) (3) (ii), the impact of changes and errors in the Emergency Core Cooling Systems (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10 CFR 50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566-P-A, "Analytical Model for Loss-of Coolant Analysis in Accordance with 10 CFR 50 Appendix K".

There have been no changes or errors identified for the SAFER/GESTR model described in NEDE 23785-1-P-A, "The GESTR-LOCA and SAFER Models for Evaluation of Loss-of-Coolant Accidents", and NEDE 30996-P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants".

By copy of this letter, Licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no re analysis or technical specification modifications are required, this submittal is believed to satisfy 10 CFR 50.46 (a) (3) (ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions, please call me or H.C. Pfefferlen at (408) 925 3392.

Sincerely,

R.C. Mitchell, Manager
Safety Evaluation Programs
(408) 925 2755
Mail Code 487

cfr94/hcp

cc: H.C. Pfefferlen

bcc: D.G. Albertson
R.A. Hanvelt*
J.K. Klapproth
L.E. Miller
L.D. Noble
H.C. Pfefferlen
D.C. Serrell
B.S. Shiralkar
J. G. Andersen
G.L. Sozzi
J.E. Wood

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology

GE Nuclear Energy
3901 Castle Haynes Rd, Wilmington, NC 28401

GE Nuclear Energy
General Electric Company
P. O. Box 780, Wilmington, NC 28402

June 24, 1995

JFK–95–042
MFN–087–95

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

Attention: R. C. Jones, Jr.

Subject: **Reporting Of Changes And Errors In ECCS Evaluation Models**

Reference: Letter, R. C. Mitchell to the Office of Nuclear Reactor Regulation, *Reporting of Changes and Errors in ECCS Evaluation Models*, dated July 1, 1994 (MFN # 088–94)

The purpose of this letter is to report, in accordance with 10 CFR 50.46 (a) (3) (ii), the impact of changes and errors in the Emergency Core Cooling Systems (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10 CFR 50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566–P–A, *Analytical Model for Loss–of–Coolant Analysis in Accordance with* 10 CFR *50 Appendix K.*

There have been no changes or errors identified for the SAFER/GESTR model described in NEDE 23785–1–P–A, *The GESTR–LOCA and SAFER Models for Evaluation of Loss–of–*

Coolant Accidents, and NEDE 30996–P–A, *SAFER Model for Evaluation of Loss–of–Coolant Accidents for Jet Pump and Non–Jet Pump Plants.*

By copy of this letter, Licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no re–analysis or technical specification modifications are required, this submittal is believed to satisfy 10 CFR 50.46 (a) (3) (ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions, please call me or J. L. Embley at (910) 675–5774.

Sincerely,

J. F. Klapproth

J. F. Klapproth, Manager
Fuels and Facilities Licensing
(910) 675–5608, MC J26

cc: T. M. Hauser
J. L. Embley

bcc: J. G. Andersen
R. A. Hanvelt*
L. E. Miller
H. C. Pfefferlen
J. C. Shaug
G. L. Sozzi
M. R. Stepp
P. Wei

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology

GE Nuclear Energy

3901 Castle Haynes Rd, Wilmington, NC 28401

NEDO-32950 Revision 1
Non-proprietary Version

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

December 15, 1995

RJR-95-118
MFN-278-95

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

Attention: R. C. Jones, Jr.

Subject: **Reporting of Changes and Errors in ECCS Evaluation Models**

Reference:

1. Letter, J. F. Klapproth to the Document Control Desk (R. C. Jones, Jr., *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 24, 1995 (MFN-087-95).
2. Letter, R. C. Mitchell to the Office of Nuclear Reactor Regulation, *Reporting of Changes and Errors in ECCS Evaluation Models*, dated July 1, 1994 (MFN No. 088-94).

GE is submitting this letter which revises the Reference 1 letter. Revisions are marked by change bars in the margin.

The purpose of this letter is to report, in accordance with 10 CFR 50.46 (a) (3) (ii), the impact of changes and errors in the Core Cooling Systems (ECCS) evaluation methodology used by GE. This report covers the period from the last report (Reference 2) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10 CFR 50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566–P–A, *Analytical Model for Loss–of–Coolant Analysis in Accordance with* 10 CFR *50 Appendix K.*

There have been no changes or errors identified for the SAFER/GESTR model described in NEDE 23785–1–P–A, *The GESTR–LOCA and SAFER Models for Evaluation of Loss–of–Coolant Accidents*, and NEDE 30996–P–A, *SAFER Model for Evaluation of Loss–of–Coolant Accidents for Jet Pump and Non–Jet Pump Plants.*

In March 1995, a domestic utility requested that GENE review a concern regarding the RPV bottom head drain (BHD) impact on the LOCA analysis. The concern was that because the bottom head drain line is directly connected to the reactor recirculation loops, that a recirculation line break LOCA would also break the BHD, and the vessel would depressurize to the drywell faster than assumed in current models. Also, upon such an event occurring, some water required to keep the core covered to the 2/3 core height would exit the core due to either gravity or core pressure via the interconnected recirculation and bottom head RWCU suction lines.

A GENE evaluation concluded that while no analysis had been performed to precisely evaluate the PCT impact of the recirculation line break LOCA including the BHD, it is believed that the impact is less than 10°F based on engineering judgment and extrapolation of previous LOCA analyses. Since an event is considered by the NRC to be significant if the PCT is increased more than 50°F (10CFR50.46 (a)(3)(i)), this amount of increase can be considered insignificant and well within the margins of the safety analysis.

The impact of the BHD exiting flow on maintaining RPV level inside the shroud is similarly insignificant. It was determined that a slightly higher minimum makeup flow will be required, however, the increased makeup is well within the margins of available ECCS systems. The minimum makeup flow corresponds to that necessary to makeup for decay heat and the drain rate from the BHD.

By copy of this letter, Licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no re–analysis or technical specification modifications are required, this submittal is believed to satisfy 10 CFR 50.46 (a) (3) (ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions, please call me or J. L. Embley at (910) 675–5774.

Sincerely,

Original signed by R. J. Reda, 12/15/95

R. J. Reda, Manager

Fuels and Facilities Licensing
(910) 675–5889, MC J26

cc: W. J. Sependa
J. L. Embley

bcc:	J. G. Andersen	MC F21
	R. A. Hanvelt*	MC A32
	P. C. Hecht	MC 781 (for MFN)
	P. D. Knecht	MC 747
	L. E. Miller	MC A16
	J. C. Shaug	MC 196
	G. L. Sozzi	MC 706
	M. R. Stepp	MC A17
	P. Wei	MC A13

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

3901 Castle Haynes Rd, Wilmington, NC 28401

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

February 20, 1996

RJR–96–016
MFN–020–96

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

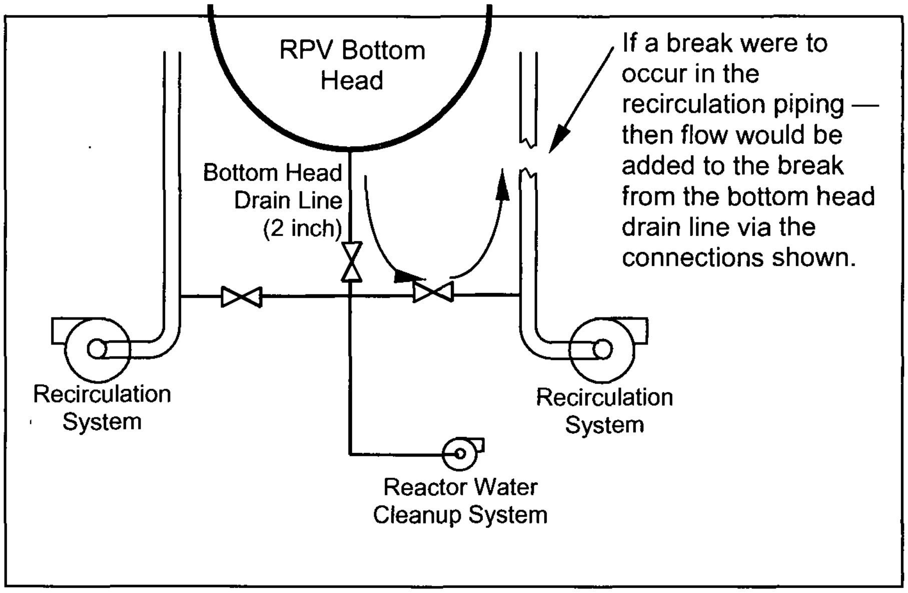
Attention: R. C. Jones, Jr.

Subject: **Reporting of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, R. J. Reda to the Document Control Desk (R. C. Jones, Jr., *Reporting of Changes and Errors in ECCS Evaluation Models*, dated December 15, 1995 (MFN–278–95).

GE is submitting this letter which revises the Reference letter. The Reference letter did not adequately describe the bottom head drain line situation as described on the second page. This letter will better describe the contribution of flow to the recirculation line break.

The RPV bottom head drain (BHD) has been found to have a slight impact on the LOCA analysis. A simplified arrangement is shown in the figure.



The concern was that because the bottom head drain line is directly connected to the reactor recirculation loops, that a recirculation line break LOCA would have additional flow contribution from the BHD, and the vessel would depressurize to the drywell faster than assumed in current models. Also, upon such an event occurring, some water required to keep the core covered to the 2/3 core height would exit the core due to either gravity or core pressure via the interconnected recirculation and bottom head RWCU suction lines.

A GENE evaluation concluded that while no analysis had been performed to precisely evaluate the PCT impact of the recirculation line break LOCA including the BHD, it is believed that the impact is less than 10°F based on engineering judgment and extrapolation of previous LOCA analyses. This bounding evaluation conservatively neglected friction losses through the drain line and RWCU line piping. Since an event is considered by the NRC to be significant if the PCT is increased more than 50°F (10CFR50.46 (a)(3)(i)), this amount of increase can be considered insignificant and well within the margins of the safety analysis.

The impact of the BHD exiting flow on maintaining RPV level inside the shroud is similarly insignificant. It was determined that a slightly higher minimum makeup flow will be required, however, the increased makeup is well within the margins of available ECCS systems. The minimum makeup flow corresponds to that necessary to makeup for decay heat and the drain rate from the BHD.

By copy of this letter, Licensees utilizing the GE ECCS methodology in their plant licensing are informed of the status of changes in the evaluation methodology. Since no re–analysis or technical specification modifications are required, this submittal is believed to satisfy 10CFR 50.46 (a)(3)(ii) for evaluation model changes without further reporting on the part of individual utilities.

If you have any questions, please call me or J. L. Embley at (910) 675–5774.

Sincerely,

R. J. Reda, Manager
Fuels and Facilities Licensing
(910) 675–5889, MC J26

cc: W. J. Sependa
J. L. Embley

bcc:	J. G. Andersen	MC F21
	K. F. Cornwell	MC 172
	D. A. Hamon	MC 172
	R. A. Hanvelt*	MC A32
	P. C. Hecht	MC 781 (for MFN)
	P. D. Knecht	MC 747
	L. E. Miller	MC A16
	J. C. Shaug	MC 196
	G. L. Sozzi	MC 706
	S. R. Stark	MC 182
	M. R. Stepp	MC A17
	P. Wei	MC A13
	M. R. Wuestefeld	MC 747

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

3901 Castle Haynes Rd, Wilmington, NC 28401

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

June 28, 1996

RJR–96–071
MFN–088–96

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555–0001

Attention: R. C. Jones, Jr., Chief
Reactor Systems Branch

Subject: **Reporting of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, J. F. Klapproth to the Document Control Desk (R. C. Jones, Jr.), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 24, 1995 (MFN–087–95), and revised by Letter, R. J. Reda to the Document Control Desk (R. C. Jones, Jr.), *Reporting of Changes and Errors in ECCS Evaluation Models*, February 20, 1996 (MFN–020–96).

The purpose of this letter is to report, in with 10 CFR 50.46 (a) (3) (ii), the impact of changes and errors in the methodology used by GE to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10 CFR 50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566–P–A, *Analytical Model for Loss–of–Coolant Analysis in Accordance with* 10 CFR *50 Appendix K.*

There have been no changes or errors identified for the SAFER/GESTR model described in NEDE 23785–1–P–A, *The GESTR–LOCA and SAFER Models for Evaluation of Loss–of–Coolant Accidents*, and NEDE 30996–P–A, *SAFER Model for Evaluation of Loss–of–Coolant Accidents for Jet Pump and Non–Jet Pump Plants.*

During the reporting period an error was discovered in some applications of the GE LOCA evaluation model SAFER/GESTR. It was determined that in some analyses cases an algorithm used to compute the number of fuel rods in a BWR lattice was incorrectly specified. As a result, SAFER input prepared in accordance with the automation process may have had incorrect data. The only impact was on the SAFER analyses for fuel designs containing large water rods where the input generation was automated. This finding does not impact plant safety.

This incorrect value for the number of active fuel rods resulted from a specification error in an automated SAFER/GESTR basedeck generation procedure. As a result of this specification error, the SAFER/GESTR basedecks for those fuel types containing large water rods (GE9/10/11/12/13) contained both an incorrect number of fuel rods and inappropriate values for the bundle flow areas and hydraulic diameters. Calculations performed to assess the significance of this error indicate that the impact on the calculated cladding temperature is less than 30°F.

Until recently, the limiting fuel types had not been associated with the large water rod designs and the base decks generated with the automated procedure were correct. The inconsistency was discovered as part of a normal GE quality assurance review of the SAFER/GESTR analysis for a specific plant with a large water rod limiting bundle. Actions have been taken to correct the problem and to ensure that the correct variable is used in all future applications. It should be noted that the PCT impact was small compared to the available margin to specified limits demonstrated by the SAFER/GESTR results and no impact on technical specification limits was found.

All utilities using these evaluation models have been notified of this error.

If you have any questions, please call me or J. L. Embley at (910) 675–5774.

Sincerely,

R. J. Reda, Manager
Fuels and Facility Licensing
(910) 675–5608

cc: W. J. Sependa
J. L. Embley

bcc: J. G. Andersen	MC F21
R. A. Hanvelt*	MC A32
P. C. Hecht	MC 781 (for MFN)
P. D. Knecht	MC 747
L. E. Miller*	MC A16
J. C. Shaug	MC 196
G. L. Sozzi	MC 706
M. R. Stepp*	MC A17
P. Wei	MC A13

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

June 27, 1997

RJR-97-084
MFN-029-97

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: J. E. Lyons, Chief
Reactor Systems Branch

Subject: **Reporting of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, R. J. Reda to the Document Control Desk (R. C. Jones, Jr.), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 28, 1996 (MFN-088-96).

The purpose of this letter is to assist licensees with reporting, in accordance with 10CFR50.46 (a) (3) (ii), the impact of changes and errors in the methodology used by GE to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

There have been no changes or errors identified for the SAFE/REFLOOD model described in NEDE 20566-P-A, *Analytical Model for Loss-of-Coolant Analysis in Accordance with* 10 CFR *50 Appendix K.*

There have been no changes or errors identified for the SAFER/GESTR model described in NEDE 23785-1-P-A, *The GESTR-LOCA and SAFER Models for Evaluation of Loss-of-*

Coolant Accidents, and NEDE 30996–P–A, *SAFER Model for Evaluation of Loss–of–Coolant Accidents for Jet Pump and Non–Jet Pump Plants.*

During the reporting period an input error was discovered in the GEGAP gap conductance model which impacts ECCS/LOCA MAPLHGR margins in SAFE/REFLOOD plants using GE11 or GE13 fuel. The nature of the input error in the GEGAP analysis was the use of a mean value of fuel pellet densification when a 95% confidence value should have been used. The expectation of the potential consequence of this type of error is a higher gap conductance between the fuel pellet and the cladding. This higher gap conductance would result in a lower initial stored energy in the fuel pellet at the onset of the LOCA and, thus, result in the calculation of a lower PCT during the LOCA. An analysis showed that the new corrected inputs from GEGAP resulted in an increase in the calculated PCT of as much as 15°F.

In the mid–1980s, prior to the reporting requirements of 10CFR50.46, GE increased the manufactured fuel density for all fuels. This increased fuel density was a recognized conservatism in the ECCS analysis, therefore no effort was made to redo all of the plant analysis, but rather to hold it as a known conservatism in the analysis. This conservatism, were it to be implemented in an ECCS analysis would result in a calculated PCT decrease of 25°F and could be used to offset the PCT increase due to the GEGAP error. This conservatism, which was the use of a lower than actual fuel pellet density in the core heatup calculation, affects both the SAFE/REFLOOD and the SAFER/GESTR models. Most licensees have determined that they do not need to incorporate this known conservatism in their current ECCS analysis.

All utilities using these evaluation models have been notified of these changes.

If you have any questions, please call me or J. L. Embley at (910) 675–5774.

Sincerely,

R. J. Reda, Manager
Fuels and Facility Licensing
(910) 675–5608

cc: C. J. Monetta
J. L. Embley

bcc: J. G. Andersen	MC F21
R. A. Hanvelt*	MC A32
C. Anderson	MC 706 (for MFN)
D. C. Pappone	MC 172
J. C. Shaug	MC 196
G. L. Sozzi	MC 706
P. Wei	MC A13

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

3901 Castle Haynes Rd, Wilmington, NC 28401

NEDO-32950 Revision 1
Non-proprietary Version

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

June 30, 1998

GAW–98–013
MFN–032–98

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555–0001

Attention: T. E. Collins, Chief
Reactor Systems Branch

Subject: **Reporting of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, R. J. Reda to the Document Control Desk (J. E. Lyons), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 27, 1997 (MFN–029–97).

The purpose of this letter is to assist licensees with reporting, in accordance with 10CFR50.46 (a) (3) (ii), the impact of changes and errors in the methodology used by GE to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

There have been no changes or errors identified for any of the approved GE LOCA analysis models which would impact the PCT results. These models are the SAFE/REFLOOD model described in NEDE 20566–P–A, *Analytical Model for Loss–of–Coolant Analysis in Accordance with* 10 CFR *50 Appendix K*, the SAFER/GESTR model described in NEDE 23785–1–P–A, *The GESTR–LOCA and SAFER Models for Evaluation of Loss–of–Coolant Accidents*, and NEDE 30996–P–A, *SAFER Model for Evaluation of Loss–of–Coolant Accidents for Jet Pump and Non–Jet Pump Plants.*

All utilities using these evaluation models have been notified.

If you have any questions, please call me or J. L. Rash at (910) 675–5612.

Sincerely,

{signed copy on file}

G. A. Watford, Manager
Nuclear Fuel Engineering
(910) 675–5446

cc: C. P. Kipp
J. L. Rash

bcc: J. G. M. Andersen	MC F21
C. Anderson	MC 706 (for MFN)
B. D. Arndt*	MC A20
K. R. Fletcher	MC 772
D. C. Pappone	MC 172
J. C. Shaug	MC 196
P. Wei	MC A13
W. Wong	MC772

* Please provide a copy of this letter to each utility utilizing the SAFE or SAFER methodology.

GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

June 30, 1999

GAW–99–003
MFN–004-99

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555–0001

Attention: J. L. Wermiel, Chief
Reactor Systems Branch

Subject: **Summary of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, G. A. Watford to the Document Control Desk (T. E. Collins), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 30, 1998 (MFN–032–98).

The purpose of this letter is to summarize the impact of changes and errors in the methodology used by GE to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from plant specific system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

A summary of the changes and errors is provided in the attached table. The table describes the approved methodology affected, the range of applicability of the change/error, a brief description of the change/error and the estimated impact.

All utilities using these evaluation models have been notified of these changes/errors to assist them in reporting, in accordance with 10CFR50.46 (a) (3) (ii).

If you have any questions, please call me.

Sincerely,

{signed copy on file}

G. A. Watford, Manager
Nuclear Fuel Engineering
(910) 675–5446

Error/ Change	Approved Methodology	Applicability	Description	**Impact**
Error	NEDE-30996P-A, *SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants,* October 1987.	Non-jet pump plants, GE9 and later fuel designs with large central water rods	In CORCL (used for fuel rod heatup calculations during spray cooling conditions) the diameter of the large central water rod is not passed as needed into one of the initialization routines. This problem does not affect the view factor or heat transfer calculations, however, it does affect the cross-section distribution of droplets within subchannels. This is a conservative error. The error has been corrected in the CORCL module.	-30 to -40°F
Error	NEDC-23785-1-PA, Rev. 1, *The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident*, October 1984.	Jet pump plants with GE8, GE9, GE10 and Siemens 8x8 and 9x9 fuel designs	The SAFER code models counter current flow limiting (CCFL) in the upper part of the bundle at the upper tie plate (UTP). The CCFL correlation uses the UTP flow area and a coefficient based on test data to determine the liquid downflow into the bundle. For fuel designs in which CCFL is expected to occur at the top spacer due to enlarged UTP flow areas, the CCFL constant must be adjusted to account for the difference in flow areas at the spacer and UTP. This was recognized for GE11 and later fuel types but was not applied to GE8, GE9, GE10 and Siemens 8x8 and 9x9 fuel types. The Technical Design Procedures have been modified to ensure that consistent inputs are used.	+5 to +25°F

Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

Global Nuclear Fuel – Americas, LLC
Castle Hayne Road, Wilmington, NC 28401
(910) 675-5446, Fax (910) 675-5764
Glen.Watford@gnf.com

Glen A. Watford
Manager, Nuclear Fuel Engineering

June 30, 2000

FLN-2000-06

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: J. L. Wermiel

Subject: **Summary of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, G. A. Watford to the Document Control Desk (J. L. Wermiel), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 30, 1999 (MFN–004–99).

The purpose of this letter is to summarize the impact of changes and errors in the methodology used by GE/GNF-A to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from system or fuel changes are not addressed in this letter. These should be treated, as appropriate, on a plant specific basis in accordance with other sections of 10CFR50.

A summary of the changes and errors is provided in the attached table. The table describes the approved methodology affected, the range of applicability of the change/error, a brief description of the change/error and the estimated impact.

All utilities using these evaluation models have been notified of these changes/errors to assist them in reporting, in accordance with 10CFR50.46 (a) (3) (ii).

If you have any questions, please call me at (910) 675-5446.

Sincerely,

Glen A. Watford, Manager
Nuclear Fuel Engineering

Summary of Changes and Errors in ECCS Evaluation Models
July 1999 through June 2000

Error/ Change	Approved Methodology	Applicability	Description	**Impact**
Error	NEDC-32950P, Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000.	BWR/6 plants	The reactor pressure vessel thermal response is simulated in the SAFER code as several heat slabs for which the one-dimensional radial conduction equation is solved (Reference). A logic error was discovered in an automated SAFER/GESTR basedeck generation procedure that calculated the heat transfer areas for the vessel heat slabs. As a result of this logic error, the heat transfer areas for the vessel heat slabs in the downcomer region were incorrectly specified for BWR/6 plants. This error affects the steam generation in the vessel during the reflooding stage of the event once the lower plenum fills and water spilling over from the jet pumps comes into contact with the vessel wall in the downcomer region.	0 to -45°F

Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

Global Nuclear Fuel – Americas, LLC
Castle Hayne Road, Wilmington, NC 28401
(910) 675-5446, Fax (910) 675-5684
Glen.Watford@gnf.com

Glen A. Watford
Manager, Fuel Engineering Services

August 10, 2001

FLN-2001-13

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: J. L. Wermiel

Subject: **Summary of Changes and Errors in ECCS Evaluation Models**

Reference: Letter, G. A. Watford to the Document Control Desk (J. L. Wermiel), *Reporting of Changes and Errors in ECCS Evaluation Models*, dated June 30, 2000 (FLN-2000-06).

The purpose of this letter is to summarize the impact of changes and errors in the methodology used by GE/GNF-A to demonstrate compliance with the Emergency Core Cooling System (ECCS) requirements of 10 CFR 50.46. This report covers the period from the last report (Reference) to the present. It is noted that Peak Cladding Temperature (PCT) variations resulting from input errors, plant system changes or fuel design changes are not addressed in this letter.

A summary of the changes and errors is provided in the attached table. The table describes the approved methodology affected, the range of applicability of the change/error, a brief description of the change/error and the estimated impact.

All utilities using these evaluation models have been notified of these changes/errors to assist them in reporting, in accordance with 10CFR50.46 (a) (3) (ii). This report is provided for information only.

If you have any questions, please call me at (910) 675-5446.

Sincerely,

Glen A. Watford, Manager
Fuel Engineering Services

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

Error/ Change	Approved Methodology	Applicability	Description	**Impact**
Error	NEDC-23785-1-PA, Rev. 1, *The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident*, October 1984. NEDE-30996P-A, *SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants,* October 1987.	BWR/2-6 plants	The ECCS piping inside the vessel (between the vessel wall and shroud) has various leakage paths through slip joints and vent holes. Not all the ECCS water injected into the vessel reaches the region inside the shroud. Some of the water is lost through these leakage paths into the downcomer region. The core spray and LPCI flow rates provided in the OPL-4 usually define flow rates to the vessel and may not account for these leakages. The OPL-4 flow rates must then be adjusted to account for the leakage inside the vessel by subtracting the leakage from the OPL-4 flows. In the SAFER analyses for some plants, the leakage flows had not been subtracted from the OPL-4 values for the ECC system flows. This may result in a disconnect between what the utility understands as the system flow requirement (the flow to the vessel) and the flow rate used in the analysis (the flow inside the shroud). The OPL-4 form has been revised to clearly address the ECCS leakage flows in future SAFER analyses.	<+15°F small BWR/4s with LPCI mods <+5°F other affected plants

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Change	NEDC-23785-1-PA, Rev. 1, *The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident*, October 1984. NEDE-30996P-A, *SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants*, October 1987.	All plants	As the result of a BWROG audit of GENE's LOCA methodology, the SAFER code development documentation was reviewed for conformance with the requirements of Appendix K. The audit team felt that numerical convergence had not been adequately demonstrated for the time step size used in plant-specific calculations. An evaluation was performed to determine the appropriate time step size to be used for plant-specific calculations and to demonstrate convergence for the recommended time step size. This evaluation recommended a change in the time step size to be used in plant-specific calculations.	-35°F to +25°F

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Error/ Change	Approved Methodology	Applicability	Description	**Impact**
Error	NEDE-30996P-A, SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Octo`ber 1987.	BWR/3 and BWR/4 with LPCI injection through the jet pumps	In SAFER, the amount of condensation that occurs when subcooled ECCS flow enters the vessel is dependent on the location of the injection sparger relative to the fluid level in the injected region and an input maximum condensation efficiency. When the fluid level covers the sparger, no condensation is calculated. When the fluid level is below the injection elevation plus an input mixing length, steam is assumed to condense with the maximum allowable efficiency. When the fluid level is within the mixing length, a linear variation in condensation between the two limits is assumed. The mixture of injection flow and condensate is added to the injected region. For ECCS flow injected into region 1 (lower plenum/jet pump) a coding error was discovered that results in twice the calculated amount of condensate being added to the region. For typical BWR/4 applications, the amount of condensate will be in the range of 10 to 15 percent of the injection flow depending on the vessel pressure. The increased condensate will impact the mass and energy of the lower plenum as well as the calculated liquid and/or vapor flow to the core. Any change in core inventory will impact the calculated second Peak Clad Temperature (PCT) that occurs after ECCS initiation. Injection into all other SAFER regions is calculated correctly.	+45 to +90°F

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Error/ Change	Approved Methodology	Applicability	Description	**Impact**
Error	NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident," October 1984. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants," October 1987. .	All plants	In SAFER, steam condensation on the subcooled ECCS injection flow is calculated as long as sufficient steam mass is available in the vessel. The pressure rate equation maintains sufficient steam mass to fill the vessel by adjusting the flashing rates as the vessel depressurizes. Only when the vessel pressure is predicted to fall below the drywell pressure will the pressure rate be forced to zero, which allows steam mass to be reduced by condensation and not be replenished by flashing due to a decrease in pressure. When there is a change in the two-phase level position in the core, an inconsistent core exit steam flow was used in the SAFER pressure equation. This caused an error in the calculated pressure, which, in some cases, resulted in reduced flashing and the premature termination of ECCS condensation due to insufficient steam mass. Any change in core inventory will impact the calculated second Peak Clad Temperature (PCT) that occurs after ECCS initiation.	+5 to +10°F

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2002-01 Transmittal Date: June 13, 2002

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-01***

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject: SAFER Core Spray Injection Elevation Error

References:

1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984.
2. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984.

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	X
Error in plant-specific application of such model?	

Description of Change/Error

An error was found in the automation code that prepares the input basedecks for the SAFER analysis. This error resulted in too low a value being calculated for the core spray injection elevation for the lower core spray sparger. The injection elevation for the lower sparger was set slightly above the top of the fuel channels (bottom of the lower plenum region in the SAFER code). This error affects the buildup and draining of the pool in the upper plenum. The error also affects the amount of steam quenched by the core spray water. The incorrect injection elevation may result in an incorrect calculation for the PCT.

Because the core spray injection elevation controls several competing phenomena, the effect of correcting the injection elevation may result in an increase or decrease in the PCT. Raising the injection elevation increases the amount of inventory that can be held up in the pool of water that may form in the upper plenum. This inventory holdup may delay the reflooding of the core, which can result in an increase in the PCT. On the other hand, the higher injection elevation results in more steam being condensed by the spray water. The increased condensation can result in a faster vessel depressurization and higher ECCS flows, which can result in an earlier reflooding of the core and a decrease in the PCT. In addition, the spray water flowing to the lower plenum will be warmer (having condensed more steam). The core may then reflood faster with a more highly voided mixture, again resulting in a decrease in the PCT. The analysis assumptions (nominal or Appendix K) can also affect whether the correction results in an increase or decrease in PCT.

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Evaluation of Change/Error	
A study was performed to assess the impact of the correction in the core spray injection elevation on the PCT. A set of representative jet pump plants covering the BWR/3-6 product lines was selected, and SAFER runs were performed to obtain the change in PCT for both Nominal and Appendix K conditions. The impact on the PCT ranged from –95°F to +60°F. A small break analysis was also performed for both Nominal and Appendix K conditions on a few selected plants. The impact on the PCT was increases of up to +30°F.	
Analyses Affected by Change/Error	
This error applies to SAFER analysis for all jet pump BWRs. The non-jet pump BWR/2 plants are not affected because the core spray sparger elevation is explicitly accounted for in the core spray distribution methodology used for these plants. The PCT impact on individual plant analyses affected by this error is shown in the attached table.	
Issued by: Glen A. Watford, Manager, Fuel Engineering Services	
Technical Source: Dan Pappone, Nuclear & Safety Analysis	

Plant	***Comments***	***Licensing Basis PCT Change (°F)***

Notes:	
References	

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Additional Considerations

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. For compliance with criterion 50.46(b)(1), peak cladding temperature shall not exceed 2200°F, the Licensing Basis PCT is evaluated. The requirements of 10 CFR 50.46 are therefore only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative.

The impact of the core spray injection elevation correction on the Upper Bound PCT is provided in the table below.

To determine the new estimated Upper Bound PCT, the actual value of the change in PCT should be added to or subtracted from the current Upper Bound PCT. Accounting for the condensation error in SAFER may result in the estimated Upper Bound PCT for some plants exceeding the 1600°F restriction specified by the NRC in their SER approving the SAFER/GESTR-LOCA application methodology. Following the table, a discussion is provided that demonstrates that the licensing basis and Upper Bound PCTs are sufficiently conservative even though the Upper Bound PCT may exceed 1600°F. This justification may be used to satisfy the SER requirement for additional supporting information for Upper Bound PCTs above 1600°F. If a reduction in LHGR and MAPLHGR limits is required to keep the Upper Bound PCT below 1600°F, the maximum LHGR and corresponding MAPLHGR limits for the affected fuel types can be reduced at a rate of 1% for every 13°F of PCT reduction required.

Plant	***Comments***	***Upper Bound PCT Change (°F)***

Notes:

Additional Upper Bound PCT Considerations

Correction of the condensation error in SAFER may result in the Upper Bound PCT for some plants exceeding the 1600°F restriction specified by the NRC in their SER approving the SAFER/GESTR-LOCA application methodology. This discussion 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.

BACKGROUND

The SAFER application methodology was approved under SECY 83-472 (Reference 1), 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. The limiting LOCA, defined by the combination of break size, location, and worst single failure

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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 in order 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 2). 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 LTR was performed over a temperature range where effects such as metal-water reaction are negligible. The SER states that above 1600°F, additional supporting information is needed to provide assurance that the Upper Bound PCT prediction is sufficiently conservative. This additional supporting information is provided below.

CODE QUALIFICATION

The NRC SER approving the SAFER/GESTR-LOCA application methodology (Reference 2) 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 3) 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.

The CORECOOL bundle heatup model has been extensively qualified against test data over a wide range of temperatures (up to about 2100°F). Even though the SAFER heatup calculation has not been qualified against test data at higher temperatures, it is easy to compare the SAFER and CORECOOL PCT results to demonstrate the conservatism in the SAFER PCT calculation because both codes perform a PCT calculation for the same system conditions. A comparison of the analysis results for a BWR/4 with limited ECCS capacity is shown in the figure below. These results show that the PCT calculated by SAFER is 100-200°F higher than the PCT calculated by CORECOOL. The SAFER PCT calculation is higher than the CORECOOL PCT calculation because of the radiation and core spray heat transfer simplifications in SAFER, which uses a simplified (conservative) radiation model compared to CORECOOL. The CORECOOL model takes credit for direct core spray flow and core spray heat transfer in the hot bundle. These results demonstrate that the SAFER PCT calculation is conservative at higher temperatures.

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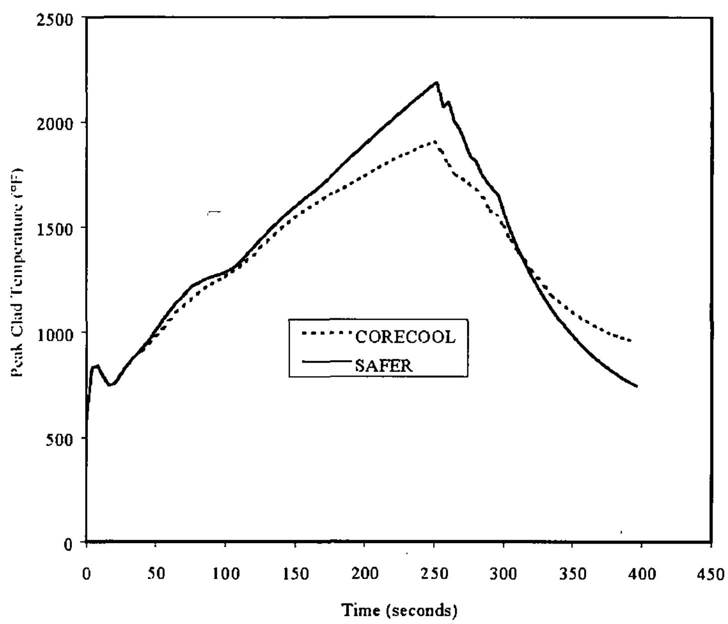
SAFER vs CORECOOL PCT



UPPER BOUND PCT CALCULATION

The NRC SER approving the SAFER/GESTR-LOCA application methodology (Reference 2) restricted the Upper Bound PCT to 1600°F in part because the Monte Carlo simulation presented in the SAFER LTR was performed over a temperature range where effects such as metal-water reaction are negligible. The 1600°F restriction was applied to both the SAFER plant Modeling Uncertainty term ($\Delta 4$) term and the SAFER Mean-Nominal Bias term ($\overline{\Delta 3}$) in the Upper Bound PCT calculation.

Metal-Water Reaction

The major effects that come into play at higher temperatures are the metal-water reaction, core spray cooling, and radiation heat transfer. As described above, SAFER uses simplified, conservative approaches for modeling core spray cooling and radiation heat transfer that remain bounding at higher temperatures. The metal-water reaction was determined to be a negligible effect at the lower temperatures being calculated by SAFER and was not included as a significant parameter in the Upper Bound PCT calculations.

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Even though the metal-water reaction was not varied as an explicit parameter in the Upper Bound PCT calculation, the perturbation of the other parameters does introduce the effect of oxidation at higher temperatures into the Upper Bound PCT calculation.

The Licensing Basis PCT and the Upper Bound PCT are similar in that the same set of parameters is varied in the calculation (PLHGR, decay heat, break flow, fuel rod stored energy, MCPR, transition boiling temperature). The Upper Bound PCT calculation uses parameter values that are two standard deviations above the nominal. The Upper Bound PCT calculation varies the parameters individually, and then combines the results statistically. The Licensing Basis PCT calculation uses the required Appendix K models, each of which exceeds a 95th percentile confidence level on the parameter. The Appendix K models bound the parameter values used in the Upper Bound PCT calculation with the exception of the PLHGR (while the nominal value for the PLHGR is less than the Technical Specification value, the PLHGR used in the upper bound calculations is greater than 1.02 times the Technical Specification value required by Appendix K). The Licensing Basis PCT is based on a single case with all the Appendix K assumptions used simultaneously. The impact of varying all the parameters simultaneously is greater than combining the individual impacts statistically. In addition, the Licensing Basis PCT calculation includes the conservative Baker-Just metal-water reaction model required by Appendix K. Because of these factors, the Licensing Basis PCT will be higher than the Upper Bound PCT.

The figure below presents a comparison of the Licensing Basis PCT and Upper Bound PCT for all the jet pump plant SAFER analyses. The comparison shows that the Licensing Basis PCT and Upper Bound PCT are fairly close at lower temperatures where the heatup is not sufficient to clearly differentiate between the two sets of models. The comparison shows that as the PCT increases, the difference between the Licensing Basis PCT and the Upper Bound PCT increases. At an Upper Bound PCT of 1600°F, the Licensing Basis PCT is at least 150°F to 350°F higher. The metal-water reaction does not become a factor until the cladding temperatures reach 1700°F and does not become significant until the cladding temperatures exceed 1800°F. When the Upper Bound PCT reaches 1800°F (where metal-water reaction is just beginning to become significant), the Licensing Basis PCT will be approaching 2200°F where it would be restricted by the 50.46 limit. Even if the metal-water reaction was explicitly included as a term in the Upper Bound PCT calculation, the 2200°F limit on the Licensing Basis PCT will restrict the Upper Bound PCT to temperature ranges where metal-water reaction is not a large contributor. Based on the trend shown in the figure below, the Upper Bound PCT cannot go much above 1600°F before the Licensing Basis PCT reaches 2200°F. Therefore, metal-water reaction is not a significant parameter in the Upper Bound PCT calculations, even for Upper Bound PCTs above 1600°F.

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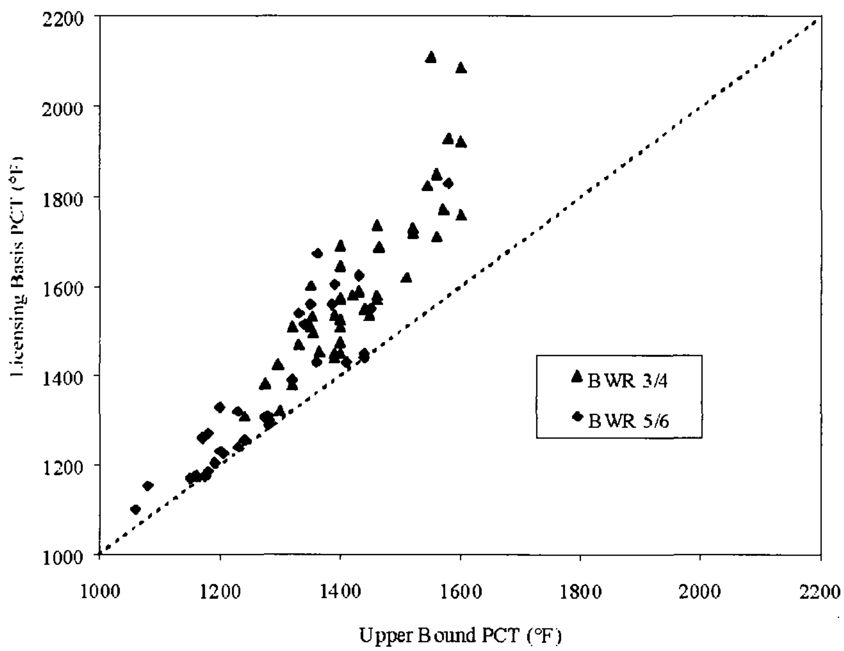
Comparison of Upper Bound and Licensing Basis PCT



SAFER Plant Modeling Uncertainty Term (Δ4)

The SAFER Plant Modeling Uncertainty Term is made up of two basic terms: a) the TRACG-SAFER Modeling Uncertainty (Δ2), and b) the Total TRACG Experiment Modeling Uncertainty (Δ7). The Δ7 term is based on TRACG predictions of experimental results and is not affected by changes in plant conditions or LOCA analysis assumptions. The Δ2 term is the difference between the TRACG and SAFER PCTs for the same plant operating condition and LOCA analysis assumptions (break size, single failure, etc.). The Δ2 term will be affected by the change in plant conditions or fuel type that can lead to higher calculated Upper Bound PCTs. The current Δ2 term was chosen based on the maximum positive value from the TRACG-SAFER results for various high-power conditions with different break sizes. The current Δ2 term has also been shown to be applicable to current fuel types.

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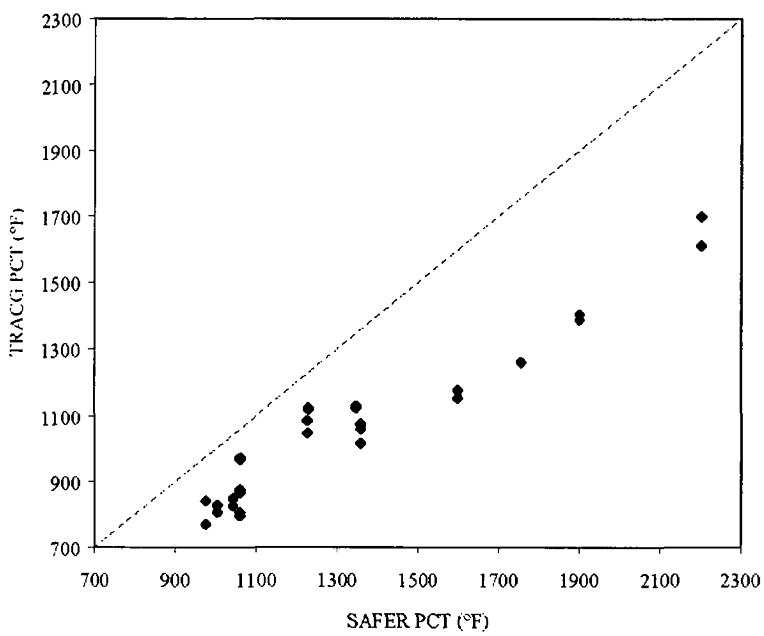
The figure below shows a comparison of SAFER and TRACG second peak PCTs for a typical BWR/4. The ECCS flow rates were reduced and the system initiation times were increased in order to drive up the calculated PCTs. Different combinations of available ECCS configurations were analyzed. The results show that the SAFER PCT is always higher than the TRACG PCT. These results also demonstrate the overall conservatism introduced into the SAFER PCT calculations by the model simplifications discussed below. More noteworthy is that at higher temperatures, the margin between the SAFER PCT and the TRACG PCT significantly increases as the PCT increases. If the Δ2 term were evaluated at the higher temperature conditions, this would result in a lower Δ2 term and lower calculated Upper Bound PCTs than would be calculated using the current values for the Δ2 term. Since the Licensing Basis PCT is based solely on the SAFER results, the Licensing Basis PCT at higher temperatures will always increase at a higher rate than the Upper Bound PCT. Therefore, the Licensing Basis PCT will be sufficiently conservative when the Upper Bound PCT is above 1600°F. Also, use of the current values for the Δ2 term will result in a conservative Upper Bound PCT calculation at higher temperatures.

Comparison of SAFER and TRACG PCTs



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

The $\overline{\Delta 3}$ term in the Upper Bound PCT calculation is defined as the difference between the nominal SAFER PCT and the true mean PCT. The intent of this term is to account for bias from two different sources: a) the effect of non-linearity in the dependence of PCT on key plant variables; and b) the effect on PCT of differences between nominal input values and the mean of each variable. The $\overline{\Delta 3}$ term was estimated based on the results of the Monte Carlo simulation. The original $\overline{\Delta 3}$ terms indicated that the nominal SAFER PCT was 27°F to 31°F lower than the Monte Carlo mean for the first peak PCT and +24°F to -5°F higher than the Monte Carlo mean for the second peak PCT. Numerical convergence studies performed since that time show that the timestep values used in the original Monte Carlo simulation introduced a bias that accounts for most of the mean-nominal difference shown in the original $\overline{\Delta 3}$ terms.

The numerical convergence study reported in 10CFR50.46 notification 2000-04 showed that original time step values introduced, on the average, a bias of -20°F for the first peak PCT and +20°F for the second peak PCT. These biases are about the same as the $\overline{\Delta 3}$ terms and result from the same cause. The original timestep values were optimized for the computing power available at the time SAFER was developed almost 20 years ago. Increases in computing power over last 20 years make it practical to use significantly smaller timestep sizes in production calculations. The convergence study was performed by reducing the timestep sizes for a large number of nominal base cases until the bias was eliminated and the numerical uncertainty was at a minimum. These small perturbations about the nominal base case identified the bias introduced by the original timestep values. The sensitivity studies also showed a relatively large numerical uncertainty for the second peak PCT when using the original timestep values.

The Monte Carlo simulations identified the same bias introduced by the original timestep values using a different approach. The Monte Carlo approach uses a large number of trials with the input parameters varied over a wide range. The large number of trials and the wide range of input parameter values outweigh the bias introduced by the time step values; the resulting mean PCT from the simulation represents a fully converged solution for the nominal case. The end result is the same as the convergence study approach. If the Monte Carlo simulations were repeated based on SAFER calculations using the new timestep values, the resulting $\overline{\Delta 3}$ terms would be much closer to zero. The spread in the original second peak $\overline{\Delta 3}$ term can be accounted for by the numerical uncertainty shown for the second peak PCT in the convergence study. Therefore, the values for the original $\overline{\Delta 3}$ terms are primarily due to the bias introduced into the nominal base case by the original timestep sizes and are not significantly influenced by the Upper Bound PCT.

CONSERVATISMS IN SAFER MODELING

SAFER is a realistic LOCA evaluation model. All the significant phenomena for a LOCA are modeled. Nominal models and correlations are used in the code. No effort was made

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to intentionally introduce conservatism into the correlations during the development of SAFER as is done when developing a pure Appendix K model. However, the SAFER modeling does contain several simplifications that introduce conservatism into the overall PCT calculation. These simplifications include a single node lower plenum region, simplified radiative heat transfer, and no direct core spray flow to the hot bundle. The SAFER PCT calculations are inherently conservative as a result of the overall effects of these simplifications.

The most significant simplification in the SAFER model is that the lower plenum is modeled as a single hydraulic node. This approach conservatively neglects the effects of any thermal stratification that may occur. When modeled as a single node, the region becomes subcooled based on the average fluid enthalpy. When the lower plenum subcools, the steaming from the lower plenum stops. Any water that is being held up in the bundles due to CCFL at the side entry orifice then drains out of the core. This also stops the steam updraft that may be providing steam cooling to the core. The core then undergoes an adiabatic heatup, resulting in higher calculated PCTs. In addition, premature subcooling of the water in the lower plenum quenches the voids in the lower plenum and results in a level collapse. This level collapse delays the core reflooding, which also contributes to higher calculated PCTs. With thermal stratification, the colder LPCI water would settle to the bottom of the lower plenum and the layer of hot water on the surface would continue to provide steam to the core. The stratification would extend the time that steam is generated in the lower plenum, thus extending the time that steam cooling is provided to the core. The lower plenum subcooling observed in the SAFER analyses is not expected to occur and steaming is expected to be maintained until the core is reflooded. This has been confirmed by a benchmark calculation using the TRACG model for a BWR/4 plant with limited ECCS capacity. Therefore, the single node lower plenum modeling in SAFER results in a conservative PCT calculation.

A simplified model for rod-to-rod and rod-to-channel radiation heat transfer has been used in the SAFER code because SAFER only models a single hot rod and a single average rod in the channel. This simplified radiation model results in radiation heat transfer that is conservative compared to more detailed multiple rod models such as CHASTE and CORECOOL. The effect of this conservatism is greater at higher temperatures where radiation heat transfer becomes significant. Because the conservatism is greater at higher temperatures, the SAFER PCT calculation will become more conservative at higher temperatures.

SAFER calculations for jet pump plants do not take credit for direct core spray cooling to the hot channel. Spray flow is assumed to reach the hot channel only if a pool of water builds up in the upper plenum. This simplifying assumption was made in order to conservatively address issues concerning spray distribution in a steam environment. Though the spray flow reaching the hot channel may be less than the original design flow rate, some spray flow will directly reach the hot channel. Even partial spray cooling can significantly reduce the fuel heatup rate. In addition, since core spray heat transfer is more effective at higher temperatures, this simplification increases the conservatism at higher temperatures. Therefore, the SAFER PCT calculation will become more conservative at

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higher temperatures.

The SAFER PCT calculations are inherently conservative due to the overall effects of these simplifications. The conservatism introduced by the radiation and core spray heat transfer simplifications becomes larger at higher temperatures. Therefore, the overall PCT prediction becomes more conservative at higher temperatures.

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 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. The current TRACG-SAFER modeling uncertainty term ($\Delta 2$) is more conservative at higher temperatures, resulting in a more conservative Upper Bound PCT calculation at higher temperatures. The values for the mean-nominal bias term ($\overline{\Delta 3}$) are primarily due to the bias introduced into the nominal base case by the original timestep sizes and are not significantly influenced by the Upper Bound PCT. 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.

References

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

2. 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.

3. 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.

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2002-02 Transmittal Date: June 13, 2002

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-02***

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject: Impact of SAFER Bulk Water Level Error on the Peak Clad Temperature (PCT).

References:

1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984.
2. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984.
3. NEDC-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.
4. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987.
5. NEDE-20566-P-A, "General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50 Appendix K," September 1986.

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	X

Description of Change/Error

The initial vessel water level used in some SAFE/REFLOOD and SAFER LOCA analyses did not properly account for the effect of the steam dryer pressure drop on the initial inventory of water in the vessel. In the LOCA analyses, the initial water level is assumed to be at either normal water level or at the low water level scram (Level 3) analytical limit, depending on the analysis assumptions. The numerical value used in the analysis was based on the level as indicated by the level instrumentation. The indicated level shows the water level in the annular region between the dryer skirt and the vessel wall. The water

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-02***

inside the dryer skirt is at a lower level; the difference between the levels inside and outside the dryer skirt is equivalent to the steam dryer pressure drop. The SAFE and SAFER codes do not model the steam dryer effects on the initial water level. The initial liquid inventory in the vessel is determined by the value of the initial bulk water level input in the SAFE and SAFER codes. Using the indicated water level as the initial water level results in too high an initial liquid inventory because the lower water level inside the dryer skirt is not addressed. This additional water in the vessel assumed in the analysis may delay the core uncovery, which may result in a non-conservative calculation of the peak cladding temperature (PCT).

Evaluation of Change/Error

When corrected for the dryer pressure drop, the initial bulk water level in the vessel is lower than that used in the original SAFE or SAFER analyses. A SAFER evaluation was performed to assess the impact of the correction in the bulk water level on the PCT. A set of representative plants covering the BWR/2-6 product lines was selected and SAFER runs were performed to obtain the change in PCT for both Nominal and Appendix K conditions. The impact on the PCT ranged from -5°F to +20°F. A similar evaluation showed that the impact of the error was negligible for plants using the SAFE/REFLOOD methodology.

Analyses Affected by Change/Error

This error applies to SAFE/REFLOOD and SAFER analyses for BWR/2-6 plants. The plant analyses affected by this error are identified in the attached table, along with the PCT impact.

The absolute value of the change in PCT that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, the actual value of the change in PCT should be added to or subtracted from the current Licensing Basis PCT from the analysis of record.

Issued by: Glen A. Watford, Manager, Fuel Engineering Services

Technical Source: Dan Pappone, Nuclear & Safety Analysis

Plant	***Comments***	***Licensing Basis PCT Change (°F)***

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46 Notification Letter 2002-02**

References

Additional Considerations

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. For compliance with criterion 50.46(b)(1), peak cladding temperature shall not exceed 2200°F, the Licensing Basis PCT is evaluated. The requirements of 10 CFR 50.46 are therefore only applicable to the Licensing Basis PCT and do not apply to the Upper Bound PCT. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative.

The impact of the bulk water level correction on the Upper Bound PCT is provided in the table below.

To determine the new estimated Upper Bound PCT, the actual value of the change in PCT should be added to or subtracted from the current Upper Bound PCT. Accounting for the bulk water level error in SAFER may result in the estimated Upper Bound PCT for some plants to exceed the 1600°F restriction specified by the NRC in their SER approving the SAFER/GESTR-LOCA application methodology. In this case, a justification can be provided to satisfy the SER requirement for additional supporting information for Upper Bound PCTs above 1600°F or MAPLHGR limits can be reduced to limit the Upper Bound PCTs to 1600°F. If a reduction in MAPLHGR limits is required, the MAPLHGR limits for the affected fuel types can be reduced at a rate of 1% for every 13°F of PCT reduction required.

Plant	*Comments*	*Upper Bound PCT Change (°F)*

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46 Notification Letter 2002-03** **August 26, 2002**

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject: Impact of GESTR Input File Interpolation Error on the Peak Clad Temperature (PCT).

References:

1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984.
2. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984.
3. NEDC-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.
4. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987.

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	X
Error in plant-specific application of such model?	

Description of Change/Error

The GESTR input files provide the steady state gap conductance initialization information for the SAFER code. The GESTR input files consist of tables of gap conductance and related fuel input parameters as functions of Linear Heat Generation Rate (LHGR) and exposure (EXP). To determine the initial gap conductance, SAFER must perform a double interpolation in the tables for the specified LHGR and exposure inputs. An error in the interpolation coding resulted in an error in the initial gap conductance for cases at or beyond the knee in the LHGR curve. Due to this error, the initial gap conductance used in the SAFER calculations was slightly lower than it should have been.

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-03*** ***August 26, 2002***

Evaluation of Change/Error

An evaluation was performed in order to determine the impact of the GESTR file interpolation error on the PCT results. This evaluation concluded that the PCT results were conservative when compared to the corrected cases. However, the PCT impact is small enough that it was determined to be negligible with respect to the Licensing Basis PCT and Upper Bound PCT.

Analyses Affected by Change/Error

This error applies to SAFER analysis of BWR/2-6 plants. The plant analyses affected are identified in the attached table, along with the PCT impact

"NA" in the Licensing Basis PCT Change column means that the analysis does not have the GESTR Input File Interpolation Error. "0" in the Licensing Basis PCT Change column means that some or all of the analysis has the GESTR Input File Interpolation Error but the PCT impact is negligible.

The absolute value of the change in PCT that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, the actual value of the change in PCT should be added to or subtracted from the current Licensing Basis PCT from the analysis of record.

Issued by: Glen A. Watford, Manager, Fuel Engineering Services

Technical Source: Dan Pappone, Nuclear & Safety Analysis

Plant	***Comments***	***Licensing Basis PCT Change (°F)***

References

Additional Considerations

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1) - peak cladding temperature shall not exceed 2200°F. The requirements of 10 CFR 50.46 are therefore only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative.

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46 Notification Letter 2002-03** **August 26, 2002**

The impact of the GESTR File Error correction on the Upper Bound PCT is provided in the table below.

To determine the new estimated Upper Bound PCT, the actual value of the change in PCT should be added to or subtracted from the current Upper Bound PCT.

Plant	*Comments*	*Upper Bound PCT Change (°F)*

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-04*** ***August 26, 2002***

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject: Impact of SAFER04 Computer Platform Change on the Peak Clad Temperature (PCT).

References:

1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984.
2. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984.
3. NEDC-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.
4. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987.

Change in an acceptable evaluation model or application of such model?	X
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	

Description of Change/Error

The LOCA evaluation code SAFER04 has been migrated from the VAX computer platform (SAFER04V) to the Alpha computer platform (SAFER04A). The change in computer platform may result in a change in the calculated peak cladding temperature (PCT) due to changes in the processor word size and FORTRAN compiler characteristics.

Evaluation of Change/Error

To determine the impact of changing from the VAX computer platform to the Alpha computer platform, SAFER and SAFER/CORECOOL calculations were performed over the range of plant types, fuel types, break sizes, locations, and initial analysis assumptions

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-04*** ***August 26, 2002***

using SAFER04V and SAFER04A. The results of these calculations showed that the change in the SAFER computer platform did not introduce any bias in the calculated PCTs for any plant.

Analyses Affected by Change/Error

This change applies to SAFER analysis of BWR/2-6 plants. The plant analyses affected are identified in the attached table, along with the PCT impact.

"NA" in the Licensing Basis PCT Change column means that the analysis has been migrated to the Alpha platform. "0" in the Licensing Basis PCT Change column means that some or all of the analysis has not been migrated to the Alpha platform.

The absolute value of the change in PCT that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, the actual value of the change in PCT should be added to or subtracted from the current Licensing Basis PCT from the analysis of record.

Issued by: Glen A. Watford, Manager, Fuel Engineering Services

Technical Source: Dan Pappone, Nuclear & Safety Analysis

Plant	***Comments***	***Licensing Basis PCT Change (°F)***

Notes:

References

Additional Considerations

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1) - peak cladding temperature shall not exceed 2200°F. The requirements of 10 CFR 50.46 are therefore only applicable to the Licensing Basis PCT and do not apply to the Upper Bound PCT. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative.

The impact of the SAFER04 computer platform change on the Upper Bound PCT is provided in the table below.

To determine the new estimated Upper Bound PCT, the actual value of the change in PCT should be added to or subtracted from the current Upper Bound PCT.

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July 2000 through June 2001

GE Proprietary Information		***10 CFR 50.46 Notification Letter 2002-04*** ***August 26, 2002***
Plant	***Comments***	***Upper Bound PCT Change (°F)***
Notes:		

Summary of Changes and Errors in ECCS Evaluation Models July 2000 through June 2001

GE Proprietary Information	***10 CFR 50.46 Notification Letter 2002-05*** ***August 26, 2002***

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of WEVOL S1 Volume Error on the Peak Clad Temperature (PCT).
References:	1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984. 2. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. 3. NEDC-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. 4. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987.

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	X
Error in plant-specific application of such model?	

Description of Change/Error

The WEVOL code is used to calculate the weight and volume inputs for jet pump plant SAFER analyses. An error was found in the WEVOL code, which affects the calculated vessel volume in the downcomer region. The free volume in the region of the shroud head is calculated incorrectly. The code did not properly account for the volume of the standpipes inside the shroud head thickness. This resulted in the value for the free volume in the downcomer being too small by 4 – 10 ft^3.

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46 Notification Letter 2002-05** **August 26, 2002**

Evaluation of Change/Error

A study was performed to assess the impact of the downcomer volume correction on the peak cladding temperature (PCT). A set of representative jet pump plants covering the BWR/2-6 product lines was selected and SAFER runs were performed to obtain the change in PCT for both Nominal and Appendix K conditions. Based on these analyses, it was determined that the impact of the volume error on the PCT was negligible.

Analyses Affected by Change/Error

This error applies to SAFER analysis of BWR/2-6 plants. The plant analyses affected by this error are identified in the attached table, along with the PCT impact.

The absolute value of the change in PCT that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, the actual value of the change in PCT should be added to or subtracted from the current Licensing Basis PCT from the analysis of record.

Issued by: Glen A. Watford, Manager, Fuel Engineering Services

Technical Source: Dan Pappone, Nuclear & Safety Analysis

Plant	***Comments***	***Licensing Basis PCT Change (°F)***

Notes:

References

Additional Considerations

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. For compliance with criterion 50.46(b)(1), peak cladding temperature shall not exceed 2200°F, the Licensing Basis PCT is evaluated. The requirements of 10 CFR 50.46 are therefore only applicable to the Licensing Basis PCT and do not apply to the Upper Bound PCT. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative.

The impact the S1 volume correction on the Upper Bound PCT is provided in the table below.

To determine the new estimated Upper Bound PCT, the actual value of the change in PCT should be added to or subtracted from the current Upper Bound PCT.

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Summary of Changes and Errors in ECCS Evaluation Models
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GE Proprietary Information		***10 CFR 50.46 Notification Letter 2002-05*** ***August 26, 2002***
Plant	***Comments***	***Upper Bound PCT Change (°F)***
Notes:		

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Summary of Changes and Errors in ECCS Evaluation Models
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GE Proprietary Information	**10 CFR 50.46**
Utiliaty	**Notification Letter**
Plant	**2003-01**
	May 6, 2003

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of SAFER Level/Volume Table Error on the Peak Cladding Temperature (PCT)
References:	(SAFER/GESTR Models Description) 1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984. 2. NEDC-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. 3. NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000. (Application Methodology Description) 4. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. (Jet Pump Plant – SAFER) 5. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987. (Non-jet Pump Plant – SAFER/CORCL) 6. NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987. (Jet Pump Plant – SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	X

Description of Change/Error

In the process for constructing the initial level/volume table for SAFER, it was assumed that the value of initial water level was the same as the volume break point in the original RPV level/volume calculation. However, the level/volume tables were generated with revised initial water levels, which did not consider this assumption. This resulted in an incorrect volume split in the nodes above and below the water surface, and incorrect initial liquid mass. The total volume in the vessel was correct.

The root cause of this error was that the process for generating the nodalization did not explicitly state the assumption or provide instructions for cases where the initial water level for LOCA analysis was different from that used in the original RPV level/volume calculation.

Evaluation of Change/Error

The level/volume nodalization table used in the evaluation of the Licensing Basis PCT was reviewed for each plant to determine which plants were affected by this error. A number of representative plants were selected and a series of Appendix K runs were performed to cover the range of the change in the nodal volume due to this error. The corrected liquid volume is lower if the water level was raised relative to the original RPV volume calculation, and higher if the water level has been lowered relative to the original RPV volume calculation. Higher initial liquid volume results in lower peak cladding temperature.

Summary of Changes and Errors in ECCS Evaluation Models
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GE Proprietary Information — **10 CFR 50.46**

Utility — **Notification Letter**

Plant — **2003-01**
May 6, 2003

The PCT effect of the error (PCT correct – PCT w/ error) for individual plants has been determined from the calculations for the representative plants.		
Analyses Affected by Change/Error		
The table below identifies which current ECCS-LOCA analyses are affected.		
Change in the Calculated Peak Cladding Temperature		
The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT 10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1): peak cladding temperature shall not exceed 2200°F. The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table below to the current Upper Bound PCT.		
Fuel	***Report***	***PCT Change (°F)***

Issued by:	Margaret E. Harding, Manager, Fuel Engineering Services
Technical Source:	Lichao Du, Nuclear & Safety Analysis

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Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information — **10 CFR 50.46**

Utility — **Notification Letter**

Plant — **2003-03**

May 6, 2003

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of SAFER Initial Separator Pressure Drop Error on the Peak Cladding Temperature (PCT)
References:	(SAFER/GESTR Models Description) 1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984. 2. NEDC-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 3. NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000 (Application Methodology Description) 4. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. (Jet Pump Plant – SAFER) 5. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987 (Non-jet Pump Plant – SAFER/CORCL) 6. NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987. (Jet Pump Plant – SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	X

Description of Change/Error

The initial steam separator pressure drop is an input to the SAFER model. The calculation of this value uses a loss coefficient derived from steam separator tests. This loss coefficient is product line dependent. Calculations for some plant/fuel types applied the wrong loss coefficient or erroneously included a term to account for the hydrostatic pressure (which is calculated separately by the SAFER model). These errors resulted in a higher initial steam separator pressure drop and overly restricted the flow through the separator during the LOCA event.

The root cause of this error is inadequate documentation of the steam separator loss coefficient and an incorrect formulation of the steam separator pressure drop input value No plant calculation was affected by both causes.

Evaluation of Change/Error

The calculation of the initial steam separator pressure drop used in the ECCS-LOCA evaluation of the Licensing Basis PCT was reviewed for each plant For each initial steam separator pressure drop calculation it was determined if the incorrect steam separator loss coefficient or the elevation term was present. For each calculation affected, the initial steam separator pressure drop was correctly recalculated. A series of Appendix K runs were performed for a number of representative plants to predict the changes in PCT over the range of the change in the initial steam separator pressure drop due to the correction of the errors. The corrected initial steam separator value for all cases was slightly lower that the original calculation resulting in higher flow through the core during the LOCA event. This in turn resulted in higher core water levels and a small decrease in the calculated PCTs for jet pump plants For non-jet pump plants where the water level does not recover for the design basis accident, the slightly higher updraft through the core resulted in a small increase in PCT due to a minor interference with core spray cooling.

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GE Proprietary Information

Utility

Plant

10 CFR 50.46
Notification Letter
2003-03
May 6, 2003

For jet pump plants the impact on the calculated PCT was conservatively determined to be 0°F. For non-jet pump plants the impact was conservatively determined to be +5°F.

Analyses Affected by Change/Error

The table below identifies which current ECCS-LOCA analyses are affected.

Change in the Calculated Peak Cladding Temperature

The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46 To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1): peak cladding temperature shall not exceed 2200°F.

The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table below to the current Upper Bound PCT.

Fuel	*Report*	*PCT Change (°F)*

Issued by:	Margaret E. Harding, Manager, Fuel Engineering Services
Technical Source:	Frank M. Paradiso, Nuclear & Safety Analysis

Summary of Changes and Errors in ECCS Evaluation Models July 2000 through June 2001

GE Proprietary Information **10 CFR 50.46**

Utility **Notification Letter 2003-05**

Plant **May 13, 2004**

The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of Postulated Hydrogen-Oxygen Recombination
References:	(SAFER/GESTR Models Description) 1 NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984 2. NEDC-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. 3. NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000 (Application Methodology Description) 4. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. (Jet Pump Plant – SAFER) 5. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987 (Non-jet Pump Plant – SAFER/CORCL) 6. NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987 (Jet Pump Plant – SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	X
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	

Description of Change/Error

A new heat source during the LOCA event has been postulated. This heat source involves the recombination of hydrogen and oxygen within the fuel bundle during the core heatup. The additional heat will raise the temperature of the steam heat sink in the bundle, resulting in a potential increase in the peak cladding temperature and local oxidation. This recombination is spontaneous at temperatures above approximately 900°F. The hydrogen is generated by the steam-zirconium reaction during heatup. The oxygen enters the vessel either as a dissolved gas in the ECCS water or through the break when the vessel fully depressurizes and draws the containment noncondensible gases back into the vessel. The current LOCA evaluation models do not include this new heat source

Pending disposition of this phenomenon, a change notification is supplied to provide the impact of hydrogen-oxygen recombination on the cladding temperature and local oxidation

Evaluation of Change/Error

The impact of hydrogen-oxygen recombination was incorporated by increasing the heat generated due to metal water reaction. The evaluations were performed assuming that recombination occurs within the fuel channels at the cladding surface The additional source of oxygen from the containment will only contribute to increasing the PCT for the non-jet pump plants This is due to the fact that the oxygen from the containment enters the vessel late in LOCA event, after the core has reflooded for jet pump plants. The LOCA scenario for BWR/2 plants is different since the core remains uncovered and there is no period of reflooding for large breaks. The cladding will still be heating up when the oxygen from the containment gets into the vessel for non-jet pump plants

The amount of oxygen released due to evaporation of ECCS liquid is based on the quantity of oxygen dissolved in the suppression pool liquid (in equilibrium with air or with the inerted containment atmosphere). For jet pump plants, the increase in heat of reaction was calculated from the combination of oxygen released

Summary of Changes and Errors in ECCS Evaluation Models
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GE Proprietary Information	**10 CFR 50.46**
Utility	**Notification Letter**
Plant	**2003-05**
	May 13, 2004

from evaporation of the ECCS liquid and hydrogen released from metal water reaction. This reaction is always oxygen limited because there is not sufficient oxygen to react with all the available hydrogen

For the jet pump plants with inerted containments, the change in the PCT was found to be insignificant. An impact of 0°F on the Licensing Basis PCT is reported for jet pump plants with inerted containments. For jet pump plants with non-inerted containments where the PCTs are less than 1700°F, the hydrogen generation from the metal-water reaction is very small and the Licensing Basis PCT impact due to hydrogen-oxygen recombination is insignificant. For jet pump plants with non-inerted containments where thePCTs are more than 1700°F, the impact of the hydrogen-oxygen recombination on the Licensing Basis PCT is +5°F and on the maximum local oxidation is negligible. The maximum local oxidation and core wide oxidation for the jet pump plants remained below the 10CFR50.46 limits

The evaluation for the non-jet pump plants was performed using SAFER/CORCL methodology by incorporating the heat of reaction due to recombination of oxygen released from ECCS liquid and the oxygen entering the vessel from the containment.

The MAPLHGRs for BWR/2 plants are optimized to limit both the Appendix K PCT and the local oxidation below the 10CFR50.46 limits Therefore, the effect of H_2-O_2 recombination on the local oxidation was also evaluated. The impact of this phenomenon for non-jet pump plants is +25 °F increase in PCT and 1.73% increase in maximum local oxidation.

Analyses Affected, Change in Peak Cladding Temperature

The table below identifies which current ECCS-LOCA analyses are affected.

Fuel	*Report*	*PCT Change (°F)*

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46**
Utility	**Notification Letter**
Plant	**2003-05**
	May 13, 2004

Application of Error to Licensing Basis PCT and Compensatory Measures

The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT.

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1); peak cladding temperature shall not exceed 2200°F. The impact of this phenomenon on the 10CFR50.46 acceptance criteria is given below:

Criterion 1 – Peak Cladding Temperature. The impact of this phenomenon on the jet pump and non-jet pump plants is given above. If the peak clad temperatures exceed this limit, compensatory measures are provided which will result in reducing the peak cladding temperatures to meet this criterion.

Criterion 2 – Maximum Cladding Oxidation - The impact of this phenomenon on the jet pump and non-jet pump plants is given above. If the maximum cladding oxidations exceed this limit, compensatory measures are provided which will result in reducing the oxidation to meet this criterion.

Criterion 3 – Maximum Hydrogen Generation – The maximum hydrogen generation limit will not be exceeded due to this phenomenon for the jet pump and non-jet pump plants.

Criterion 4 – Coolable Geometry – Conformance to Criteria 1 and 2 will result in conformance with criterion 4.

Criterion 5 – Long-Term Cooling – Once the core is quenched and returned to saturation temperature, the temperatures are too low to support either spontaneous hydrogen/oxygen recombination or significant hydrogen generation from the steam-zirconium reaction. Therefore, conformance to Criterion 5 is not affected by this phenomenon.

If needed as a compensatory measure, a 1% reduction in PLHGR will produce 13 °F reduction in PCT for all plant types. For non-jet pump plants a 1% reduction in PLHGR will produce a 0.68% reduction in the maximum local oxidation. These compensatory measures are applicable to all fuel types and at all exposure points. Therefore, for a core with 0.5% oxidation margin to 10CFR50.46 limit, a 2% MAPLHGR reduction ((1.73-0.5)/0.68<2%) will compensate for the postulated phenomenon.

The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and <u>do not directly apply to the Upper Bound PCT</u>. The Upper Bound PCT is included in the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table above to the current Upper Bound PCT.

Issued by:	Margaret E. Harding, Manager, Fuel Engineering Services
Technical Source:	D. Abdollahian, Nuclear & Safety Analysis

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information
Utility
Plant

10 CFR 50.46
Notification Letter
2003-05 Rev. 2
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The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject: Impact of Postulated Hydrogen-Oxygen Recombination

References:

(SAFER/GESTR Models Description)

1. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984.
2. NEDC-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.
3. NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000.

(Application Methodology Description)

4. NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984.
(Jet Pump Plant – SAFER)
5. NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987.
(Non-jet Pump Plant – SAFER/CORCL)
6. NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987. (Jet Pump Plant – SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	X
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	

Description of Change/Error

A new heat source during the LOCA event has been postulated. This heat source involves the recombination of hydrogen and oxygen within the fuel bundle during the core heatup. The additional heat will raise the temperature of the steam heat sink in the bundle, resulting in a potential increase in the peak cladding temperature and local oxidation. This recombination is spontaneous at temperatures above approximately 900°F. The hydrogen is generated by the steam-zirconium reaction during heatup. The oxygen enters the vessel either as a dissolved gas in the ECCS water or through the break when the vessel fully depressurizes and draws the containment non-condensible gases back into the vessel. The current LOCA evaluation models do not include this new heat source.

Evaluation of Change/Error

The impact of hydrogen-oxygen recombination was incorporated by increasing the heat generated due to metal water reaction. The evaluations were performed assuming that recombination occurs within the fuel channels at the cladding surface. The additional source of oxygen from the containment will only contribute to increasing the PCT for the non-jet pump plants This is due to the fact that the oxygen from the containment enters the vessel late in LOCA event, after the core has reflooded for jet pump plants. The LOCA scenario for BWR/2 plants is different since the core remains uncovered and there is no period of reflooding for large breaks. The cladding will still be heating up when the oxygen from the containment gets into the vessel for non-jet pump plants.

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Plant	**2003-05 Rev. 2**
	April 27, 2006

The amount of oxygen released due to evaporation of ECCS liquid is based on the quantity of oxygen dissolved in the suppression pool liquid (in equilibrium with air or with the inerted containment atmosphere).

This evaluation (for the non-jet pump plants) was performed using SAFER/CORCL methodology. A non-level 2 version of CORCL computer program which incorporates the heat generated due to hydrogen-oxygen recombination and was used to calculate the fuel element temperatures during core heatup transients. A TRACG model was developed to simulate a guillotine break of the recirculation discharge line and to estimate the amount of non-condensable rate entering hot bundle for CORCL input. SAFER/CORCL calculation was performed for the nominal assumptions and to determine the impact of H_2-O_2 recombination on the Upper Bound PCT and oxidation

The MAPLHGRs for BWR/2 plants are optimized to limit both the Appendix K PCT and the local oxidation below the 10CFR50.46 limits. BWR/2 plants operate with an inerted containment. The evaluation showed that there is sufficient conservatism in the Appendix K analysis which bounds the Upper Bound PCT and oxidation with H_2-O_2 recombination in both PCT limited (10GWd/ST) and oxidation limited (35 GWd/ST) exposure ranges. Therefore, SAFER/CORCL application methodology for conformance of Appendix K analysis 10CFR50.46 limits, remain applicable. H_2-O_2 recombination phenomenon does not need to be considered in the Appendix K analysis for BWR/2 plants

Analyses Affected, Change In Peak Cladding Temperature

The table below identifies which current ECCS-LOCA analyses are affected.

Fuel	***Report***	***PCT Change (°F)***

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46**
Utility	**Notification Letter**
Plant	**2003-05 Rev. 2**
	April 27, 2006

Application of Error to Licensing Basis PCT and Compensatory Measures

The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT.

10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1): peak cladding temperature shall not exceed 2200°F. The impact of this phenomenon on the 10CFR50.46 acceptance criteria is given below:

Criterion 1 – Peak Cladding Temperature. The impact of this phenomenon on the jet pump and non-jet pump plants is given above. If the peak clad temperatures exceed this limit, compensatory measures are provided which will result in reducing the peak cladding temperatures to meet this criterion.

Criterion 2 – Maximum Cladding Oxidation - The impact of this phenomenon on the jet pump and non-jet pump plants is given above. If the maximum cladding oxidations exceed this limit, compensatory measures are provided which will result in reducing the oxidation to meet this criterion.

Criterion 3 – Maximum Hydrogen Generation – The maximum hydrogen generation limit will not be exceeded due to this phenomenon for the jet pump and non-jet pump plants.

Criterion 4 – Coolable Geometry – Conformance to Criteria 1 and 2 will result in conformance with criterion 4.

Criterion 5 – Long-Term Cooling – Once the core is quenched and returned to saturation temperature, the temperatures are too low to support either spontaneous hydrogen/oxygen recombination or significant hydrogen generation from the steam-zirconium reaction. Therefore, conformance to Criterion 5 is not affected by this phenomenon.

If needed as a compensatory measure, a 1% reduction in PLHGR will produce 13 °F reduction in PCT for all plant types. For non-jet pump plants a 1% reduction in PLHGR will produce a 0.68% reduction in the maximum local oxidation. These compensatory measures are applicable to all fuel types and at all exposure points.

This analysis showed that there is no challenge to the 10CFR50.46 criteria for the postulated phenomenon for BWR/2 plants if the plant license basis does not require the assumption of a LOCA event (based on the low probability of occurrence) at elevated power levels during the de-inerted period.

The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and do not directly apply to the Upper Bound PCT. The Upper Bound PCT is included in the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table above to the current Upper Bound PCT.

Issued by:	Mark J. Colby
Technical Source:	WM Wong, Nuclear Analysis

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information

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The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of Changing the CORCL Boundary Conditions
References:	(SAFER/GESTR Models Description) 1 NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER - Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984 2 NEDC-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 3 NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000 (Application Methodology Description) 4 NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. (Jet Pump Plant - SAFER) 5 NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987 (Non-jet Pump Plant - SAFER/CORCL) 6 NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987 (Jet Pump Plant - SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	X
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	

Description of Change/Error

The ECCS-LOCA evaluations for non-jet pump plants and KKM are performed using the SAFER and CORCL computer codes. SAFER is used to evaluate the blowdown phase of the LOCA event and provides CORCL with bundle initial conditions at the end of blowdown and system boundary conditions such as vessel pressure and core spray flow versus time. CORCL is used to evaluate the overall hot bundle heatup due to the LOCA. The analysis is performed at discrete exposure points to obtain the MAPLHGR values at every analyzed exposure such that the peak cladding temperature and local oxidation are below specified target values. One long SAFER run is performed at a representative exposure point to provide the boundary conditions. Short SAFER runs are performed at each analyzed exposure point to provide the bundle initial conditions. Recently it was determined that using the boundary conditions based on a different exposure point can have a non-conservative effect on the CORCL results.

Evaluation of Change/Error

The impact of the exposure effect on the CORCL boundary conditions was evaluated by performing a long SAFER run for each exposure point analyzed. The impact of this process change on the calculated PCT is provided below. Only Nine Mile Point 1 showed a 0.3% increase in maximum local oxidation.

Analyses Affected, Change in Peak Cladding Temperature

The table below identifies which current ECCS-LOCA analyses are affected

Application of Error to Licensing Basis PCT and Compensatory Measures

The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46. To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT.

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10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process. The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1); peak cladding temperature shall not exceed 2200°F. The impact of this process change on the 10CFR50.46 acceptance criteria is given below.

Criterion 1 - Peak Cladding Temperature. The impact of this change is given below. If the peak cladding temperatures exceed this limit, compensatory measures are provided which will result in reducing the peak cladding temperatures to meet this criterion.

Criterion 2 - Maximum Cladding Oxidation - The impact of this change is given above. If the maximum cladding oxidations exceed this limit, compensatory measures are provided which will result in reducing the oxidation to meet this criterion

Criterion 3 - Maximum Hydrogen Generation - The maximum hydrogen generation limit will not be exceeded due to this change.

Criterion 4 - Coolable Geometry - Conformance to Criteria 1 and 2 will result in conformance with criterion 4.

Criterion 5 - Long-Term Cooling - Conformance to Criterion 5 is not affected by this change

If needed as a compensatory measure, a 1% reduction in PLHGR will produce 13°F reduction in PCT for all plant types. For non-jet pump plants a 1% reduction in PLHGR will produce a 0.68% reduction in the maximum local oxidation. These compensatory measures are applicable to all fuel types and at all exposure points. Therefore, in this case a 0.5% MAPLHGR reduction (0.3/0.68 = <0.5%.) would compensate for the increase in local oxidation.

The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table below to the current Upper Bound PCT.

Fuel	Report	PCT Change (°F)

Issued by:	Margaret E. Harding, Manager, Fuel Engineering Services
Technical Source:	Frank M. Paradiso, Nuclear & Safety Analysis

Summary of Changes and Errors in ECCS Evaluation Models
July 2000 through June 2001

GE Proprietary Information	**10 CFR 50.46**
Utility	**Notification Letter**
Plant	**2006-01**
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The purpose of this notification is to assist licensees with reporting, in accordance with 10CFR50.46 (a)(3)(ii), the impact of changes and errors in the methodology used by GE/GNF to demonstrate compliance with the Emergency Core Cooling System (ECCS) performance requirements of 10CFR 50.46. Peak cladding temperature variations resulting from plant specific system or fuel design changes are not addressed in this notification and should be treated, as appropriate, on a plant specific basis.

Subject:	Impact of Top Peaked Power Shape for SB Analysis
References:	(SAFER/GESTR Models Description) 1 NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume II, SAFER – Long Term Inventory Model for BWR Loss-Of-Coolant Analysis," October 1984 2 NEDC-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. 3 NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000 (Application Methodology Description) 4 NEDC-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. (Jet Pump Plant – SAFER) 5 NEDC-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume II, SAFER Application Methodology for Non-jet Pump Plants," October 1987 (Non-jet Pump Plant – SAFER/CORCL) 6 NEDC-31355P, "KKM SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, Volume II, SAFER Application to KKM," August 1987 (Jet Pump Plant – SAFER/CORCL)

Change in an acceptable evaluation model or application of such model?	X
Error in an acceptable evaluation model or application of such model?	
Error in plant-specific application of such model?	

Description of Change/Error

Past small break ECCS-LOCA analyses have assumed a mid-peaked power shape, consistent with DBA break analyses. Recently, it has been determined that for small break cases, a top-peaked axial power shape can result in higher calculated peak cladding temperature (PCT). An ECCS-LOCA analysis methodology change has been implemented to perform the small break analysis considering both mid-peaked and top-peaked axial power shapes. The most limiting results from these analyses will be reported for the small break analysis.

A study involving the DBA large break ECCS-LOCA analysis determined that it is not significantly affected by the axial power shape assumption. No change is reported in any analysis cases assuming DBA breaks

Evaluation of Change/Error

Evaluations have been performed on representative plants spanning all BWR plant types BWR/2 plant analyses were not affected by the axial power shape assumption. For most BWR/3-6 plants, an increase in PCT for the limiting small break Appendix K case was required to address this axial power shape analysis assumption change. The effect on the Licensing Basis (LB) PCT, on a plant by plant basis, was determined as follows:

If the current LB PCT is based on a limiting small break case, then the change in PCT as a result of this evaluation is reported in terms of the resulting change that may be seen in the LB PCT. The reported change in LB PCT can range from no effect to direct application of a small break PCT increase.

If the current LB PCT is based on the DBA large break, but the revised small break PCT remains below the current DBA large break PCT, then the impact on the LB PCT is reported as zero

If the current LB PCT is based on the DBA large break and the revised small break PCT is higher than the current DBA large break PCT, then the impact on the LB PCT is reported as the difference between the DBA large break and the revised small break PCT. The small break condition becomes the limiting case and that difference is the net amount by

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which the LB PCT is increased.

Analyses Affected, Change in Peak Cladding Temperature
The table below identifies which current ECCS-LOCA analyses are affected.
Change in the Calculated Peak Cladding Temperature
The absolute value of the change in PCT (PCT correct - PCT w/ error) that is reported in this error/change notification should be added to the accumulation of changes and errors since the last analysis of record for purposes of evaluating the 50°F reporting threshold defined in 10CFR50.46 To determine the new estimated Licensing Basis PCT, add the PCT change from the table below to the current Licensing Basis PCT 10 CFR 50.46(b) defines the acceptance criteria for the LOCA analysis process The Licensing Basis PCT is evaluated for compliance with criterion 50.46(b)(1); peak cladding temperature shall not exceed 2200°F The requirements of 10 CFR 50.46 are only applicable to the Licensing Basis PCT and <u>do not apply to the Upper Bound PCT</u>. The Upper Bound PCT is provided as part of the calculational methodology to ensure that the Licensing Basis PCT is conservative. If desired, a new estimated Upper Bound PCT can be determined by adding the PCT change from the table below to the current Upper Bound PCT.

Fuel	***Report***	***PCT Change (°F)***

Issued by:	Andrew A. Lingenfelter, Manager, Fuel Engineering Services
Technical Source:	Frank M. Paradiso, Nuclear Analysis Center of Excellence

ENCLOSURE 3

MFN 06-0406

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, GE-Hitachi Nuclear Energy Americas LLC ("GEH"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in the GEH proprietary report NEDC-32950-1-P, *Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model,* Revision 1, Class III (GEH Proprietary Information), dated July 2007. The proprietary information is delineated by a [[dotted underline inside double square brackets.{3}]] Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation{3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualifies under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b., above.

(5) To address 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed information about the results of analytical models, methods and processes, including computer codes, which GEH has developed, obtained NRC approval of, and applied to perform evaluations of loss-of-coolant accident events in the GEH Boiling Water Reactor ("BWR").

The development and approval of the BWR loss-of-coolant accident analysis computer codes was achieved at a significant cost to GEH, on the order of several million dollars.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 17th day of July 2007.

George B. Stramback

George B. Stramback
GE-Hitachi Nuclear Energy Americas LLC