Enclosure 5

MFN 09-525

Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files

GOTHIC Heat Up Analysis Summary

Public Version

Addendum 1.0

Summary of GOTHIC Control Building Heat Up Analysis

1. BACKGROUND

This document is a continuation and an improvement of the analysis performed with CONTAIN, addressed in Document No 092-134-F-M-05001 Issue 3 (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5) regarding the calculation of the maximum temperature inside rooms housing safety-related equipment in accident conditions within the Control Building.

The improvements of this calculation compared to the CONTAIN analysis include the introduction into the heatup calculations of the effect of the shape of the rooms and the evaluation of the effective mixing produced inside the Control Room Habitability Area (CRHA) due to the communication among rooms through openings in the suspended ceiling and raised floor.

GOTHIC is a code widely used in the design, licensing, operating and safety analysis of the containment in nuclear power plants and other containment buildings.

For the purpose of this document, GOTHIC is a more advanced calculation tool than CONTAIN. CONTAIN is a lumped code, so dependent variables are calculated as volume averaged quantities, whereas GOTHIC is able to work using single-cell volumes (lumped volumes) or multi-cell volumes (subdivided volumes). Then, for a subdivided volume, the dependent variables are calculated at each cell center, thereby providing a distribution of parameters across the modeled region. Therefore, phenomena such as natural convection or the effect of stratification can be observed.

2. PURPOSE AND SCOPE

The purpose of this document is to demonstrate that with the GOTHIC code, acceptable environmental conditions and habitability are maintained in the Control Building (CB). The CB is designed to provide and maintain a controlled temperature environment to ensure both comfort and safety of the operators and the integrity of the safety-related equipment located in the building.

The CRHA emergency habitability system passive heat sink is designed to limit the temperature rise inside the CRHA to allowable values during emergency operation. Similarly, the heat sink capacity of the CB structures is designed so that the environmental qualification temperatures of the safety-related components located inside the CB are not exceeded in case of accident.

The calculation considers moist air and its effect on the maximum CRHA air temperature, the latent heat inside the CRHA and temperature gradients in the horizontal and vertical directions inside the CRHA.

3. INPUT DATA AND ASSUMPTIONS

Some assumptions (e.g., equipment heat load per room and location) are based on estimates because the individual equipment is not yet defined. Nevertheless, since the heat loads per room are included in DCD Tier 2 Appendix 3H, should the actual heat loads turn out to be greater than the estimates, the calculations would be updated or any modifications that may be needed would be carried out (e.g., relocating equipment, increasing the heat absorption capacity of the structures by placing steel fins, or some other viable solution) to ensure that the equipment qualification temperature is not exceeded.

3.1 ACCIDENT SCENARIO

The event of Station Black-Out (SBO) or simultaneously SBO&LOCA is considered.

The discussion of the Accident Scenario is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.2 CONTROL BUILDING ROOM MAXIMUM TEMPERATURE

3.2.1 Safety-Related Equipment Qualification Temperatures

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.2.2 Control Room Habitability Area

Given that the GOTHIC model calculates temperatures at different locations inside the CRHA, a criterion must be defined for room #3275 (MCR) to select the representative zone or area that must meet the temperature requirement. Lumped modeled rooms must meet the temperature requirement also.

It is assumed that the temperature increase must be met in zones below 2 m (6.6 ft) high in the MCR, from the raised floor elevation in rooms modeled multidimensionally (MCR). This is called the “occupied zone” further on.

In rooms inside the CRHA other than MCR modeled as lumped, the temperature must remain below the maximum allowable temperature of 93°F (33.9°C) .

3.3 ROOMS HOUSING SAFETY-RELATED EQUIPMENT

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.4 INITIAL TEMPERATURE

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.5 INTERNAL HEAT LOADS IN SBO

Room active ventilation and cooling is lost for 72 h in SBO. Heat loads remaining active during these 72 h increase the air temperature of the room where they are located. Heat loads mainly come from electric and electronic equipment.

3.5.1 Control Room Habitability Area (CRHA)

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.5.2 Mechanical Equipment

There are no active mechanical components in the CB during the accident, with the exception of the emergency filter unit (EFU), which provides filtered outside airflow to the CRHA.

The electric power associated to the EFU in service is 1 hp to 1-1/2 hp. The electric power of 1 hp (746 W) has been associated to the EFU fan and added to the outside airflow heat load entering the CRHA.

This value has been increased by 15% for summer time. A total heat load of 860 W (2934 Btu/h) will be considered.

3.5.3 Latent Heat Load

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.5.4 MCR Panels and Heat Load Distribution

It has been assumed that the panel distribution is as illustrated in the General Arrangement Drawings, see Figure 3.5-1.

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Figure 3.5-1. MCR Active Panels and Heat Load Distribution

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A conservative assumption has been made that the total CRHA heat load (except for the Emergency Filter Unit (EFU) fan power) is distributed among the three marked panels according to the percentages shown in Figure 3.5-1.

3.6 VENTILATION AND EXTERNAL HEAT LOADS

3.6.1 Ventilation Loads

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.6.2 External Loads

This discussion is the same as 092-134-F-M-05001 Issue 3, (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5) with the exception that heat transfer to the ground is considered.

3.7 CONCRETE CHARACTERISTICS

This discussion is the same as 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

3.8 ROOM, FLOOR, AND WALL DIMENSIONS

This discussion is the same as 092-134-F-M-05001 Issue 3.(Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

4. CALCULATION METHOD AND ASSUMPTIONS

4.1 MODELING OF CONTROL BUILDING

Rooms are modeled using the GOTHIC Code. A single model has been built for the CB, which it has been subdivided into rooms, taking into account the thermal interactions between rooms during the simulation.

This model includes all elevations in the CB and all rooms housing safety-related equipment, including those that act as boundaries.

EL-7400, EL-2000, EL+4650 and EL+9060 containing rooms which house safety-related equipment have been modeled. All thermal paths (connections) - like walls, partitions, floors and ceilings - have been incorporated into the model in order to calculate heat flux between rooms. The structures store heat from the air when it is at a higher temperature and release heat when the surface temperature is over the air temperature that surrounds it. Except EL-2000 (CRHA), all rooms have been modeled as lumped, i.e., no temperature differences in the room air have been considered.

4.2 MODELING OF THE CRHA

The CRHA is located at EL-2000 and includes the following rooms: 3270, 3272, 3271, 3201, 3202, 3273, 3206, 3205, 3204, 3275, 3207 and 3208. Rooms inside the CRHA are arranged around the MCR which contain the active equipment that releases most of the heat in normal and accident conditions.

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Figure 4.2-1 Control Room Habitability Area. CRHA

Figure 4.2-2 shows a block diagram of how the CRHA has been modeled and which rooms/volumes have been modeled as lumped or multidimensional.

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Figure 4.2-2 CRHA Modeling

CRHA Modeling: thermal structures and flow path (openings) connections between rooms surrounding the MCR are not illustrated; however, the thermal and flow path communication in the partition walls, over the raised floor and below the suspended ceiling has been considered in the partitions between rooms (#3204 - #3205), (#3205 - #3206), (#3206 - #3270), (#3270 - #3272), (#3272 - #3271), (#3271 - #3201&2), (#3201&2 - #3273), (#3273 - #3207), (#3201&2 - #3207), (#3201&2 - #3275) and (#3207 - #3208).

Note that on the occupied level there are no flow path connections: this means that, conservatively, doors inside CRHA have been considered closed.

Panels inside the MCR have been modeled as cuboids. Inlet louver locations and outlets (fans) on the upper and lower part of the panels have been modeled. A provision has also been made for additional openings at the base of the panels, where the cables enter into the panel.

It has been assumed that the total 200 l/s of outside air is released directly into the MCR environment.

There is a flow path below the raised floor, close to airlock #3274, to release the excess air created by the injection of the outside air. The orifice has been sized to create an overpressure inside the CRHA of 31 Pa (1/8"w.g.).

The following openings have been assumed in the suspended ceiling and at the bottom of the walls, below the false floor:

- All walls communicating the MCR with adjacent and surrounding rooms with the exception of chases #3251, #3250, #3261 and #3260
- Walls connecting rooms: (#3204 - #3205), (#3205 - #3206), (#3206 - #3270), (#3270 - #3272), (#3272 - #3271), (#3271 - #3201&2), (#3201&2 - #3273), (#3273 - #3207), (#3201&2 - #3207), (#3201&2 - #3275) and (#3207 - #3208)

4.3 MODELING ASSUMPTIONS

The following assumptions are considered:

- The program considers rooms as nodes except the CRHA where multidimensional rooms are considered.
- Radiant heat transmission is not taken into account either as a fraction of heat load generated inside the room or as a radiant heat transfer coefficient.
- Room #3275 (MCR) is subdivided into cells and different temperatures inside them are calculated. In the rest of the rooms, no temperature differences have been considered.
- Conservatively, internal heat load in the CRHA has been considered inside the active panels in the MCR
- WDP and MCC have been assumed to be located parallel to the walls

- Air paths in the suspended ceiling and the raised floor in all rooms inside the CRHA have been sized to comply with the exceedance temperature inside the CRHA.

4.4 METHODOLOGY

The following approach has been used to evaluate the maximum environmental conditions in the different rooms with safety-related equipment:

a) Identification of initial room temperatures under normal operation

b) Identification of quantity and quality of electronic, electrical and/or mechanical heat loads located inside each room

c) Modeling of the Control Building using the GOTHIC code. Compartments are interconnected by appropriate thermal paths (walls, floors, ceilings, etc) taking into account the impact of inertia in each path (mass, conductivity, specific heat, surface exposed arrangement and heat transfer coefficient)

d) Multidimensional modeling of the CRHA

e) No occupancy rate is considered when estimating the free volume of each compartment because the heat capacity of furniture is higher than that of the air space occupied by it.

f) Considering wall and ceiling structures as heat sinks, concrete characteristics and initial temperature must be taken into account to achieve accurate results.

g) The initial temperature considered on structural surfaces is made equal on both faces, and equal to the room temperature, when the room temperature is the same on both sides of the wall, floor or ceiling. When rooms don't have the same temperatures in normal operation, a linear temperature distribution across the wall is considered.

4.5 HEATUP CALCULATIONS PERFORMED

4.5.1 Calculation Performed (0-72h)

Following an SBO, the heat generated in the rooms is absorbed by the surrounding walls, floor and ceiling. Since the heat absorption capacity of air is very low, the room temperature rises quickly before the walls and ceilings start to warm. As the CRHA temperature is affected by the outside air temperature due to air intake, the CRHA temperature rise profile follows the temperature variations of the outside air.

4.5.1.1 Control Building (0-72h)

Case A is used as the base to analysis for the temperature in summer conditions in all rooms with safety related-equipment, including the CRHA.

The Control Building initial room temperatures and heat loads are the same as in document 092-134-F-M-05001 Issue 3. (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5)

Case A analysis conditions are summarized in Table 4.5.1.1-1.

Table 4.5.1.1-1

CASE A. BASIC CASE	0h-72h	
OUTSIDE AIR CONDITIONS	Maximum at 3 pm	Minimum at 5 am
Dry bulb Temp	47.2 ºC [2] (117ºF)	32.2ºC (90ºF)
Coincident wet bulb Temp.	26.7 ºC [2] (80 ºF)	22.8 ºC [2] (73 ºF)
Coincident Relative humidity	20 %	45 %
Humidity ratio	0.0136 kg_w/kg_{da}	0.0136 kg_w/kg_{da}
DAILY RANGE	15.0 ºC (27 ºF)	
Total (Sensible)	7630 W (26035 Btu/h)	
a. Equipment	5000 W (17061 Btu/h)	
b. Lighting	200 W (682 Btu/h)	
c. Miscellaneous	200 W (682 Btu/h)	
d. EFU fan+15%	746x1.15= 860 W [4] (2934 Btu/h)	
e. People. 5 p	5x75 [1] = 375 W (1280 Btu/h)	
f. Margin 15%	995 W (3395 Btu/h)	
Total (Latent)	275 W (938 Btu/h)	
a. People. 5 p	5x55 [1] = 275 W (938 Btu/h)	
HVAC Air	--	
Ventilation Air	200 l/s [3] (424 cfm)	

4.5.1.2 CRHA (0-72 h)

To analyze the CRHA air temperature evolution in further detail during the first 72 h after the accident, the following heatup calculations have been performed

a) Case A. Base case. The maximum 0% exceedance coincident dry bulb (DB) and wet bulb (WB) ambient temperature [47.2ºC (117ºF) DBt and 26.7ºC (80ºF) WBt] has been considered.

5. RESULTS AND CONCLUSIONS

5.1 RESULTS OF THE HEATUP CALCULATIONS

Table 5.1-1 shows the maximum temperatures obtained in Case A for CB rooms.

Table 5.1-1

Rooms & Equipment	Max. Allowable Temp. Up to 72h. Target	Max. Temp. obtained in calculations. Up to 72h
Division I, II, III and IV electrical rooms Q-DCIS panels Rooms No 3110, 3120, 3130 and 3140	45°C (113°F)	36.1°C (97°F)
Control Room Habitability Area. (CRHA)		
Control Room Habitability Area. Room No 3275. MCR	33.9°C (93°F)**	32.2°C (90.0°F) / 33.7°C (92.7°F) /31.5 °C(88.7°F) *
Control Room Habitability Area. Room No 3204	33.9°C (93°F)**	31.4°C (88.5°F)
Control Room Habitability Area. Room No 3205	33.9°C (93°F)**	32.0°C (89.6°F)
Control Room Habitability Area. Room No 3206	33.9°C (93°F)**	31.6°C (88.9°F)
Control Room Habitability Area. Room No 3270	33.9°C (93°F)**	31.0°C (87.8°F)
Control Room Habitability Area. Room No 3272	33.9°C (93°F)**	31.5°C (88.7°F)
Control Room Habitability Area. Room No 3271	33.9°C (93°F)**	31.3°C (88.3°F)
Control Room Habitability Area. Rooms No 3201 and 3202	33.9°C (93°F)**	27.1°C (80.8°F)
Control Room Habitability Area. Room No 3273	33.9°C (93°F)**	31.7°C (89.1°F)
Control Room Habitability Area. Room No 3207	33.9°C (93°F)**	31.1°C (88.0°F)
Control Room Habitability Area. Room No 3208	33.9°C (93°F)**	31.4°C (88.5°F)
Electrical chases Rooms 3250, 3261	110°C (230°F)	34.8°C (94.6°F)
Safety Portions of CRHAVS Rooms 3406, 3407	50°C (122°F)	45.5°C (114°F)

* Average temperature in MCR /Maximum temperature in the "occupied zone" / Minimum temperature in the "occupied zone."
** Maximum allowable temperature inside the CRHA 33.9°C (93°F).

5.1.1 Heatup Results up to 72 h

The relevant results are the following:

a) The maximum temperature obtained inside the CRHA, including the occupied zone of the MCR is 33.9°C (93°F) and it occurs in Case A and does not exceed the limit.

b) The maximum temperature obtained at 72 h in Q-DCIS rooms (Case A) is 36.1°C (97°F) and does not exceed the limit 45°C (113°F)

5.2 CONCLUSIONS

5.2.1 Comparison with Previous Calculations

The conclusions reached in the document 092-134-F-M-05001 Issue 3 (Ref 6.17 of Control Building Environmental Equipment Qualification Temperature Sensitivity Analysis, GEH 0000-0084-3844R5) are met and the results obtained are similar to those obtained with the previous code CONTAIN:

a) The maximum allowable temperature 72 h after the accident is not exceeded in any room with safety-related equipment in the CB.

b) The maximum allowable temperature in the occupied zone in the CRHA, i.e., 33.9°C [93°F], is not exceeded even considering 0% exceedance outside air 47.2°C (117°F) DBT and coincident 26.7 °C (80°F) WBT.

5.2.2 3D Analysis in the MCR

a) Considering the occupied zone, i.e., the zone below 2 m (6.6 ft), 33.9°C [93°F] is not surpassed in the MCR

b) Due to the high heat load from the wide display panel inside the MCR, the zones close to this panel reach temperatures close to the limit.

c) Stratification is found in the MCR obtaining higher temperatures in the false ceiling than in the occupied zone of the MCR.

d) With the suspended ceiling and raised floor openings, thermal forces promote natural recirculation inside the CRHA that allows cooling by taking advantage of the cold structures or heat sinks to obtain the desired passive cooling of the CRHA.

e) 3D temperature profiles of the MCR from the top of the raised floor to the bottom of the suspended ceiling can be seen below. Note that all temperatures provided are the worst case, all other profiles from 092-134 F-M-07001 Issue 1 are lower temperatures.

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[[ ]]

MCR Temperature Profiles - Side View

[[ ]]

[[ ]]

MCR Temperature Profiles - Top View

Enclosure 6

MFN 09-525

Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Larry J. Tucker, state as follows:

(1) I am Manager, ESBWR Engineering, GE Hitachi Nuclear Energy ("GEH"), 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 enclosures 1, 2 and 3 of GEH's letter, MFN 09-525, Mr. Richard E. Kingston to U.S. Nuclear Energy Commission, entitled "Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files," dated August 3, 2009. The proprietary information in enclosure 1, entitled "*Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files – Document No. 092-134-F-M-05011, Issue 1, "Control Building Environmental Qualification Temperature Sensitivity Analysis – GEH Proprietary Information,*" and enclosure 2, entitled, "*Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files –GOTHIC Heat Up Analysis Summary – GEH Proprietary Information,*" is delineated by a [[dotted underline inside double square brackets[3]]]. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation [3] refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination. Enclosure 3 is a compact disc (CD) containing electronic format files that contain GEH proprietary information in their entirety.

(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) is classified as proprietary because it contains details of GEH's 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 to GEH.

(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 4th day of August 2009.

Larry J. Tucker

Larry J. Tucker
GE-Hitachi Nuclear Energy Americas LLC