GE-Hitachi Nuclear Energy Americas LLC

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

MFN 06-216 Supplement 3
October 16, 2007

Docket No. 52-010

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. 34 Related to ESBWR Design Certification Application Standby Liquid Control System RAI Number 9.3-5 S02.**

The purpose of this letter is to submit the GE-Hitachi Nuclear Energy Americas (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent via Reference 3 which supplemented Reference 2. The original RAI response was submitted in response to NRC letter dated June 22, 2006, Reference 1. GEH response to RAI Number is addressed in Enclosure 1.

Should you have any questions about the information provided here, please contact me at 910-675-5057 or jim.kinsey@ge.com.

Sincerely,

Kathy Sedney for

James C. Kinsey
Vice President, ESBWR Licensing

D068
NRO

References:

1. NRC letter to David Hines, Manager, ESBWR, *Request For Additional Information Letter No. 34 Related To ESBWR Design Certification Application*, dated June 22, 2006 (MFN 06-216).
2. E-mail 12/1/06 from A. Cubbage to RAI List, Accession Number ML070670068.
3. E-mail 6/26/07 from L. Quinones to D. Lewis et-al, Accession Number ML072150013.

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 34 Related to ESBWR Design Certification Application Standby Liquid Control System RAI Number 9.3-5 S02.

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	eDRF	0000-0073-7310

Enclosure 1

MFN 06-216 Supplement 3

Response to Portion of NRC Request for

Additional Information Letter No. 34

Related to ESBWR Design Certification Application

Standby Liquid Control System

RAI Numbers 9.3-5 S02

For historical purposes, the original text and GE response to RAIs 9.3-5 and 9.3-5 S01 are included.

NRC RAI 9.3-5

Since SLCS is part of the ECCS, General Design Criteria (GDC): 2 (Seismic design), 5 (Sharing among units), 17 (Electric power), 27 (Capability to cool the core), 35 (Emergency core cooling), 36 (Inspection of ECCS) and 37 (Testing of ECCS) apply. Include application of these GDC in the DCD. Also, add 10 CFR 50.46, in regard to the ECCS being designed so that its cooling performance is in accordance with an acceptable evaluation model. We understand that the above GDC are included in DCD Section 6.3 for ECCS, but for clarity, refer to them in the corresponding sections of the DCD describing the individual ECCS systems.

Explain in detail how the SLCS meets GDC 4, as related to dynamic effects associated with flow instabilities and loads.

GE Response

DCD Tier 2, Rev. 1, Subsection 9.3.5.3 (page 9.3-12) references the applicability of Section I (Overall Requirements) of the GDC to the SLCS. This covers GDC 2, 4 and 5. Conformance with GDC 27 is also addressed in the DCD at the same location.

With respect to the remaining GDC cited in this RAI (GDC 17, 35, 36, 37 and 10 CFR 50.46), GE will add the following text to Subsection 9.3.5.3 (Safety Evaluation):

"For its function to provide makeup water to the RPV during a LOCA, the SLCS is designed to meet the requirements of GDC 17, 35, 36 and 37 and 10 CFR 50.46 in conjunction with the other ECCS systems. Conformance to these criteria is discussed in Section 6.3, Emergency Core Cooling Systems."

The statement in DCD Tier 2, Rev. 1, Section 6.3 regarding conformance to GDC 4 relating to dynamic effects associated with flow instabilities and loads (e.g., water hammer) is primarily directed to the GDCS. The GDCS functions at low pressure and does not have pumps or other equipment that will generate high differential pressures internal to its piping that can cause water hammer loads to be generated. Thus, the GDCS design eliminates the flow instabilities and water hammer loads that plants in the current operating fleet may experience with pump-driven ECCS systems.

For the SLCS, the discharge piping will be designed to accommodate the water hammer loads generated by the fast-opening squib valves and high pressure accumulator.

DCD Tier 2 Subsection 9.3.5.3 will be revised in the next update as noted above.

NRC RAI 9.3-5 S01

The staff requested in RAI 9.3-5 that GE explain in detail how the standby liquid control system (SLCS) meets General Design criteria (GDC) 4. The staff understands that compliance with GDC 4 is implied by reference to compliance with the General Requirements as indicated in the DCD, page 9.3-12; however, the staff is concerned that equipment and piping located near the SLCS piping that extends from the SLCS rooms to the reactor vessel penetration may present the hazard of missiles from pipe whipping associated with proximity to other high energy pipe lines. The staff is also concerned about water hammer loads generated by the fast-opening squib valves and high pressure accumulator. Please update the DCD specifically to reference GDC 4 and to address these related concerns.

GE Response

DCD, Tier 2, Revision 3, Subsection 9.3.5.3 states: "Because the SLC system is located within its own compartment inside the Reactor Building, it is adequately protected from flooding, tornadoes, and internally/externally generated missiles. The SLC system equipment is protected from pipe break by providing adequate distance between the Seismic Category I and non-seismic SLC equipment, where such protection is necessary. In addition, appropriate distance is provided between the SLC system and other high energy piping systems." The path of the small bore (3") SLCS injection line has not been determined. During future detailed engineering, the pipe is routed and analyzed in order to prevent or mitigate the potential dynamic effects from high-energy piping systems in order to satisfy the requirements of GDC4.

To prevent water hammer, the injection valves are arranged at the lowest point, and the injection line is continuously vented at the injection nozzle inside the vessel (4mm vent hole). This maintains the injection line full of water at all times and provides reasonable assurance that water hammer is prevented. There are no adverse affects on SLC operation from the vent hole because it is located inside the vessel.

DCD Impact

No DCD changes have been made in response to this RAI.

NRC RAI 9.3-5 S02

GE's supplemental response to RAI 9.3-5 is unacceptable. The staff specifically indicated that a reference to GDC 4 and an indication of compliance therewith is necessary in the DCD. If the path of the Standby Liquid Control System (SCLS) injection line has not yet been determined, the staff can resolve this issue under one of the following two circumstances:

1. The applicant establishes acceptance criteria to establish that "appropriate distance is provided between SLCS and other high energy piping systems," (quote from DCD Tier 2, Rev. 3, Subsection 9.3.5.3) and establishes a corresponding ITAAC, or

2. Confirmation that the SLCS injection line is "routed and analyzed in order to prevent or mitigate the potential dynamic effects from high-energy piping systems in order to satisfy the requirements of GDC 4" as a COL action item (applicant/holder as necessary).

Update DCD to discuss the approach to compliance with GDC 4.

GEH Response

The SLC system complies with GDC 4. A statement is being added to DCD Tier 2, Subsection 9.3.5.3 for Revision 5 that discusses the system's compliance with GDC 4.

DCD Impact

DCD Tier 2, Subsection 9.3.5.3 will be revised as noted in the attached markup of Revision 5.

9.3.5.3 Safety Evaluation

The SLC system is mainly a reactivity control system that is maintained in an operable status whenever the reactor is critical. A large number of independent control rods are available to shutdown the reactor including redundant and diverse methods to insert the control rods, at any time during the core life.

Availability of the SLC system is ensured by redundancy in the injection valves. Adequate functioning of the system is ensured if one of the two injection valves open in each train. No other function is required for proper system operation. Addition of nitrogen to recover gas pressure after initial injection is not necessary for adequate functioning of the system.

The system is designed to bring the reactor from rated power to a cold shutdown condition at any time in core life. The reactivity compensation provided reduces reactor power from rated to zero and allows cooling of the nuclear system to less than the cold shutdown temperature with the control rods remaining withdrawn in the rated power pattern. These conditions (hot shutdown and cold shutdown) include, where applicable, the reactivity gains that result from complete decay of the rated power xenon. They include the positive reactivity effects from eliminating steam voids, changing water density from hot to cold, reduced Doppler effect in uranium, reducing neutron leakage from boiling to cold, and decreasing control rod worth as the moderator cools.

The minimum uniformly mixed equivalent concentration of natural boron required in the reactor core to provide adequate cold shutdown margin after operation of the SLC system is 760 ppm. Calculation of the minimum quantity of isotopically enriched sodium pentaborate to be injected into the reactor is based on the required 760 ppm equivalent natural boron concentration in the reactor coolant at 20°C (68°F) and reactor water level conservatively taken at the elevation of the bottom edge of the main steam lines. This result is then increased by a factor of 1.25 to provide a 25% general margin to discount potential non-uniformities of the mixing process within the reactor. This result is then increased by a factor of 1.15 to provide a further margin of 15% to discount potential dilution by the RWCU/SDC System in the shutdown cooling mode.

Cooldown of the nuclear system requires a minimum of several hours to remove the thermal energy stored in the reactor, reactor water, and associated equipment. The limit for the reactor vessel cooldown is 55.6°C/hr (100°F/hr) and the normal operating temperature is approximately 288°C (550°F). Use of the main condenser and the shutdown cooling systems normally requires 10 to 24 hours to decrease the reactor vessel temperature to 20°C (68°F). Although hot shutdown is the condition of maximum reactivity, cold shutdown condition is associated with the largest total water mass in which the particular shutdown concentration must be established and therefore, this condition determines the total mass of boron solution to be injected.

The extremely rapid initial rate of isotopically enriched boron injection ensures that hot shutdown boron concentration is achieved within several minutes of SLC system initiation based on initial reactor water inventory. Maintaining normal water level with the voids collapsed causes some dilution of this concentration but does not cause hot shutdown concentrations to be violated. As the reactor cools and begins to depressurize, completion of all boron solution injection occurs long before cold shutdown conditions are reached. The high injection velocity of the injection spargers and the natural circulation flow within the reactor vessel ensures efficient mixing and distribution of the boron throughout the reactor vessel.

The SLC system is designed to conform with the requirements for equivalent reactivity control capacity specified in 10 CFR 50.62(c)(4).

The SLC system equipment is Safety-Related for injection of boron solution into the reactor is designed as Seismic Category I for withstanding the specified earthquake loadings (refer to Section 3.7). The system piping and equipment are designed, installed, and tested in accordance with the requirements stated in Section 3.9.

The safety functions of the SLC system are powered from the Class 120 VAC electrical systems. Environmental conditions to prevent precipitation of solute do not require operation of the Reactor Building HVAC systems during the time that SLC operation is required.

The initial accumulator tank inventory of compressed nitrogen is adequate to ensure full injection of the boron solution inventory at a reactor pressure of 6.9 MPa (1000 psia). After the boron injection is complete, the redundant shut-off valves close to prevent the injection of nitrogen into the reactor vessel. A single shut-off valve is sufficient to prevent nitrogen from entering the reactor vessel. Protection against inadvertent premature operation of the shut-off valve is ensured by use of redundancy in the initiation signal for this function.

The SLC system is evaluated against the applicable General Design Criteria (GDC) as follows:

The SLC system is designed to conform to the GDC of 10 CFR 50. The overall requirements (Section I) of the GDC are applicable to the system, and the system equipment has been designed and installed in conformance with the presentations in Chapter 3. For its function to provide makeup water to the RPV during a LOCA, the SLC system is designed to meet the requirements of GDC 17, 35, 36 and 37 and 10 CFR 50.46 in conjunction with the other ECC systems. Conformance to these criteria is discussed in Section 6.3, Emergency Core Cooling Systems. Other related GDCs are presented individually below:

Criterion 4, Environmental and Dynamic Effects Design Bases: Due to its location inside the Reactor Building, within its own compartment, the SLC system is protected from internally and externally generated missiles. The system piping is routed and analyzed, so that an appropriate distance is provided between it and other high-energy piping. To prevent, or mitigate the dynamic effects of the discharging fluid (i.e. water hammer), the injection line is designed with proper venting. The system components are qualified for the range of environmental conditions postulated for their location.

Criterion 26, Reactivity Control System Redundancy and Capability: The FMCRD system is the intended means for normal operational control of reactivity. Anticipated operational occurrences initiate the hydraulic scram function and rapidly insert all rods to ensure a safe limit on reactivity changes. These systems are capable of safely accommodating all reactivity changes from the normal power range (including xenon influences) to cold shutdown conditions. The SLC system is redundant to these functions and represents a diverse means for reactor shutdown to ensure the ability to bring and maintain the core to such critical conditions for the full range of reactor conditions from hot shutdown to cold shutdown.

Criterion 27, Combined Reactivity Control Systems Capability: Operation of the SLC system is not required to meet the intent of this criterion. The system could, for many conditions exceeding the design basis of the plant, provide additional reactor shutdown capability to ensure achieving shutdown conditions.

Criterion 28, Reactivity Limits: This criterion applies only to the reactivity control systems intended for normal operation.

The SLC system is evaluated against the applicable regulatory guides as follows:

Regulatory Guide 1.26, Quality Group Classifications and Standards: Because the SLC system is an ECC system, all mechanical components required for boron injection are at least Quality Group B. Those portions that are part of the reactor coolant pressure boundary are Quality Group A.

Regulatory Guide 1.29, Seismic Design Classification: All components of the SLC system necessary for injection of the boron solution into the reactor are Seismic Category I.

SRP Branch Technical Positions SPLB 3-1 and EMEB 3-1: Because the SLC system is located within its own compartment inside the Reactor Building, it is adequately protected from flooding, tornadoes, and internally/externally generated missiles. The SLC system equipment is protected from pipe break by providing adequate distance between the Seismic Category I and non-seismic SLC equipment, where such protection is necessary. In addition, appropriate distance is provided between the SLC system and other high energy piping systems. This system is used in ATWS events presented in Section 15.5. The ATWS events are extremely low probability postulated events.