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

MFN 06-324 Docket No. 52-010

September 18, 2006

U.S. Nuclear Regulatory Commission
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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 21.6-44 and 21.6-50**

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 06-324 – 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 21.6-44 and 21.6-50 – GE Proprietary Information
2. MFN 06-324 – 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 21.6-44 and 21.6-50 – Non Proprietary Version
3. Affidavit – George B. Stramback – dated September 18, 2006

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRFs	0058-1420 and 0058-3801

ENCLOSURE 3

MFN 06-324

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 06-324, 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 21.6-44 and 21.6-50*, dated September 18, 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 21.6-44 and 21.6-50,* 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, <u>Critical Mass Energy Project v. Nuclear Regulatory Commission,</u> 975F2d871 (DC Cir. 1992), and <u>Public Citizen Health Research Group v. FDA,</u> 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 18th day of September 2006.

George B. Stramback
General Electric Company

ENCLOSURE 2

MFN 06-324

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 21.6-44 and 21.6-50

Non Proprietary Version

NRC RAI 21.6-44

Pg. 5.4-2 of your Reference 15, NEDC-32725P Revision 1 "TRACG Qualification for SBWR Vol. 1 and 2," states that "The test model provided for boron injection at one of three locations: high pressure core spray (HPCS) sparger, Jet Pump Injection (JPI) lines in 16 of 20 jet pumps or SLCS injection line in the lower plenum." Explain how these injection points would bound SLCS injection for ESBWR which injects into the lower half of the core bypass. Explain how the analysis you describe in terms of scaling, mixing coefficients, etc. applies to ESBWR.

GE Response:

The test model, referred above, is more fully described in Reference 5.4-1 (NEDE-22267, Class III, October 1982) of NEDC-32725P Revision 1. Three-Dimensional Boron mixing tests were conducted in a [[ ]] (BWR/5 and 6) reactor pressure vessel (RPV) using the high-pressure core spray (HPCS) spargers as the primary location for injection of the simulated boron solution. Two alternate injection locations, namely, the SLCS standpipe located in the lower plenum, and 16 of the 20 jet pumps, were also examined.

In ESBWR, boron would be injected horizontally through a number of nozzles located at the periphery of the lower half of the core bypass. As explained in References 21.6-44-1 and 21.6-44-2, the high-velocity horizontal jets of cold borated water would entrain the surrounding warm water and would significantly lose their momentum when they hit the channel boxes at [[ ]] distance. Thereafter, the dilute borated water would travel downwards along with the downward core bypass flow, at least in the peripheral region. So we expect reasonable similarity between the boron concentrations in the ESBWR and the [[ ]] model tests with simulated boron injection through the HPCS spargers. Also, the geometry of the [[ ]] test model, as it represents the channels, interstitial and peripheral regions, and the major leakage paths, is similar to the ESBWR since these are similar for the BWR/5 and 6 and the ESBWR.

In order to show the pattern and path of boron transport in the [[ ]] model, the boron mixing coefficients of the three Tests (342, 345 and 332), most representative of the ESBWR ATWS situation, are plotted below. Table 21.6-44-1 shows the important operating conditions of these tests. In all of these tests, the SLC was injected in the upper plenum at [[ ]] elevation through the HPCS spargers. However, the HPCS flow rate was zero in the selected tests; only the SLC was injected. The core flow rates in the selected tests were either zero or very small, which is representative of the ESBWR ATWS condition during boron injection.

Table 21.6-44-1 Important Parameters of Selected [[ ]] Boron Mixing Tests

Test No.	Reactor Conditions			Model Test Conditions	
	Core Flow (% Rated)	Power (%)	SLC (GPM)	Starting Water Level (inch)	Injection Period (sec)
342	[[				
345					
332					]]

The Boron "Mixing Coefficient" (defined as the ratio of the Local concentration of Boron to the Global average concentration of Boron) at various radial and vertical locations of the bypass and the core regions of the test model was reported in Reference 21.6-44-3. The experimental data of boron mixing coefficients at relevant radial [[

]] locations are shown in Figures 21.6-44-1 through 21.6-44-6 for the selected tests.

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Fig. 21.6-44-1 Boron Mixing Coefficients for Test 342 at [[ ]]

[[

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Fig. 21.6-44-2 Boron Mixing Coefficients for Test 342 at [[ ]]

[[

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Fig. 21.6-44-3 Boron Mixing Coefficients for Test 345 at [[ ]]

[[

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Fig. 21.6-44-4 Boron Mixing Coefficients for Test 345 at [[ ]]

[[

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Fig. 21.6-44-5 Boron Mixing Coefficients for Test 332 at [[ ]]

[[

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Fig. 21.6-44-6 Boron Mixing Coefficients for Test 332 at [[ ]]

It is seen that for all cases, the mixing coefficient is [[

]]Although the boron injection took place in the upper plenum, the data indicate a boron-mixing pattern as if the boron were injected in the peripheral region of the bypass. From that point of view, the boron flow paths in the [[ ]] test (with boron injection through the HPCS spargers) and the ESBWR (with boron injection in the peripheral bypass) are expected to be similar.

Regarding the scaling or scale factor between the ESBWR and the test model, we observe the following:

1. In the radial direction, [[

   ]] Based on this, the radial length factor, L_R [[

   ]]

   This is because the [[ ]] of the ESBWR is about [[ ]] that of the BWR/5 or BWR/6.

2. In the axial direction, [[

   ]] On this basis and taking [[

   ]] we obtain the axial scale factor, L_A, as [[ ]]. This is the consequence of injecting boron in the lower bypass region rather than at the top of the bypass in the ESBWR.

We recognize that the radial and the axial scale factors, as discussed above, are different from the original scale factor of [[ ]] and therefore some distortion is expected when applying the test data to the ESBWR case. However, using the above scale factors, we can still map the mixing coefficient measurement locations of the test model to the TRACG noding diagram for ESBWR ATWS calculation as shown in Reference 21.6-44-4. In the radial direction, [[

]] of TRACG noding diagram. In the axial direction, [[
]] of the TRACG noding diagram.

Figures 21.6-44-7 through 21.6-44-10 show the comparison between the "boron mixing coefficients" at various important locations of all the three selected tests and the TRACG calculation for the ESBWR MSIV closure ATWS.

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Fig. 21.6-44-7a Comparison between the Experimental Data and the TRACG-calculated Boron Mixing Coefficient at Peripheral Bypass (at upper region)

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Fig. 21.6-44-7b Comparison between the Experimental Data and the TRACG-calculated Boron Mixing Coefficient at Peripheral Bypass (at lower region)

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Fig. 21.6-44-8 Comparison between the Experimental Data and the TRACG-calculated Boron Mixing Coefficient at Mid Bypass (at lower region)

[[

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Fig. 21.6-44-9 Comparison between the Experimental Data and the TRACG-calculated Boron Mixing Coefficient at Peripheral Core (at lower region)

[[

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Fig. 21.6-44-10 Comparison between the Experimental Data and the TRACG-calculated Boron Mixing Coefficient at Mid Core (at lower region)

It is seen from Figures 21.6-44-7a and 7b that there is [[

]] So only the data at [[ ]] are compared with the TRACG results in Figures 21.6-44-8 to 10.

Figures 21.6-44-7a and 7b indicate that [[

]]

As mentioned earlier, this is the consequence of [[

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Based on the above response, GE concludes that although the [[ ]] test model does not exactly represent the ESBWR boron injection location and direction, the test results (particularly the relevant tests selected in this response) are useful in showing the boron mixing pattern and the flow paths that are expected in the ESBWR if boron has to be injected to shut down the reactor. The comparison between the test data and the TRACG calculation also indicates that TRACG, [[ ]] would underpredict the boron concentration in the interior region of both bypass and core, and thus would be conservative for the ESBWR ATWS application.

No change to the ESBWR ATWS LTR will be made because of this RAI response.

References:

21.6-44-1. "TRACG Application for ESBWR Anticipated Transients Without Scram Analysis," Licensing Topical Report, Section 5, GE Energy Nuclear, *GE Proprietary Information,* NEDE-33083P Supplement 2, Class III, January 2006.

21.6-44-2. "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 21.6-7, 21.6-10, 21.6-11, 21.6-13 through 21.6-26, and 21.6-30 through 21.6-32," GE Energy Letter dated July 10, 2006, to USNRC, MFN 06-208.

21.6-44-3. "Test Report Three-Dimensional Boron Mixing Model," General Electric Co., *Proprietary Information*, NEDE-22267, Class III, October 1982.

21.6-44-4. "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 21.5-1, 21.6-5, 21.6-6, 21.6-9, 21.6-33, 21.6-39, 21.6-40, and 21.6-47," GE Energy Letter dated July 24, 2006, to USNRC, MFN 06-232.

NRC RAI 21.6-50

Regarding your uncertainty analysis for Interfacial Shear on Page 5-18, explain how the uncertainty in Co and entrainment fraction captures all of the uncertainty in interfacial shear? If you considered data from another facility at another set of pressures and flow rates that haven't been tested, would you find that some other parameter needs to be varied to capture the interfacial shear uncertainty for FRIGG, Toshiba, and some third test facility? Provide a plot of actual void fraction data from the Toshiba data rather than just the mean deviations. Does the Toshiba data include more annular mist flow regime void fractions than the FRIGG test facility? Toshiba data is referenced at 5 bar and 10 bar. Is there any void fraction data at 1 bar? Is the uncertainty in entrainment fraction also applied in the chimney region?

GE Response:

Comparisons to BWR bundle void fraction data at normal operating conditions showed a negligible bias, [[ ]], and a standard deviation of [[ ]] (Reference 21.6-50-1). The uncertainty in the predicted void fraction is due to an uncertainty in the interfacial shear or the relative velocity between the vapor and liquid phases. This uncertainty in the relative velocity between the phases is either due to an uncertainty in the local relative velocity or an uncertainty in the distribution between the phases. From the drift flux model

$$<v_v> = C_0 <j> + \bar{v}_{gj},$$

where the brackets <> indicate a cross sectional average value. The difference between the average velocities for the phases is obtained as:

$$<v_v> - <v_l> = \frac{C_0 - 1}{1 - <\alpha>} <j> + \frac{\bar{v}_{gj}}{1 - <\alpha>}$$

Since for normal operating conditions the distribution parameter C_0 is in the range of 1.1 to 1.2, the drift flux velocity $\bar{v}_{gj}$ is in the range of 0.2 m/sec and the average volumetric flux <j> is in the range of 2-10 m/sec, it is easily seen from the above equation that the largest variation in the difference between the average velocities for the vapor and liquid phases can be attributed to the distribution parameter C_0. Consequently it was decided to simulate the uncertainty in the void fraction as an uncertainty in the distribution parameter. Calculations where C_0 was perturbed for typical operating conditions are shown in Reference 21.6-50-2 and it was found that a variation of 0.7 in a multiplier on (C_0-1) would produce a variation in the void fraction equal to the standard deviation from the void fraction qualification.

For low pressure, the uncertainty in the void fraction was determined from comparisons to void fraction data from the Toshiba test facility as described in Reference 21.6-50-1. The mean error was found to be negligible [[ ]] and the standard deviation was found to be [[ ]]. It should be noted that these values are very similar to the bias and standard deviation obtained for operating conditions indicating that the uncertainty in the void fraction prediction is in the [[ ]] range for a very wide range of conditions. The relative velocity between the phases is more significant at lower pressures and high void fractions and it was found that the uncertainty range in the void fraction could not be covered by perturbing the distribution parameter alone. The uncertainty range, however, could be covered by including an additional perturbation to the relative velocity. Such a perturbation that only affects the relative velocity for high void fractions was introduced through a perturbation to the entrainment fraction for the dispersed annular flow regime (Reference 21.6-50-1).

Figure 21.6-60-1 shows the comparisons between TRACG and the Toshiba void fraction data for pressures of [[ ]] MPa and mass fluxes of [[ ]] kg/m^2-sec. Most of the data from the Toshiba facility are in the [[ ]], while the FRIGG data are evenly distributed over the range of [[ ]]

[[

]]

Figure 21.6-50-1.
TRACG versus Toshiba CT Void Fraction Data

To evaluate whether uncertainty range of [[ ]] would apply to other test facilities; TRACG was compared to data from the CISE test facility (Reference 21.6-50-3). The CISE tests are simple geometry tests in a vertical tube with a hydraulic diameter of [[ ]] cm. Note, this hydraulic diameter is very close to the hydraulic diameter for a 10X10 BWR fuel bundle, which is [[ ]] cm in the fully rodded section of the bundle. The measurement technique used quick closing valves, which produced highly accurate void fraction measurements with an error of [[ ]]. Figure 21.6-50-2 shows a comparison of calculated versus measured void fractions for a pressure of [[ ]] MPa and mass fluxes of [[ ]] kg/m^2-sec.

[[

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Figure 21.6-50-2.
TRACG versus Measured Void Fraction for the CISE Test Facility

The mean error for this comparison is [[ ]] and the standard deviation is [[ ]]. This is very similar to the statistics for the TRACG comparisons to the FRIGG and Toshiba void fraction data, and therefore no other parameter than those described in Reference 21.6-50-1, Section 5, C2AX is needed to cover the uncertainty in the void fraction.

The separate effects tests comparisons to void fraction data for TRACG covers the pressure range of [[ ]] MPa. No comparisons have been made to separate effects tests at atmospheric pressure. TRACG, however, has been compared to data from several integral effects tests such as the TLTA, FIST and GIST facilities (Reference 21.6-50-4), which cover the entire pressure range down to atmospheric pressure. The good comparisons to liquid inventories for these tests demonstrate the adequacy of the void fraction prediction at atmospheric pressure.

The description of the uncertainty in the interfacial shear in Reference 21.6-50-1, Section 5, C2AX on page 5-18 covers the uncertainty in the interfacial shear for regions with small hydraulic diameters such as the core and bypass regions. For regions with large hydraulic diameters such as the chimney, the distribution parameter C_0 is close to one and the entrainment fraction is large. Therefore the uncertainty in the void fraction is primarily given by the uncertainty in the interfacial drag. This is described in Reference 21.6-50-1, Section 5, F1 on page 5-35.

References

21.6-50-1. TRACG Application for ESBWR Anticipated Transient Without Scram Analyses, NEDE-33083P Supplement 2, January 2006.

21.6-50-2. TRACG Application Methodology for Anticipated Operational Occurrences (AOO) Transient Analyses, NEDE-32906P-A, April 2003.

21.6-50-3. G. Agostini, A. Era and A. Premoli, Density Measurements of Steam-Water Mixtures Flowing in a Tubular Channel Under Adiabatic and Heated Conditions, CISE-R-291, December 1969, Proprietary Report.

21.6-50-4. TRACG Qualification, NEDE-32177P, Revision2, January 2000.