HITACHI

GE Hitachi Nuclear Energy

Richard E. Kingston
Vice President, ESBWR Licensing

P.O. Box 780 M/C A-65
Wilmington, NC 28402-0780
USA

T 910.675.6192
F 910.362.6192
rick.kingston@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 09-522

Docket No. 52-010

July 31, 2009

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. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAIs) 9.1-124, 9.1-125, 9.1-126 and 9.1-127 sent by NRC Letter 337, Reference 1.

The GEH responses to RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127 are addressed in Enclosures 1 and 2. Enclosure 1 contains GEH proprietary information as defined by 10 CFR 2.390. GEH customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 2 is a non-proprietary version that is suitable for public disclosure.

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

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 09-331, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5*, May 14, 2009.

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127 – GEH Proprietary Information
2. Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127 – Public Version
3. Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127 – Affidavit

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF Sections	0000-0102-5613 (RAI 9.1-124)
		0000-0102-5616 (RAI 9.1-125)
		0000-0102-5620 (RAI 9.1-126)
		0000-0102-5621 (RAI 9.1-127)

Enclosure 2

MFN 09-522

Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5

Spent Fuel Pool

RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127

Public Version

NRC RAI 9.1-124

Clarify the application of the CFD model and the geometry used.

1. The CFD model appears to be a [[ ]] fuel regions. What are the overall dimensions of the water region modeled? What are the dimensions of each fuel rack region? Is there a gap between the regions within the model? Is there a gap between the rack regions and the base of the pool? Please confirm the spacing between the racks and the side walls and back wall. What are the flow areas and locations of the inlets and outlets?

2. Each rack region (sub-domain) represents 1 fuel rack. Are there different rack designs within the pool? Is the fresh fuel assumed to be in high density racks? How is the loss coefficients applied in this region? What are the specific equations and constants used by the code to apply the loss coefficients and are these applied uniformly over the entire region? Assuming the correct mass flow is computed for a given rack region and that the CFD model has no obstructions in the rack region; the predicted vertical velocities in the rack region are lower than the expected velocities in a prototypical rack. How is the loss coefficients in the CFD model adjusted to account for the reduced velocity in the rack region?

3. For the spent fuel pool (SFP) CFD model, are the FAPCS inlet and outlet locations typical for the ESBWR? Are the rack locations fixed or could racks be moved closer to the inlet locations?

GEH Response

[[

]]

1) As per the attached sketch, the overall dimensions of the modeled water region are [[ ]]. These dimensions are conservative as they represent minimum values based on construction tolerances.

   The racks are modeled [[

   ]]

2) As seen in the attached sketch, the pool layout consists of two rack sizes, utilizing 15 x12 and 14 x12 arrays.

   Even though new fuel can be stored in the spent fuel storage racks before it is staged in the buffer pool, modeling was not performed assuming the presence of new fuel.

   The loss coefficient (K) for a fuel assembly is defined by GEH specification 22A5866, which is Reference 8 of the analysis. A curve is provided in this reference, which presents pressure drop through the assembly as a function of mass flow through it. This curve is presented in the analysis as Figure 5-2.

   The CFD code requires that the loss coefficient be applied as a function of velocity in the assembly. Section 5.2.3.1 of the analysis calculates the loss coefficient (K), then re-calculates the equivalent loss coefficient (K_n) as a function of velocity for use in the CFD model. Equations used for these calculations are included in the section. Once determined, the loss coefficient (K_n) is input into the code the same as other boundary conditions (i.e. inlet flow, water properties, etc.). This coefficient is applied uniformly over the entire region.

   The CFD code solves momentum and energy equations in the rack as a function of mass flow, external pressure gradient, heat generation, and pressure drop due to the loss coefficient. Mass flow and temperatures are input, then the code calculates velocity using the modeled rack section.

3) The water inlet and outlet locations in the spent fuel pool are typical for ESBWR. Likewise, the layout of racks in the pool represents the standard plant as offered. This is the layout that's been analyzed in the dynamic, thermal-hydraulic, and criticality analyses. Any changes would be the responsibility of the utility, who would then be responsible for the required re-analyses of the rack locations.

To add conservatism to the thermal-hydraulic analysis, the hottest of the discharged fuel assemblies are assumed to be placed in the racks the farthest from the water inlets.

DCD/LTR Impact

No changes to the DCD or subject LTR will be made in response to this RAI.

NRC RAI 9.1-125

The CFD model has a series of assumptions and limitations built into the coding such as the turbulence modeling approach. Have any sensitivity studies been performed to determine the impact of specific assumptions such as the turbulence model, treatment of buoyancy, or the mesh density?

GEH Response

The fuel storage rack designer, ENSA, has evaluated the sensitivity of several Thermal-Hydraulic analyses for other rack design projects. Their sensitivity studies are typically presented in two parts: sensitivity to the numerical method and sensitivity to the mesh density. The results of their evaluations demonstrate their modeling methodology to be valid.

Considering the numerical method, many parameters have been evaluated as shown below:

1) Inlet mass flow increased by 10%,
2) Inlet temperature reduced by 10%,
3) Loss coefficient increased by 20%,
4) Turbulence model validated by a different model (k-ε model vs. SST-k-ω model),
5) Reference temperature of buoyancy increased by 9% (maximum allowed by the program).

The results of this sensitivity analysis show the model to be valid. The shape of temperature distribution throughout the pool remains constant, with temperature variations (peak and bulk) of ≈ 1.5%. Variations for inlet temperature and mass flow are typically ≈ 4% to 6%.

With regard to the sensitivity of mesh density, specific examples from a specific Thermal-Hydraulic analysis of an operating BWR are presented below. Typically, three cases are used for comparison of mesh density sensitivity: the original mesh density, a 50% increase over the original mesh density, and a 100% increase over the original mesh density.

1) The first example considers the bulk pool temperatures and the shape of temperature distribution for each mesh density case. The temperature profiles of horizontal "slices" through the spent fuel pool are analyzed at various elevations for comparison purposes. In comparing the three models, the temperature distributions within the pools were constant and the global (bulk pool) temperature variance was less than 2°C. These results are consistent with results produced in the evaluation of other rack design projects.

2) The second example considers the maximum temperature in the fuel racks. The original mesh density produced a maximum rack temperature of 101.1°C for the hottest location in the spent fuel pool. The 50% mesh density increase case produced a maximum temperature of 105.9°C. The doubled mesh density case produced a maximum temperature of 107.0°C.

If the variations described above were applied to the ESBWR Thermal-Hydraulic analysis results, sufficient margin exists to ensure the rack exit temperature limit is not exceeded and nucleate boiling is prevented.

DCD/LTR Impact

No changes to the DCD or subject LTR will be made in response to this RAI.

NRC RAI 9.1-126

Are the values in Figure 5-2 for the pressure drop in Racks calculated or determined experimentally? What does the flow rate represent? Is this LBM/HR for an entire rack or for a specific number of bundles? Does the pressure drop represent the entire rack? How does the flow rate range in Figure 5-2 compare to the flow rate in the rack regions computed using the CFD model?

GEH Response

The pressure drop values in Figure 5-2 of LTR NEDC-33373P were calculated. This curve was developed to bound all GEH-GNF fuel designs. An additional measure of conservatism is provided for ESBWR fuel as the overall length is approximately 2 feet shorter than other GEH fuel elements.

The flow rate, in lb_m/hr, represents flow for a single assembly and is bounding for each storage location in the rack. The pressure drop represents water flow from the inlet of the stored bundle at the bottom of the rack to the outlet of the stored bundle at the top of the rack. The CFD model mathematically applies the loss coefficient as an input. There are no manipulations or corrections by the CFD model.

Considering the cross-sectional area of the ESBWR fuel assembly, the lower end of the curve in Figure 5-2 is applicable for hot fuel assemblies. The average flow per fuel assembly in the analyzed "hottest" rack is approximately 1180 lb_m/hr. As this is an average value, some individual assemblies will see more flow. However, the variation in flow through individual assemblies and the effect on the associated pressure drop is small.

As the fuel assemblies dissipate heat, the flow reduces below the range of the curve, however, sufficient cooling of the fuel has occurred.

DCD/LTR Impact

No changes to the DCD or subject LTR will be made in response to this RAI.

NRC RAI 9.1-127

The peak cladding temperature determination carried out in section 5.3.5 is dependent upon the heat transfer coefficients used. What is the basis for using a heat transfer coefficient of 50 (283 W/m2-K) from Table 5-1 in the calculation of the cladding temperature? Does this value represent fuel bundle heat transfer? Is the flow in the fuel rack turbulent or laminar? Does GEH have experimental data or correlations for bundle heat transfer coefficients under these conditions? What is the range of possible crud layer thermal resistances based on GEH experience?

GEH Response

Having demonstrated in LTR NEDC-33373P that water does not boil before exiting the fuel storage rack, using the heat transfer coefficient for "water, heating" is appropriate in calculating the maximum cladding temperature. As specified in Table 5-1, the source is Table 1-1 from "Heat Transmission" by William H. McAdams. The heat transfer coefficient of 50 $BTU/hr \cdot ft^2 \cdot °F$ (283.9 $W/m^2 \cdot °K$) used in the calculations is the lower limit of a range of coefficients (50 – 3000 $BTU/hr \cdot ft^2 \cdot °F$ per the reference) of heat transfer for water as it is heated. This range is consistent with other references. For example, Table 2-2 from "Conduction Heat Transfer" by Vedat Arpaci presents the forced convection heat transfer coefficient range for water as 50–2000 $BTU/hr \cdot ft^2 \cdot °F$. This comparison provides independent confirmation that the use of 50 $BTU/hr \cdot ft^2 \cdot °F$ (283.9 $W/m^2 \cdot °K$) is both conservative and consistent. By using the minimum heat transfer coefficient for water, the expected heat transfer coefficients in the fuel rack are bounded and the maximum peak cladding temperature is conservatively calculated for free convection flow of water through the racks.

Considering sensitivity of the heat transfer coefficient of water (h), the maximum peak cladding temperature was re-calculated reducing 50 $BTU/hr \cdot ft^2 \cdot °F$ (283.9 $W/m^2 \cdot °K$) by 50% and 75%. The Thermal-Hydraulic analysis in the LTR calculates the maximum cladding temperature to be [[ ]]. The results of the calculations using the reduced heat transfer coefficients are below.

[[			
			]]

As can be seen in the table above, a 75% reduction in the heat transfer coefficient of water yields a result that provides a [[
]].

The heat transfer coefficient represents the transfer of heat from the discharged fuel assembly to water flowing through the fuel assembly.

Based on the average flow of water through the racks and assuming the characteristics of water at the maximum bulk temperature for abnormal conditions, the Reynolds number is calculated to be approximately 180. Therefore, flow is laminar based on average flow. The variation between the average flow through a fuel assembly and the maximum flow through a fuel assembly does not impact the Reynolds number such that the laminar range is exceeded.

GEH does not have experimental data for bundle heat transfer coefficients under these conditions. However, given the simple single-phase nature of this heat transfer condition, a textbook correlation (such as use of the references above) is sufficient.

GEH experience has found that the heat transfer coefficient of the fouling layer of fuel rods, when converted to an equivalent thermal conductivity, is small as compared to the thermal conductivity of water. The fouling layer heat transfer coefficient source is Table 8-2 from "Heat Transmission" by William H. McAdams. The value used in LTR NEDC-33373P, 5673 W/M2°C (1000 BTU/hr·ft^2·°F), is a commonly accepted value, applicable to the following parameters for treated boiler feed water:

- Temperature of heating medium – up to 240°F
- Temperature of water – 125°F or less
- Water velocity (ft/s) – 3 and less

This value is not presented within a defined range of values.

Considering the sensitivity of the fouling layer heat transfer coefficient, if the value used in LTR NEDC-33373P, is reduced by 90%, the maximum cladding temperature would increase from [[ ]]. This approximate 1°C difference is due to use of the small heat transfer coefficient for water and demonstrates that the fouling layer has a very small impact on the overall heat transfer.

<u>DCD/LTR Impact</u>

No changes to the DCD or subject LTR will be made in response to this RAI.

Enclosure 3

MFN 09-522

Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5

Spent Fuel Pool

RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, David H. Hinds, state as follows:

(1) I am Manager, New Units 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 enclosure 1 of GEH's letter, MFN 09-522, Mr. Richard E. Kingston to U.S. Nuclear Energy Commission, entitled "*Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127*," dated July 31, 2009. The proprietary information in enclosure 1, which is entitled "*Response to Portion of NRC Request for Additional Information Letter No. 337 Related to Design Control Document (DCD) Revision 5 – Spent Fuel Pool - RAI Numbers 9.1-124, 9.1-125, 9.1-126 and 9.1-127 – 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.

(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 31st day of July 2009.

David H. Hinds
GE-Hitachi Nuclear Energy Americas LLC