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

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

MFN 06-297
Supplement 1

Docket No. 52-010

November 8, 2006

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

Subject: **Supplemental Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application – DCD Chapter 4 and GNF Topical Reports – RAI Number 4.3-3**

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

Enclosure 1 contains GNF proprietary information as defined by 10 CFR 2.390. GNF customarily maintains this information in confidence and withholds it from public disclosure. A non proprietary version is provided in Enclosure 2.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GNF. GE hereby requests that the information of Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17.

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

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

Enclosures:

1. MFN 06-297, Supplement 1 – Supplemental Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application – DCD Chapter 4 and GNF Topical Reports – RAI Number 4.3-3 – Contains GNF Proprietary Information
2. MFN 06-297, Supplement 1 – Supplemental Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application – DCD Chapter 4 and GNF Topical Reports – RAI Number 4.3-3 – Non Proprietary Version
3. Affidavit – Jens G. M. Andersen – dated November 8, 2006

Reference:

1. MFN 06-288, Letter from U. S. Nuclear Regulatory Commission to Mr. David H. Hinds, *Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application,* August 16, 2006

cc: AE Cubbage USNRC (with enclosures)
AA Lingenfelter GNF/Wilmington (w/o enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRFs 0056-7217/R2

ENCLOSURE 2

MFN 06-297, Supplement 1

Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application

Nuclear Design

RAI Number 4.3-3

Non-Proprietary Version

NRC RAI 4.3-3

In DCD Tier 2, page 4.3-3, reference is made to the lattice code TGBLA06, which has recently been modified to accommodate a minor correction in the programming of analytical formulation in the code. Please submit the modification(s) to TGBLA06. The submittal should include the changes made to the code and validation of the code as it pertains to recent application(s) since the modification of the code, and any natural circulation database, as it pertains to the analysis of the ESBWR steady-state neutronic performance. The contents of the submittal should include before and after calculational results with technical justification(s) in support of the changed results. Also, provide a comparison between the modified TGBLA06 and MCNP results in Section 1.3 of NEDC-33239P.

Additional request: *Provide more detailed description of the modifications in TGBLA to improve the Pu^{240} resonance treatment.*

GE Response

The TGBLA modification (identified as T6E5) referred to in RAI 4.3-3 is associated with the evaluation of the 1.058 eV. resonance peak under high void conditions (>70% void fractions). The current revision of TGBLA06A is identified as T6E4 for purposes of this discussion. The desire to extend the accepted application range of the TGBLA system to this high void condition (>90%) for study purposes necessitated an improvement in the treatment of the Pu^{240} 1.058 eV resonance. [[

]] This change will be a function of lattice design, lattice exposure, void history, and instantaneous state of the lattice.

The modification to the Pu^{240} 1.058 eV resonance evaluation has a small effect on the lattice reactivity and can be best seen by reviewing the Pu^{240} concentration prediction. [[

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The general impact of the revised TGBLA06 (T6E5) can be seen by reviewing the lattice hot uncontrolled reactivity as a function of exposure and void for the standard design conditions of 0, 40, and 70% void fraction, the impact of the code modification in the evaluation of lattice parameters at 90% voids from both TGBLA06A computed conditions and the 0, 40, 70 void fraction fitted data evaluations, and the overall impact on an operating cycle of the ESBWR.

Figures 4.3-3 and 4.3-4 demonstrate the impact of the modified code (T6E5) on the vanished zones in the two (2) proposed ESBWR bundles. [[

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Figures 4.3-5 and 4.3-6 demonstrate the impact on the extrapolation of the hot reactivity to the 90% void condition performed with the modified (T6E5) and unmodified (T6E4) TGBLA06A for the two vanished lattices in the proposed ESBWR design. The reactivity data from the 0, 40, and 70% void depletion state points is fitted as a function of lattice average moderator density and extrapolated to a 90% void condition with a quadratic fit and compared with a TGBLA06A calculated 90% void fraction case. From this, it can be seen that the impact on the fit evaluations at the 90% void history point agrees very well with the computed 90% void history analysis.

Figures 4.3-7 and 4.3-8 demonstrate impact on the cold reactivity evaluations performed with the modified (T6E5) and unmodified (T6E4) TGBLA06A for the two vanished lattices in the proposed ESBWR design. Here, the impact of the code modification on the evaluation of the cold uncontrolled lattice reactivity for a void history of 90% is evaluated. Again the extrapolation of the fitted data to the computed 90% void history point agrees well.

Figures 4.3-5 through 4.3-8 indicate that the Pu^{240} modification has a minor impact on the extrapolation of the 0, 40, 70% lattice reactivity to the 90% void condition and that all three methods (1. extrapolation of T6E4 data, 2. extrapolation of T6E5 data, and 3. the T6E5 computed results) of generating the 90% void history data can be considered identical.

Figures 4.3-9, 4.3-10, and 4.3-11 demonstrate the performance impact of the proposed ESBWR cycle resulting from the code modifications contained in T6E5. [[

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This level of perturbation on the core parameters presented in Figure 4.3-9, 4.3-10, and 4.3-11 is considered below the level of significance and the results are considered to be virtually identical.

As a result of the small observed changes in the lattice parameters, it is concluded that the comparisons between TGBLA06 and MCNP found in Section 1.3 of NEDC-33239P continue to be valid. The modified version of TGBLA06 is in the process of internal reviews and will be implemented as soon as all reviews are completed.

No DCD change will be made in response to this RAI.

Figure 4.3-1: Pu^{240} Concentration for Lattice 81805

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Figure 4.3-2: Pu^{240} Concentration for Lattice 81905

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Figure 4.3-3: Depletion Evaluation for Hot Uncontrolled Reactivity for Lattice 81805

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Figure 4.3-4: Depletion Evaluation for Hot Uncontrolled Reactivity for Lattice 81805

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Figure 4.3-5: Fit Evaluation for 90% Void Hot Uncontrolled Reactivity for Lattice 81905

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Figure 4.3-6: Fit Evaluation for 90% Void Hot Uncontrolled Reactivity for Lattice 81905

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Figure 4.3-7: Fit Evaluation for 90% Void History Cold Uncontrolled Reactivity for Lattice 81805

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Figure 4.3-8: Fit Evaluation for 90% Void History Cold Uncontrolled Reactivity for Lattice 81905

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Figure 4.3-9: Core Reactivity Impact from TGBLA modification

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Figure 4.3-10: Core Linear Heat Generation Impact from TGBLA modification

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Figure 4.3-11: Core Critical Power Ratio Impact from TGBLA modification

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Additional information response:

The lattice physics system TGBLA provides lattice-averaged diffusion cross-sections, relative rod power peaking, and lattice edge discontinuity factors for the BWR simulator core calculations. The system consists of four major modules.

The solution techniques begin with the generation of thermal (<0.625 eV) broad-group neutron cross-sections for all homogenized fuel rod cells and external regions in a lattice. In the thermal energy range module, the rod-by-rod thermal spectra are calculated by a method similar to the THERMOS (Reference 4.3-3.1) formulation. The major difference is that neutron leakage from rod to rod is taken into account. The leakage is determined by diffusion theory and is fed into the thermal spectrum calculation. Iterations between diffusion theory and collision probability thermal spectrum calculations are carried out to determine accurate, spatially dependent, thermal energy range cross sections.

The purpose of the second or fast/epithermal module is to generate the cell- and region-homogenized cross sections for the fast [[

]] broad groups. The pin specific Dancoff factors are developed in this module for use in the evaluation of the Breit-Wigner resonance parameters. In the epithermal and fast energy range, the level-wise resonance integrals are calculated by an improved intermediate resonance (IR) approximation in which the IR parameters are fuel-rod-temperature dependent. This temperature dependence is omitted in conventional IR approximations. In addition, the fuel rod escape probability is calculated according to an improved treatment by Mizuta (Reference 4.3-3.2). The resulting 68 energy group fast and epithermal cross sections are utilized in a lattice average 3 region pin cell collision probability model to generate cell fast and epithermal heterogeneity factors. A one dimensional collision probability slab representation of the lattice is used to develop transport to diffusion correction factors and cross section condensation fluxes. The fast and epithermal 68 energy group cross sections are collapsed to two broad-group fast and epithermal cross section sets.

The third step utilizes the cross sections generated in steps one and two in a two-dimensional, coarse-mesh, broad-group, diffusion-theory calculation to determine the nodal flux and power distributions in the bundle. Intra-region flux information from steps 1 and 2 is combined with the cell average flux information to construct a detailed flux distribution within each region.

The fourth and final step is to perform the nuclide depletion calculation. In the depletion calculation, 100 nuclides are treated, including 25 fissile and fertile (actinide) nuclides and up to 48 fission products plus one pseudo fission product and one gadolinium tail pseudo product. An improved burnup integration scheme is employed in nuclide depletion calculations.

The preceding steps are repeated for each burn step until all given burn steps are completed.

The modification for the improvement in the Pu^{240} resonance treatment is made in the second or fast and epithermal module. The module of the TGBLA system is briefly described in Section 1.2.2.2 of NEDC-33239P. The discussion that follows is at a low level in the fast/epithermal model and only one of many stages in the evaluation of the fast/epithermal cross sections.

In the current TGBLA (T6E4), the analytical and accurate method for calculating the effective resonance integral (RIC) and the contribution of a single resonance to the absorption cross section of the fine group "g" is based on equations (0.1) through (0.5).

$$\sigma_a(g) = \frac{\int_{E_g}^{E_{g-1}} \sigma_a(E)\phi_f(E)\,dE}{\int_{E_g}^{E_{g-1}} \phi(E)\,dE} \qquad (0.1)$$

The problem is limited to the case of a two-region cell consisting of a fuel (f) region and a moderator (m) region. A single level Breit-Wigner shape is assumed for the resonance cross section, and the effect of many resonances of a resonant nuclide and other nuclide are taken into account by simply adding the contribution from individual resonance.

The effective resonance (absorption) integral is calculated, at first,

$$I_a = \int_{level} \sigma_a(E)\phi_f(E)\,dE \qquad (0.2)$$

where the improved IR (Intermediate Resonance) approximation and an improved rational approximation to the so-called fuel escape probability, $P_f = S_p / (\sigma_t + S_p)$, are applied. And then an approximate value for the fraction of absorptions that occur in group "g"

$$f(g)=\frac{1}{I_a}\int_{E_g}^{E_g-1}\sigma_a(E)\phi_f(E)dE \quad (0.3)$$

is evaluated. We then obtain

$$\sigma_a(g)=I_a\, f(g)\Big/\phi(g) \quad (0.4)$$

where $\phi(g)$ is the integral of the cell-average flux over group "g".

Basic equations for the neutron fluxes in the fuel (f) and the moderator (m) regions, ϕ_f and ϕ_m, are known as Chernick's equations and are given by:

$$\begin{aligned}\sigma_t\phi_f &= (1-P_f)\{K_f(\sigma_s\phi_f)+\sigma_{am}K_{am}(\phi_f)\}+P_mS_mK_m(\phi_m)\\ S_m\phi_m &= P_f\{K_f(\sigma_s\phi_f)+\sigma_{am}K_{am}(\phi_f)\}+(1-P_m)S_mK_m(\phi_m)\end{aligned} \quad (0.5)$$

where

P_i = resonance escape probability for region i

$K_i(\varphi)$ = slowing down operator for material i

S_m = background cross section for material m

ϕ_i = relative flux in region i

$\sigma_{s,t,am}$ = microscopic cross section in materials f and am based on potential scattering

f, m, and am refers to fuel, moderator, and admixed moderator respectively

While the resonance integral method described above is believed to be among the best of the IR methods and has been shown to be accurate for standard BWR lattice conditions, a more accurate evaluation is desired for cases where the resonance self-shielding effects are greater than the nominal range for standard UO2 lattice designs. Lattice designs such as Mixed Oxide designs or analysis conditions with very low background absorption cross sections indicate a need for an improvement in the evaluation of the cell regional fluxes in the TGBLA groups where wide resonance absorption peaks occur.

The desired improvement in the IR model is based on the fine energy mesh resonance integral calculation module (RICM) discussed in Reference 4.3-3.3. This module is also based on Chernick's equations (0.5) and a FFCP (First Flight Collision Probability) solution of a 3-region pin cell where the fuel material is in Region 1, the clad material is in Region 2, and the moderator is in Region 3. From the FFCP solution, the improved accuracy in the region fluxes $\phi_f(g)\phi_c(g)$ and $\phi_m(g)$ is realized which provides for a significant improvement in the calculation of the cell averaged self-shielded absorption cross section.

The self-shielded cross section for the isotope of interest in the fuel region for group G is determined by:

$$\sigma_i^{fuel}(G) = \int_{g_1}^{g_2} \sigma_i(g)\phi_f \Big/ \int_{g_1}^{g_2} \phi_f \qquad (0.6)$$

and the cell-averaged self-shielded cross section for group G is determined by:

$$\sigma_i^{cell}(G) = \int_{g_1}^{g_2} \sigma_i^{fuel}(g)\phi_f(g)\mathrm{V}_f \Big/ \int_{g_1}^{g_2} \left(\phi_f(g)\mathrm{V}_f + \phi_c(g)\mathrm{V}_c + \phi_m(g)\mathrm{V}_m\right) \qquad (0.7)$$

where

g is the fine mesh (RICM) energy grid

g_1 and g_2 are the lower and upper energy bounds of the individual group of the TGBLA 68 group spectrum, and

G is the TGBLA group number of interest

The energy range for the resolved SLBW resonance parameters for Pu^{240} is from 0.66 eV to 3.91 keV and contains 200 resolved resonance parameter sets. A smooth or background cross section provides the cross section below the 0.66 eV level and the unresolved resonance parameters in combination with the smooth or background cross section provide the cross section data above the upper resolved resonance energy range.

When the current TGBLA RIC model is used to evaluate the $\sigma_a(g)$ for the energy group (group 65 : 0.993-1.125eV) that contains the Pu^{240} 1.056 eV. resonance under low background total cross section and sufficient Pu^{240}atom density, the resulting accuracy in the pin cell average absorption cross section for this group is less than desired. This low background condition is present only in high void conditions (90% in-channel void fraction or greater) in concert with a sufficiently high Pu^{240} concentration. To improve the accuracy of the representation of the Pu^{240} 1.065 eV. resonance, the RICM fine energy mesh model was introduced in the modified TGBLA (T6E5) and has demonstrated excellent results in the modeling of the Pu^{240} absorption in Group 65. In the evaluation of the 1.056 eV. resonance, [[

]]is utilized in this model as compared to 18 groups for the same energy range in the original TGBLA RIC model. The contribution from this resonance is combined with the contributions from the other 199 resonance parameters and the smooth background cross section over the energy range from 0.66 eV to 3.91 KeV to obtain the reconstructed Pu^{240} absorption and fission cross sections.

This modification is a refinement of the application of Chernick's equations to the calculation of the cell region flux magnitudes and does not constitute a change in the fundamental methodology.

References:

4.3-3.1 H. C. Honeck, "THERMOS: A Thermalization Transport Code for Reactor Lattice Calculations," BNL 5826 (1961).
4.3-3.2 H. Mizuta, "Analytical Expression for Factor A in Rational Escape Probability," J. Nucl. Sci. Tech. 10, 192 (1973).
4.3-3.3 JAERI-1134, RICM - An IBM-7090 Code of Resonance-Integral Calculation for Multi-region Lattice, August 1967.

ENCLOSURE 3

MFN 06-297, Supplement 1

Affidavit

Affidavit

I, Jens G. M. Andersen, state as follows:

(1) I am Consulting Engineer, Thermal Hydraulic Methods, Global Nuclear Fuel – Americas, L.L.C. ("GNF-A") 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 06-297, Supplement 1, David H. Hinds to U. S. Nuclear Regulatory Commission, *Supplemental Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application – DCD Chapter 4 and GNF Topical Reports – RAI Number 4.3-3* dated November 8, 2006. The proprietary information in Enclosure 1, MFN 06-297, Supplement 1 – *Response to Portion of NRC Request for Additional Information Letter No. 53 Related to ESBWR Design Certification Application – DCD Chapter 4 and GNF Topical Reports – RAI Number 4.3-3,* is delineated by double underlined dark red font text and is enclosed inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. 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, GNF-A 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 GNF-A's competitors without license from GNF-A 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 GNF-A customer–funded development plans and programs, of potential commercial value to GNF-A;

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 the 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 GNF-A, and is in fact so held. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in (6) and (7) following. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GNF-A, 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.

(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 GNF-A. Access to such documents within GNF-A 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 GNF-A 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) is classified as proprietary because it contains details of GNF-A's fuel design and licensing methodology.

The development of the methods used in these analyses, along with the testing, development and approval of the supporting methodology was achieved at a significant cost, on the order of several million dollars, to GNF-A or its licensor.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GNF-A's competitive position and foreclose or reduce the availability of profit–making opportunities. The fuel design and licensing methodology is part of GNF-A'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 GNF-A or its licensor.

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.

GNF-A's competitive advantage will be lost if its competitors are able to use the results of the GNF-A 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 GNF-A 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 GNF-A 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 at Wilmington, North Carolina this 8th day of November 2006.

Jens G. M. Andersen
Global Nuclear Fuels – Americas, LLC