GE Energy

David H. Hinds
Manager, ESBWR

PO Box 780 M/C L60
Wilmington, NC 28402-0780
USA

T 910 675 6363
F 910 362 6363
david.hinds@ge.com

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 06-408

Docket No. 52-010

October 19, 2006

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application – TRACG Application for ESBWR ATWS – RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter.

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.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-203, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application*, June 23, 2006

Enclosures:

1. MFN 06-408 – Response to Portion of NRC Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application – TRACG Application for ESBWR ATWS – RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48 – GE Proprietary Information
2. MFN 06-408 – Response to Portion of NRC Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application – TRACG Application for ESBWR ATWS – RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48 – Non Proprietary Version
3. Affidavit – George B. Stramback – dated October 19, 2006

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRFs	0058-6635, 0058-6636, 0058-6637 and 0058-6639

ENCLOSURE 2

MFN 06-408

Response to Portion of NRC Request for

Additional Information Letter No. 31

Related to ESBWR Design Certification Application

TRACG Application for ESBWR ATWS

RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48

Non Proprietary Version

NRC RAI 21.6-34

On Page 5-15, you state that as a result of evaluations using TGBLA06, "B10 cross-sections were not sensitive to the void history and that the TRACG modeling error had a weak dependence on the exposure, boron concentration and fuel temperature." Please provide more detailed information about this evaluation as the staff believes that the boron cross section would likely be sensitive to void history and exposure since it is likely at high voids that plutonium buildup will have a substantial impact on the void coefficient.

GE Response

Conclusions regarding the TRACG04 modeling error were based on two sets of evaluations involving a spread of [[ ]] different lattices in "Set A" and [[ ]] other lattices in "Set B". Set A was evaluated for all of the following conditions: [[

]] The total number of lattice evaluation points from Set A was [[ ]]. Set B was evaluated for all of the following conditions: [[

]] There were [[ ]] lattice evaluations at 0% instantaneous voids (%IV). Set B was also used to obtain [[ ]] additional lattice evaluations corresponding to 50%IV for all of the following conditions: [[

]] Altogether there were [[ ]] lattice evaluations performed using Set B.

Set A was primarily used to develop and test the fundamental aspects of the model related to 1/v absorption, exposure, void history, temperature and control state. Set B was **not** used to develop these aspects of the TRACG04 model so the first group of [[ ]] lattice evaluations from Set B serve as an independent check of the model in this area. The second group of [[ ]] lattice evaluations from Set B was used to confirm that the fundamental model relationships developed at 0%IV were applicable at 50%IV. In addition, this group of [[ ]] lattice evaluations was used to develop the modifications to the 1/v modeling in order to account for the change in B10 absorption cross section due to a change in the neutron energy spectrum [[

]] This latter utilization of Set B was independently verified by propagating the lattice calculations into PANAC11 so that the predicted impacts on reactivity could be compared between TRACG04 and PANAC11.
[[

]]

The effective microscopic absorption cross section for B10 is sensitive to exposure as the NRC staff expects. In fact, the B10 absorption cross section is sensitive to anything that changes the neutron energy spectrum in the thermal energy range. A change in the neutron spectrum in the thermal energy group that is due to the lattice design and the change in the isotopics of the lattice with exposure is reflected by a change in the lattice library reference velocity for the thermal energy group. This velocity is denoted as $v_3(L_{kij})$. The impact that this velocity has on the microscopic absorption cross section for boron-10 is explicitly considered as shown in Equation (9.5-4) of Revision 3 to the *TRACG Model Description LTR* (Reference [21.6-34.1]). It is evident that for a harder spectrum that the value of $v_3(L_{kij})$ will increase and cause the effective absorption cross section to decrease. The TRACG04 modeling error is not sensitive to exposure because the TRACG04 model accounts for how exposure changes the thermal neutron spectrum and thus is able to reproduce the trends in the lattice physics calculations. In the following discussion, the trends with exposure will be shown for different conditions so that the dependency on exposure can be viewed relative to the sensitivities to other parameters such as moderator temperature, instantaneous void fraction, void history, and boron self-shielding.

How the B10 microscopic absorption cross section changes with exposure is strongly dependent on the lattice design as shown in Figure 21.6-34- 1 for all the lattices from the "B" set. The "B" set was chosen because it includes unenriched, partly-rodded lattices that were not included in the development "A" set of lattices. Thus the "B" set tests the extensibility of the model. From those lattices shown, the two lattices with the lowest and highest lattice enrichments were chosen for presentation in the remaining figures. Lattice 60523 is a partly-rodded, 10x10 lattice with natural enrichment. It is representative of the lattices shown grouped together in the upper set of curves in Figure 21.6-34- 1. Lattice 60533 is at the other extreme. It is a fully-rodded, 10x10 lattice with a high lattice enrichment of [[ ]] and has [[ ]] gad rods with a gad concentration of [[ ]]. It is representative of the lattices whose curves are part of the lower grouping of curves in the figure. The lower grouping of lattices all have high enrichments and high initial gad content. Notice that the effective B10 cross section decreases in lattices where it must compete with the gad for neutrons up to about 20 to 30 GWd/sT at which time the gad has burned out. This can be seen by the inflection in the lower curves in Figure 21.6-34- 1. It is evident from all the lattices in Figure 21.6-34- 1 that the trends with exposure depend on the lattice design and isotopics. The TRACG04 model accounts for these trends because they are correlated to the value of $v_3(L_{kij})$ via the 1/v relationship. Note that the value of $v_3(L_{kij})$ is obtained from the TGBLA06 lattice calculation via the PANAC11 wrapup for each lattice. The value $v_3(L_{kij})$ depends on the exposure of the specific lattice (L_{kij}) assigned to node kij.

The trends in the B10 microscopic absorption cross section versus exposure for the two selected lattices are shown for no boron at 0%IV and at different moderator temperatures in Figure 21.6-34- 2. The figure shows how the temperature of the moderator changes the B10 absorption cross section. This is the result of the fact that the energy distribution of thermal neutrons in the thermal group follows a Maxwellian distribution once the mean value of $v_3(L_{kij})$ is used to factor out the gross effect of thermal absorptions. The temperature effect is accounted for [[

]]

The temperature-adjusted $1/v_3(L_{kij})$ dependency [[

]] provide for almost all the variations seen in the lattice calculations. The ability of TRACG04 to model these effects is shown in Figure 21.6-34- 2. The symbols in the figure correspond to the lattice calculations for 0% instantaneous voids (IV) and a void history (VH) of 40% with no boron present. The dashed and solid lines were calculated for the same fluid conditions using the TRACG04 model [[

]]. These comparisons for the two selected lattices show that the TRACG04 model simulates the dominant effects due to lattice design, isotopics (exposure), and moderator temperature quite well.

The effect of void history (VH) [[

]] This fact is illustrated by the calculated lattice results shown in Figure 21.6-34- 3 for the two selected uncontrolled lattices. The evaluations are shown for void histories (VH) of 0%, 40% and 70% at an instantaneous void (IV) of 0%IV at 160C with no boron present. These results are representative of all the calculations that have been performed for all lattices, all temperatures, 0% and 50% instantaneous voids, and all boron concentrations at both controlled and uncontrolled states. The effect due to void history on the boron-10 microscopic absorption cross section is [[ ]] at the highest evaluated exposures.

The plutonium build up at higher exposures is accounted for by the 1/v part of the model [[

]]. Plutonium is most relevant in how it changes the energy distribution within the thermal spectrum where neutron absorption in B10 occurs. Plutonium has a higher removal cross section in the thermal spectrum than U235 thus it more effectively competes for thermal neutrons that might otherwise be absorbed by B10. Thus one would expect that the lattice evaluations at higher void histories that tend to produce more plutonium would result in a decrease in the effective B10 microscopic absorption cross section at the higher exposures. This is exactly what the curves in Figure 21.6-34- 3 show.

Figure 21.6-34- 4 shows how the effective boron-10 microscopic absorption cross section in the two selected lattices decreases as the boron concentration increases. These lattice evaluations were performed [[ ]] at 160C. At the zero exposure point in the 60533 lattice, the boron absorption cross section decreases [[ ]] at 935 ppm natural boron. The amount of decrease from the TRACG04 model that is predicted by the term

[[ ]] in Equation (9.5-2) of Reference [21.6-34.1] is [[ ]] barns for

these same conditions.

For voided conditions with less moderation, the neutron energy spectrum gets harder. The 1/v modeling of the B10 microscopic absorption cross section accounts for this effect because the mean neutron velocity in the thermal energy group increases and consequently the effective B10 absorption cross section decreases. The spectral effect due to a change in

instantaneous voids is modeled in TRACG04 [[ ]] in Equation (9.5-

4) of Reference [21.6-34.1] for the reasons discussed in greater detail in the response to RAI 21.6-35. The magnitude of this effect without boron can be seen by comparing the blue curves from Figure 21.6-34- 5 with the blue curves from Figure 21.6-34- 4. For the 60533 lattice at zero exposure the lattice evaluations indicate that boron-10 absorption cross section will decrease [[ ]]. For these same conditions the TRACG04 model predicts a reduction by [[ ]].

Figure 21.6-34- 5 is also useful for showing how the self-shielding model performs for a voided condition. At the zero exposure point in the 60533 lattice, the boron-10 microscopic absorption cross section from the lattice calculation for the 50%IV condition decreases [[ ]] at 1870 ppm natural boron. The TRACG04 model predicts for the 50%IV condition the same [[ ]] reduction as for the 0%IV case because the boron atom density for 1870 ppm at 50%IV is practically the same as for 935 ppm at 0%IV.

TRACG04 was compared to PANAC11 as a confirmation of the implementation of the model. These comparisons were made over a range of boron concentrations for 0%IV and 50%IV conditions for moderator temperatures of 160C and 286C. [[ ]] The results from the comparisons are indicated in Figure 21.6-34- 6 and Figure 21.6-34- 7. [[

]] These expectations are met.

In addition the core that was being simulated had a considerable number of inserted control blades corresponding to a critical reactor at the beginning of the cycle operating at rated power and flow. Thus these comparisons also confirm the treatment of boron for both controlled and uncontrolled lattices. The intersection of a curve in the figures with an eigenvalue equal to 1.0 suggests the uniform natural boron concentration required to compensate for the excess reactivity due to changing the initial distributed moderator temperatures and void fractions to the uniform void fraction and moderator temperature associated with the curve. These are only approximate concentration values because in reality the moderator temperatures, void fractions and boron concentrations are not uniform as was assumed in these comparisons.

Overall the TRACG04 model for the boron-10 microscopic absorption cross section captures all the important effects. [[

]]

No changes in the licensing topical reports are required because of this response.

Reference:

21.6-34.1 *TRACG Model Description*, NEDE-32176P, Revision 3, April 2006.

[[

]]

Figure 21.6-34- 1 Exposure Effect on Different Lattices at 0%IV and No Boron

[[

]]

Figure 21.6-34- 2 Exposure and Temperature Effects at 0%IV, Uncontrolled

[[

]]

Figure 21.6-34- 3 Effect due to Void History at 0%IV, 160C, Uncontrolled

[[

]]

Figure 21.6-34- 4 Self-Shielding Effect at 0%IV and 160C

[[

]]

Figure 21.6-34- 5 Self-Shielding Effect at 50%IV and 160C

[[

]]

Figure 21.6-34- 6 PANAC11 and TRACG04 Comparison at 0%IV

[[

]]

Figure 21.6-34- 7 PANAC11 and TRACG04 Comparison at 50%IV

NRC RAI 21.6-35

On Page 5-15, you state that "The lattice calculations do not capture the effect of change in neutron spectrum with voids." The staff believes that the spectral change as a result of the addition of boron will have an impact on the void coefficient. It will also have an impact on boron energy self shielding. Provide further justification as to why the spectral change was not considered. Additionally, explain why the cross section is modeled as 1/v as opposed to using TGBLA to calculate lattice parameters for various boron concentrations directly for use within the PANACEA Wrapup file.

GE Response

The spectral change as a result of changes in the isotopics versus exposure is captured by the value of library reference neutron velocity for the thermal energy group, $v_3(L_{kij})$, as explained in the response to RAI 21.6-34. [[

]]

The spectral effect due to a change in instantaneous voids is modeled [[

]] in Equation (9.5-4) of Revision 3 of the *TRACG Model Description LTR* (Reference 21.6-35.1). In a similar way, the effect of changes in the moderator temperature on the value $v_3(L_{kij})$ is modeled [[ ]] in Equation (9.5-4). The last consideration is the effect due to boron self-shielding. This effect is modeled by the second term enclosed in the brackets in the second line of Equation (9.5-4) of Reference 21.6-35.1. Thus, all the dominant mechanisms that modify the neutron energy spectrum are modeled.

The effects of instantaneous voids and moderator temperature could be obtained in a *brute force* way by performing multiple TGBLA branch calculations. To obtain the same effects in the lattice calculations would require at least 3 temperatures times 3 void conditions times 3 boron calculations at each exposure point for each control state for each lattice in order to obtain a crude quadratic approximation in terms of temperature, voids and boron concentration. This *brute force* approach is time consuming and lacks the flexibility required to cover the full range of ATWS conditions and its accuracy will be hindered by the fact that the functional dependencies are exponential rather that quadratic.

The TRACG04 1/v model [[
]] is used because [[
]] it captures essentially all of the major variations calculated in a wide spectrum of lattice evaluations. The TRACG04 model has been validated by comparing it to a large number of TGBLA06 lattice calculations over a wide range of conditions as discussed in the response to RAI 21.6-34. Some additional details are also provided in Section 9.5.2 of Reference 21.6-35.1. The residual errors not captured by the TRACG04 model are depicted in Figure 9-8 of Reference 21.6-35.1. These errors are small in comparison to other known sources of error such as the error in knowing the distribution of boron in the core.

No changes in the licensing topical reports are required because of this response.

Reference:

21.6-35.1 *TRACG Model Description*, NEDE-32176P, Revision 3, April 2006.

NRC RAI 21.6-43

On Page 9.2-2 of NEDE-32176P Revision 2 "TRACG Model Description," Equation 9.2-5 has a Δk/k factor that includes "boron reactivity coefficients." What is the value of these coefficients? Explain the basis for determining these coefficients.

GE Response

Equation (9.2-5) of Revision 2 of NEDE-32176P does not apply to TRACG04. For TRACG04 the treatment of soluble boron is described in Section 9.5 of Revision 3 of NEDE-32176P. [[

]]

For earlier TRACG02 calculations the coefficients in the expression for $\Delta k/k$ below Equation (9.2-5) in Revision 2 of NEDE-32176P were determined by [[

]].

No changes in the licensing topical reports are required because of this response.

NRC RAI 21.6-48

How does TRACG handle the boron concentration when the concentration level reaches the saturation value? Does TRACG precipitate as solid particles enough of the boron salts to maintain the boron concentration at or below the saturation value? What saturation curve does TRACG use for the boron salts?

GE Response:

The boron solubility model for TRACG04 is described in Section B.3.4 of Revision 3 of the TRACG Model Description (Reference 21.6-48.1). The boron solubility limit ($c_{b,max}$) for a fluid node is defined as a function of the liquid temperature (T_l) for the node. The value of $c_{b,max}$ is the maximum ratio of elemental boron mass in solution to water mass in the node according to Equation (B.3-45). The default values of the constants used in the equation have been chosen to model the supplier's published solubility data for sodium pentaborate over the entire temperature range from 0 C to 100 C for which data is available. The TRACG04 model for the solubility limit (saturated value) and the data are compared in Figure B-2 of Reference 21.6-48.1. Note from the figure that the solubility increases almost linearly with temperature above about 60 C.

The solubility limit is usually very far above the concentrations that are common in a BWR. For example, even at a relatively low temperature of 30 C the published solubility limit of sodium pentaborate is 12.2% anhydrous salt by weight which translates to a mass ratio of boron mass to water mass of 0.02545 or about 25,450 ppm in terms of elemental unenriched boron. Typical values in a BWR to achieve shutdown are less than 1000 ppm of elemental B10 or less than 5,050 ppm of natural, elemental boron. Thus the plausible scenario where the solubility limit may be encountered is when boiloff of the liquid is occuring so that boron transported into the node is not being transported out of the node. This is a consequence of the assumption that only liquid water can transport boron.

[[

]] Mass conservation for the boron on a nodal basis is maintained since it considers both the boron in solution and the boron not in solution. The code requires the boron density for purposes of calculating the impact on the neutronics. This density is simply the total boron mass in the node (either in solution or as precipitates) divided by the water mass in the node. The neutronics calculation depends on atom density of B10 atoms in the node [[

]]

No changes in the licensing topical reports are required because of this response.

Reference:

21.6-48.1 *TRACG Model Description*, NEDE-32176P, Revision 3, April 2006.

ENCLOSURE 3

MFN 06-408

Affidavit

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, General Electric Company ("GE") and 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 letter MFN 06-408, David H. Hinds to NRC, *Response to Portion of NRC Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application – TRACG Application for ESBWR ATWS – RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48*, dated October 19, 2006. The proprietary information in Enclosure 1, *Response to Portion of NRC Request for Additional Information Letter No. 31 Related to ESBWR Design Certification Application – TRACG Application for ESBWR ATWS – RAI Numbers 21.6-34, 21.6-35, 21.6-43 and 21.6-48,* is delineated by a double underline inside double square brackets. 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, 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 2.790(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 General Electric's competitors without license from General Electric 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 General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

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. 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, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, 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 TRACG analytical models, methods and processes, including computer codes, which GE has developed, and applied to perform ATWS evaluations for the ESBWR. 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 ATWS evaluations for the BWR was achieved at a significant cost, in excess of one quarter million dollars, to GE.

The development of the testing and 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 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 19th day of October 2006.

George B. Stramback
General Electric Company