HITACHI

GE Hitachi Nuclear Energy

James C. Kinsey
Vice President, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Numbers 9.1-9 S02, 9.1-18 S02, and 9.1-41 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated October 15, 2007, Reference 1. Previous responses for RAIs 9.1-9 S01 and 9.1-18 S01 were submitted via Reference 2 in response to Reference 3. The original response to RAIs 9.1-9 and 9.1-18 were submitted via Reference 4 in response to Reference 5. The original response to RAI 9.1-41 was submitted via Reference 6 in response to Reference 7. GEH response to RAI Numbers 9.1-9 S02, 9.1-18 S02, and 9.1-41 S01 are addressed in Enclosure 1.

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

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

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References:

1. MFN 07-556, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, Senior Vice President, Regulatory Affairs, *Request For Additional Information Letter No. 111 Related To ESBWR Design Certification Application*, dated October 15, 2007
2. MFN 06-309, Supplement 2, Letter from James C. Kinsey, GHNEA to U. S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 54 Related to ESBWR Design Certification Application – Auxiliary Systems – RAI Numbers 9.1-9 S01, 9.1-10 S01, 9.1-11 S01, 9.1-17 S01, 9.1-18 S01, and 9.1-19 S01,* dated June 11, 2007
3. E-mail from L. Quinones U. S. Nuclear Regulatory Commission, dated May 3, 2007
4. MFN 06-309, Letter from David H. Hinds, GE, to U. S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 54 –Auxiliary Systems– RAI Numbers 9.1-1 through 9.1-26, and Amended Response to RAI Number 2.4-23 from NRC RAI Letter No. 32,,* dated September 8, 2006
5. MFN 06-302, Letter from U. S. Nuclear Regulatory Commission to David Hinds, Manager, ESBWR, *Request For Additional Information Letter No. 54 Related To ESBWR Design Certification Application*, dated August 23, 2006
6. MFN 07-341, Letter from James C. Kinsey, GNHEA, to U. S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information, Letter No. 100 – Auxiliary Systems – RAI Numbers 9.1-41 and 9.1-42*, dated June 18, 2007
7. MFN 07-327, Letter from U. S. Nuclear Regulatory Commission to Robert E. Brown, General Manager, Regulatory Affairs, *Request For Additional Information Letter No. 100 Related To ESBWR Design Certification Application*, dated May 30, 2007

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application – Auxiliary Systems – RAI Numbers 9.1-9 S02, 9.1-18 S02, and 9.1-41 S01

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	eDRF	0000-0076-8153

Enclosure 1

MFN 07-646

Response to Portion of NRC Request for

Additional Information Letter No. 111

Related to ESBWR Design Certification Application

Auxiliary Systems

RAI Numbers 9.1-9 S02, 9.1-18 S02, 9.1-41 S01

On the last page of this transmittal is a table of references. These references correspond to a series of GEH proprietary calculations/analyses that are available for NRC audit at the GEH offices in Washington D.C.

For historical purposes, the original text and GE response to RAIs 9.1-9, 9.1-9 S01, 9.1-18, 9.1-18 S01, and 9.1-41 are included.

NRC RAI 9.1-9

DCD Tier 2, Section 9.1.2 states that spent fuel storage racks in the buffer pool area provide storage in the reactor building spent fuel pool for spent fuel received from the reactor vessel during the refueling operation. DCD Tier 1, Figure 2.6.2-1 indicates that the emergency makeup water line does not extend to the reactor building buffer pool. For the reactor building buffer pool, explain how the requirements of GDC 61 are satisfied with respect to providing adequate residual heat removal and preventing a significant reduction in fuel storage coolant inventory during accident conditions, such as loss of the non-safety related forced cooling system.

GHNEA Response

Spent fuel is not stored in the buffer pool except for very brief periods of time when fuel assemblies are being shuffled to different locations in the core. According to DCD section 9.1.2.3, "The fuel storage racks in the Reactor Building buffer pool deep pit can hold a total of 154 spent fuel assemblies."

During an outage, the available water inventory is increased by opening gates that allow the buffer pool to communicate with the water in the reactor well and dryer/separator pool. This effectively increases the pool surface area to more than twice that of the spent fuel pool. The buffer pool would have to boil off a larger margin of water volume than the spent fuel pool in order to reach the minimum water level, and it has only a small fraction of the heat load. Therefore, if the FAPCS cooling were lost during an outage, the large water inventory would provide ample time for transferring this fuel from the buffer pool to the spent fuel pool.

The requirements of GDC 61 are satisfied by the excessive water margin, having sufficient time to relocate the fuel to the spent fuel pool, and by the anti-siphoning provisions discussed in the response to RAI 9.1-11.

No changes will be made to the DCD as a result of this RAI.

NRC RAI 9.1-9 S01

Supplement received via e-mail dated 5/3/07 from L. Quinones (NRC) to P. Jordan (GHNEA):

Response is insufficient. Provide a description of controls that will be used to ensure the required volume of water will be maintained at all times.

GHNEA Response

As previously noted, fuel is only stored in the buffer pool during refueling operations. During normal refueling conditions, the FAPCS adds makeup water to the buffer pool where level control (excess water) is maintained by the pool weir. The FAPCS is designed to accommodate the loss of a single train and still remain functional. If one train were lost, the remaining train is still able to pump makeup water from the surge tanks to the buffer pool. The flow rate delivered by a single train of the FAPCS is more than adequate to maintain the water level in the buffer pool. Therefore, since it is not necessary to postulate a loss of both trains of the FAPCS while in a refueling outage, no additional controls are needed to ensure the required volume of water will be maintained.

DCD Impact

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

NRC RAI 9.1-9 S02

The intent of the RAI is to clarify how sufficient coolant inventory will be maintained in the reactor building buffer pool during accident conditions, such as the loss of the non-safety related forced cooling system for 72 hours. In its response to RAI 9.1-9 S01, GEH described how the fuel and auxiliary pools cooling system (FAPCS) is designed to withstand a single failure during normal refueling conditions. This response does not address the conditions identified in the RAI.

Please provide an analysis to demonstrate that the volume provided by the buffer pool is sufficient to provide cooling and shielding without makeup. If the analysis relies on additional water inventory in the reactor building, such as from the reactor well and the dryer storage pool, please provide a description of the controls relied upon to ensure this inventory is available to the buffer pool whenever there is fuel present.

GEH Response

In the event both trains of the FAPCS are lost, it can be shown that the buffer pool contains sufficient water inventory to allow for 72 hours of passive cooling and still maintain safe shielding, thus complying with the requirements of GDC 61.

Included with this transmittal is a table of references. These references correspond to a series of GEH proprietary calculations and analyses that are available for NRC audit.

The analysis in Reference 1 conservatively evaluates the heat load and available water inventory to demonstrate that the design has adequate margin. To summarize, the heat load in the buffer pool cannot exceed 2.5 MW due to the capacity of the deep pit area (maximum of 154 bundles of the hottest fuel at end-of-cycle). If a heat load of 2.5 MW were applied to the pool with no FAPCS cooling, it would take 12.5 days for the water to heat and boil down to a level 3.05 m above the top of the active fuel. The level of 3.05m corresponds to the minimum level of coolant above the top of the fuel assemblies which would still provide an adequate shielding depth in accordance with Regulatory Guide 1.13.

DCD Impact

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

NRC RAI 9.1-18

DCD Tier 2, Section 7.5.5.5 states that the skimmer surge tanks have instruments for monitoring water level in the tanks. These instruments generate high, low and low-low water level signals when the water level reading exceeds their setpoints. These signals initiate high and low water level alarms in the main control room (MCR). DCD Tier 2, Section 9.1.3.5 states that the SFP has two wide-range safety-related level transmitters that transmit signals for water level indication and to initiate high/low-level alarms to the MCR and other pools (suppression pool, upper transfer pool, buffer pool, reactor well, dryer and separator storage pool) have local, non-safety related, panel-mounted level transmitters to provide signals for high/low-level alarms in the MCR. DCD Tier 1, Figure 2.6.2-1 does not indicate the location of the instrumentation, but DCD Tier 1, Table 2.6.2-1 states that level instruments are provided for monitoring and controlling the water levels in the skimmer surge tanks and IC/PCCS pool.

GDC 63 states that appropriate systems shall be provided in fuel storage and associated handling areas to (1) detect conditions that may result in loss of residual heat removal capability and excessive radiation levels, and (2) initiate appropriate safety actions. Explain how the skimmer surge tank level instrumentation satisfies the requirements of GDC 63 when forced cooling flow is not available for the SFP. Also, explain how the buffer pool level instrumentation is adequate to satisfy the requirements of GDC 63 since DCD Tier 2, Section 9.1.3 states that fuel will be stored in that pool. Update DCD Tier 1, Figure 2.6.2-1 to indicate the location of instrumentation necessary to satisfy GDC 63 requirements.

GHNEA Response

The level instruments on the surge tank provide for automatic makeup water from the Condensate Storage and Transfer System when the forced cooling trains are being used, but they are not designed to satisfy the requirements of GDC 63.

When forced cooling is not available, the surge tank level instruments become irrelevant and safety related cooling is provided by the heat-up and boiling of water in the SFP. In this situation, the requirements of GDC 63 are satisfied by the safety-related SFP level instruments, which will sound an alarm in the MCR on a low SFP water level. Because the safety-related cooling is provided by passive boil-off, these level instruments are not required to initiate any additional safety actions.

The response to RAI 9.1-9 addresses the heat loads and water inventory of the buffer pool. This pool does contain level instruments that will sound an alarm in the MCR when detecting a low pool level signal. This alarm provides an adequate level of safety considering the small amount of fuel, and excessive volume of water contained in the auxiliary pools.

No changes will be made to the DCD as a result of this RAI.

NRC RAI 9.1-18 S01

Supplement received via e-mail dated 5/3/07 from L. Quinones (NRC) to P. Jordan (GHNEA):

The response is insufficient. Provide a description of the SFP water level instrumentation including its location relative to the top of the fuel. Describe how will the operators respond to alarm during an accident.

GHNEA Response

There are redundant safety-related level instruments for the Spent Fuel Pool that provide level indication spanning the normal water level down to the top of the active fuel. In the event of an accident, no operator action is credited during the first 72 hours because sufficient water inventory exists to allow for 72 hours of boil off without exposing the top of the active fuel. Following 72 hours, the operator responds by replenishing the pools as necessary through the emergency connections to the Fire Protection System or an alternative water source.

DCD Impact

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

NRC RAI 9.1-18 S02

The RAI response was insufficient. The amount of water between the top of the active fuel and the SFP low level alarm must be specified to ensure that the operators are able to detect a condition that may result in a loss of decay heat removal or excessive radiation levels. Since the applicant stated that no operator actions are needed for 72 hours, the staff requests the applicant to demonstrate that the low level set point is set such that there are at least 72 hours before the top of active fuel is reached, assuming a loss of forced cooling during the maximum decay heat load conditions.

GEH Response

Included with this transmittal is a table of references. Refer to Reference 2 for a calculation of the worst-case boil-off in the SFP.

The analysis concludes that the maximum amount of boil-off that can occur in 72 hours is 1690 m^3. This would reduce the pool water height from its normal level of 14.35 m to 5.5 m. This leaves an excess of approximately 2.0 m of depth above the top of the active fuel (TAF).

Several alarm set points will be included at various depths in the pool. The specific elevations will be determined as part of the detailed design. However, at a minimum, the following set points will be provided:

Low level: A set point will be included just below the normal water level to alert operators of a loss of inventory with sufficient margin to still allow for 72 hours of boil-off without exposing TAF. The analysis in Reference 2 shows that after 72 hours of passive cooling, the water level in the SFP will be at least 2.0 m above TAF. Therefore an alarm could be located anywhere within the top 2.0 m of the pool height and still provide at least 72 hours advanced notice before the TAF could potentially be exposed.

Safe shielding level: In accordance with Regulatory Guide 1.13, a depth of water of 10 ft (3.05 m) above TAF is considered a sufficient margin for safe shielding. Providing an alarm at 3.05 m above TAF (with some margin) will alert operators to a loss in coolant elevation that may affect adequate shielding.

Elevation of the active fuel: To alert operators of a situation in which the TAF has become exposed.

DCD Impact

DCD Tier 2, Subsection 9.1.3 will be revised in Revision 5 as noted in the attached markup.

NRC RAI 9.1-41

DCD Tier 2, Rev. 3, Section 9.1.3.3 states that safety-related level instrumentation is provided in the spent fuel pool and the isolation condenser/passive containment cooling system (IC/PCC) pools to detect a low water level that would indicate a loss of decay heat removal ability in accordance with GDC 63. Discuss how these instrumentations' accuracy is effected {sic, affected} during boiling conditions in the associated pools.

GHNEA Response

The level instruments in the IC/PCC pools are located in the expansion pool area – away from the heat load which is restricted to the heat exchanger subcompartments. Because the boil off occurs in these subcompartments, coolant flows from the expansion pool into these compartments. Therefore, the level instruments for these pools are not subjected to boiling conditions that could affect their accuracy.

Boiling of water in the spent fuel pool (SFP) may introduce some inaccuracy in level measurement. However, because boiling decreases the density of the water, the level instruments can only indicate a water level that is less than the actual level. Therefore, the instruments conservatively err on the side of safety. Setpoint methodology considers the inaccuracy in level measurement when determining the setpoints for the needed actions.

DCD Impact

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

NRC RAI 9.1-41 S01

The RAI response indicates that boiling water in the spent fuel pool (SFP) may introduce some inaccuracy in water level, but any errors would be conservative. The staff is not clear as to how a decrease in density of water in the spent fuel pool will result in a conservative water level measurement. Provide a detailed description of the instrumentation to be used, including the elevation of the instrumentation taps in the SFP relative to the top of the active fuel, how it will be affected by the increase in temperature and the boiling conditions, and why this results in a conservative estimate.

GEH Response

Specific design of level instrument for the spent fuel pool has not been selected. This information will be determined as part of the detailed design.

The response to RAI 9.1-41 was intended to generically address the concern related to boiling in the spent fuel pool, changes in density, and the resultant effect on a common differential pressure type level indicator. To clarify:

Water at higher temperature (or water that is boiling) will be slightly less dense than cool water. If a differential pressure type level instrument were used, it would be located at the bottom of the pool, and it would function based on the mass of the water in the pool. As temperature rises, the density will decrease and the volume taken up by the pool water must increase because the mass has not changed. Therefore the instrument will still record the same level (same amount of mass acting on the instrument), but the actual level may have increased. This phenomenon could only result in an erroneously low reading, which is conservative from the standpoint of safety because it would trip low level alarms prior to actually reaching the low level.

Depending on the type of level instrument used, boiling in the pool may not need to be considered at all. However, the above example illustrates how pool boiling can be conservatively addressed in the design.

In order to ensure that the level instrumentation (regardless of the ultimate design and arrangement) can provide adequate monitoring and alarm capability, additional ITAAC description is included in Tier 1, Table 2.6.2-2, Item 9.

DCD Impact

DCD Tier 1, Table 2.6.2-2 will be modified for Revision 5 as shown in the attached markup.

GEH Proprietary Calculations/Analyses

Ref #	Title	eDRF Section
1)	Buffer Pool Boil-off & Make Up Capacity	0000-0076-3483
2)	Spent Fuel Pool Boil-off	0000-0038-9392 R3

The use of two containment isolation valves meets NRC GDC 56 requirement. The use of two air-operated outboard containment isolation valves also satisfies GDC 56 based on the allowable exception (Section II.6.d of SRP 6.2.4).

Containment isolation provisions that differ from the explicit requirements of GDC 56 are acceptable if the basis for the difference is justified. The exception for the suppression pool suction line is quoted in the SRP 6.2.4 Section II.6.d and is acceptable because an inboard valve would be submerged following a severe accident. In order to take credit for this alternate arrangement, the valve closest to containment shall be designed in accordance with SRP Section 3.6.2.

The containment isolation valves on the suppression pool supply and return lines are fail as-is on loss of electric power or the air supply. All other containment isolation valves are fail closed.

The Reactor Building and the Fuel Building provide adequate protection against natural phenomena for the safety-related components of the FAPCS as required by GDC 2 and GDC 4.

Safety-related level instrumentation is provided in the spent fuel pool and IC/PCC pools to detect a low water level that would indicate a loss of decay heat removal ability in accordance with GDC 63.

9.1.3.4 Testing and Inspection Requirements

The FAPCS is designed to permit surveillance test and in-service inspection of its safety-related components and components required to perform the post-accident recovery functions, in accordance with GDC 45 and ASME Section XI. The FAPCS is designed to permit leak rate testing of its components required to perform containment isolation function in accordance with 10 CFR 50 Appendix J.

9.1.3.5 Instrumentation and Control

System Instrumentation

Water Levels - The skimmer surge tank level is monitored by a level transmitter mounted on a local panel. The skimmer surge tank level is displayed in the MCR. In addition to level indication, this signal is used to initiate low and high water-level alarms and to operate the Condensate Storage and Transfer System makeup water control valve for the skimmer surge tank.

The IC/PCC pool has two local panel-mounted, safety-related level transmitters for both expansion pools. Both transmitter signals are indicated on the safety-related displays and sent through the gateways for nonsafety-related display and alarms. Both signals are validated and used to control the valve in the makeup water supply line to the IC/PCC pool.

The Spent Fuel Pool has two wide-range safety-related level transmitters that transmit signals to the MCR. These signals are used for water level indication and to initiate high/low-level alarms. At a minimum, alarm set points are included at the top of the active fuel, an adequate shielding level (3.05 m above TAF), and an elevation just below normal water level to give operators advanced notice of a loss of inventory but with sufficient margin to allow for 72 hours of pool boiling.

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The FAPCS functional arrangement is as described in Design Description of Subsection 2.6.2 and Figure 2.6.2-1.	Inspections of the as-built system will be conducted.	Inspection report(s) document that the as-built FAPCS configuration is as described in Subsection 2.6.2 and as shown on Figure 2.6.2-1.
2. The components and piping identified in Table 2.6.2-1 as ASME Code Section III are designed and constructed in accordance with ASME Code Section III requirements.	Inspection(s) will be conducted of the as-built FAPCS as documented in the ASME design reports.	Report(s) document that an ASME Code Section III design report(s) exist for the as-built components identified in Table 2.6.2-1 as ASME Code Section III.
3. Pressure boundary welds in components and piping identified in Table 2.6.2-1 as ASME Code Section III meet ASME Code Section III requirements.	Inspection(s) of the as-built pressure boundary welds will be performed in accordance with ASME Code Section III.	A report exists and documents that the ASME Code Section III requirements are met for non-destructive examination of pressure boundary welds.

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
4. The components and piping identified in Table 2.6.2-1 as ASME Code Section III retain their pressure boundary integrity at their design pressure.	i) A hydrostatic or pressure test will be performed on the components required by the ASME Code Section III to be tested.	i) A report exists and documents that the results of the pressure test of the components identified in Table 2.6.2-1 as ASME Code Section III conform with the requirements of the ASME Code Section III.
	ii) Impact testing will be performed on the containment and pressure-retaining materials in accordance with the ASME Code Section III to confirm the fracture toughness of the materials.	ii) A report exists and documents that the containment and pressure-retaining penetration materials conform with fracture toughness requirements of the ASME Code section III.
5. The seismic Category I equipment and piping identified in Table 2.6.2-1 can withstand seismic design basis loads without loss of structural integrity and safety function.	i) Type tests and/or analyses of seismic Category I equipment will be performed.	i) A report exists and documents that the seismic Category I equipment can withstand seismic design basis dynamic loads without loss of structural integrity and safety function.
	ii) Inspections will be performed for the existence of a report verifying that the as-installed equipment including anchorage is seismically bounded by the tested or analyzed conditions.	ii) The as-built equipment including anchorage is seismically bounded by the tested or analyzed conditions.
6. The containment isolation portions of the FAPCS are addressed in Tier 1, Subsection 2.15.1.	See Tier 1 Subsection 2.15.1.	See Tier 1 Subsection 2.15.1

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
7. The FAPCS performs the following nonsafety-related functions: a. Suppression pool cooling mode	Perform a test to confirm the flow path between the FAPCS to the suppression pools.	Test report(s) document that the cooling flow path is demonstrated and confirmed by operation of the function
b. Low-pressure coolant injection mode.	Perform a test to confirm the flow path from the FAPCS to the RWCU/SDC system.	Test report(s) document that the injection flow path is demonstrated and confirmed by operation of the function. The flowrate is ≥340 m^3/hr (1500 gpm) at a differential pressure of 1.03 MPa (150 psi).
c. External connection for emergency water to IC/PCC pool and Spent Fuel Pool from the Fire Protection System and offsite water supplies	Perform a test to confirm flow path and flow capacity from the Fire Protection System and offsite water sources to the pools.	Test report(s) document that the makeup water flow path is demonstrated and confirmed by operation of the function.
8. FAPCS minimum inventory of alarms, displays, and status indications in the main control room (MCR) are addressed in Section 3.3.	See Tier 1 Section 3.3.	See Tier 1 Section 3.3.

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
9. Level instruments with adequate operating ranges are provided for a. ~~the~~ Spent Fuel Pool, and b. IC/PCC pools.	Inspections of the FAPCS will be conducted to verify that level instruments with adequate operating ranges are provided for the Spent Fuel Pool and IC/PCC pools.	Inspection report(s) document that the as-built FAPCS provides Spent Fuel Pool and IC/PCC pool level instrumentation with adequate operating ranges. a. Instruments for the SFP accurately indicate pool level over the range from normal water level to the top of the active fuel. b. Instruments for the IC/PCC pools accurately indicate pool level over the range from normal water level to the midpoint of the IC heat exchanger tube.
10. Equipment qualification for the FAPCS is addressed in Tier 1 Section 3.8.	See Tier 1 Section 3.8.	See Tier 1 Section 3.8.