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MFN 06-309
Supplement 2

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 54 –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**

Enclosure 1 contains GHNEA's response to the subject NRC RAI transmitted via Reference 1 which is a supplemental request to the RAIs transmitted via Reference 2. The original response was submitted in Reference 3.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

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NRO

Reference:

1. E-mail request from L. Quinones (NRC) to P. Jordan (GHNEA) dated May 3, 2007. Subject: Supplemental RAI request for section 9.1.
2. MFN 06-302, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 54 Related to the ESBWR Design Certification Application*, August 23, 2006.
3. MFN 06-309, Letter from David Hinds to the U.S. Nuclear Regulatory Commission, *Partial Response to NRC Request for Additional Information Letter No. 54 Related to ESBWR Design Certification Application – Auxiliary Systems - RAI Numbers 9.1-12 through 9.1-26 and Amended Response to RAI Number 2.4-23 from NRC RAI Letter No. 32,* September 8, 2006.

Enclosure:

1. MFN 06-309 Supplement 2– Response to Portion of NRC Request for Additional Information Letter No. 54 – 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

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Enclosure 1

MFN 06-309
Supplement 2

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

For historical purposes, the original text of RAIs 9.1-9, 9.1-10, 9.1-11, 9.1-17, 9.1-18, and 9.1-19, and the GHNEA responses are included. To avoid confusion, DCD markup pages from these responses are not 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 9.1-10

DCD Tier 2, Section 9.1.3 states that each FAPCS cooling and cleanup (C/C) train has sufficient flow and cooling capacity to maintain the SFP bulk water temperature below 48.9°C (120°F) under normal heat load conditions and that, during the maximum SFP heat load conditions of a full core off-load plus irradiated fuel in the SFP resulting from 10 years of plant operations, both FAPCS C/C trains are needed to maintain the bulk temperature below 60°C (140°F). However, the DCD neither specifies the method of determining the associated heat load for each case nor the design heat removal capacity of each FAPCS C/C train.

The above capabilities are consistent with the guidance of SRP Section 9.1.3, Revision 3, July 1981, Criterion III.1.d, but Criterion III.1.h specifies a method of calculating the necessary heat removal capacity. Describe an acceptable method of demonstrating adequate heat removal capacity or identify administrative controls to be established by the COL applicant that maintain the heat load of stored irradiated fuel within the FAPCS C/C system heat removal capacity for the specified pool temperature.

GHNEA Response

SFP heat power as a function of time after shutdown is calculated using a GE-developed computer code based on the standards in ANSI/ANS-5.1-1994. Output of the calculation includes shutdown power & integrated shutdown power from fission products, actinides, and activation products. Consistent with the recommendations of SIL636, contributions from U-239 and Np-239 plus other actinides, as well as from activation products generated in the structural materials, are also included in the calculation. Validation of code outputs is through regeneration of the Tables in the ANSI/ANS-5.1-1994 Decay Heat Standard.

The scope of the calculation covers all requirements contained in SRP 9.1.3, Section III.1.h. 2σ conservatism is used to determine the decay heat values, which more than compensates for uncertainties in the calculation.

The FAPCS equipment heat removal capacity will be verified by performing a calculation to demonstrate that the pumps and heat exchangers are sized to accommodate the expected maximum heat loads and the required temperature limits are satisfied.

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

NRC RAI 9.1-10 S01

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

The response to RAI 9.1-10 is insufficient to determine the acceptability of FAPCS C/C as related to GDC-44. The applicant did not provide specific performance requirements (heat transfer capacity and flow rate) nor described a method for calculating the required cooling capacity. Provide the performance requirements as requested.

GHNEA Response

The FAPCS C/C trains are not used to satisfy GDC 44. Rather, GDC 44 is satisfied by passive pool boiling for 72 hours and subsequent makeup.

The SFP is designed with sufficient excess coolant to allow passive boil for 72 hours with the maximum heat load in the pool. The maximum heat load occurs when the pool contains its normal capacity (20 years of spent fuel) plus a full core offload.

DCD Impact

DCD Tier 2 Subsection 9.1.3.3 is to be modified for Revision 4 as shown in the attached markup.

NRC RAI 9.1-11

DCD Tier 1, Figure 2.6.2-1 indicates that the common emergency makeup header and the cooling system return lines extend below the normal water level in the SFP. DCD Tier 2, Section 9.1.3.2 states that anti-siphoning devices are used to prevent unintended drainage of the pools, but the minimum protected water level was not specified for the SFP. DCD Tier 2, Section 3.1.6.2 states that the spent fuel storage pool is designed with no penetrations below the water level necessary for adequate shielding at the operating floor, but the specific water level necessary for adequate shielding is not specified.

Consistent with the guidelines of SRP Section 9.1.3, Revision 1, July 1981, Criterion III.1.e, identify the minimum level reached in the SFP assuming a piping failure outside the pool boundary in lines extending below the normal water level.

GDC 61 requires the prevention of a significant reduction in storage pool coolant inventory under accident conditions. Because the emergency makeup function may be inoperable following a piping failure in the common makeup line and because even a small loss of inventory could result in a loss of forced circulation cooling, describe how adequate SFP cooling and adequate SFP water level for safe shutdown would be maintained for a piping failure in the common emergency makeup line.

GHNEA Response

The common emergency makeup header is not be submerged below the surface of the pool. DCD Tier 1, Figure 2.6.2-1, is not an accurate representation of pipe-routing, and the makeup header was drawn below the surface to clarify that the SFP is the pool where it will discharge its water – not because it will be physically submerged.

The cooling system return lines (from the active cooling and cleaning trains) are submerged below normal water level, and these lines require anti-siphoning provisions. Anti-siphon holes are located at the normal water level for all FAPCS cooling system discharge lines, thus preventing any significant draining in the event of a pipe break.

Because the SFP does not contain suction piping, these anti-siphon holes would ensure the water level would not drop below the normal elevation in the event of a piping failure.

In addition to the cooling return lines, the FAPCS has suction lines for the GDCS pools, Suppression Pool, and IC/PCCS pools. These lines also require anti-siphoning provisions. Suction lines cannot have holes at the normal water level, therefore the anti-siphon holes are included on all suction lines at the elevation of minimum water level for each respective pool.

In the event of an accident that results in a loss of FAPCS forced cooling, the emergency makeup line provides an adequate backup, which satisfies the requirements of Reg Guide 1.13 Section C.8. It is not necessary to postulate a passive failure of this emergency makeup header in addition to a loss of FAPCS normal cooling to satisfy the requirements of GDC 61. This piping is safety-related, seismic category I, and it operates very infrequently, outside containment, at low temperature and pressures.

The DCD is to be updated as follows to clarify that anti siphon holes are used to satisfy GDC 61.

DCD Tier 2, Section 9.1.3.2:
Anti-siphoning devices are used on all submerged FAPCS piping to prevent unintended drainage of the pools. The anti-siphoning holes for all FAPCS discharge lines are located at the elevation of normal water level to prevent significant draining of the pool in case of a suction line break at a lower elevation. The anti-siphoning holes in the suction piping of the Suppression Pool, GDCS Pools, and IC/PCCS C/C subsystem are located at the elevation of minimum water level to prevent significant draining of the pool in case of a suction line break at a lower elevation.

NRC RAI 9.1-11 S01

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

The response is acceptable; however, the DCD should be revised to reflect that the makeup header will not be submerged below the surface of the pool.

GHNEA Response

The DCD Tier 2, Subsection 9.1.3.2 is to be revised to incorporate the following statement:

"The emergency makeup lines to the Spent Fuel Pool and IC/PCC Pools are not submerged below the normal water level."

DCD Impact

Subsection 9.1.3.2 is to be revised in DCD Tier 2 Revision 4 as noted in the attached markup.

NRC RAI 9.1-17

DCD Tier 2, Table 9.3-2 identifies that the fuel and reactor buildings have sumps to collect waste water from equipment and floor drains. Clarify how leakage from the storage pools and the FAPCS piping is detected and how the capacity of leakage collection devices and drains is assured to be adequate consistent with the guidance of SRP Section 9.1.3, Revision 3, July 1981, Criterion III.3.a.

GHNEA Response

Leakage from Fuel Storage Pools: Leakage channels are provided behind each weld of the fuel pool liners to collect leakage. All leakages are channeled to headers and drain lines from which they are routed to a small collection tank with level sensing devices. Tank level and leakage inflow information is displayed in the Main Control room with an alarm feature to prompt the operator for action if abnormal leakage occurs.

Flow rates are monitored as well. The radioactive contaminated liquid is then piped to the Equipment and Floor Drainage System (EFDS) sumps and is then processed as described in DCD Tier 2 Section 9.3.3 – Equipment and Floor Drainage System. The FAPCS is to be detailed in the next phase of design.

Leakages from other FAPCS components such as pumps, valves, etc., go directly to Equipment and Floor Drainage System sumps for collection and routing to Radwaste System for appropriate processing as described in DCD Tier 2 Section 9.3.3.

There are no changes to DCD Tier 2 Rev 1 as a result of this RAI.

NRC RAI 9.1-17 S01

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

Revise the DCD to include this information.

GHNEA Response

Information regarding pool liner weld leak detection for the FAPCS is included in Revision 3 of the DCD Tier 2, Subsection 9.1.3.2. Leak detection and collection for other FAPCS components such as pumps and valves is provided by the Equipment and Floor Drains System as discussed in DCD Tier 2, Subsection 9.3.3.

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 9.1-19

DCD Tier 2, Section 9.1.3 states that the FAPCS is designed to provide post accident recovery (defense-in-depth) functions of suppression pool cooling, low pressure coolant injection drywell spray, and alternate shutdown cooling, which all take suction from the suppression pool. Section 9.1.3 also states that the SFP cooling mode of the FAPCS may be initiated following an accident to cool the SFP for accident recovery. Describe how adequate net positive suction head is assured for these functions, consistent with the guidance of SRP Section 6.2.2, Revision 4 October 1985, assuming the respective pool is at saturation temperature for the pressure at its surface.

GHNEA Response

The FAPCS pumps are located approximately 14 meters below the bottom of the suppression pool, which is significantly higher available NPSH than exists for pumps performing these same functions in most BWRs. When the detailed pump design is performed, the available NPSH will be taken into account.

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

NRC RAI 9.1-19 S01

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

The response is insufficient to meet 10 CFR 52.47 which requires the application to include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the NRC, and procurement specifications and construction and installation specifications by an applicant. Provide a NPSH analysis, as requested.

GHNEA Response

Most of the FAPCS functions are nonsafety-related and an NPSH analysis for all operating modes is performed as part of the detailed design as required by the ITAAC in DCD Tier 1 Table 2.6.2-1 item 4.

The FAPCS modes that are classified as RTNSS can be shown to have more than adequate NPSH based on the following rationale:

The RTNSS functions of Low Pressure Coolant Injection (LPCI) and Suppression Pool Cooling (SPC) take suction from the Suppression Pool and either return to the

suppression pool or discharge to a depressurized RPV. The floor of the Suppression Pool is located approximately 16.3m above the floor of the FAPCS pump room. To account for the elevation of the pump nozzle centerline above the floor, a difference of 15m is assumed. A comparison between the FAPCS pump and any other pump in an existing plant operating at conditions similar to those found in LPCI or SPC mode show that an NPSH on the order of 3m to 5m is sufficient to deliver a comparable flow rate. Therefore, because the provided NPSH (15m) bounds the required NPSH by such an excessive margin, adequate NPSH is assured.

DCD Impact

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

automatically initiated during normal operation in response to a high temperature signal from the suppression pool.

Low Pressure Coolant Injection (LPCI) Mode - This mode may be initiated following an accident after the reactor has been depressurized to provide reactor makeup water for accident recovery. In this mode the FAPCS pump takes suction from the suppression pool and pumps it into the reactor vessel via RWCU/SDC loop B and then Feedwater loop A.

Alternate Shutdown Cooling Mode – This mode may be initiated following an accident for accident recovery. In this mode, FAPCS operates in conjunction with other systems to provide reactor shutdown cooling in the event of loss of other shutdown cooling methods. FAPCS flow path is similar to that of LPCI mode during this mode of operation. Water is drawn from the suppression pool, cooled and then discharged back to the reactor vessel via the LPCI injection flow path. The warmer water in the reactor vessel rises and then overflows into the suppression pool via two opened safety-relief valves on the main steam lines, completing a closed loop for this mode operation.

Drywell Spray Mode - This mode may be initiated following an accident for accident recovery. During this mode of operation, FAPCS draws water from the suppression pool, cools and then spays the cooled water to drywell air space to reduce the containment pressure.

9.1.3.3 Safety Evaluation

The FAPCS is a Nonsafety-Related system except for the portions of the system that establish flow paths necessary for

- The interface with safety-related RWCU/SDC piping;
- The supply of emergency makeup water to the Spent Fuel Pool and IC/PCCS pools following an accident; and
- The system's containment isolation function.

The SFP is designed to dissipate the maximum fuel decay heat through heat up and boiling of the pool water. The most conservative heat load for the SFP occurs when the pool contains spent fuel from 20 years of operation plus one full core offload. The pool water performs the safety-related heat removal function stipulated in GDC 44. Upon loss of power, the Fuel Building HVAC isolates the fuel building as described in Subsection 9.4.2.5. Steam generated by boiling of the SFP is released to the atmosphere through a relief panel in the Fuel Building. Water inventory in the SFP is adequate to keep the fuel covered through 72 hours, thereby avoiding heat up of the fuel and the potential for fission product release. Engineered safety feature atmosphere cleanup systems and associated guidance described in RG 1.52 are not provided in the ESBWR design as indicated in Subsection 15.4.1.4.1. The Fuel Building does not house any safety-related equipment, subject to flooding, as stated in Subsection 3.4.1.4.3. Sufficient reserve capacity is maintained on-site to extend the safe shutdown state from 72 hours through 7 days ensuring compliance with GDC 61. Post 72-hour inventory makeup is provided via safety-related connections to the Fire Protection System and to offsite water sources.

radioactive contamination of these pools. The subsystem consists of one pump, one heat exchanger, and one water treatment unit.

FAPCS contains two containment isolation valves on the lines that penetrate the primary containment. One isolation valve is located inside the containment and the other isolation valve is outside the containment. For added reliability, the suppression pool suction and return lines shall branch to form parallel flow paths as they penetrate containment. The suppression pool return line shall branch outside containment, and both parallel flow paths shall have one isolation valve outside and one isolation valve inside containment. The suppression pool supply line shall branch inside containment and each parallel flow path shall have two isolation valves in series outside containment. It is acceptable to locate both valves outside of containment because

An isolation valve inside the drywell would be submerged under water during severe accident conditions.

All outboard valves shall be located as close as possible to the containment boundary. This arrangement with two outboard valves in series is in accordance with the criteria in SRP 6.2.4 section II.6.d (see Table 1.9-20).

Pipes equipped with normally closed manual valves are provided for establishing flow paths from off-site emergency water supplies or the Fire Protection System to refill the IC/PCCS pools and Spent Fuel Pool following a design basis loss of coolant accident.

Anti-siphoning devices are used on all submerged FAPCS piping to prevent unintended drainage of the pools. The anti-siphoning holes for all FAPCS discharge lines are located at the elevation of normal water level to prevent significant draining of the pool in case of a suction line break at a lower elevation. The anti-siphoning holes in the suction piping of the Suppression Pool, GDCS Pools, and IC/PCCS C/C subsystem are located at the elevation of minimum water level to prevent significant draining of the pool in case of a suction line break at a lower elevation. The emergency makeup lines to the Spent Fuel Pool and IC/PCC Pools are not submerged below the normal water level.

The spent fuel pool is equipped with drainage paths behind the liner welds. These paths are designed to:

- Prevent stagnant water buildup behind the liner plate;
- Prevent the uncontrolled loss of contaminated pool water; and
- Provide liner leak detection and measurement.

The reactor well, dryer/separator pool, buffer pool, upper and lower fuel transfer pools, cask pool, and IC/PCCS pools are also equipped with stainless steel liners, and shall be equipped with leak detection drains as part of the FAPCS. All leak detection drains are designed to permit free gravity drainage to the Liquid Waste Management System.

The containment isolation valves and other equipment required for the post-accident recovery function are provided with electric power from reliable power supplies. In the event of loss of off-site power, these electric power supplies are automatically connected to the on-site power sources. The electrical power supplies, control and instrumentation of the two FAPCS trains and their supporting systems are divisionally separated. Pneumatic power assisted containment isolation valves on the suppression pool supply and return lines are designed to fail as-is upon