BWR OWNERS' GROUP

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Proprietary Notice

This letter transmits proprietary information in accordance with 10CFR2.390. Upon removal of Enclosure 1, the balance of the letter may be considered non-proprietary.

Project Number 691

BWROG-09020
March 20, 2009

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

Attention: Chief, Information Management Branch
Division of Program Management

SUBJECT: BWROG Response to NRC Requests for Additional Information (RAIs) on GEH BWROG Topical Reports NEDC-33347P Revision 0 (Proprietary Version) and NEDO-33347 Revision 0 (Non-Proprietary Version), "Containment Overpressure Credit for Net Positive Suction Head (NPSH)"

Enclosed are the BWROG responses to NRC Requests for Additional Information (RAI) on GEH BWROG Topical Reports NEDC-33347P Revision 0 (Proprietary Version) and NEDO-33347 Revision 0 (Non-Proprietary Version), "Containment Overpressure Credit for Net Positive Suction Head (NPSH)." The topical reports were submitted on February 15, 2008, and we received the draft RAIs on November 5, 2008. We provided draft responses to NRC on December 26, 2008. On February 9, 2009, NRC provided supplemental comments on these draft responses. The responses and supplemental comments were clarified with NRC staff in a telephone call on February 12, 2009. We request your timely review of these responses and issuance of a draft Safety Evaluation.

Enclosure 1 contains proprietary information of the type that GEH maintains in confidence and withholds from public disclosure. The affidavit (Enclosure 3) identifies that the information in Enclosure 1 has been handled and classified as proprietary to GEH. The BWROG hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. Enclosure 2 is a non-proprietary version of the responses.

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Please also note that in a letter dated December 4, 2007, the NRC Chief Financial Officer granted a waiver of NRC review fees for this topical report under 10 CFR 170.11(a)(1)(iii).

Should you have additional questions please contact Fred Emerson (BWROG Project Manager) at 910-819-5615 or Alan Wojchouski (BWROG Containment Overpressure Credit Committee Chairman) at 763-295-1335.

Respectfully,

Douglas W. Coleman

Douglas W. Coleman, Chairman
BWR Owners' Group

Enclosures:

1. Final BWROG Responses to NRC Requests for Additional Information Regarding Containment Overpressure Credit for Net Positive Suction Head (NPSH) (NEDC-33347P) – Proprietary Version
2. Final BWROG Responses to NRC Requests for Additional Information Regarding Containment Overpressure Credit for Net Positive Suction Head (NPSH) (NEDO-33347) – Non-Proprietary Version
3. Affidavit

cc: Michelle Honcharik, NRC
F.P. "Ted" Schiffley, BWROG Vice Chairman
K.A. McCall, BWROG Program Manager
BWROG Primary Representatives

ENCLOSURE 2

BWROG-09020

Final BWROG Responses To NRC Requests For Additional Information Regarding Containment Overpressure Credit For NPSH (NEDO-33347)

Non-Proprietary Information

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1 to BWROG-09020 from which the proprietary information has been redacted. Portions of the document that have been removed are indicated by white space with open and closed double square bracket as shown here [[ ]].

FINAL BWROG RESPONSES TO NRC REQUESTS FOR ADDITIONAL INFORMATION REGARDING CONTAINMENT OVERPRESSURE CREDIT FOR NPSH (NEDO-33347)
Non-Proprietary Version

Requests for Additional information

1. Please describe how the proposed approach of TR NEDC-33347P is consistent with and where it varies from the methodology set forth in Section 2 of NUREG/CR-5249, "Quantifying Reactor Safety Margins." Please address the 14 steps discussed in NUREG/CR 5249. In particular, Step 3, Phenomena Identification and Ranking, Step 7 (which addresses code uncertainty), and Steps 11 to 14.

   Supplemental NRC Question: The only model conservatisms pointed out in the LTR Section 4.4 are items 3, 4 and 5. What other model conservatisms are in the code for NPSH analysis?

   Final BWROG Response:
   The deterministic analysis is the design and licensing basis methodology and is not modified. The deterministic methodology is not a best estimate methodology. It is a bounding methodology (described in LTR Section 3.1 and in response to RAI 12, 13, 15, & 16). NUREG/CR 5249 applies to best estimate methodology.

   Section 1.6 of NEDC-33347P describes: "The licensing basis methodology forms the basis for requested COP. Additional statistical analysis (Section 3.1.3) provides a demonstration of additional containment overpressure margin."

   The statistical analysis does employ some of the CSAU steps but many of the key steps are omitted since many aspects of the deterministic methodology are retained.

   CSAU Step 1 Scenario Specification
   The scenario is described in Section 3.1.

   CSAU Step 2 Nuclear Power Plant Selection
   The applicable plants and containment types are described in Section 3.3.4. Currently only Mark I plants take credit for COP.

   CSAU Step 3 Phenomena Identification and Ranking
   Phenomena Identification and Ranking has not been performed. The PIRT process is integral to the determination of model uncertainty when best estimate models are applied. The approved analysis code used for the LTR containment analysis, unlike more detailed best estimate codes such as TRACG, uses simplified models which are conservatively developed to maximize suppression pool temperature. These conservatisms in the code models are identified in Sections 3.1 and 4.4 of the LTR. [[

]] For the deterministic analysis and also for the statistical approach 100% thermal mixing efficiency for the containment spray is modeled (which means the spray water fully mixes with the containment atmosphere and reaches thermal equilibrium with the containment atmosphere fluids) to minimize the wetwell pressure response.

All aspects of the deterministic method are retained with the exception of the Section 3.1.2 input. This LTR can be considered to focus on CSAU Step 11 (Determination of the Effect of Reactor Input Parameters and State).

CSAU Step 4 Frozen Code Version Selection
The code, as applied in the deterministic analysis, must be NRC approved. Code changes are subject to licensing requirements pertinent to application (e.g. CPPU licensing or 10CFR50.59).

CSAU Step 5-10 Code Documentation, Determination of Code Applicability, Establishment of Assessment Matrix, Nuclear Power Plant Nodalization Definition, Definition of Code and Experimental Accuracy, and Determination of Effect of Scale

For GEH applications, the NRC approved licensing basis methodology for containment pressure and temperature response is described in Appendix G of GE Nuclear Energy, "Generic Guidelines for General Electric Boiling Water Reactor Extended Power Uprate," NEDC-32424P-A, February 1999. Other NRC approved deterministic methods can also be applied.

CSAU Step 11 Determination of the Effect of Reactor Input Parameters and State
This step is described in Section 3.

CSAU Step 12 Performance of Nuclear Power Plant Sensitivity Calculations
A demonstration analysis is described in Appendix A. Sensitivities relate only to input parameters.

CSAU Step 13 Determination of Combined Bias and Uncertainty
The combined bias and uncertainty method is described in Section 3.1.2. The results for the demonstration analysis is described in Appendix A.

CSAU Step 14 Determination of Total Uncertainty
The combined bias and uncertainty method is described in Section 3.1.2. The results for the demonstration analysis are described in Appendix A.

The conservatisms in the code (SHEX) models are mainly identified in Sections 3.1 and 4.4 of the LTR. One other conservatism exists in calculating heat and mass transfer between suppression pool and wetwell airspace. In the long term containment response calculation, [[

]] , which conservatively underestimates the heat and mass transfer from the pool to the wetwell airspace and thus maximize the pool temperature and minimize the wetwell pressure. It is expected that there will be some agitation of the pool surface due to RHR and ECCS pump operation for all events, or SRV operation for non-LOCA events and for smaller break accidents.

2. Deleted

3. Deleted

4. The TR does not appear to require that a licensee using this TR to support its license amendment request use the same containment response analysis model as used in the TR (i.e., the SHEX computer code). Is it intended that approval of the TR will be limited to only SHEX? If not, please describe the proposed steps to justify use of a different containment response model. The NRC staff suggests the appropriate steps of NUREG/CR 5249.

   Supplemental NRC Question: In case a licensee uses a best-estimate code model or methodology approved by the staff for deterministic analysis, a quantification and inclusion of model uncertainty in the results of statistical analysis should be included.

   Final BWROG Response:
   The intent of the Topical report is not to limit the containment response model just to SHEX. The topical report expected that a licensee would use the containment response model that is currently licensed. Justification of a different containment response model was not considered within the scope of the topical report. Aspects of the LTR specific to the SHEX methodology, as discussed in Section 3.1, must be evaluated and dispositioned for applications applying a different containment response model. We agree that a licensee should submit an uncertainty analysis if a best estimate code is used. Please note that SHEX is not a best estimate code.

5. Discuss the impact on the proposed statistical method if a change is made to a model or models in SHEX. How would such a change affect the proposed method? For example, would the model uncertainty be reevaluated? Would the version of SHEX used for this TR be frozen?

   Final BWROG Response:
   As discussed in the response to RAI 1, the deterministic analysis is the licensing basis methodology. SHEX, as applied in the deterministic analysis, is NRC approved. SHEX changes are subject to licensing requirements pertinent to application (e.g. CPPU licensing or 10CFR50.59). The statistical analysis provides a demonstration of additional containment overpressure margin (further discussed in the response to RAI 25). The statistical analysis is performed with the same SHEX models as applied in the deterministic analysis. Change made to a model or models in SHEX for deterministic application would be applicable to the proposed statistical method.

   Since SHEX is a conservative methodology, model uncertainty has not been determined and is therefore not subject to reevaluation.

   The version of SHEX used for this LTR will not be frozen since the code is routinely updated to improve the user interface. SHEX changes are subject to licensing requirements pertinent to application.

6. The term “overpressure” has several definitions (pressure above atmospheric, pressure above saturation, etc.); if it is to be used, please define.

   Final BWROG Response:
   The intended use of the term “overpressure” within the topical report is to describe wetwell airspace pressure above atmospheric. In some tables the “overpressure” condition is described in terms of absolute pressure. In this way any pressure greater than atmospheric pressure would have positive “overpressure” and any pressure less than atmospheric would have a negative “overpressure” as it relates to NPSH.

7. For some boiling water reactors (BWRs), main streamline isolation valve (MSIV) leakage is considered separately from containment leakage (La). In these cases, how is MSIV leakage to be considered?

   Final BWROG Response:
   The Topical Report Section 3.1 lists as one of the conservative assumptions that “The containment leakage rate is its maximum allowed value specified in the Technical Specification.” Licensee should input the containment leakage rate at the allowed value specified in their Technical specifications. If a licensee has a separate allowable MSIV leakage from the containment leakage (La), then the maximum allowed MSIV leakage should be combined with the maximum containment leakage rate (La) for input as a conservative leakage assumption.

8. Please define the terms “nominal” and “realistic" as used in the TR. Are they synonymous? For example:

   (Section 3.1.2) “For the statistical approach with realistic assumptions...”
   (Section 4.3) “It is expected that the deterministic approach utilizing nominal input values will be used to calculate NPSHa...”

   For those parameters which cannot be statistically defined, will nominal, realistic, or conservative values be used?

   Final BWROG Response:
   In overview discussions, the terms “nominal “and “realistic” are synonymous. Nominal values are used only for special events. These inputs are described in Sections 4.1 and 4.3. Realistic values are described in Sections 3.1.2 and 4 as applied to the statistical analysis. For the deterministic method, parameters which cannot be statistically defined will use conservative values. For the statistical method, parameters which cannot be statistically defined will use a combination of conservative values and nominal values.

9. Section 3.1 - Submittals to the NRC on this subject have shown that the design-basis accident (DBA) loss-of-coolant accident (LOCA) does not always produce the highest peak suppression pool temperature.

   Supplemental NRC Comment: Acceptance criteria in Section 6 are to be revised.

Final BWROG Response:
It is acknowledged that the DBA LOCA does not always produce the highest peak pool temperature. When this occurs for special events or a smaller break LOCA, the detailed NPSH analysis for this pool temperature-limiting case is performed according to the method specified in this topical report. The acceptance criteria defined in Section 6 must be met. Acceptance criteria in Section 6 are to be revised to reflect this.

10. For the variables that will be included in the statistical analysis, what type of statistical distribution will be used for each? Will this be determined on a plant-specific basis? What guidance or criteria, if any, are used to determine the statistical distribution?

Final BWROG Response:
Variables used in the statistical analysis are evaluated assuming a normal distribution or with a distribution that represents plant/parameter-specific data.

The assumed distributions are discussed in Section 3.1.2 and Section A-2 of this LTR and as follows.

(1) Initial reactor power: The plant operates at reactor thermal power level not exceeding its licensed power level. The reactor thermal power is a derived value, calculated using measured values of reactor operating parameters, such as feedwater flow rate and enthalpy, etc. The accuracy of these measurements determines the uncertainty in the power level calculation. A normal distribution is assumed.

(2) Decay heat value after reactor scram: For containment analyses, a decay heat table is usually generated for a plant, based upon the American National Standards Institute (ANSI)/American Nuclear Society (ANS) 5.1-1979 (or 1994) decay heat model. The decay heat calculation provides nominal values and one-sigma uncertainty values (as percentage of nominal value) as a function of time after reactor SCRAM. A normal distribution is assumed.

(3) For the variables that can be measured periodically at power plants, the plant data can be processed to derive the probability distributions, also called probability of exceedance, as described in Section A.2.

(4) Containment leakage rate: If only limited measurement data are available and the probability distribution can not derived from those data, the resulting probabilities as a function of pre-existing leakage sizes from EPRI report can be used, as described in Section A.2 of this LTR.

11. Section 2.3 - This section states that when evaluating whether containment overpressure (COP) is required, the most realistic NPSHr curve available should be used.
f. What is meant by "most realistic?"
g. Why is it not necessary to consider the NPSHr uncertainty?

Final BWROG Response:
The intended meaning of the term "most realistic" was the standard 3% NPSHr curve, but the "most realistic" term was used to allow licensees the option to contact pump vendors to establish NPSHr values commensurate with the minimum hydraulic performance requirements for each pump and the time duration over which the reduced NPSHa can exist.

The NPSHr curves are supplied by the pump manufacturer in accordance with national standards (Ref. 1 & 2). The standard requires careful control of all factors that influence the operation of the pump. The standard does not require uncertainty analysis for the NPSHr values determined. The standard states, "any change in performance, either a deficiency at a given capacity, or change in sound or vibration, may be an indication of cavitation. But because of the difficulty in determining just when the change starts, a drop in head of 3%, which is the standard value in determining NPSHr, is accepted as evidence that cavitation is present." Therefore, in accordance with industry standards, for reliable pump operations for the duration of the applicable event, consideration of NPSHr uncertainty is not required.

References:

11.1 ANSI/HI 1.6-1994, American National Standard For Centrifugal Pumps Tests
11.2 ANSI/HI 2.6-1994, American National Standard For Vertical Pumps Tests

12. Section 3.1, Page 8 - The list of conservative assumptions lists nominal decay heat plus 2-sigma as a conservative assumption. Typically, the decay heat value used is the value predicted for the most conservative conditions during an operating cycle. Please clarify.

Final BWROG Response:
For the post-LOCA containment analyses, the nominal decay heat plus 2-sigma values are used. The nominal decay heat values, which are the values predicted for the most conservative conditions during an operating cycle, have been calculated for existing US BWR plants based on ANSI/ANS-5.1 1979 (but can be calculated with the1994 standard), considering fuel enrichment, plant fuel cycle, EOC core average exposure, and fuel residence time. In addition, consistent with the recommendations of GE SIL636, contributions from U-239 & Np-239 plus other actinides, as well as contributions from activation products produced within the structural materials, have been included in the calculation as well. Plus 2-sigma is applied for the deterministic method. The corresponding distribution is applied in the statistical approach.

13. Section 3.1.1, Page 9 - (a) Please provide a sensitivity study similar to that in Table 3-1 for (i) mixing efficiencies, (ii) containment leakage, (iii) drywell and wetwell volumes, and (b) for the example plant used in the TR, please provide the effect on NPSHa.

Supplemental NRC Question: (i) In Table under the column "Variation", please explain [[ ]] Does this mean [[ ]]?

Final BWROG Response:
i) The results for the sensitivity study of the mixing efficiency are shown below: [[

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(ii) The containment leakage rate will not have impact on suppression pool temperature. Since the containment leakage rate is usually in the range of 1% to 2% per day (1.2% Per day for the sample plant in the LTR), the containment leakage will have a negligible effect on the short-term wetwell pressure calculation. The long-term calculation results in Figures A-4 and A-11 of this LTR show that the peak pool temperature and the maximum required WW pressure occur at around 35,000 seconds (less than half day). Therefore, compared with the wetwell pressure with zero containment leakage, the decrease in wetwell pressure due to 1.2% leakage per day is expect to be less than 0.6% [~0.15 psi] at ½ day, which takes up approximately 3% of the margin between the required WW pressure and the available WW pressure (Table A-21).

(iii) [[

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Supplemental NRC Statement: Further review of comment is required. Staff will perform the sensitivity analysis.

14. Section 3.1 - For conservative input assumption Number 6, please define the "RHR [residual heat removal] heat exchanger heat transfer factor" and how it is related to the RHR heat exchanger effectiveness and Number of Transfer Units (NTU).

Supplemental NRC Question: It appears that K-value of the RHR heat exchanger will vary with the hot fluid (or suppression pool) temperature. Is the variation of K-value taken into account in the analysis or a constant conservative value used?

Final BWROG Response:
The RHR heat exchanger heat transfer factor K (Btu/sec °F) is defined as follows (See NEDO-20533-1, Appendix A):

$$K = \frac{Q}{T_H - T_C} \qquad (1)$$

where

Q	Heat exchanger heat removal rate (Btu/sec)
T_H	known hot side inlet temperature (°F)
T_C	known cold side inlet temperature (°F)

The heat exchanger effectiveness is defined as (Reference 14.2):

$$\varepsilon = \frac{(T_{inlet} - T_{outlet})_{\max}}{T_H - T_C} \qquad (2)$$

where the numerator is the temperature difference of either cold fluid or hot water, whichever is larger (T_{inlet} and T_{outlet} correspond to the liquid with the minimum value for Gc, with G as mass flow rate (lbm/sec), and c specific heat at constant pressure (Btu/(lbm °F))

Therefore the heat transfer rate Q can be written either from Eq. (1) as

$$Q = K(T_H - T_C) \qquad (3)$$

or from Eq. (2) as

$$Q = (Gc)_{\min}(T_{inlet} - T_{outlet})_{\max} = \varepsilon (Gc)_{\min}(T_H - T_C) \qquad (4)$$

From Eqs. (3) and (4), one can get

$$K = \varepsilon (Gc)_{\min} \, . \qquad (5)$$

It is noted that the heat exchanger effectiveness is a function of NTU and ratio of $(Gc)_{\min}$ to $(Gc)_{\max}$. The specific relations between the heat exchanger effectiveness and the NTU are heat exchanger type dependent, and some of the examples can be found in Reference 14.2. It is noted that Equation A-2 in NEDO-20533-1 (Reference 14.1) show a relationship between the heat exchanger *K* value and the heat exchanger effectiveness or NTU although neither the effectiveness or NTU is explicitly defined.

To further clarify, Eq. (1) is not used in the containment analysis to calculate K as a function of suppression pool temperature in SHEX. Instead, Eq. (1) provides a means of defining the value for K for a given (known) heat removal rate (Q) and for a known corresponding set of given hot side (suppression pool) and cold side (service water) temperatures. Rather, Eq. (3) is used in the containment analysis in SHEX to calculate a time varying RHR heat removal rate "Q" as a function of suppression pool temperature, using a user input value for K, and a user input value for service water temperature.

The value for K may be obtained from tests (empirical data) or can be analytically derived (outside of the containment code calculation) with the methodology for heat exchanger effectiveness as described in Eqs. (2) to (5). The value for NTU (equal to UA/(Gc)min, Reference 14.2), which is used to calculate the heat exchanger effectiveness, is established by key heat exchanger design characteristics including the heat exchanger heat transfer area (A), the minimum heat capacity rate (Gcmin) and the overall heat transfer coefficient (U).

It is noted that the overall heat exchanger coefficient "U" can vary with either the hot fluid (or suppression pool) temperature or the cold side (or service) water temperature due to changes in the heat transfer properties for water with changes in water temperature. This would affect the K value of the RHR heat exchanger, as defined in Eq. (1). [[

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The option to use a temperature dependent, time varying K value was not used for either the deterministic cases or the statistical analyses for the sample plant in this LTR. For the deterministic calculation in this LTR, a constant minimum K value was used. For the statistical calculation in this LTR, a constant K value was also used for each trial. However, for the statistical trial cases the K value was allowed to vary between trials. The effect of both hot side (or suppression pool) and cold side (or service) liquid temperatures on the RHR K value was considered in determining the constant K value for each trial.

References

14.3 W.J. Bilanin, "The General Electric Mark III Pressure Suppression Containment System Analytical Model Supplement 1," NEDO-20533-1, September 1975.

14.4 F.P. Incropera and D.P. Dewitt, "Fundamentals of Heat and Mass Transfer," Fourth condition, John Wiley & Sons, New York, 1996.

15. Section 3.1 - For conservative input assumption Number 11, please provide responses to the following:
    a. How is "mixing thermal efficiency" defined?
    b. How is the short-term time domain defined?
    c. How is the long-term time domain defined?
    d. Why is break flow temperature lower than the drywell temperature toward the end of the short-term time domain?
    e. Why is the break flow temperature higher than the drywell temperature for the long-term time domain?

Final BWROG Response:

a. The mixing thermal efficiency refers to the break flow thermal mixing efficiency, which is an input to the model (SHEX). [[

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b. The short-term time domain is usually defined as from the event initiation to 10 minutes. No operator action is credited in the analysis during this time.

c. The long-term domain is referring to the time domain beyond 10 minutes. Operator action is credited during this time.

d. For the short-term analysis low pressure ECCS systems are aligned to flood the RPV after the RPV is depressurized to the ECCS permissive pressure. The ECCS injected water (which is pumped from the suppression pool) mixes with the RPV liquid, reducing the temperature of the RPV liquid and therefore the vessel break flow temperature. After enough ECCS water has mixed with the RPV water, the RPV liquid temperature and therefore the RPV break flow temperature is less than the ambient drywell atmosphere temperature. This occurs towards the latter portion of the short-term period. This describes the expected response with the assumption that the break flow to the drywell comes from the RPV only. It is noted that for the sample plant calculation a different, more conservative break configuration is modeled. [[

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e. For a long term NPSH calculation, containment sprays (DW spray and WW spray) are assumed for RHR operation mode. By assuming the 100% thermal equilibrium between the spray liquid drops and containment airspace, the drywell temperature is very close to the spray liquid temperature, which is lower than the suppression water temperature since the containment spray water passes through the RHR heat exchanger before being discharged to the drywell and wetwell airspaces. On the other hand, the break flow temperature is slightly higher than the suppression pool temperature since it absorbed decay heat in the RPV before being discharged to the drywell. Thus the break flow temperature will be higher than the drywell temperature in the long term.

16. Section 3.1 - For conservative input assumption Number 12, please explain why is it conservative to assume that the containment spray droplets are in thermal equilibrium with the containment airspace before falling to the bottom of the drywell or the suppression pool?

Final BWROG Response:
In NPSH calculations, the RHR mode of containment sprays, rather than of suppression pool cooling, is modeled to minimize the containment pressure response. The temperature of the spray liquid, after passing through the RHR system, is always lower than either the drywell or wetwell airspace temperature. By assuming the thermal equilibrium between the spray liquid drops and the containment airspace before they fall to the bottom of the drywell or the suppression pool, the containment (drywell or wetwell) pressure would be minimized due to the energy transfer from the containment airspace to the spray liquid drops, which is conservative for NPSH calculations.

17. Section 3.3.1 - Please explain how conservatism is introduced in the last four bulleted items, i.e., "Water Properties," "Manual calculations," "Manual Hydraulic (Head Loss) calculation methodology," and "Piping Systems modeling in software used for Hydraulic (Head loss) calculations."

Final BWROG Response:
Conservatism is introduced in the Utility NPSH calculations for the "Water Properties" area by in some cases applying a bounding component pressure drop (e.g. suction strainer) based on colder water temperature properties yet applying the head loss conservatively at the minimum NPSH combination of conditions for maximum pool temperature. Utility NPSH calculations for the "Manual calculations" area were intended to cover those calculations that are completed by hand calculations which may include simplifications such as selection of the limiting train of ECCS piping lengths, number of elbows, number of valve loss coefficients, and the like. Utility NPSH calculations for the "Piping Systems modeling in software used for Hydraulic (Head loss) calculations" can apply global characteristics such as friction factor which may be biased high to introduce conservatism.

18. Section 3.1 - Please explain why initial drywell and wetwell gas space temperature is not included in the list of conservative assumptions. Please also note that Table A-1 does list the initial drywell temperature and does not list the initial wetwell gas space temperature.

Final BWROG Response:
In Section 3.1, the list of conservative assumptions is presented to show the conservatisms in deterministic NPSH calculations. The initial wetwell airspace temperature is assumed to be [[

]] These are conservative assumptions that could have been added to Section 3.1.

19. Section 4.4, Page 20 - Item 8 states that credit may be taken for operators throttling emergency core cooling system flow. How is this action included in the analyses since the timing of the action is not specified? For pumps injecting into the vessel, how is it ensured that the flow rate is equal to or greater than that assumed in the LOCA analysis?

Final BWROG Response:
Section 4.4 address relaxations of conservatisms for special events and states that "relaxation of typical input values in LOCA licensing analyses will produce more realistic results for the special events (ATWS, SBO and Appendix R).

The timing for the special events would be dictated by the analysis results and consistent with the operator actions as directed by procedures. Core cooling for special events is achieved by restoring and maintaining the core covered. For special events there is not a requirement to assure flow rate is equal to or greater than that assumed in the LOCA analysis.

20. Section 4.3: The TR states that the proposed method for evaluation of special events will utilize nominal input values. It goes on to state that if this approach does not show that NPSHa – NPSHr ≥ 0 then the statistical approach using mean values will be used.

a. How is the mean determined?
b. If the statistical approach does not show acceptable results, what is the next step?

NRC Supplemental Comment: a. & b The LTR proposal that the deterministic analysis be the licensing basis when it yields an unacceptable result is not acceptable. The staff proposal of an acceptable process is shown in Figure 1 which applies to containment analysis for LOCA, ATWS, SBO and Appendix R events. If "statistical analysis with COP" (C in Figure 1) is used as a licensing basis, a revised analysis would not be necessary if the change in data were small.

An NRC-developed flow chart is below:

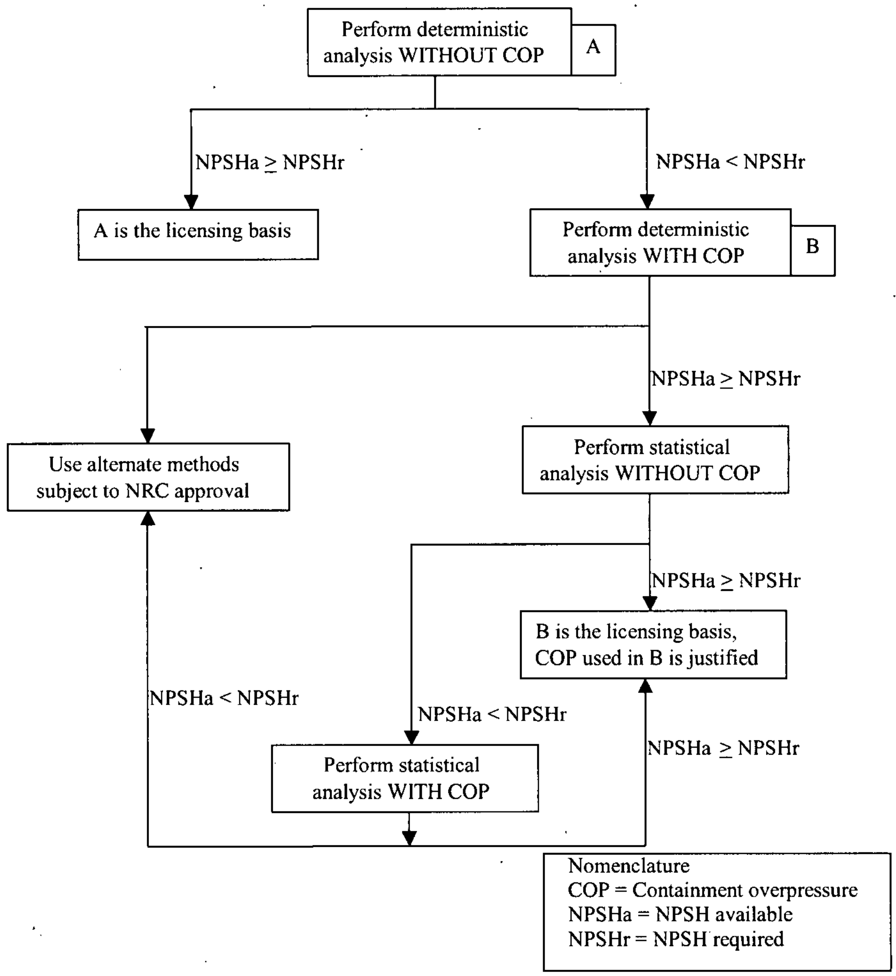


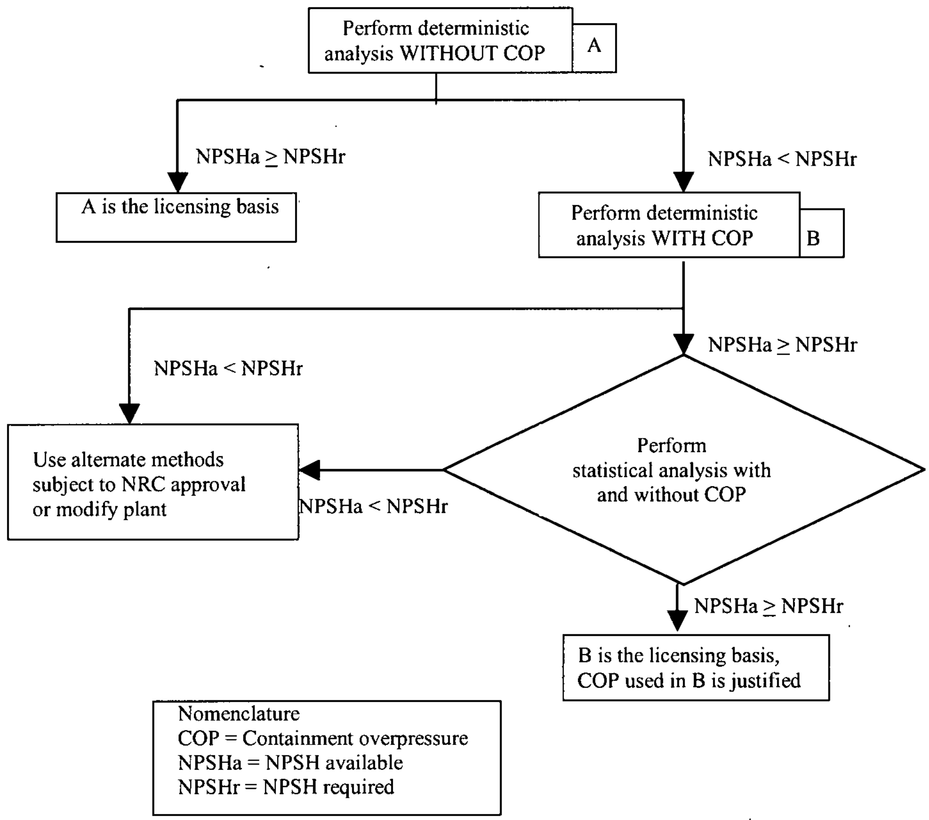
Figure 1: Flow diagram for statistical containment analysis for LOCA, ATWS, SBO, and Appendix R events

Final BWROG Response:

a. The mean output statistical approach uses the Monte Carlo method to produce 59 containment analyses. The results of these analyses are utilized to produce a term called Hww. Each of the 59 containment analyses produces Hww for each time step. For each time step of the 59 analyses, the maximum Hww, mean Hww and the minimum Hww can be determined and plotted. Special event determined mean values would have a family of curves similar to the examples in Figures A-1 and A-2 of the topical report. The mean Hww term per each time step is combined with the elevation head and the head losses from the suction strainer and suction line per time step to produce a mean statistic NPSHa value.

b. The next step if the statistical approach does not show acceptable results would be to review appendix C and D of the topical report titled "Alternate methods to containment overpressure" and "COP Credit" and implement scenario changes or plant modifications as appropriate.

The NRC clarified the definition of "unacceptable result" to mean "NPSHa < NPSHr," and an acceptable result to mean "NPSHa > NPSHr." The BWROG understands that the NRC objects to retaining the deterministic licensing basis if the deterministic results are unacceptable and the corresponding statistical results are acceptable. The BWROG believes that the corresponding deterministic and statistical analyses will either both be acceptable or both unacceptable, so the situation postulated by the NRC should not arise. If it does, the licensee will need to take alternate action. The BWROG recommends the following changes to the NRC flow chart to improve clarity:



21. Section 6.1 Step 2 - In order to be consistent with Step 3, should Step 2 state "without COP included" rather than "with COP included" in second line? If not, please explain why the statement is correct.

Final BWROG Response:
We concur, Section 6.1 step 2 should read " If the NPSHa without COP, based on the deterministic approach is found to be lower than the NPSHr, then the NPSHa, without COP included, is evaluated using a statistical approach as outlined in step 3."

22. Section 6.1 - Steps 1 through 6 are not clear as to which approach would be the licensing basis.

The NRC staff's understanding of these steps is as follows:

First a deterministic calculation without COP is performed in order to demonstrate that NPSHa is greater than NPSHr. If this requirement is not met, the licensee will perform a deterministic analysis with COP. If this analysis does not yield an acceptable result (NPSHa ≤ NPSHr) then a statistical analysis without COP is performed. If this analysis gives an acceptable result (NPSHa ≥ NPSHr), then the assumption is made that the deterministic analysis using COP is acceptable. If the statistical analysis without COP is not acceptable (NPSHa ≤ NPSHr) then a statistical analysis is done with COP. If this analysis is not acceptable, then plant-specific measures would be necessary based on "alternative methods" such as those of Sections 5.1 and 5.2 of NEDC-33347P.

Please confirm that the above description is consistent with the intent of the TR.

NRC Supplemental Comment: See comment for Item 20.

Final BWROG Response:
An improved description is as follows:

Although not explicitly stated in Step 2 through 5, it is expected that deterministic analysis will demonstrate that NPSHa – NPSHr >= 0 (See Section 2.4)

The licensing basis is the deterministic calculation (see the response to RAI 1). First a deterministic calculation <u>without COP</u> is performed in order to determine if NPSHa is greater than NPSHr. If this acceptance criterion is not met, the licensee will perform a deterministic analysis <u>with COP</u> and a statistical analysis <u>without COP</u> is performed. If this analysis gives an acceptable result (NPSHa ≥ NPSHr), *then credit for COP is justified based on assurance of available COP under expected conditions with the supporting fact that realistically COP would not be required*. If the statistical analysis without COP is not acceptable (NPSHa ≤ NPSHr) then a statistical analysis is done with COP *and credit for COP is justified based on assurance of available COP under expected conditions*. If this analysis is not acceptable, then plant-specific measures would be necessary based on "alternative methods" such as those of Sections 5.1 and 5.2 of NEDC-33347P. See also the response for Item 20.

23. Section 6.1 Item 1.a - The acceptance criterion for the deterministic calculation states that the calculated wetwell pressure should be greater than the wetwell pressure required for adequate (available) NPSH "such that the wetwell pressure credit granted in the licensing basis minimizes the likelihood of having to seek additional ad hoc regulatory relief."

The NRC staff approach to this issue (used in recent extended power uprate (EPU) reviews and intended for future use) is that an analysis is acceptable if the pressure required for adequate available NPSH is less than the calculated accident pressure. No amount of wetwell pressure is "granted." Therefore, the quoted words above are not needed. The LOCA calculation of accident pressure and the pressure required for adequate available NPSH should be calculated conservatively. The "special events" may be calculated with realistic input.

Final BWROG Response:
We concur that the words in quotes are not needed and can be deleted.

24. Section 6.1 Item 1.b - Acceptance criterion b. states that a possible duration of the time that the wetwell pressure should be shown to be available may be the maximum coping time after

which assured cooling sources other than the suppression pool will be available for core and containment cooling.

a. For the LOCA, which is a DBA, why should not only safety related water sources and systems be credited?

   Final BWROG Response:
   For the DBA LOCA analysis only safety related water sources and systems should be credited. For Special events, non-safety related equipment maybe credited in accordance with emergency or abnormal operating procedures.

b. For the "special events," the assumptions in the analysis about the use of other equipment must be consistent with emergency or abnormal operating procedures.

   Final BWROG Response:
   We concur, for special events the assumptions in the analyses about the use of non-safety related equipment must be consistent with emergency or abnormal operating procedures.

25. Section 6.1 Item 3

a. Why is this step used only to justify that the deterministic approach is acceptable?
b. If NPSHa is greater than NPSHr using the statistical approach without COP included, why is this not the licensing basis?
c. If use of the deterministic approach as the licensing basis depends on the results the statistical analysis, is not the statistical analysis included in the licensing basis?
d. Why is not the 95/95 criterion stated?

Final BWROG Response:

a. The statistical approach was developed to show the inherent conservatism of the deterministic approach. The statistical derived NPSHa values when compared with the deterministic derived NPSHa values will show the margin between the deterministic/licensing values and that expected under real event conditions.

   Section 6.1 item 3 was expressing the argument that if deterministically containment overpressure credit was needed and statistically no COP was required, then the COP requested based on the deterministic analysis should be acceptable since no COP is realistically needed.

b. The philosophy being applied is that the deterministic approach will be used for the licensing basis and that the statistical approach will be used to show the margin as expected under real event conditions. The statistical approach method would be completed once and be a snapshot in time.

c. The basis for the acceptability of containment overpressure credit is that during LOCAs or special events that physical conditions inside the containment for pressure and temperature can be predicted and as long as the conservatively predicted containment pressure exceeds the amount of pressure to assure adequate NPSH, its use should be acceptable. Additionally, if a statistical method shows that adequate NPSH exists without the use of containment pressure then this would be just an additional factor that would support acceptance but would not be the basis for acceptability. Therefore, the acceptability of the deterministic results is not dependent on the statistical method and the statistical method would not be part of the licensing basis.

d. The statistical approach with realistic assumptions is described in Section 3.1.2 and utilizes the Monte Carlo process to obtain statistically meaningful results at 95%-probability and 95%-confidence (95/95) level. This is what was meant when the term " statistical approach" was used in Section 6.1 item 3.

26. Section 6.2 Step 3 of Section 6.1 states that if NPSHa is greater than NPSHr using the statistical approach without COP included, then credit for deterministic COP from Step 1 is justified. In order to maintain this justification, do not Title 10 of the *Code of Federal Regulations* Part 50 Appendix B requirements have to apply? Therefore, is not configuration control still needed?

NRC Supplemental Comment: See comment for Item 20.

Final BWROG Response:
The deterministic analysis stands alone as the licensing and design basis, and it will be maintained in accordance with Appendix B. The statistical analysis provides a one-time evaluation to demonstrate that it is appropriate to use COP as a licensing and design basis. See also the response for Item 20.

27. Section 6.1 Item 4.a - The acceptance criterion states that the calculated 95/95 wetwell pressure (Pww) using the statistical method with COP included should be greater than the wetwell pressure required for adequate NPSH "such that the wetwell pressure credit granted in the licensing basis minimizes the likelihood of having to seek additional ad hoc regulatory relief."

The NRC staff approach to this issue (used in recent EPU reviews and intended for future use) is that an analysis is acceptable if the pressure required for adequate available NPSH is less than the calculated accident pressure. No amount of wetwell pressure is "granted." Therefore, the quoted words above are not needed.

Final BWROG Response:
We concur that the words in quotes are not needed and can be deleted.

28. Section 6.1 Item 4.b - The acceptance criterion states that the calculated mean wetwell pressure (Pww) using the statistical method with COP included should be greater than the wetwell pressure required for adequate NPSH "such that the wetwell pressure credit granted in the licensing basis minimizes the likelihood of having to seek additional ad hoc regulatory relief."

The NRC staff approach to this issue (used in recent EPU reviews and intended for future use) is that an analysis is acceptable if the pressure required for adequate available NPSH is less than the calculated accident pressure. No amount of wetwell pressure is "granted." Therefore, the quoted words above are not needed.

Final BWROG Response:

We concur that the words in quotes are not needed and can be deleted.

29. Section 6.1 Item 5 - Credit for acceptable operation of a pump in cavitation should comply with Positions 1.3.1.3 and 2.1.1.3 of Regulatory Guide 1.82 Revision 3 which discusses an approach acceptable to the NRC staff.

Final BWROG Response:
Section 6.1 Item 5: It was the intent of NEDC-33347P that if the NPSHa does not meet the NPSHr developed under the industry standard approach, consistent with the RAI #11 response, documentation will be supplied to comply with Positions 1.3.1.3 and 2.1.1.3 of Regulatory Guide 1.82 Revision 3.

30. Section 6.1 Item 6 - A risk assessment in support of using COP in determining the available NPSH of a pump should be plant-specific.

NRC Supplemental Comment: Staff does not intend to review and provide a safety evaluation for Section 5 of the LTR.

Final BWROG Response:
Within Section 5.3.8 COP Risk Assessment conclusions is a subsection titled "Applicability to BWR fleet". The intent of the COP risk assessment was to present a risk assessment for use of containment overpressure that would bound most if not all BWR plants. The topical report states that the BWR plants should review and verify that the COP risk assessment bounds their plant or perform a plant specific risk assessment. This is stated in Section 5.3.8 and in Section 6.1.

31. Section 2.2, Page 5 states that the statistical analysis uses certain inputs, each based on randomly generated factor applied to their input exceedance probability.
   a. Please describe how these inputs were chosen and compare the method of selection with the phenomenon importance ranking table (PIRT) process described in NUREG/CR 5249 if not addressed in RAI 1.
   b. Explain why the exceedance probability is used.

Final BWROG Response:
   a. As discussed in the response to RAI 1, the Phenomena Identification and Ranking process in NUREG/CR 5249 has not been performed. The inputs that are varied in statistical calculations are chosen through individual sensitivity studies for each chosen parameter, as described in Section 3.1.1 of this LTR.

   b. The exceedance probability is used to introduce plant-specific data into the analysis. The application of exceedance probability is described in Appendix A.2 of the LTR.

32. Section 2.3 lists the outputs from the Monte Carlo calculation. One of these is the time step distribution. Please explain the significance of this output. How is it used or interpreted?

Final BWROG Response:
The time step distributions from Monte Carlo statistical calculations, described in Section 2.2,

provide the values of the output parameters of interest at each time step, which show the variations of each parameter from 59 different runs at that time. No time step distribution results are presented in this LTR. The information from the time step distributions is used to find the maximum, mean, and minimum values of those parameters of interest at each time step. These results are presented in Appendix A.

33. Section 3.1, Page 8 - Other conservative assumptions are typically included in deterministic analyses. These include minimum flow rates for service water and suppression pool water through the RHR heat exchangers, the worst single failure, wetwell (air space) volume maximized, passive heat sinks modeled to maximize heat transfer from the containment atmosphere to the heat sinks, etc. Is the list presented in the TR meant to be complete for an acceptable calculation? If so, would these other variables be realistic values?

NRC Supplemental Comment: Please either provide a complete list of the parameters varied statistically in the LTR or verify that it will be included in the licensee's submittal.

Final BWROG Response:
As discussed in the response to RAI 18, the list presented in the topical report is provided for information purposes and not meant to represent a complete requirements list for an acceptable calculation. For the other variables not listed, their values are chosen in a way so that the pool temperature is maximized and/or the wetwell pressure is minimized.
The list of parameters varied for the statistical calculations for the sample plant in the LTR is presented in Section A.2. The licensee submittal in the future shall list the parameters that are varied for their analysis.

34. Section 2.3 states that when evaluating if COP is required, the most realistic NPSHr should be used. Does this mean the 3 percent value? If not, please explain what is meant by the realistic NPSHr value.

Final BWROG Response:
The intended meaning of the term "most realistic" was the standard 3% NPSHr curve, but the "most realistic" term was used to allow licensees the option to contact pump vendors to establish NPSHr values commensurate with the minimum hydraulic performance requirements for each pump and the time duration over which the reduced NPSHa can exist. See also RAI response 11.

35. Section 3.1, Page 8 - Other conservative assumptions are typically included in deterministic analyses. These include minimum flow rates for service water and suppression pool water through the RHR heat exchangers, the worst single failure, wetwell volume maximized, passive heat sinks modeled to maximize heat transfer from the containment atmosphere to the heat sinks, etc. Is the list presented in the TR meant to be complete for an acceptable calculation?

Final BWROG Response: See the response to RAI 33.

36. Section 7.0.. A discussion of the acceptability of NPSHr values used should be included in individual license amendment requests if based on other than 3 percent or 1 percent head

drop values.

Final BWROG Response:
We concur, a discussion of the acceptability of the NPSHr values used should be included in individual license amendment requests.

ENCLOSURE 3

BWROG-09020

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, James F. Harrison, state as follows:

(1) I am Vice President, Fuels Licensing, Regulatory Affairs, 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 Enclosure 1 of BWROG-09020, Douglas W. Coleman (BWROG) to Document Control Desk (USNRC), *BWROG Response to NRC Requests for Additional Information (RAIs) on GEH BWROG Topical Reports NEDC-33347P Revision 0 (Proprietary Version) and NEDO-33347 Revision 0 (Non-Proprietary Version), "Containment Overpressure Credit for Net Positive Suction Head (NPSH),"* dated March 20, 2009. The proprietary information in Enclosure 1, *Final BWROG Responses To NRC Requests For Additional Information Regarding Containment Overpressure Credit For Net Positive Suction Head (NPSH) (NEDC-33347P),* is identified by a [[single dotted underline inside double square brackets{3}]]. Figures and other large 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 or licensee, 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 qualify 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 results and conclusions regarding supporting evaluations of the safety-significant changes necessary to demonstrate the regulatory acceptability for the Containment Overpressure Credit for Net Positive Suction Head for a GEH Boiling Water Reactor ("BWR"). The analysis utilized analytical models and methods, including computer codes, which GEH has developed, obtained NRC approval of, and applied to perform evaluations of Containment Overpressure Credit for NPSH analysis for a GEH BWR.

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 and obtaining 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 20th day of March 2009.

James F. Harrison

James F. Harrison
Vice President, Fuels Licensing, Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC