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MFN 09-546 Docket No. 52-010

August 14, 2009

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S04**

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) 9.1-115 S01 sent by NRC Letter 340, Reference 1. The response to RAI Number 9.1-20 S03 was previously submitted to the NRC via Reference 2 in response to Reference 3.

GEH response to RAI Number 9.1-115 S01 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

References:

1. 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
2. MFN 09-341, Response to Portion of NRC Request for Additional Information Letter Number No. 263, Related to ESBWR Design Certification Application – Auxiliary Systems - RAI Numbers 9.1-18 S03 and 9.1-20 S03, May 29, 2009
3. MFN 08-899, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 263 Related to ESBWR Design Certification Application*, November 6, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S04
2. Response to Portion of NRC Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application – Fuel and Auxiliary Pool Cooling System - RAI Number 9.1-20 S04 – DCD Markups

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Enclosure 1

MFN 09-546

Response to Portion of NRC Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application

Fuel and Auxiliary Pool Cooling System

RAI Number 9.1-20 S04

NRC RAI 9.1-24 S04

In RAI 9.1-20 S03, the staff asked GEH to provide the performance requirements of the Fuel and Auxiliary Pool Cooling System (FAPCS) trains in order for them to satisfy the PRA success criteria for the respective coolant injection and heat removal functions. In response, GEH included information from DCD Tier 2 Table 9.1-8 in Tier 1. However, GEH did not clarify how these numbers satisfy the PRA success criteria.

DCD Tier 2 Section 19A.4.2 identifies that the FAPCS suppression pool cooling mode is to provide a backup or diverse method of containment heat removal. Accident sequences (event trees) credit 1/2 train FAPCS in suppression pool cooling mode as complete back-up for the passive containment cooling system (PCCS), i.e., success of the FAPCS suppression pool cooling MODE after failure of PCCS avoids core damage.

DCD Tier 2 Table 9.1-8 identifies that the heat removal capacity of FAPCS (one train at design conditions) is 9.6 MW. DCD Tier 2 Table 9.2-3 also identifies 9.6 MW as the nominal heat load of the FAPCS system. However, DCD Tier 2, Figures 6.2-14c1 to 6.2-14c3 show much higher heat removal for the PCCS. Figure 6.2-14c1 shows heat removal of approximately 40 MW at 3 hours deceasing to 20 MW at 72 hours while Figure 6.2-14c2 shows it is above 50 MW for at least 500 seconds. NEDO-33301, Revision 3, Figure 8.3-1e shows PCCS heat removal of approximately 20 MW at 14 hours deceasing to 14 MW at the 72 hours. All of these values are well above the nominal heat removal capacity of one train of FAPCS. The DCD, in particular Section 9.1.3.2 and Tables 9.1-8 and 9.2-3, appears to address suppression pool cooling during normal operations but not the RTNSS function.

The staff notes that neither NEDO-33301 Section 4.7, FAPCS System Analysis, nor NEDO-33301 Section 8, Containment Performance, defines the performance requirements for the FACPS to perform its suppression pool cooling function.

1. Identify the performance requirements for FAPCS suppression pool cooling mode during accident conditions considered in the PRA. These should be included in DCD Tier 2 Chapter 9 and NEDO-33301.

2. As the DCD includes only nominal design information, show that the FAPCS and RCCWS can remove the heat as assumed in the PRA. If documented in internal GEH calculations, provide summary information (assumptions, results) in the RAI response.

3. Clarify whether the FAPCS can provide the heat removal function for all applicable scenarios evaluated in the PRA. If not, clarify this in the PRA and make applicable modifications to the PRA.

GEH Response

Note: The report "NEDO-33301" should be "NEDO-33201".

The DCD will be revised to more clearly state the FAPCS performance requirements, and correct areas where this value has been misrepresented. The value of 9.6 MW dates from earlier in the design, when it was necessary to use a conservative bounding value to describe components such as the FAPCS heat exchanger for which only minimal design work had been completed.

The intention of Table 9.1-8 is to serve as a "benchmark" for the heat exchanger performance, so that a nominal performance is clearly stated for the system's main responsibility of spent fuel pool (SFP) cooling, but with the understanding that the actual amount of heat transfer is dependent on the flow rates and temperatures of the pool water and the cooling water.

As described in the response to RAI 9.1-10 S02 (transmitted via Letter MFN 06-309, Supplement 8, December 14, 2007), the SFP heat load is limited to 8.3 MW during normal operation. More recent design work has been performed on the FAPCS heat exchanger that concludes a nominal heat transfer rate of 8.3 MW is achievable with an optimal flow rate of 2500 gpm (567.8 m^3/hr) and with the pool at it's upper temperature limit of 48.9°C and the cooling water at it's upper temperature limit of 35°C. Therefore, Table 9.1-8 will be revised to clearly describe the above parameters as the "nominal" performance values for the FAPCS heat exchanger. These parameters will also be used to supersede the values being introduced to Tier 1 by the previous supplement to this RAI.

Also, the value of 9.6 MW that appears in Table 9.2-3 for FAPCS heat load will be replaced with the revised value.

1) The revised Table 9.1-8 represents the nominal performance requirements of the FAPCS pump and heat exchanger. A separate set of performance requirements specific to suppression pool cooling mode are not included in the DCD because they can be estimated from the nominal values contained in Table 9.1-8 as described in Item 2 below.

2) The suppression pool cooling mode of FAPCS was evaluated for its contribution to the PRA success criteria using MAAP (see response to RAI 9.1-20 S02, transmitted via Letter MFN 06-309, Supplement 8, December 14, 2007). The analysis has been updated to reflect the parameters in the revised Table 9.1-8. The MAAP runs model the FAPCS heat exchanger design parameters and the results reflect an increased heat transfer rate as suppression pool temperatures exceed the rated value of 48.9°C. The results of the MAAP runs show maximum suppression pool cooling heat rates of 27 - 34 MW with maximum suppression pool temperatures reaching 87.5 – 91.0°C (190 – 196°F). The corresponding drywell peak pressures are 162 – 411 KPa

(23.5 – 59.6 psia). Furthermore, the analysis shows that even with the heat exchanger degraded by 29%, the system is still able to keep the suppression pool below 100°C. The result of the PRA analysis demonstrates that FAPCS can remove heat from the suppression pool at a rate sufficient to prevent the containment from reaching its ultimate pressure rating.

3) The FAPCS is capable of providing heat removal for the scenarios in which it is credited in the PRA. A statement will be added to DCD Tier 2 Subsection 9.1.3.2 to confirm that the FAPCS is designed for the temperatures and pressures expected for suppression pool cooling during a severe accident.

DCD Impact

The following DCD Tables and Sections will be modified as shown in the attached DCD markup:

Tier 1, Table 2.6.2-2

Tier 2, Subsection 9.1.3.2

Tier 2, Table 9.1-8

Tier 2, Table 9.2-3

Enclosure 2

MFN 09-546

Response to Portion of NRC Request for Additional Information Letter No. 340 Related to ESBWR Design Certification Application

Fuel and Auxiliary Pool Cooling System

RAI Number 9.1-20 S04

DCD Markups

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	iii.) Inspection and analyses will be performed for the existence of a report to verifying that the as-installedas-built equipmentcomponents identified in Table 2.6.2-1,including anchorage, is seismically bounded by the testinged or analyzed conditions.	iii). A report exists and concludes that tThe as-installedas-built equipmentcomponents identified in Table 2.6.2-1, including anchorage, is seismically bounded by thehas been tested or analyzed under the conditions necessary to ensure compliance with Seismic Category I design requirements.
6. The containment isolation portions of the FAPCS are addressed in Tier 1, Subsection 2.15.1.(Deleted)	See Tier 1 Subsection 2.15.1.	See Tier 1 Subsection 2.15.1
7a. The FAPCS performs the following nonsafety-related suppression pool cooling functions.: a. Suppression pool cooling mode	i. Perform a test to confirm the flow path and minimum flowrate between the FAPCS to and the suppression pools.	i. Test report(s) document that tThe cooling flow path is demonstrated and confirmed by operation of the function. The flow rate is ≥ 545.1567.8 m³/hr (1998.422500 gal/min).

Table 2.6.2-2

ITAAC For The Fuel and Auxiliary Pools Cooling Cleanup System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	ii. Perform a type test to confirm the heat transfer capacity of the FAPCS heat exchanger.	ii. The design heat removal capacity of a single FAPCS train is ≥ 8.3 MW under the following conditions: • Primary and secondary side flow rate of 567.8 m^3/hr (2500 gpm) • Process inlet temperature of 48.9ºC (120ºF) • Cooling water inlet temperature of 35ºC (95ºF)
7b. The FAPCS performs the nonsafety-related Llow-pressure coolant injection modefunctions.	Perform a test to confirm the flow path and minimum flowrate [AH1117]from the FAPCS to the RWCU/SDC system.	Test report(s) document that tThe injection flow path is demonstrated and confirmed by operation of the function. The flowrate is ≥340 m3/hr (1500 gal/pmmin)[AH1118] at a differential pressure of ≥ 1.03 MPa (150 psi) and < 1.05 MPa (152 psi).
7c. The FAPCS provides the nonsaftey-realted eExternal connection for emergency water to IC/PCC pool and Spent Fuel Pool from the Fire Protection System and offsite water supplies functions.	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 tThe makeup water flow path and flow capacity (see ITAAC Table 2.16.3-2, Item 7) are demonstrated and confirmed by operation of the function.

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 temperatures as high as 91.0°C (196°F) 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 separate motor-driven pump in the fire pump enclosure can take suction from the fire protection storage tank and pump water into the reactor vessel via a tie in with the primary LPCI flow path.

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 post-accident makeup water to the Spent Fuel Pool and IC/PCCS pools following an accident; and
- The system's containment isolation function. (Subsection 6.2.4.3.2)

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~~FB HVAC isolates the ~~fuel building~~FB 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~~FB. 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 credited by the FAPCS in the ESBWR design as indicated in Subsection 15.4.1.4.1. The ~~Fuel Building~~FB does not house any safety-related equipment, subject to flooding, as stated in

Table 9.1-8

Design Parameters for FAPCS System Components

Main Pumps	
Number of Pumps	2
Pump Type	Centrifugal
Drive Unit	Constant Speed Induction Motor
Flow Rate	~~545.1~~567.8 m^3/hr (~~2400~~ 2500 gpm)
NPSH Available	13.0 m (42.65 ft)
Heat Exchangers	
Number of units	2
Heat Removal Capacity	~~9.6~~8.3 MW (at ~~design~~ rated conditions)
Seismic	Category II design and analysis
Heat Exchanger Type	Shell & Tube or Plate
Maximum Pressure ~~(tube side)~~	2.0 MPag (290 psig)
Performance Data	
(1) Flow (~~tube~~ hot side)	~~545.1~~567.8 m^3/hr (~~2400~~ 2500 gpm)
(2) Flow (~~shell~~ cold side)	~~545.1~~567.8 m^3/hr(~~2400~~ 2500 gpm)
(3) ~~Design~~ Rated Inlet Temp (tube side)	48.9ºC(120ºF)
(4) Maximum Inlet Temp (shell side)	35.0ºC(95ºF)

Table 9.2-3

RCCWS Nominal Heat Loads

Normal Operation		
Nominal Heat Load Contributions		
RWCU/SDC:	9.6 MW	32.8 MBtu/hr
FAPCS:	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
CWS:	12.3 MW	41.9 MBtu/hr
Diesel Generator	0 MW	0 MBtu/hr
Other:	2.3 MW	7.8 MBtu/hr
Total Trains A & B:	~~33.8~~32.5 MW	~~115~~ 111 MBtu/hr
Normal Cooldown [2]		
Nominal Heat Load Contributions (Train A)		
RWCU/SDCS:	28 MW	95.6 MBtu/hr
FAPCS:	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
CWS:	12.3 MW [1]	41.9 MBtu/hr
Other	1.9 MW	6.5 MBtu/hr
Diesel Generator A	0 MW	0 MBtu/hr
Total Train A:	~~51.8~~50.5 MW	~~177~~ 172 MBtu/hr
Nominal Heat Load Contributions (Train B)		
RWCU/SDC:	28 MW	95.6 MBtu/hr
FAPCS	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
Diesel Generator B	0 MW	0 MBtu/hr
Other:	1.5 MW	5.1 MBtu/hr
Total Train B:	~~39.1~~37.8 MW	~~133~~ 129 MBtu/hr
Total Train A&B:	~~90.9~~88.3 MW	~~310~~ 301 MBtu/hr

Table 9.2-3

RCCWS Nominal Heat Loads (Continued)

Cooldown with LOPP		
Nominal Heat Load Contributions (Train A)		
RWCU/SDC:	28 MW	95.6 MBtu/hr
FAPCS:	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
CWS:	12.3 MW [1]	41.9 MBtu/hr
Other	1.9 MW	6.5 MBtu/hr
Diesel Generator A	15 MW	51.1 MBtu/hr
Total Train A:	~~66.8~~65.5 MW	~~228.1~~223.4 MBtu/hr
Nominal Heat Load Contributions (Train B)		
RWCU/SDC:	28 MW	95.6 MBtu/hr
FAPCS	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
Diesel Generator B	15 MW	51.1 MBtu/hr
Other:	1.4 MW	4.8 MBtu/hr
Total Train B:	~~54~~ 52.7 MW	~~184.3~~179.8 MBtu/hr
Total Train A&B:	~~120.8~~118.2 MW	~~412.2~~403.2 MBtu/hr
Single Failure Cooldown (Extended Cooldown)		
Nominal Heat Load Contributions (Train A or B)		
RWCU/SDC:	36 MW	123 MBtu/hr
FAPCS:	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
CWS:	12.3 MW	41.9 MBtu/hr
Diesel Generator	0 MW	0 MBtu/hr
Other:	1.9 MW	6.5 MBtu/hr
Total Train A or B:	~~59.8~~58.5 MW	~~204~~ 200 MBtu/hr

Table 9.2-3
RCCWS Nominal Heat Loads (Continued)

Single Failure Cooldown w/ LOPP [3]		
Nominal Heat Load Contributions (Train A or B)		
RWCU/SDC:	36 MW	123 MBtu/hr
FAPCS:	~~9.6~~8.3 MW	~~32.8~~28.3 MBtu/hr
CWS:	12.3 MW	41.9 MBtu/hr
Diesel Generator	15 MW	51.1 MBtu/hr
Other:	1.9 MW	6.5 MBtu/hr
Total Train A or B:	~~74.8~~73.5 MW	~~255.2~~250.8 MBtu/hr

1 [1] Total CWS Heat Load shown is applicable to Train A or B, or shared between the two trains.

2 Normal Shutdown Cooling such that the reactor coolant temperature is reduced to 60°C (140°F) in 24 hours.

3 Design Limiting Condition - Reach cold shutdown conditions of 93.3°C (200°F) in 36 hours.