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

MFN 08-483
May 30, 2008

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

Subject: Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)

In Reference 1, the USNRC provided a Request for Additional Information regarding the subject topical report. In Reference 2, responses to RAIs 1-10, 12, 14, 15, 24, 25, 28, 29, and 33 were transmitted. The response to RAI 13 (ESBWR 21.6-75) was provided separately in MFN 07-452. Reference 3 included responses to RAIs 16, 17, 22, 23, 26, 27, 31, and 34. This transmittal provides the response to RAI 30.

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

If you have any questions, please contact Jim Harrison at (910) 675-6604 or me.

Sincerely,

James J Harrison for

Richard E. Kingston
Vice President, Methods Licensing
Regulatory Affairs

Project No. 710

D065
NRR

Reference:

1. Letter, M. C. Honcharik (USNRC) to R. E. Brown (GE), "Request for Additional Information RE: General Electric Nuclear Energy (GENE) Topical Report (TR) NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)," MFN 07-144, March 5, 2007.

2. Letter, R. E. Kingston (GEH) to M. C. Honcharik (USNRC), "Partial Response to Request for Additional Information RE: GE Topical Report NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)," MFN 07-445, August 15, 2007.

3. Letter, R. E. Kingston (GEH) to M. C. Honcharik (USNRC), "Partial Response to Request for Additional Information RE: GE Topical Report NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)," MFN 07-445, Supplement 1, December 20, 2007.

Enclosures:

1. Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569), GEH Proprietary Information

2. Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569), Non-Proprietary Information

3. Affidavit, James F. Harrison, dated May 30, 2008

cc: JM Andersen (GEH/Wilmington)
RE Brown (GEH/Wilmington)
PL Campbell (GEH/Washington)
MJ Colby (GEH/Wilmington)
C Heck (GEH/Wilmington)
MC Honcharik (USNRC)
MA Lalor (GEH/San Jose)
GB Stramback (GEH/San Jose)
PT Tran (GEH/Vallecitos)
eDRF Section 0000-0086-4047

ENCLOSURE 2

MFN 08-483

Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients*, (TAC No. MD2569)

Non-Proprietary Version

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1 to MFN 08-483, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by open and closed double square brackets as shown here [[ ]].

RAI # 30

NRC Staff Question

TRACG internally models the response surface for the void coefficient biases and uncertainties for known dependencies due to the relative moderator density and exposure on a nodal basis. Section 2.8.7 of the Vermont Yankee extended power uprate (EPU) safety evaluation report (Reference 8) reviewed the impact of the void history bias on the safety analyses. RAI SRXB-A-68 response (Reference 9) quantified the void history bias and discussed its impact. Section 2.2.2.2, "Treatment of Fuel Parameter Uncertainties," of Reference 10 also addressed the void history bias. Based on the quantified void history bias typical for the fuel designs typical of the EPU and the maximum extended load line limit analysis plus (MELLLA+) operating domain, modify the TRACG methodology to account for void history bias. The void history bias can be incorporated into the response surface "known" bias or through changes in lattice physics/core simulator methods for establishing the instantaneous cross-sections. Including the void history bias in the methodology negates the need for ensuring that each plant-specific application has sufficient margin available to account for the impact of the void history bias. Revise the nodal void reactivity coefficient biases and uncertainties an incorporate the void history biases. Provide sufficient technical details for the NRC staff to assess that the void history bias applied on a nodal level will conservatively bound the non-conservatisms in the current assumptions for nodes depleting at high void conditions.

NRC References

8. Vermont Yankee Nuclear Power Station - Draft Safety Evaluation for the Proposed Extended Power Uprate (TAC No. MC0761), October 21, 2005. (ML052910200)

9. BVY 05-088 Letter, J. Thayer (Vermont Yankee) to NRC, Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263, Supplement No. 35, Extended Power Uprate - Response to Request for Additional Information, September 28, 2005. (ML052770039)

10. NEDC-33173P, Applicability of GE Methods to Expanded Operating Domains, February 2006. (ML060720281)

GEH Response

Overview

The method to account for the biases and the uncertainties in the void coefficient model has been modified to include the effects due to void history (VH). Section *C1AX* has been updated to describe the TRACG methodology with the void history effects included. Calculations have been performed including the void history effects as part of the void coefficient correction model. By comparison to similar calculations performed with the model deactivated, these calculations reveal that correcting for biases in the void coefficient is expected to caused the key AOO calculated parameter of ΔCPR/iCPR to become somewhat more conservative as indicated in Figure 30-1 by a typical response for the usually limiting pressurization event. [[

]] These impacts may vary by core and cycle since the model depends on core and cycle-specific elements such as exposure, instantaneous voids and void history. The key point is that the impacts, either positive or negative, are now incorporated in the TRACG AOO methodology which is amended by incorporating the effects due to void history in determining the biases and uncertainties in the void coefficient on a plant and cycle-specific basis.

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Figure 30-1 Typical Impact of Updated Void Coefficient Correction Model

It is unclear what is meant in the NRC request by "conservatively bound the non-conservatisms" since the purpose of a realistic model is to provide a means to quantify and account for the impact due to biases and uncertainties for the expected applications. That is what the revised TRACG04 model does. Additional details for the model are provided in the *Technical Description* subsection. This updated technical description has been expanded to incorporate details previously contained in a multi-part RAI response associated with the previous model. Those details have also been updated to describe how void history is accounted for in the updated model. Care has been taken to provide the same level of detail and where possible in almost the same order as in the original responses.

C1AX Void Coefficient, H

This section is an update to section by the same title in Reference [30-3].

TRACG04 uses a 3-D neutron kinetics model based on the PANAC11 model that uses neutronics parameters provided by TGBLA06 (see References [30-1] and [30-2]). The nodal reactivity is calculated [[ ]]. All of these parameters are expressed in terms of the instantaneous moderator density and also include a dependency on moderator density history and nodal exposure. Consequently, the infinite multiplication factor also has these same dependencies.

The biases and uncertainties in void coefficient as determined from the PANAC11 originate in the biases and uncertainties in the infinite lattice eigenvalues (k_∞) calculated by the TGBLA06 lattice physics code [[ ]] Values of k_∞ at a total of [[ ]] points were calculated for a representative set of [[ ]] lattices with 10x10 geometry at [[ ]] different exposures of [[ ]] and at different void histories (VH) of [[ ]] for in-channel instantaneous voids (IV) of [[ ]] using both TGBLA06 and MCNP. The results for each lattice, exposure, and void history were fit to a [[ ]] function to determine k_∞ as a function of instantaneous voids. The functional forms derived separately for TGBLA06 and MCNP were extrapolated to obtain [[ ]] values of k_∞ corresponding to 100% in-channel voids for each code. The void coefficients at a total of [[ ]] points were defined separately for TGBLA06 and MCNP by evaluating the derivative of k_∞ [[ ]]. Biases and uncertainties in TGBLA06 void coefficients were evaluated by performing [[ ]] comparisons between TGBLA06 and the corresponding MCNP benchmark values. These assessments were made using uncontrolled lattices (lattices without a control blade). An earlier independent set of [[ ]] other TGBLA04 lattices all at zero exposure were evaluated [[ ]] as a check on the process. The check set using TGBLA04 comparisons to MCNP included [[ ]] controlled lattices to confirm that the uncontrolled lattices bound the biases and uncertainties for the controlled lattices. Because of the similarity in the TGBLA04 and TGBLA06 comparisons, the comparisons based on TGBLA06 using uncontrolled lattices are also expected to bound the biases and uncertainties for the controlled lattices.

To obtain the response surfaces that are modeled in TRACG04, the set of [[ ]] points was used to characterize the biases and uncertainties in the void coefficient as a function [[

]]. The response surfaces for the relative biases are shown in Figure 30-2 and the response surfaces for the relative standard deviations are shown in Figure 30-3. In both figures there are [[ ]] surfaces corresponding to different void histories. For each surface the vertical axis is the in-channel instantaneous void fraction and the horizontal axis is the nodal exposure. The color scheme shown in the legends at the top of the figures denote the ranges for the biases in Figure 30-2 and the ranges for the standard deviations in Figure 30-3. A negative bias means that the TGBLA06 void coefficient is smaller in absolute magnitude than the corresponding MCNP value.

The response surfaces for the biases and uncertainties shown in Figures 30-2 and 30-3 show that in the exposure range from about 15 to 30 GWd/STU that corresponds to the limiting CPR bundle for AOO analyses that the void coefficient bias [[ ]] For exposures less than 15 GWd/STU the PANAC11 standard process as supplied with TGBLA06 nuclear information [[ ]] Also for low exposures, the uncertainties tend to be [[ ]]. As the poison is *burned* and the bundles approach their peak reactivity and power, the void coefficient biases and uncertainties [[ ]] as indicated in Figure 30-4. Figure 30-4 also shows that void history does not begin to make any discernable differences until the exposure has exceeded about 25 GWd/STU. At exposures above this point the standard process tends to [[ ]] A larger void coefficient (in the absolute sense) is conservative because it tends to produce a more dynamic power response and a less favorable CPR response. [[ ]]

The implementation of void history effects into the TRACG04 model has allowed us to demonstrate (see Figure 30-1) that the CPR response with the complete model is [[ ]] The implications are that the importance of the void coefficient correction model for purposes of calculating the CPR response [[ ]]

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Figure 30-2. Void Coefficient Relative Bias

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Figure 30-3. Void Coefficient Relative Standard Deviation

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Figure 30-4. Average Absolute Value of Void Coefficients from MCNP

Figure 30-4 is also useful to understand the trends seen in Figures 30-2 and 30-3. Although the results and trends are shown only for the MCNP reference values, TGBLA06 values and trends are similar. In the absolute sense the void coefficient biases of TGBLA06 to MCNP are nearly constant up to about 30 GWd/STU. The relative biases in Figure 30-2 are higher for exposures less than 15 GWd/STU simply because the absolute void coefficient values to which the relative values are normalized are smaller for these exposures. The same statement applies to the relative uncertainties shown in Figure 30-3. At the higher exposures, Figure 30-4 shows that void history begins to make a discernable difference in the calculated void coefficient values from once the lattice exposures have exceeded about 25 GWd/STU (as noted previously). The *standard process* used in PANAC11 to capture these trends is based on void coefficient dependencies with respect to IV that were established at a void history of 40% (solid triangle symbols in Figure 30-4). Figure 30-4 shows that at exposures above 25 GWd/STU the standard process (solid triangles) at all IV values tends to [[

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[[

]] Additional detail is provided in this response in the section titled *C1AX Void Coefficient - Technical Description.*

TRACG04 internally models the response surfaces for the void coefficient biases and uncertainties in order to account for the known dominant dependencies due to relative moderator density, exposure, and void history [[ ]]. Lattices also are explicitly modeled on a nodal basis because cross sections are generated within TRACG04 using data from the lattice physics code that gets passed through via the PANAC11 wrap-up. The void coefficient biases and uncertainties are implemented in TRACG04 calculations [[

]]. Thus, the normality of the [[ ]] residual errors can be tested at each of these locations. This is what was done to get the P-values presented in Table 30-1. The Anderson-Darling test for normality was used because it is effective for small sample sizes.

A sample size of [[ ]] is too small to expect that a specific P-value for each lattice state point can be accurately determined; however, the set of all [[ ]] such values can be judged as a whole to support the conclusion that it is reasonable to assume that the residual errors are normally distributed. As shown in Table 30-1, the P-values from all the sets average to 0.432±0.277 which is well above the traditional 0.05 threshold where normality would be rejected. This conclusion has been further supported by creating a composite histogram of the standard residuals errors as shown in Figure 30-5. The composite population shown in the figure contains all [[ ]] standard residual errors that can be obtained from the database. Because this population is in standard form, it should theoretically have a mean of zero and a standard deviation of unity. Actually it does have a mean of zero but its standard deviation is 0.9358 which means that modeling it with an assumed normal distribution conservatively yields a larger variability.

Table 30-1
Normality Test P-values for the Void Coefficient Residual Errors

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[[

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Figure 30-5. Histogram of Standard Residual Errors with Normal Curve

TRACG04 input has been structured to allow the internally calculated uncertainties to be correlated [[

]] For most fast pressurization events, the impact of not modeling the void coefficient biases is on the order of [[ ]] in calculated values of transient ΔCPR/ICPR. Whether the bias is conservative or not depends on the exposure distribution and the relative water density distribution in the core. That is why it is important to model the bias as a function of the nodal conditions.

For sensitivity studies, a core-wide bias and uncertainty in void coefficient can be specified through the TRACG04 input. As an example of the importance of the void coefficient uncertainty, consider that for a typical BWR/4 plant a variation of [[ ]] in the void coefficient when applied to all nodes in the core corresponds to a sensitivity of [[ ]] in the ΔCPR/ICPR for a turbine trip without bypass.

C1AX Void Coefficient – Technical Description

This section is an updated version of the details that were previously provided in response to RAI 13 in NEDE-32906P-A[30-3].

The *void coefficient* (C_V) is introduced and defined as

$$C_v \equiv \frac{1}{k}\frac{\partial k}{\partial \alpha} \cong \frac{1}{k_\infty}\frac{\partial k_\infty}{\partial \alpha} \quad (1)$$

where α is void fraction, k is the neutron multiplication constant for a spatially finite geometry and k_∞ is the neutron multiplication constant for a spatially infinite geometry. Following the historical approach outlined in response to Q38 given in Volume 1 of NEDO-24154-P-A[30-4], it is instructive to envision a quadratic fit in void fraction (α) to get

$$k_\infty(\alpha) = k_\infty(0.0)\frac{(\alpha-0.4)(\alpha-0.7)}{0.28} - k_\infty(0.4)\frac{\alpha(\alpha-0.7)}{0.12} + k_\infty(0.7)\frac{\alpha(\alpha-0.4)}{0.21} \quad (2)$$

where the values of k_∞ at specified values of in-channel void fraction are determined from the lattice physics calculations. For a given TGBLA lattice at a particular exposure, k_∞ is presumed to be a smooth function of in-channel void fraction [[

]]. The essential point is that lattice physics values at discrete moderator conditions are fitted to a continuous function that can be differentiated to define the void coefficient. For example, the expression for $k_\infty(\alpha)$ in Eq. (2) is differentiated to obtain

$$\frac{\partial k_\infty(\alpha)}{\partial \alpha} = k_\infty(0.0)\frac{(\alpha-0.55)}{0.14} - k_\infty(0.4)\frac{(\alpha-0.35)}{0.06} + k_\infty(0.7)\frac{(\alpha-0.2)}{0.105} \quad (3)$$

which is a linear function of void fraction.

A similar approach is used to determine the bias and uncertainty for the void coefficient. First the calculated values of k_∞ at in-channel instantaneous void (IV) fractions [[

]] are calculated using both TGBLA06 and MCNP. [[

]] Uncertainty and bias for the void coefficient do <u>not</u> refer to errors associated with the polynomial fit rather they refer to how the TGBLA06 and MCNP void coefficient results compare to each other. Generally, the calculated values of k_∞ from TGBLA06 and MCNP for the same particular lattice, exposure, instantaneous void, and void history point will be different; thus, an equation like Eq. (3) produces different values for TGBLA06 and MCNP. The calculated values for k_∞ from MCNP are assumed to be the *true* values thus the void coefficients derived from them are also the assumed *true* values. In other words, any bias and uncertainty in the values of k_∞ from MCNP due to the Monte Carlo process are assumed to be negligible compared to differences between TGBLA06 and MCNP that are presumed to be larger. Table 4.14 from Reference [30-5] was previously provided to show that for UO2 lattices the average bias in the MCNP calculated k_∞ values compared to critical experiments is –0.0006 and the standard deviation from the mean is 0.0015. These values are much less than the corresponding values expected for the differences between TGBLA06 and MCNP.

Given that the k_∞ values from MCNP are true, the true void coefficient (C_V) for a particular lattice at a particular exposure, void history (VH) and any specified instantaneous void (IV) is obtained from a function similar to Eq. (1) that fits the specified MCNP calculated k_∞ values obtained specifically for that lattice at the exposure of interest. An equation like Eq. (3) can be evaluated at any desired value of α to get $\partial k_\infty / \partial \alpha$. Similarly, Eq. (2) can be evaluated at any desired value of α to get k_∞. Both equations are extrapolated to get values for k_∞ and $\partial k_\infty / \partial \alpha$ at $\alpha = 1$. [[

]]

For a number (N) of different lattices (n) at different conditions m corresponding to an instantaneous void, void history, and exposure condition $(\alpha_{i,m}, \alpha_{h,m}, X_m)$ obtain

$$C_{V,n}\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right) = \left[\frac{1}{k_\infty\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)} \frac{\partial k_\infty\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)}{\partial \alpha}\right]_n \qquad (4)$$

for instantaneous void fractions of $\alpha_{i,m}$ [[ ]] and void history values of $\alpha_{h,m}$ [[ ]] at every void point. These evaluations are made using separate input sets of k_∞ values from TGBLA06 and MCNP [[

]] for each lattice n and exposure (X_m). One set of evaluations is obtained from MCNP and another set of evaluations is obtained from TGBLA06. At each IV, VH and X condition a ***relative deviate*** is defined as the ratio of the void coefficient predicted by MCNP to the void coefficient predicted by TGBLA06, or mathematically

$$z_{n,m} \equiv \frac{C_{V,n,m}^{M}}{C_{V,n,m}^{T}} \tag{5}$$

where the superscript T denotes the TGBLA value and the superscript M denotes the MCNP value. As before, the subscript m denotes a particular point corresponding to $\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)$. All N lattices are evaluated at the same particular condition m then the $z_{n,m}$ ratios for these lattices at that particular condition are averaged to define the ***mean relative bias*** for condition m as

$$\mu_m \equiv \frac{1}{N}\sum_{n}^{N}\left(1 - z_{n,m}\right) \tag{6}$$

Note that the mean relative bias is the average of all the relative biases considering all N lattices at the same condition. The value of μ_m is what we have called the ***relative bias***. By definition this bias is specified at a particular point m in the two-dimensional space defined by all voids and exposures. The $\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)$ conditions are maintained separately. The ***relative standard deviation*** for the N samples ($\sigma_m \equiv \sigma_m\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)$) for each condition m is obtained using the common expression

$$\sigma_m \equiv \sqrt{\frac{1}{N-1}\sum_{n}^{N}\left[\left(1 - z_{n,m}\right) - \left(1 - \overline{z}_m\right)\right]^2} = \sqrt{\frac{1}{N-1}\sum_{n}^{N}\left[\overline{z}_m - z_{n,m}\right]^2} \tag{7}$$

The value of σ_m is what we have called the ***relative uncertainty***. By definition, this uncertainty is also specified at a particular point m in the two-dimensional space defined by all voids and exposures. The *N-1* form for defining the standard deviation is used because the lattices that are considered are an incomplete sample of essentially an infinite population of lattices that could be evaluated at that particular void and exposure condition.

The relative bias is the mean of the ratios between the estimate and the *truth*. Such a bias or mean of ratios is only meaningful when comparing two lattice evaluations performed for the same lattice at the same conditions, for example, at the same void fraction and exposure. There is no such thing as a "true" lattice; however, for a given lattice the *true* characterization of the lattice is assumed to be that from MCNP. The *estimate* for the lattice is the characterization obtained from TGBLA. For our purposes the key parameter from this characterization is the void coefficient (C_V). It has been shown from Eqs. (3) and (4) that the void coefficient is directly related to the lattice-physics-calculated k_∞ values at in-channel void fractions of 0%, 40% and 70%.

Equation (6) contains the mathematical expression for the relative bias at a particular (instantaneous void, void history, exposure) point. Equation (7) contains the mathematical expression for the relative uncertainty at a particular (instantaneous void, void history, exposure) point. There are [[ ]] such expressions corresponding to the [[ ]] discrete (instantaneous void, void history, exposure) points where TGBLA06 and MCNP comparisons were performed.

Statistics for the relative deviates such as the mean and standard deviation from Eqs. (6) and (7) are directly applicable for modeling the bias and uncertainty in the void coefficient. That is because the statistics as defined in the relative sense account for the fact that the lattices that are evaluated have varying amounts of reactivity. The purpose for characterizing the void coefficient bias and uncertainty is to assure that the correct change in reactivity is obtained from an associated change in void fraction.

The goal of the void coefficient correction model is to cause the reactivity impact of the void coefficient to be the same between TGBLA06 and MCNP. Mathematically, the goal is that

$$\tilde{\rho}^{T} = \tilde{\rho}^{M} \tag{8}$$

or equivalently that

$$\left(C_v \Delta\alpha\right)^{T} = \left(C_v \Delta\alpha\right)^{M} \tag{9}$$

The void coefficient values are not explicitly defined in the TRACG model, thus the only way to achieve the desired result in Eq. (9) is to modify the change in void fraction ($\Delta\alpha$) calculated by the hydraulics model before it gets applied in the evaluation of the nuclear parameters. These nuclear parameters are evaluated for each neutronics node using the nodal relative water density (u). To define u it is helpful to first define the nodal water density (ρ). In general, the nodal water density is a volume average of the water densities in the water rod, in-channel (excluding the water rod) and the out-channel.

$$\rho = \sum_{\gamma}^{3} g_{\gamma} \rho_{\gamma} \tag{10}$$

where

g_{γ} is the fraction of water volume in region γ where $\gamma = \{w, i, o\}$ corresponding to the water rod (w), in-channel (i) and out-channel (o) regions;

ρ_{γ} is the water density for region γ.

The nodal densities are defined for each axial node of each channel group. Within a particular node, the axial projection is constant over the height of the node so that volume fraction in each region is the same as the axial projection of the area fraction for that region. The water density in each region is related to the void fraction (α_{γ}) in that region by

$$\rho_{\gamma} = \alpha_{\gamma} \rho_{g,\gamma}(P_{\gamma}) + (1-\alpha_{\gamma}) \rho_{\ell,\gamma}(P_{\gamma}) \tag{11}$$

where

$\rho_{g,\gamma}\left(P_{\gamma}\right)$ is the saturated steam density in region γ at the pressure (P_{γ}) of that region and

$\rho_{\ell,\gamma}\left(P_{\gamma}\right)$ is the saturated liquid density in region γ at the pressure (P_{γ}) of that region.

The mean deviate and its corresponding standard deviation are modeled respectively by Eqs. (6) and (7) at discrete instantaneous void, void history, and exposure conditions corresponding to each member from the set of all pairs of $\left(\alpha_{i,m}, \alpha_{h,m}, X_m\right)$. These discrete points are assumed to be samples from a continuous distribution. The continuous distribution is constructed using the following process. [[

]]

There are minor variations between lattices for the in-channel versus out-channel volumes. These variations are accounted for by evaluating the fits in terms of instantaneous voids so that all the lattices are evaluated for the same relative water density. The functional forms are $f_{\mu_m(X_m)}\left(u_{\alpha_i}\right)$ and $f_{\sigma_m(X_m)}\left(u_{\alpha_i}\right)$ in order to facilitate the evaluation of $\mu_m(u)$ and $\sigma_m(u)$ in terms of the relative water density across all lattices. This form is most convenient for use in the 3D neutron kinetics formulation used in TRACG.

Thus a function ($f_{\mu_m(X_m)}\left(u_{\alpha_i}\right)$) for each exposure that will exactly reproduce the values of $\mu_m(u)$ corresponding to [[

]]. (12)

A similar function ($f_{\sigma_m(\alpha_{h,m},X_m)}\left(u_{\alpha_i}\right)$) created for each exposure that will exactly reproduce the values of $\sigma_m(u)$ corresponding to [[

]]. (13)

Such an equation in terms of *u* is obtained for each of the exposure conditions thus there is a set of [[ ]] coefficients for each exposure for both $\mu_m(u,\alpha_{h,m},X_m)$ and $\sigma_m(u,\alpha_{h,m},X_m)$. Double linear interpolation [[ ]] is used to define functions for $\mu_m\left(u,\alpha'_{h,m},X'\right)$ and $\sigma_m\left(u,\alpha'_{h,m},X'\right)$ for values of $\alpha'_{h,m}$ and X' that are not at one of specified void history and exposure points where the lattice evaluations were performed.

Next consider how the functional forms for $\mu_m(u,X_m)$ and $\sigma_m(u,X_m)$ are used. For each neutronics node the mean bias $\mu_m(u,X_m)$ and standard deviation $\sigma_m(u,X_m)$ are evaluated in terms of the nodal relative water density ($u_{k,i,j}$) and nodal exposure ($X_{k,i,j}$). The *k,i,j* subscript denotes the node indices for the axial and the two planar directions, respectively. [[

]] (14)

is defined. [[

]] Note that $N_{i,j}$ is a ***standard normal deviate*** that is randomly determined [[

]]. Note that a *standard normal*

deviate (δ) is one from a normal distribution that has been expressed in standard form. The definition of a ***standard normal deviate*** is

$$\delta \equiv \frac{s-\mu}{\sigma} \tag{15}$$

where s is a sample value, μ is the mean for the population and σ is the standard deviation for the population.

[[

]] The trends in mean bias and standard deviation, on the other hand, have been explicitly correlated to independent lattice conditions in terms of voids and exposure so it is appropriate to apply them consistently with how they were derived.

The goal from Eq. (9) is achieved [[

]] (16)

The purpose of the void coefficient correction model is to provide a representation of the ratio C_v^M / C_v^T as a function of the nodal relative water density u and the nodal exposure X. [[

]] (17)

The ratio of C_v^M / C_v^T is available at discrete points from the lattice evaluations as suggested by Eq. (5). Although these ratios are obtained only at the discrete conditions at which the lattice evaluations were performed, the void coefficients themselves are evaluated from a continuous function obtained by substituting the expression from Eq. (3) into Eq. (1). Thus the void coefficients can be evaluated at any in-channel void fraction in the range of [0,1]. Separate such functions for the void coefficients exist for the TGBLA and MCNP lattice evaluations so that the ratio of C_v^M / C_v^T can be constructed at any desired void fraction and exposure. Similarly, the response surface defined by the evaluation of $z_{k,i,j}$ from Eq. (14) models the ratio of C_v^M / C_v^T at any desired void fraction and exposure.

The continuity of C_v^M / C_v^T is an important feature that is useful for calculating the values of C_v^M / C_v^T as α_i approaches zero. [[

]] Fortunately, the model only requires that we be able to represent the mean and standard deviation of the C_v^M / C_v^T ratio as α_i approaches zero. [[

]]

The two-dimensional response surface for the void coefficient biases for each void history $\alpha_{h,m}$ is defined from Eq. (12) and is obtained by fitting the [[ ]] discrete μ_m values obtained from Eq. (6). There are [[ ]] values because there are [[ ]] exposures and [[ ]] instantaneous relative water densities corresponding to in-channel void fractions of [[ ]]. The [[ ]] coefficients are generated for each of the [[ ]] exposures where the TGBLA-MCNP comparisons were made. For exposures in between, the [[ ]] coefficients are linearly interpolated so that fitted surface is piece-wise linear in terms of exposure.

The two-dimensional response surface for the void coefficient uncertainties for each void history $\alpha_{h,m}$ is defined from Eq. (13) by fitting the [[ ]] discrete σ_m values obtained from Eq. (7). This surface is also [[ ]] in terms of the instantaneous relative water density. The [[ ]] coefficients are generated for each of the [[ ]] exposures where the comparisons between TGBLA and MCNP were made. Linear interpolation is used to get values for exposures between the know grid lines.

TRACG has been modified so that it can evaluate the fits to these two relative surfaces in order to reproduce the statistics at the known [[ ]] points and interpolate for conditions in between. This process is repeated for each void history and linear interpolation between void histories is used to get the value corresponding to the nodal void history value as determined from the PANAC11 wrapup information. The biases and uncertainties as characterized by the two surfaces are termed ***relative*** because they have been derived as the ratio of the void coefficient predicted by MCNP to the void coefficient predicted by TGBLA as defined by Eq. (5). As such, the surfaces are in dimensionless form and are not dependent on the absolute magnitude of the void coefficient bias and uncertainty that they are used to adjust.

The mean relative bias(es) in the TGBLA-calculated void coefficient values compared to the MCNP-calculated true values have been obtained from Eq. (6) by using a sample size of [[ ]] modern 10x10 lattices. The response surface for this bias has been coded into TRACG [[

]] If all [[ ]] lattices that were sampled showed the same relative bias at each of the (void, void history, exposure) points, then there would be no *residual* error since each sample relative deviate ($z_{n,m}$ from Eq. (5)) would be related to the mean relative deviate μ_m from Eq. (6) by $z_{n,m} = 1 - \mu_m$. It follows for this scenario that the values of σ_m obtained from Eq. (7) would be zero for all [[ ]] (void, exposure) points on the sample grid for a specified void history. Thus the term *residual error* refers to that portion of the error that remains after the mean relative bias between TGBLA and MCNP is removed.

In summary, the *generic TRACG response surface* is actually two surfaces at [[ ]] different exposure histories. One surface is the fit ($\mu_m(u, X_m)$) for the mean relative deviates (or relative biases) from Eq. (15) and the other surface is the fit ($\sigma_m(u, X_m)$) for the relative standard deviations from Eq. (16). Both fits are two-dimensional fits [[ ]] in terms of relative water density (*u*) and piecewise-linear in terms of exposure (*X*). These surfaces are obtained for each of [[ ]] different exposure histories so that $\mu_m(u, X_m)$ and $\sigma_m(u, X_m)$ values can be interpolated linearly between adjacent exposure histories that bracket the nodal void history obtained from the PANAC11 wrapup.

Response References

[30-1] *Steady-State Nuclear Methods*, NEDE-30130-P-A and NEDO-30130-A, April 1985, and for TGBLA Version 06 and PANACEA Version 11, Letter from S.A. Richards (NRC) to G.A. Watford (GE) Subject: "Amendment 26 to GE Licensing Topical Report NEDE-24011-P-A, GESTAR II Implementing Improved GE Steady-State Methods," (TAC NO. MA6481), November 10, 1999.

[30-2] J. G. M. Andersen, et al., *TRACG Model Description*, NEDE-32176P, Rev. 4, January 2008.

[30-3] J. G. M. Andersen, et al., *TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analyses*, NEDE-32906P-A, Revision 3, September 2006.

[30-4] *Qualification of the One-dimensional Core Transient Model for Boiling Water Reactors*, NEDO-24154-A and NEDE-24154-P-A, Volumes I, II and III, August 1986.

[30-5] Sitaraman, S., *MCNP: Light Water Reactor Critical Benchmarks*, NEDO-32028, Class 1, March 1992.

ENCLOSURE 3

MFN 08-483

Affidavit

GE Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, James F. Harrison, state as follows:

(1) I am Vice President, Fuel 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 GEH's letter, MFN 08-483, Richard Kingston to U.S. Nuclear Regulatory Commission, entitled "Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)." The proprietary information in Enclosure 1, which is entitled "Response to Request for Additional Information (RAI) 30, RE: NEDE-32906P, Supplement 3, *Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients,* (TAC No. MD2569)", is delineated by a dark red dotted underline inside double square brackets [[This sentence is an example.{3}]]. Figures and large equation objects containing GEH proprietary information 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 including the process and methodology for application of TRACG to the performance of evaluations of AOOs for GEH BWRs. This TRACG code has been developed by GEH for over fifteen years, at a total cost in excess of three million dollars. The reporting, evaluation, and interpretation of the results, as they relate to the BWR, were achieved at significant cost to GEH.

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 30th day of May 2008.

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