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MFN 09-761, Revision 1

Docket No. 52-010

January 27, 2010

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Revised Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6 – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S05**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) revised response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) 9.1-20 S05 sent by NRC Letter 391, Reference 1. The original response to this RAI was provided via Reference 2. The response to RAI Number 9.1-20 S04 was previously submitted to the NRC via Reference 3 in response to Reference 4.

GEH response to RAI Number 9.1-20 S05 is addressed in Enclosure 1. Enclosure 2 contains the DCD markups associated with this response.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 09-725, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6*, November 9, 2009
2. MFN 09-761, Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6 - Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S05, December 4, 2009
3. MFN 09-546, Response to Portion of NRC Request for Additional Information Letter Number No. 340 Related to ESBWR Design Certification Application – Fuel and Auxiliary Pool Cooling System - RAI Numbers 9.1-20 S04, August 14, 2009
4. MFN 09-397, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application*, June 9, 2009

Enclosures:

1. Revised Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6 – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S05
2. Revised Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6 – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S05 – DCD Markups

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	eDRF Section	0000-0110-3877, Revision 1

Enclosure 1

MFN 09-761, Revision 1

Revised Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6

Fuel and Auxiliary Pool Cooling System

RAI Number 9.1-20 S05

NRC RAI 9.1-20 S05

The design specifications provided in the ESBWR DCD, Tier 1 Table 2.6.2 and Tier 2 Table 9.1-8 appear to only pertain to the fuel and auxiliary pool cooling system (FAPCS) heat exchangers being able to remove 8.3 MW of heat from the suppression pool, while the probabilistic risk assessment (PRA) credits FAPCS with being able to remove approximately 34 MW of heat under accident conditions. In previous RAI responses, the applicant has indicated that MAAP runs have shown that if the differential temperature were high enough across the heat exchanger primary to secondary boundary and if the flow was sufficiently high on the secondary side, then 34 MW could be removed by a heat exchanger. While this is true mathematically, it does not assure that the heat exchanger physically can withstand the effects of such high temperatures (e.g., voiding, seal failure, water hammer, thermal expansion) or that the associated FAPCS pumps can handle the thermal effects (e.g., net positive suction head (NPSH) issues).

Provide a write up in the DCD (Chapter 9.1 and Chapter 19, Tier 2) that provides reasonable assurance that the FAPCS heat exchangers and pumps will be capable of removing the assumed heat load credited in the ESBWR PRA, NEDO-33201, Rev. 4. The writeup should address the 34 MW (and its associated MAAP runs) and the maximum temperatures (including differential temperature) calculated for the FAPCS heat exchanger. DCD Section 9.2 should also address how the 34 MW FAPCS heat load is handled by the FAPCS support systems. For example, the write-up should address revisions to DCD Table 9.2-3, "RCCWS Nominal Heat Loads," Table 9.2-5, "RCCWS Configuration by Mode," and Table 9.2-1, "PSWS Heat Loads." The Tier 1 PSWS interface requirements should be evaluated and modified as appropriate to be consistent with the changes made to DCD Section 9.2 in response to this RAI.

GEH Revised Response (Revision 1)

Many of the concerns described in this RAI were addressed in the response to the previous supplement (Letter MFN 09-546, dated August 14, 2009), though GEH can provide some additional clarification.

As explained in Supplement 4, the heat exchanger and pumps are designed to physically withstand the higher-than-normal temperatures associated with the PRA analysis, and DCD Tier 2 Subsection 9.1.3.2 was modified as part of that response to make this an explicit requirement. In order to provide additional assurance, language will be added to clarify that the differential temperature between the hot and cool side will be taken into account in the heat exchanger design. This limiting differential temperature is determined to be 76°K based on the maximum FAPCS temperature (91°C) and the minimum RCCWS temperature (15°C) as defined by Table 9.2-4.

An additional clarifying statement will also be added to DCD Tier 2 Subsection 19A.4.2 to explain the concept by which the FAPCS heat exchanger (described in terms of nominal rated performance in DCD Tier 2 Table 9.1-8) can remove as much as 34 MW at higher differential temperatures, and to state that the heat exchanger can accommodate these differential temperatures.

DCD Tier 2 Section 9.2 is not an appropriate place to describe RCCWS and PSWS beyond design basis scenarios. This part of the DCD describes the design basis, and Chapter 19 explains how to take credit for system capacity beyond this design basis, if necessary. This is also the reason DCD Tier 2 Table 9.1-8 does not discuss FAPCS heat loads beyond the 8.3 MW design basis.

There is no need to take any additional credit for PSWS or RCCWS capacity beyond the design basis requirements in Chapter 9. DCD Tier 2 Table 9.2-3 indicates that a single train of RCCWS can accommodate as much as 50.5 MW of heat removal. This bounds the 34 MW being rejected by FAPCS in the PRA Analysis.

It is also worth noting that for the purpose of this PRA analysis, FAPCS is the RTNSS system credited with removing heat from containment and not the Reactor Water Cleanup / Shutdown Cooling (RWCU/SDC) System. Therefore, in this PRA scenario, decay heat is rejected only through FAPCS; meaning that the RCCWS will not simultaneously receive heat from RWCU/SDC at the same time FAPCS is performing its severe accident heat removal. A brief statement will be added to DCD Tier 2 Subsections 9.2.1.1 and 9.2.2.1 stating that the design basis requirements of these support systems are sufficient to satisfy beyond design basis criteria described in Chapter 19.

The discussion in Chapter 19 will be expanded to note that the RCCWS can accommodate the severe accident heat load from FAPCS without any need to credit anything beyond its design-basis capabilities. By extension, no special consideration is needed to credit PSWS operating beyond its design basis. Therefore, no changes or clarifications are needed for DCD Tier 2 Tables 9.2-1 or 9.2-3. Table 9.2-5 describes various heat load combinations to the RCCWS during normal operation, and does not factor into this discussion.

Regarding other concerns mentioned in this RAI, DCD Tier 2 Table 9.1-8 describes available NPSH to the FAPCS pumps. The calculation that determined this NPSH margin conservatively assumed that the process fluid was at a temperature of 100°C even though it normally will not exceed 48.9°C. This conservative assumption for NPSH bounds even the temperatures considered in the PRA analysis. Because sufficient NPSH has been provided for the beyond design basis scenario, the pumps will not be subject to voiding or water hammer.

DCD Impact

The following DCD Subsections will be modified as noted in the attached DCD Markups:

Tier 2, Subsection 9.1.3.2

Tier 2, Subsection 9.2.1.1

Tier 2, Subsection 9.2.2.1

Tier 2, Subsection 19A.4.2

Enclosure 2

MFN 09-761, Revision 1

Revised Response to Portion of NRC Request for Additional Information Letter No. 391 Related to Design Control Document (DCD) Revision 6

Fuel and Auxiliary Pool Cooling System

RAI Number 9.1-20 S05

DCD Markups

Fuel and Auxiliary Pool Cooling and Cleanup Mode - During a refueling outage, one or both FAPCS cooling and cleanup trains are placed in this mode of operation to cool and clean the water in the Spent Fuel Pool and pools listed below depending on the heat load condition in these pools.

Markup to DCD Tier 2, Subsection 9.1.3.2

- Upper fuel transfer pool;
- Buffer pool;
- Reactor well; and
- Dryer and separator storage pool.

Once the core decay heat has dropped to a manageable level, this mode can be used as an alternate to the shutdown cooling function of the RWCU/SDC System.

During this mode of operation, water is drawn from the skimmer surge tanks, pumped through the heat exchanger and water treatment unit to be cooled and cleaned and then returned to these pools. When necessary, a portion or all of the water may bypass the water treatment unit.

IC/PCCS Pool Cooling and Cleanup Mode –The FAPCS-IC/PCCS pool cooling and cleanup subsystem is placed in this mode as necessary during normal plant operation. During this mode of operation, water is drawn via a common suction header from each IC/PCCS subcompartment. Water is cooled and cleaned by the IC/PCCS pool cooling and cleanup subsystem and is then returned to the two expansion pools through a common line that branches and discharges deep into each pool.

GDCS Pool Cooling and Cleanup Mode – One train of the FAPCS cooling and cleanup subsystem that is not operating in Spent Fuel Pool cooling mode is placed in this mode as necessary during normal plant operation. Water is drawn from GDCS pools A and D in this mode of operation. The water is cooled and cleaned and is then returned to GDCS pool B/C. The water level in GDCS pool B/C rises and the water is cascaded and discharged at a submerged location in the adjacent GDCS pools A and D during this mode of operation.

Suppression Pool Cooling and Cleanup Mode – One of the FAPCS cooling and cleanup trains that is not operating in Spent Fuel Pool cooling mode is placed in this mode as necessary during normal plant operation. Water is drawn from the suppression pool and is cooled and cleaned and then returned to the suppression pool in this mode of operation. This mode may be manually initiated following an accident to cool the suppression pool for accident recovery. This mode may also be automatically initiated during normal operation in response to a high temperature signal from the suppression pool. The portions of the FAPCS needed for suppression pool cooling are designed to accommodate severe accident wetwell pressures as high as 411 kPa (59.6 psia), and severe accident differential temperatures resulting from suppression pool water temperatures as high as 91.0°C (196°F) with the RCCWS cooling water restricted to the ~~same values~~minimum value described in Table 9.2-~~41~~-8. ~~and severe accident wetwell pressures as high as 411 kPa (59.6 psia).~~

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. Alternatively, a

9.2 WATER SYSTEMS

9.2.1 Plant Service Water System

9.2.1.1 Design Bases

Safety Design Bases

The Plant Service Water System (PSWS) does not perform any safety-related function. There is no interface with any safety-related component.

The PSWS has RTNSS functions as described in Appendix 19A, which provides the level of oversight and additional requirements to meet the RTNSS functions. Performance of RTNSS functions are assured by applying the defense-in-depth principles of redundancy and physical separation to ensure adequate reliability and availability as described in Subsection 19A.8.3. The design basis capabilities of the PSWS are sufficient to meet the RTNSS performance requirements described in Chapter 19A.

The PSWS meets the requirements of GDC 2 as it pertains to Position C.2 of RG 1.29. The PSWS also meets the intent of GDC 2 as it pertains to Position C.1 of RG 1.29.

The PSWS meets the intent of the acceptance criteria of GDC 4 for normal operation, maintenance, and testing. The PSWS meets the intent of the acceptance criteria of GDC 4 with respect to dynamic effects associated with water hammer. The PSWS is vented at components and high points vents and operation and maintenance procedures are used to assure sufficient measures are taken to avoid water hammer. The PSWS also meets the intent of the acceptance criteria of GDC 4 for other dynamic effects, including the effects of missiles, jet impingement, pipe whipping, and discharging fluids, as clarified by the following design considerations:

- Pipe routing;
- Piping design considerations, such as material selection, pipe size and schedule;
- Protective barriers as necessary; and
- Appropriate supports and restraints.

The PSWS meets GDC 5 for shared systems and components important to safety. The PSWS Standard Plant design does not share any structure, system, or component (SSC) with any other unit.

Although the PSWS is a nonsafety-related system, it meets the intent of certain acceptance criteria of GDCs 44, 45 and 46, as clarified by the following design considerations:

- Capability of transferring heat loads from SSCs to a heat sink under normal and accident conditions;
- Component redundancy so the system remains functional assuming a single active failure coincident with a loss of offsite power;
- Capability to isolate components or piping so system function is not compromised; and
- Design provisions to permit inspection and operational testing of components and equipment.

The pump discharge strainers have remote manual override features for their automatic cleaning cycle. Pressure drop across the strainer is indicated in the MCR and a high-pressure drop is annunciated in the control room.

Supply and return header temperatures and supply header pressure are indicated in the MCR.

Each TCCWS and RCCWS heat exchanger has a pressure differential transmitter to indicate the pressure drop across the heat exchangers. In addition, a discharge flow transmitter is placed after each RCCWS and TCCWS heat exchanger. Flow elements and transmitters in the PSWS provide monitoring of system flow in the MCR and can be used to assist in leak detection.

This PSWS instrumentation conforms with GDC 13. Refer to Subsection 3.1.2.4 for a general discussion of the GDC.

9.2.1.6 COL Information

9.2.1-1-A Material Selection

The COL Applicant will determine material selection, including the need for valve hard seat material, and provide provisions to preclude long-term corrosion and fouling of the PSWS based on site water quality analysis (Subsection 9.2.1.2).

9.2.1.7 References

9.2.1-1 RG 1.29 "Seismic Design Classification"

9.2.1-2 ANSI/HI 2.6 (M108) American National Standard for Vertical Pump Tests

9.2.2 Reactor Component Cooling Water System

9.2.2.1 Design Bases

Safety Design Bases

The RCCWS does not perform any safety-related function. Therefore, the RCCWS has no safety design basis.

The RCCWS has RTNSS functions as described in Appendix 19A, which provides the level of oversight and additional requirements to meet the RTNSS functions. Performance of RTNSS functions is assured by applying the defense-in-depth principles of redundancy and physical separation to ensure adequate reliability and availability as described in Subsection 19A.8.3. The design basis capabilities of the RCCWS are adequate to meet the RTNSS performance requirements described in Chapter 19A.

The RCCWS meets the requirements of GDC 2 as it pertains to Position C.2 of Reg. Guide 1.29. The RCCWS also meets the intent of GDC 2 as it pertains to Position C.1 of Reg. Guide 1.29.

The RCCWS meets the intent of the acceptance criteria of GDC 4 for normal operation, maintenance, and testing. The RCCWS meets the intent of the acceptance criteria of GDC 4 with respect to dynamic effects associated with water hammer. The RCCWS has high point vents and operation and maintenance procedures assure sufficient measures are taken to avoid water hammer. The RCCWS also meets the intent of the acceptance criteria of GDC 4 for other safe shutdown earthquake (SSE). Only passive safety-related systems are credited in the seismic event tree. In addition, FPS is classified as nonsafety-related but is designed so that the diesel driven pump in the Fire Pump Enclosure (FPE), the FPS water supply, the FPS suction pipe from the water supply to the pump, one of the FPS supply pipes from the FPE to the Reactor Building, and the FPS connections to the FAPCS remain operable following a seismic event. Piping and components completely separate from FAPCS pool cooling piping provide flow paths for post-accident make-up water transfer to the IC/PCCS pools and spent fuel pool. The piping and components are designed to meet Quality Group C and Seismic Category I requirements. Therefore, there are no seismic-related candidates for RTNSS consideration.

19A.4.2 Assessment of Uncertainties

The ESBWR PRA addresses passive system thermal-hydraulic uncertainty issues in a systematic process that identifies potential uncertainties in passive components or thermal-hydraulic phenomena and then applies an appropriate treatment to the component to ensure that the uncertainties are treated conservatively.

Passive system thermal-hydraulic uncertainties manifest themselves in the PRA model within failure probabilities and success criteria. Passive components that must rely on natural forces, such as gravity, have lower driving forces than conventional pumped systems so additional margin is incorporated into the design. Some passive functions are based on new engineering design, with limited operating experience to establish confidence in the failure rate estimates. The PRA models the effectiveness of passive safety functions in the failure rate estimated and success criteria that are factored into the event trees. Assessing the event tree success criteria in the PRA model identifies thermal-hydraulic uncertainties. Sensitivity studies show that the PRA results are not sensitive to changes in success criteria.

There are also uncertainties associated with the manual alignment and operation of long-term decay heat removal systems identified under RTNSS Criterion B. These uncertainties can influence the results such that there is a challenge to the CDF and LRF goals in transient sequences. This is not an issue for low frequency scenarios, such as large LOCA or seismic events.

In order to address uncertainties in the performance of passive systems, an active system with the capability to provide backup functions is added to the scope of RTNSS. The portions of FAPCS (Subsection 9.1.3.2) that provide low pressure injection and suppression pool cooling are added in the scope for RTNSS. These FAPCS modes of operation are chosen because they provide a diverse method of core cooling and containment heat removal using active components.

Using the design parameters for the FAPCS heat exchanger found in Table 9.1-8, analysis shows that additional capacity can be credited in which elevated suppression pool temperature results in a higher differential temperatures in the heat exchanger such that the heat transfer rate increases to as much as 34 MW, which is sufficient to prevent containment failure during a beyond design basis accident.

The support systems needed for FAPCS are: Reactor Component Cooling Water System (RCCWS), standby diesel generators, standby diesel generator auxiliary systems (including standby diesel generator fuel oil storage and transfer system), PIP buses, Electrical Building HVAC (to cool the standby diesel generators and the PIP buses), RCCWS and Fuel Building

HVAC (to cool the FAPCS pumps), Nuclear Island Chilled Water (to cool HVAC), and Plant Service Water System (PSWS) (to cool the RCCWS). These support systems are in scope for RTNSS Criterion C and their design basis capacity is sufficient to accommodate the beyond design basis performance of FAPCS described above. The FAPCS trains are physically and electrically separated such that no single active component failure can fail the function. This provides the CDF and LRF reduction needed to address the PRA uncertainty concerns associated with the performance of passive system components.

19A.4.3 PRA Initiating Events Assessment

The At-Power and Shutdown PRA models have been reviewed to determine whether non-safety SSCs could have a significant effect on the estimated frequency of initiating events. The following screening criteria are imposed on the at-power and shutdown initiating events:

(1) Are nonsafety-related SSCs considered in the calculation of the initiating event frequency?

(2) Does the unavailability of the nonsafety-related SSCs significantly affect the calculation of the initiating event frequency?

(3) Does the initiating event significantly affect CDF or LRF for the baseline PRA?

If the answer to all three of these questions is "Yes," then the non-safety SSC is a RTNSS candidate. The results are discussed below.

19A.4.3.1 At-Power Generic Transients

Initiating events that are considered Generic Transients are listed in Subsection 19.2.3.1. Because several initiating events in this group are caused by the failures of nonsafety-related SSCs, screening questions 1, 2, and 3 are answered "Yes." However, this category of transient initiating events includes various failures of components or operator errors. No specific nonsafety-related systems have a significant effect on risk, and there are no RTNSS candidates from this category.

19A.4.3.2 At-Power Inadvertent Opening of a Relief Valve

SRVs are safety-related. Therefore, they are not RTNSS candidates.

19A.4.3.3 At-Power Transient with Loss of Feedwater

The initiating events in this group begin with a prompt and total loss of feedwater and require the success of other mitigating systems for reactor vessel level control. The SSCs related to feedwater and condensate are nonsafety-related, and thus Questions 1, 2, and 3 are answered "Yes." The loss of feedwater is a significant contributor to CDF, so the feedwater and condensate systems are RTNSS candidates. However, several features in the advanced design of the new generation feedwater level control system add significant reliability and, thus, a lower failure probability for loss of feedwater initiating events. The feedwater level control system is implemented on a triplicated, fault-tolerant digital controller. Therefore, a control failure is much less likely to occur in the ESBWR than in the design of current generation of reactors. Also, due to the capacity of the pumps and the digital control system capability, loss of a single feedwater pump does not cause a turbine trip or scram.