GE Energy

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

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MFN 05-146
Supplement 1

Docket No. 52-010

May 4, 2007

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

Subject: **GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation**

Enclosure 1 contains a proprietary markup of the original response provided December 1, 2005 (Reference 1). The original response identified all the information as proprietary, and did not provide a non-proprietary version. As the Staff has indicated, not all of the information contained in the response was proprietary. As a result, GE has re-evaluated the previous submittal, identifying the proprietary information from the non-proprietary information and hereby resends the response so that the request from withholding can be fulfilled.

Enclosure 1 contains proprietary information as defined in 10CFR2.390. The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GE. GE hereby requests that the proprietary information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. A non-proprietary version is contained in Enclosure 2.

If you have any questions about the information provided here, please let me know.

D068

Sincerely,

James C. Kinsey

James C. Kinsey
Project Manager, ESBWR Licensing

References:

1. MFN 05-146, Letter from David H. Hinds to U.S. Nuclear Regulatory Commission, *GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC # MC8168)*

Enclosures:

1. MFN 05-146, Supplement 1 – GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation – GE Proprietary Information
2. MFN 05-146, Supplement 1 – GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation – Non Proprietary Version
3. Affidavit – James C. Kinsey – dated May 4, 2007

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
RE Brown GE/Wilmington (with enclosures)
eDRFs 0047-4835

Enclosure 3

MFN 05-146, Supplement 1

Affidavit

General Electric Company

AFFIDAVIT

I, James C. Kinsey, state as follows:

(1) I am Project Manager, ESBWR Licensing, General Electric Company ("GE"), 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 GE's letter, MFN 05-146, Supplement 1, James C. Kinsey to U.S. Nuclear Regulatory Commission, entitled "*GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation*", May 4, 2007. The proprietary information *GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation*", 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 or licensee, GE 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 GE's competitors without license from GE 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 GE customer-funded development plans and programs, resulting in potential products to GE;

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 GE, 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 GE, 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 GE. Access to such documents within GE 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 GE 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 the results of analytical models, methods and processes, including computer codes, which GE has developed, and applied to perform stability evaluations using the detection and suppression capability of the confirmation density algorithm for the BWR. GE has developed this TRACG code for over fifteen years, at a total cost in excess of three million dollars. The reporting evaluation and interpretations of the results, as they relate to the detection and suppression capability of the confirmation density algorithm for the BWR was achieved at a significant cost, in excess of one quarter million dollars to GE. 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 GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE'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 GE.

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.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE 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 GE 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 GE 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 4th day of May 2007.

James C. Kinsey

James C. Kinsey
General Electric Company

ENCLOSURE 2

MFN 05-146, Supplement 1

GE Response to NRC Request for Additional Information Letter No. 3 Related to NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis" (TAC #MC8168) Proprietary Designation

Non-Proprietary Version

Response to Request for Additional Information (RAI)
NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis"

10. MCNP is used to determine biases and uncertainty in void coefficient. What is the accuracy of the MCNP calculations? Monte Carlo calculations involve some finite number of histories, which implies some uncertainty for the results. The microscopic cross-sections data base used by the Monte Carlo calculation also has some uncertainty associated with it. The burnup calculation that identifies the concentrations for the isotopes at a given burnup has uncertainty. The uncertainty in the burnup calculation translates to an uncertainty in the Monte Carlo calculation. There is an uncertainty associated with the manufacturing tolerances for the fuel rods in terms of enrichment fraction, etc. How are these uncertainties included into the ESBWR instability calculations? TRACG includes internal biases and uncertainty for the k-infinite void coefficient based on the differences between MCNP and GE lattice code simulations. This implies that the MCNP calculations are exact. Has the uncertainty in the MCNP calculations been included in these TRACG internal biases and uncertainty functions?

Response:

The MCNP uncertainty in the calculated k-infinity values has a standard deviation of [[{3}]] based on the stochastic variability of the calculations at the number of histories that were specified [[{3}]]. The MCNP k-infinity uncertainty translated into approximately [[.......... {3}]] uncertainty in the void coefficient at 40% instantaneous void that increases gradually to around [[{3}]] instantaneous void. The uncertainty due to MCNP goes up for higher voids because k-infinity goes down whereas the MCNP standard deviation in k-infinity is approximately constant. The burnup calculation is performed in TGBLA and the isotopes are specified to MCNP for different exposures. [[{3}]] All these uncertainties are elements in the overall uncertainty in the void coefficient since uncharacterized uncertainties in MCNP relative to TGBLA cause the variation in the pair-by-pair comparisons to increase. [[{3}]]. The void history impact results in a bias in much the same way as having the incorrect exposure. Both are accommodated in the process by determining the cycle exposure where the calculated stability response is most severe.

11. The biases and uncertainty in void coefficient is based on comparing the results for the TGBLA06 and MCNP01 calculations for 11 different lattices at different void fractions and exposures. Is the GE14 design one of the 11 different lattices? Are the biases and uncertainties associated with the GE14 design bounded by the response surface developed for the 11 different lattices?

Response:

The lattices are characterized according to the fuel rod array and whether or not they are fully are partially rodded. At the lattice level there is no geometric difference in the 10x10 GE12 design and the 10x10 GE14 design. [[{3}]]. Thus, this set provides good coverage for the GE14 bundles. The void coefficient bias and uncertainty is well characterized for the entire range of instantaneous void fractions and exposures as was indicated in NEDE-32906P-A, Revision 1.

12. Is there any voiding calculated in the water rods during a typical ESBWR instability calculation with TRACG? There is some core bypass voiding calculated in the periphery of the core due to the down flow at the top of the core bypass. The biases and uncertainty in void coefficient is based on assuming the water rods and core bypass are at zero void fraction. Is the additional uncertainty in reactor kinetics associated with water rods voids and/or core bypass bounded by the response surface used by TRACG?

Response: There is no voiding in the water rods. The liquid temperature at the top of the water rod at the steady-state conditions is about 4K below saturation temperature, which is illustrated in the Figure below.

[[

{3}]]

13. NEDE-33083P, Supplement 1 page 5-11 lower tie-plate leakage (drilled holes) has an uncertainty of 5%, while on the same page the sharp-edge orifice for water rod has uncertainty of 10%. Why is the uncertainty of the flow through drilled holes less than the uncertainty for a calibrated sharp-edge orifice?

Response:

The uncertainty for the flow through the drilled holes in the lower tieplate is based on measurements in prototypical hardware and has been used before in earlier submittals (NEDE-32906 P-A). The uncertainty in the water rod flow is conservatively estimated. The calibrated orifice in the water rod will have a smaller uncertainty than the drilled holes. However, the water rod has (smaller) flow losses in the inlet and exit holes and the wall friction. Rather than accounting for these separately, a bounding estimate of 10% was used. Tables 8.2-1 and 8.2-2 in NEDE-33083P, Supplement 1 show that the sensitivity of the channel and core decay ratios to these parameters is very small.

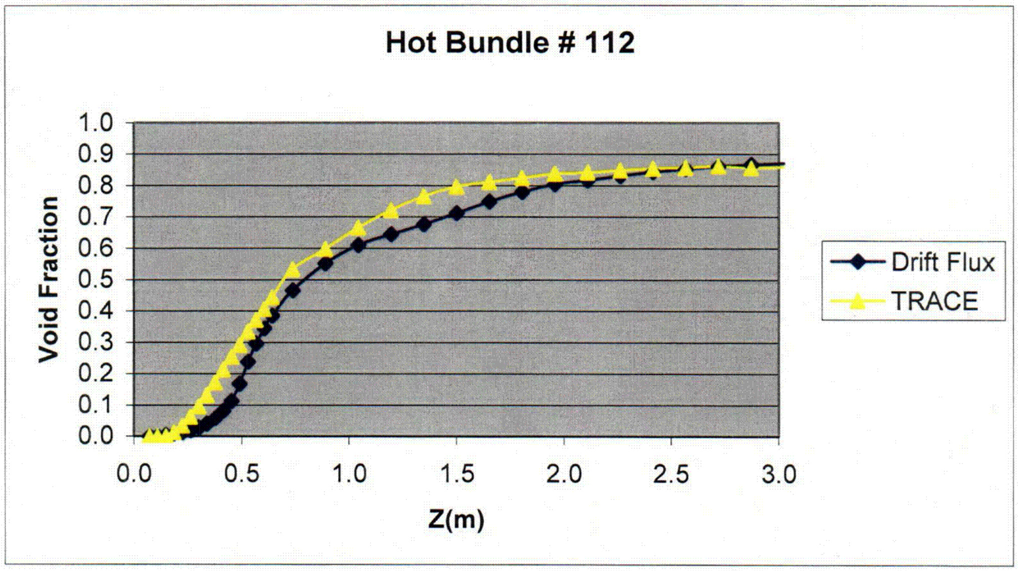
14. BOC is bounding exposure for channel decay ratio. MOC is bounding exposure for core decay ratio. What about a clean core (i.e. zero exposure) rather than an equilibrium cycle? Have any calculations been completed for completely fresh core (i.e. zero exposure)?

Response:

An initial core design has not been developed for the ESBWR. For purposes of demonstrating the application methodology, an equilibrium core was judged to be sufficient. The actual initial core will be analyzed using the approved methodology at COL.

The process of developing an initial core design begins with the equilibrium core. The characteristics of the equilibrium core are replicated by replacing the burned fuel with fuel that is lower in enrichment and gadolina. The final design following iteration usually results in a somewhat flatter radial and axial peaking to compensate for higher local peakings in the higher enrichment bundles. The flatter axial peaking is favorable for channel and regional stability. The flatter radial peaking will typically lead to a higher subcriticality for the first harmonic mode relative to the common "ring of fire" radial peaking pattern. The void coefficient is less negative at BOC than later in the cycle, and should be slightly less negative for the initial core because of the absence of plutonium in the fuel. Overall, the stability performance of the initial core at BOC is expected to be similar or slightly better than for BOC for the equilibrium core. Given the margins to the stability design criteria demonstrated in Section 8.3 of NEDE-33083P, Supplement 1, use of an initial core should not be a major perturbation to the analysis results.

15. .As part of the staff's review your interfacial drag models in TRACG, a calculation was performed that predicts void fraction as a function of elevation in the hot bundle. This was performed using TRACE and a standalone drift flux calculation that uses the models in Ref. 1. The staff found that the results were slightly different. This was expected since there are modeling differences between TRACE and the TRACG models in Ref. 1.



TRACG uses the Rouhani-Bowring model[2] for the energy distribution in subcooled boiling while TRACE uses the Lahey's mechanistic model[3]. The models are essentially the same, except the TRACE model does not include the pumping factor.

TRACG Model:

$q_l = q_w$ if $h_l < h_{ld}$.

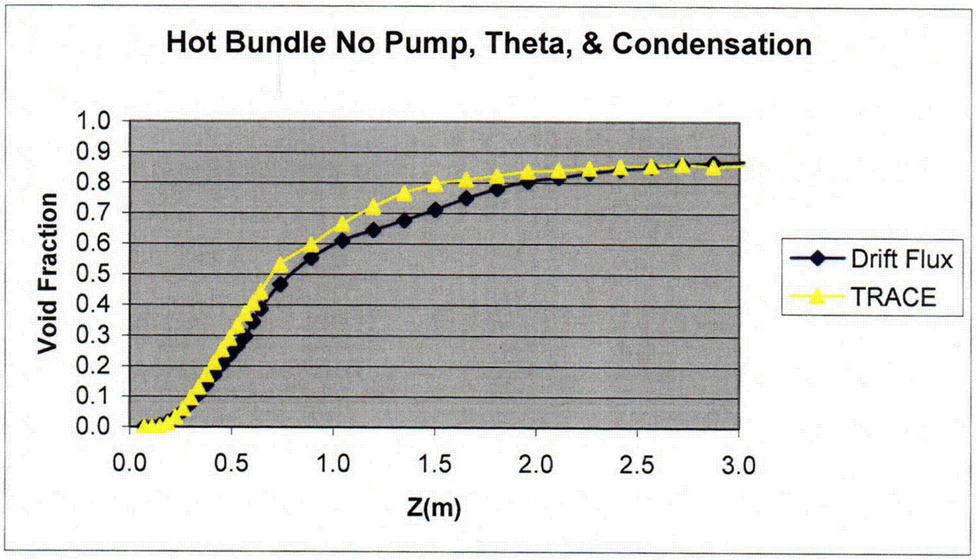
$$q_l = q_w \left[\left(\frac{h_f - h_l}{h_f - h_{ld}} \right) \left(1 + \left(\frac{h_l - h_{ld}}{h_f - h_l} \right) \left(\frac{\varepsilon}{1+\varepsilon} \right) \right) \right] \quad \text{if } h_l > h_{ld}$$

The TRACE model has ε set to zero (i.e. the pumping factor).

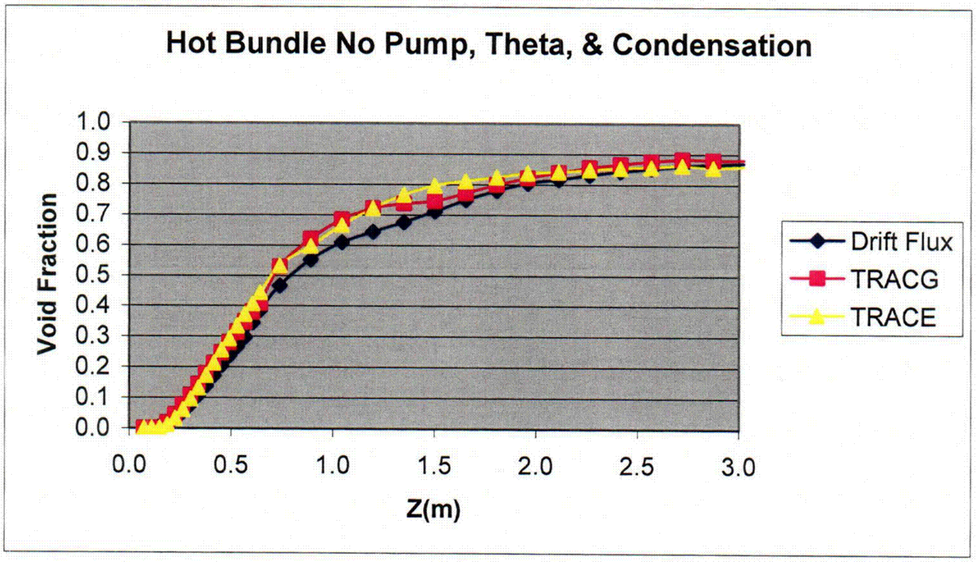
Another difference is that TRACE does not include the theta factor for modification[4] of Co in the subcooled boiling regime, while the TRACG model description indicates that this factor is included.

$$C_{o,sb} = C_o \left(\frac{h_l - h_{ld}}{h_f - h_{ld}} \right)$$

The standalone drift flux model was modified to set the pumping factor to zero, remove the theta factor for modification[4] of Co in the subcooled boiling regime, and ignore condensation in the subcooled boiling regime. The cases were re-run and the two results agree quite well.



These void fraction profiles were then compared to the TRACG data in the MS Excel file MFN 05-014 Channel Data.



This also agreed quite well, which was not expected. The staff expected that in the subcooled region the TRACG data would agree with the drift flux model in the prior to the modifications since that model is using the same models in Ref. 1.

Please provide the following so that the staff may understand or resolve the differences:

a) Confirmation that the pumping factor and theta factor are used in TRACG.

b) Axial power profile for the ESBWR hot bundle at steady-state.

c) Location of the grid spacers and the form loss used for the grid spacers and the flow area for the grid spacers.

d) Provide a density wave propagation time based on the TRACG results.

Response:

a) The code listing for TRACG04 was checked and it was confirmed that both the pumping factor and theta factor are coded as described in the TRACG Model Description (Reference 1).

b) Axial power profiles for the ESBWR hot bundle (channel #112) are illustrated in the Figure below

[[

{3}]]

c) The pressure drop due to singular losses ΔP_S is calculated in TRACG according to following equation (Ref 1.)

$$\Delta P_S = C\frac{G^2}{2\rho_l}\Phi^2_{l0\,\mathrm{hom}}$$

where

$C -$ loss coefficient
$G -$ mass flux (kg/(s*m^2))
$\rho_l -$ liquid density (kg/m^3)

$\Phi^2_{l0\,\mathrm{hom}}$ – homogeneous two-phase multiplier

$$\Phi^2_{l0\,\mathrm{hom}} = 1 + x\left(\frac{\rho_l}{\rho_v} - 1\right)$$

$\rho_v -$ vapor density (kg/m^3)
$x -$ flow quality

The local losses for the central channel are shown in the Table below
[[

{3}]]

d) The density wave propagation time can be evaluated based on the phase shift between inlet and outlet flows. The inlet and outlet flows for the hot channel #112 (BOC, Channel stability analysis, inlet flow perturbation 20%) are illustrated in the Figure below. The density wave propagation time is [[{3}]]

[[

{3}]

16. Fig. 3-11 in Ref. 5 indicates that for the Sirius test at 72 bars pressure the density-wave oscillations have a period > 10 seconds. The height of the core for the Sirius test is ~1.7 m compared to 3.0 m for the ESBWR. The ESBWR calculated power oscillations have a period ~1.3 seconds. The time period of the power oscillations in the ESBWR are related to the time required for a density wave to transport through the core. However, the density wave oscillations for the Sirius test with a shorter core have a period that is approximately an order of magnitude larger than the time period for the ESBWR power oscillations. It is assumed that the longer time period for the Sirius test is because the Sirius test is at constant power and therefore the density wave oscillation includes the time associated with a density wave propagating through the chimney. Please provide an explanation for the time period associated with the density wave oscillations in the Sirius test.

Response:

The SIRIUS tests do not demonstrate classic density wave oscillations. Rather, these tests display a Type 1 Instability (see Figure 9.1-1 of NEDE-33083P, Supplement 1). These oscillations are initiated when voiding starts in the chimney region. An increase in the void fraction in the chimney leads to an increase in the natural circulation flow, which in turn tends to quench the voids (e.g. Figure 3-9 in Reference 5 shows the void fraction in the chimney dropping to zero during each oscillation). This type of periodic behavior is more significant at low pressures due to the larger density difference between the phases. The oscillations are terminated when the heat flux is increased further and a steady void fraction is established in the core and chimney. The time period of these oscillations is related to the transport time for enthalpy changes through the core and chimney as a result of changes in flow. Hence the time periods are of the order of 10 to 15 seconds rather than the much shorter time periods for density wave oscillations, which are driven by void propagation through the core.

References:

1) J.G.M. Andersen, et al, "TRACG Model Description," NEDE-32176P, Revision 2, Class 3, December 1999.

2) R.T. Lahey, *Two-Phase Flow in Boiling Water Reactors*, NEDO-13888, July 1974.

3) R. T. Lahey, "A Mechanistic Subcooled Boiling Model," Proc. of the Sixth International Heat Transfer Conference, 1, Toronto, Canada, 1978, pp 293-295.

4) J.A. Findlay and G.E. Dix, "BWR Void Fraction Correlation and Data," NEDE-21565, January 1977.

5) J.R. Fitch, et al, "TRACG Qualification for ESBWR," NEDC-33080P, August 2002.

6) ESBWR Design Description, NEDC-33084p, Class III, DRF 0000-0007-3896, August 2002.