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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 54 Related to ESBWR Design Certification Application – 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**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter. Also, an amended related response to NRC RAI 2.4-23 previously provided in GE's Reference 2 letter.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-302, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 54 Related to ESBWR Design Certification Application,* August 23, 2006
2. MFN 06-226, Letter from David Hinds to U.S. Nuclear Regulatory Commission, *Response to NRC Request for Additional Information Letter No. 32 Related to ESBWR Design Certification Application – Hydrological Engineering – RAI Numbers 2.4-3 through 2.4-31,* July 31, 2006

Enclosure:

1. MFN 06-309 – Response to Portion of NRC Request for Additional Information Letter No. 54 Related to ESBWR Design Certification Application – 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

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Enclosure 1

MFN 06-309

Response to Portion of NRC Request for

Additional Information Letter No. 54

Related to ESBWR Design Certification Application

Chapter 9 - 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

NRC RAI 9.1-1

DCD Tier 2, Section 9.1.4 states that two fuel preparation machines are mounted on the wall of the spent fuel pool and are used to assist in the loading of new fuel into the spent fuel storage pool racks and for channeling and rechanneling of new and spent fuel assemblies. Section 9.1.4 also states that the new fuel inspection stand supports two fuel bundles contained in a mechanically driven inspection carriage. DCD Tier 2, Tables 3.2-1 and 9.1.4-1 do not specifically describe the qualification of these structures.

Describe the seismic qualification of the fuel preparation machines and the new fuel inspection stand and the basis for the qualification level. Define the basis for the seismic qualification with regard to maintenance of a subcritical array. For the fuel preparation machine, also address protection of stored spent fuel and protection of spent fuel pool (SFP) integrity.

GE Response

Fuel Preparation Machine.

The fuel preparation machine is to be seismically analyzed as a Seismic Category II to maintain its structural integrity during an SSE event to prevent possible damage to the pool structure or adjacent fuel storage racks. Table 9.1-4 (See attached) will be revised accordingly. Each machine is separated from the other by a significant distance. The fuel handling machine is only capable of handling one fuel assembly near the fuel preparation machine. If the fuel handling machine should bring a fuel assembly adjacent to a fuel assembly in the fuel preparation machine, two fuel assemblies are insufficient to form a critical array and they will remain subcritical.

New Fuel Inspection Stand

The new fuel inspection stand is in a pit. There are no adjacent structures or equipment that could be damaged should the equipment fail during a seismic event. Relative to seismic classification the new fuel inspection stand will be classified as non-seismic (NS).

See attached DCD changes for Table 9.1-4.

NRC RAI 9.1-2

DCD Tier 2, Section 9.1.5.5 states that the reactor building (RB) crane is interlocked to prevent movement of heavy loads over the fuel pools. However, Section 9.1.1 states that, should it become necessary to move major loads along or over the pools, administrative controls require that the load be moved over the empty portion of the buffer pool and avoid the area of the new fuel racks. Describe the administrative controls governing bypassing of the RB crane interlocks and handling of heavy loads over the buffer pool.

GE Response

This will remain as a COL Holder item. Heavy load handling safe load paths and routing plans, including descriptions of automatic and manual interlocks and safety devices and procedures to assure safe load path compliance, will be provided as part of the COL Holder response.

There are no identified DCD changes.

NRC RAI 9.1-3

DCD Tier 2, Section 9.1.2.3 states that the fuel storage racks provided in the SFP in the fuel building (FB) provide for storage of irradiated fuel assemblies resulting from 10 calendar years of plant operation plus one full core off load. Section 9.1.2.3 also states that the fuel storage racks in the RB buffer pool deep pit can hold a total of 154 spent fuel assemblies.

Standard Review Plan (SRP), Section 9.1.2, Revision 3,July 1981, Criterion III.1, provides guidance indicating high-density storage would be reviewed on a case-by-case basis. If high-density storage (i.e., storage configurations where solid neutron absorbers are necessary to satisfy reactivity limits) is necessary to achieve the indicated storage capacity in either the SFP or the buffer pool, provide justification for the reduced cooling effectiveness relative to low-density storage. Clarify whether any fuel rack storage locations will be used for storage of irradiated components other than fuel. Finally, describe how the size of the SFP and the buffer pool as defined in DCD Tier 1 drawings were verified to accommodate the specified storage capacities.

GE Response

It is anticipated that the spent fuel storage racks in the fuel building and the RB buffer deep pool pit will be a high density fuel storage rack design. Low density is not, nor has been a design basis for ESBWR.
The number of fuel assemblies to be stored (10 calendar years plus one full core offload) determines the required capacity of the FAPCS as well as the number of fuel storage cells.

FAPCS
The discussion of the bulk cooling capability of the FAPCS is discussed in Section 9.1.3.

Fuel Storage Racks
For the Tier 1 drawings, the size of the spent fuel storage racks and hence the pool is based on typical high density fuel storage rack designs with typical fuel to fuel spacing that includes the fuel assembly at expected maximum bow and bulge, associated neutron absorbers, and any additional structural material. For the FB building fuel storage pool, with a typical pitch-to-pitch spacing determined, an array is developed to accommodate the required number of fuel assemblies based on the pitch and the expected number of fuel assemblies to meet the design basis for number of discharged fuel bundles. Similarly for the RB deep pit the size is based on the pitch except a specific number, 154, was chosen based on historical information regarding the nominal number of fuel bundles that might be expected to be temporarily removed during a fuel shuffle/reload.

The racks are analyzed for cooling as follows. Using the FAPCS system capacity the racks are designed to handle the heat load from the expected number of fuel bundles to be discharged. The hydraulic resistance of the rack[s] with fuel is determined. Natural circulation is assumed.

No forced flow under the rack is assumed. Based on natural circulation and inlet conditions at the bottom of the rack, the exhaust temperature of an individual cell is determined. Additionally the rack array in relation to the pool walls, floors, downcomers, and weir drains is determined. Based on FAPCS flow input volume, temperature, position, and output position a bulk analysis of the racks is performed.

The fuel storage racks are not designed to accommodate items other than fuel.

There are no identified DCD changes.

NRC RAI 9.1-4

DCD Tier 2, Section 9.1.2.4 states that the racks include individual solid tube storage compartments, which provide lateral restraints over the entire length of the fuel assembly or bundle, and lead-in guides at the top of the storage spaces provide guidance of the fuel during insertion.

The guidance of SRP 9.1.2, Revision 3, July 1981, Criterion III.2.b states that the storage racks should be designed such that a fuel assembly cannot be inserted anywhere other than in a design location. Clarify how the rack design precludes storage of fuel in unanalyzed locations.

GE Response

There are no unanalyzed locations within a fuel rack or array of racks.

Individual racks are spaced less than one fuel assembly apart so that a fuel assembly cannot be inserted between racks. In the event that a fuel assembly is lowered adjacent to an exterior rack, this configuration is analyzed.

There are no identified DCD changes

NRC RAI 9.1-5

DCD Tier 2, Section 9.1.2.4 lists possible loads affecting the racks including a postulated stuck fuel assembly causing an upward force. However, the load combinations considered in the design of the racks as listed in Section 9.1.2.4 do not include such an upward force. Clarify how crane uplift forces from a stuck fuel assembly were considered in the rack design.

GE Response

The load combinations listed refer to the dynamic analysis. The uplift force analysis is a separate calculation and not combined with the dynamic analysis.

The condition of a stuck fuel assembly will be discussed in a subsequent revision of Section 9.1.1 and 9.1.2. and SRP 3.8.4, Appendix D is added as reference document as it contains all required load combinations including stuck fuel lift forces. See RAI 9.1-3.

There are no identified DCD changes.

NRC RAI 9.1-6

DCD Tier 2, Section 9.1.2.4 states that the SFP is a reinforced concrete structure with a stainless steel liner, and the fuel storage racks and the pool liner embedments are designed to meet Seismic Category I requirements. DCD Tier 2, Table 3.2-1 lists the fuel racks, the reactor building, and the fuel building as structures designed to Seismic Category I.

The guidance of SRP Section 9.1.2, Revision 3, July 1981,Criterion III.2.a states that the spent fuel storage facility including the storage pool, pool liner, and racks have been classified and designed to Seismic Category I requirements. Clarify whether the SFP and buffer pool liners are designed to Seismic Category I requirements. Describe the loading conditions and the thermal stresses used in evaluating liner integrity. If the pool liner structures are not designed to Seismic Category I requirements, address the potential for events listed in SRP Section 9.1.2, Revision 3, July 1981, Criterion III.2.b.

GE Response

The Fuel Building Spent Fuel Pool and Reactor Building Buffer Pool liners and liner anchors are designed to Seismic Category I requirements. The loads and load combinations are the same as the pool concrete structure as defined in DCD Table 3.8-15, except that load factors for all cases are equal to 1.0 and the acceptance criteria follow ASME Section III, Division 2, CC-3700. Thermal stresses are considered in the load combinations that include thermal loads.

DCD Section 9.1.2.4 will be revised in a future update as shown in the attached markup.

NRC RAI 9.1-7

DCD Tier 2, Sections 3.1.6.2 and 5.4.8.2.2 describe that cooling of the SFP can be backed up from one train of the reactor water cleanup (RWCU)/shutdown cooling (SDC) system. However, DCD Tier 1, Figures 2.6.1-1and 2.6.2-1 show only an interface with the RWCU/SDC system for the low pressure coolant injection mode of the fuel and auxilliary pool cooling system (FAPCS). Clarify the capability of the RWCU/SDC system to provide backup cooling of the SFP.

GE Response

The reactor water cleanup / shutdown cooling system (RWCU/SDC) does not support cooling of the spent fuel pool. The FAPCS only interfaces with RWCU at the low pressure coolant injection (LPCI) line and at one of the reactor well skimmer lines.

Any references to RWCU/SDC cooling of the SFP will be deleted from the DCD. The following changes will be made to the DCD:

DCD Tier 2, Section 3.1.6.2:
The nonsafety-related Fuel and Auxiliary Pools Cooling System (FAPCS) normally removes decay heat from fuel storage pools. Without the active cooling trains of the FAPCS, the safety-related method of cooling the spent fuel is to allow the spent fuel pools to boil. Sufficient pool water inventory is provided to permit boiling for several days without makeup. If required, makeup water is provided from on site sources for up to at least 7 days from the fire protection system (FPS). Safety-related FAPCS piping is used to transport makeup water to the spent fuel pool from FPS (for at least 7 days) and from a connecting point (also safety-related) in the yard area to portable water sources (see sub-section 9.1.2.2).

DCD Tier 2, Section 5.4.8.2.2:
Refueling — The RWCU/SDC system can be used to provide additional cooling of the reactor well water when the RPV head is off in preparation for removing spent fuel from the core.

NRC RAI 9.1-8

DCD Tier 2, Section 3.1.6.2 states that the safety-related method of cooling the spent fuel is to allow the SFP to boil. Sufficient pool water inventory is provided to permit pool boiling for several days without makeup.

GDC 44 requires that a means be provided to transfer heat under accident conditions to an ultimate heat sink (UHS), and GDC 61 requires that fuel storage systems be designed with residual heat removal capability having reliability and testability consistent with its importance to safety. GDC 61 also specifies that the fuel storage systems be designed to prevent a significant reduction in fuel storage pool inventory under accident conditions. The guidelines of SRP Section 9.1.3,Revision 3, July 1981, Criterion II.1, describe that either a safety-related forced cooling system or a combination of safety-related makeup and ventilation systems may be used to satisfy the residual heat removal requirements under accident conditions.

Describe how the SFP decay heat is transferred to a UHS under accident conditions (i.e., pool boiling) and how essential equipment is protected against the environmental effects of pool boiling. The response should address ventilation of water vapor to the environment,mitigation of offsite releases of radioactivity consistent with the guidelines of Regulatory Guide (RG) 1.52, and condensation of water vapor and the potential resultant flooding that could adversely affect safety-related systems in the fuel building and adjacent areas.

GE Response

The SFP is designed to dissipate fuel decay heat through heat up and boiling of the pool water. 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 (the ultimate heat sink) 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.

DCD Section 9.1.3.3 will be revised in a future update as shown in the attached markup.

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.

GE 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 9.1-10

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.

GE 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 & 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 was 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 9.1-11

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.

GE Response

The common emergency makeup header will 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 & 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 even 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 will be 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 will be updated as follows to clarify that anti siphon holes will be 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 9.1-12

DCD Tier 2, Section 9.1.3 states that pipes equipped with normally closed manual valves are provided for establishing flow paths from off-site emergency water supplies or the fire protection system (FPS) to refill the isolation condenser (IC)/passive containment cooling system (PCCS) pools and SFP following a design basis loss of coolant accident. DCD Table 3.2-1 indicates this piping is safety-related, Seismic Category I, and Quality Group C. DCD Tier 2, Section 1D.4 states that the COL applicant will identify other readily accessible and suitable volumes of water. However, the necessary characteristics of these water supplies are not specified. In addition, DCD Tier 2, Section 9.5.1 states that the FPS performs no safety-related function, and DCD Tier 2, Table 3.2-1 indicates that the fire protection piping is designed to Quality Group D or lower and the fire pump enclosure is non-seismic.

The quality and seismic design guidelines of SRP Section 9.1.3, Revision 1, July 1981 and RG 1.13 specify that the primary SFP makeup system be permanently installed and designed to Seismic Category I, Quality Group C standards. As the identified permanently installed emergency makeup system, describe how the FPS satisfies the guidance of SRP 9.1.3 and RG 1.13.

If not permanently installed, SRP Section 9.1.3 and RG 1.13 specify that the backup system be supplied from a seismic Category I source of water. Specify the design criteria for the water sources to be identified in resolving the COL action item.

GE Response

DCD Tier 2, Section 1D.1, Criterion B states that the Fire Protection System provides on-site makeup water capability from 72 hours to 7 days, after which time either on-site or offsite makeup sources can be used. This function of the FPS is considered to be RTNSS rather than safety-related due to it not being required in less than 72 hours. Thus, the statement in DCD Tier 2, Section 9.5.1 is correct when it says FPS performs no safety-related functions.

The components associated with providing makeup water from FPS were assigned to Quality Group D on the basis that this was a RTNSS function rather than a safety-related function. RG 1.26 indicates that Quality Group C applies to safety-related components. In accordance with Paragraph II.1.a of SRP 9.1.3, GE will modify the quality group classification for the Seismic Category I FPS components supporting the spent fuel pool makeup water function to Quality Group C. All other non-seismic FPS components will retain their current Quality Group assignment.

The skid-mounted SC I fire pumps (as well as their related piping and accessories) would all be mounted to the SC I concrete slab that forms the roof of the EBAS. The fire pump enclosures (FPEs) would therefore have nothing attached to them that are SC I. Thus, the FPEs themselves could be SC II, and could be standard insulated sheet-metal on metal frame buildings that are

typical for these types of enclosures in commercial construction. DCD Table 3.2-1 will be modified to show the fire pump enclosures as SC II.

Paragraph C.8 of RG 1.13 states "Appropriate redundancy or a backup system for filling the pool from a reliable source, such as a lake, river, or onsite seismic Category I water-storage facility, should be provided." DCD Tier 2 Section 1D.4 will be modified as shown in the attached markup to require the COL applicant to ensure the backup makeup system uses a reliable water source as defined in RG 1.13.

NRC RAI 9.1-13

DCD Tier 2, Section 9.1.3 states that pipes equipped with normally closed manual valves are provided for establishing flow paths from off-site emergency water supplies or the FPS to refill the IC/PCCS pools and SFP following a design basis loss of coolant accident. DCD Tier 1, Figure 2.6.2-1 indicates that the emergency makeup connections and the makeup water supply from the fire protection system each pass through a single isolation valve into a common header in the FAPCS for makeup to the SFP or to IC/PCCS pools.

Clarify how the makeup water necessary for residual heat removal is assured, consistent with the requirements of GDC 34, GDC 38, and GDC 61, assuming a single active failure.

Specify the characteristics of any pumps used with the COL applicant-specified water source necessary to satisfy the single failure criterion for the makeup water supply.

GE Response

In order to provide additional protection against a potential single active failure of the FPS makeup water supply, GE proposes to modify the connection the FAPCS design to include two parallel valves in the makeup water supply line from FPS to FAPCS for both the IC/PCC and spent fuel pools. This change ensures that on-site water sources remain available as makeup for the IC/PCC and spent fuel pools for the first seven days even if a single active failure were to occur. See also RAI 9.1-22. The addition of these parallel valves ensures that the ICS and PCCS condensers can provide sufficient heat removal capability at and beyond 72 hours to satisfy GDC 34 and GDC 38 requirements for considering a single failure.

GDC 61 does not strictly require a single failure be postulated for decay heat removal from the spent fuel storage pool. However, the ESBWR design originally addressed a single active failure by having separate makeup connections to the fire protection system and to an alternate water supply connection point in the yard area. The new parallel valve being added in response to this RAI provides further assurance that the design can withstand a single active failure.

The only way to disable the entire makeup function to the IC/PCC or spent fuel storage pool (after the change discussed above) would be to postulate a passive failure of the common header piping to the pool. This is low pressure and low temperature safety-related piping, designed to Seismic Category I requirements, which operates infrequently. Thus, there is no requirement to postulate a break in this piping.

At 72 hours a total makeup flow rate of approximately 46 m^3/hr (200 gpm) is required to compensate for the boiloff rate from the IC/PCC and spent fuel pools. This demand will decrease with time as decay heat continues to decrease. DCD Tier 1 Table 2.16.3-1 will be updated to include a flow rate requirement for this makeup water function from the fire protection system. See attached DCD markup for this change.

The flow rate requirement at 72 hours in the preceding paragraph represents an upper bound for what must be provided by any COL applicant specified makeup supply source for use later in the event.

Note that the previous response to RAI 2.4-23 will be amended as follows to agree with the current total makeup flow rate above:

NRC RAI 2.4-23 (Amended Response)

The applicant should define the volume and the minimum delivery rate of the cooling water that would be required to be stored and delivered by the external water source.

GE Response

The main water demand for normal conditions is the makeup for Plant Service Water Cooling Towers and Circulating Water cooling towers (during power operation). These are site-dependent and outside of the ESBWR Standard Plant scope.

During accident conditions, there are no water supply requirements within 72 hours after an initiating event. After 72 hours, the only function required for maintaining the plant in a safe shutdown condition is to provide makeup water to the Isolation Condenser/Passive Containment Cooling (IC/PCC) pools and Spent Fuel Pool. The required volume from 72 hours through 7 days is approximately 3,900 m^3 (138,000 ft^3), and the maximum required delivery rate is approximately 46 m^3/hr (200 gpm) at 72 hours.

See responses to RAI 2.4-5 and RAI 2.4-22 for further clarification.

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

NRC RAI 9.1-14

DCD Tier 2, Sections 5.4.6, 6.2.2, and 9.1.3 state that makeup may be necessary after 72 hours for the IC/PCCS pools and SFP. However, neither the necessary makeup rate nor the capacity of the emergency makeup line are specified.

Describe the capacity of the emergency makeup lines necessary to satisfy the requirements of GDC 34, 38, and 61 with respect to providing adequate heat removal from the reactor, containment, and SFP. Discuss how the necessary capacity was derived and how the safety related function of the makeup lines to deliver the necessary makeup rate will be verified.

GE Response

The capacity of the makeup lines must accommodate the boil-off rates associated with the maximum post-72 hr heat loads expected for the SFP and the IC/PCCS pools. For specific numbers, refer to the response to RAI 9.1-13. The value for the boil-off rate is calculated based on the most limiting condition which includes the decay heat from 10 years of accumulated spent fuel in the spent fuel pool as well as the shutdown power from the full core discharged to the ICS immediately following a scram. The heat output at the end of the 72 hour period will be converted to a boil-off rate, which will be taken as the required makeup rate for these pools. Because the makeup rate will remain constant as the heat loads continue to drop, the makeup rate at 72 hours will be sufficient to refill the pools in the long term. The ability to transfer water from the fire protection system to both pools will be confirmed during plant pre-operational testing. DCD Tier 1 Table 2.16.3-1 will be updated as shown in the response to RAI 9.1-12 to include a requirement for this test to be performed.

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

NRC RAI 9.1-15

DCD Tier 2, Section 9.1.2 states that the SFP is a reinforced concrete structure with a stainless steel liner. Operating experience indicates that damage to the liner from light load handling accidents, such as a fuel assembly drop, are credible and can allow leakage at high rates.

Consistent with the guidance of SRP Section 9.1.3, Revision 1, July 1981, Criterion III.1.f, describe how the makeup capacities and the time required to make associated hookups are consistent with expected leakage from structural damage that causes leakage through the liner.

GE Response

SRP 9.1.3, Section III.1.f states:
"A seismic Category I makeup system and an appropriate backup method to add coolant to the spent fuel pool are provided. The backup system need not be a permanently installed system, nor Category I, but must take water form a Category I source. Engineering judgment and comparison with plants of similar design are used to determine that the makeup capacities and the time required to make associated hookups are consistent with heatup times or expected leakage from structural damage."

Reg Guide 1.13, Section B.1 discusses acceptable solutions for avoiding structural damage resulting from load handling accidents:
"Possible solutions to this potential problem include (1) preventing, preferably by design rather than interlocks, heavy loads from being lifted over the pool; (2) using a highly reliable handling system designed to prevent dropping of heavy loads as a result of any single failure; or (3) designing the pool to withstand dropping of the load without significant leakage from the pool area in which fuel is stored."

The amount of leakage through the liner in the event of a load handling accident is limited by method 3. The SFP liner has been designed to the requirements contained in DCD Tier 2, Section 9.1.2.4 and as discussed in response to RAI 9.1-6. The ESBWR SFP liner is similar to existing plants such as ABWR. The liner is Seismic 1 and designed to the acceptance criteria of ASME Section III, Division 2, CC-3700.

In addition to the changes described in the response to RAI 9.1-6, the following sentence will be added to DCD section 9.1.2.4:

Pool liners will be evaluated to ensure structural integrity under fuel handling accidents.

NRC RAI 9.1-16

DCD Tier 2, Sections 3.3.2 and 3.5.2 state that safety-related structures, systems, and components listed in DCD Tier 2, Table 3.2-1 are protected within Seismic Category I structures from the effects of tornados. However, DCD Tier 1, Figure 2.6.2-1 indicates that the emergency makeup connections and isolation valves (F211 and F420) in the FAPCS for the SFP and IC/PCCS pools are located in the yard area of the plant outside of Seismic Category I structures. DCD Tier 2, Table 3.2-1 states that the piping and valves performing this function are safety-related. The FPS provides the alternate supply of water to these lines, but DCD Tier 2, Table 3.2-1 states that the FPS, including the water storage tanks and the fire pump house, are not safety-related, and therefore, not located where the components would be protected from the effects of tornados.

The requirements of GDC 2 specify that the safety-related SFP makeup water supplies and the water supplies to the IC/PCC pools be protected from the effects of tornados and other natural phenomena. Provide a detailed description of the features to protect safety-related makeup water lines from the effects of tornados.

GE Response

The only safety-related components of the FAPCS that exist outside of the reactor building are the emergency fill-up valves. These valves are attached to the Reactor Building structure, and are designed to Seismic Category I to withstand tornados and other natural phenomena.

In order to satisfy the requirements of GDC2, the FAPCS primary makeup source will be changed to the primary FPS storage tank. All FPS piping inside the Reactor Building is automatically protected from tornados and natural phenomena by the Seismic Category I structure. All FPS components located outside the Reactor Building that are needed for FAPCS makeup will be designed to Seismic Category I standards, and will be designed to withstand tornados and other natural phenomena. By upgrading the source of makeup water to Seismic Category I, the requirements of GDC 2 are satisfied.

Additional information regarding this change, as well as the appropriate changes to the DCD are described in more detail in the responses to RAI 9.1-12 and 9.1-13.

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

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.

GE 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 will 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 9.1-18

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.

GE 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 9.1-19

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.

GE 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 9.1-20

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. Describe the water flow rate and heat removal capacity to perform these defense-in-depth functions, how those values are determined, and how the FAPCS will be designed and tested to provide those flow rates and heat removal capacities.

GE Response

The FAPCS is not required to satisfy any flow rate or heat removal requirement for the functions described in the question. The FAPCS functions of suppression pool cooling, low pressure injection, drywell spray, and alternate shutdown cooling are non-essential to plant safety, and no credit is taken for them in any safety analysis. Therefore the FAPCS provides these functions to the extent it has available capacity, but it is not specifically designed to perform these functions.

The FAPCS is designed for SFP cooling based on the requirements of URD Volume III, Chapter 7, Section 2.2.2.3. This is the available capacity used to perform the defense-in-depth functions.

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

NRC RAI 9.1-21

DCD Tier 1, Figure 2.6.2-1 indicates that the emergency makeup header to the IC/PCCS pools is not redundant and that manual valve F426 separating the fire protection system from the makeup header is normally closed and located inside the reactor building. DCD Tier 2, Section 6.3.1.1.2 states that long-term cooling requirements call for the removal of decay heat from the drywell via the passive containment cooling system. DCD Tier 2, Section 6.2.2 describes that the passive containment cooling system removes heat beyond 72 hours with pool makeup.

SRP 6.3, Revision 2, April 1984, Criterion III.20 states that an intermediate heat transport system used to provide long-term cooling capability should be capable of sustaining a single active or passive failure without loss of function. Describe how the long-term cooling function of the primary containment cooling system is satisfied assuming an active failure of valve F420 or a passive failure of the emergency makeup header pressure boundary.

GE Response

As discussed in RAI 9.1-13, in order to provide additional protection against a potential single active failure of the FPS makeup water supply, GE proposes to modify the connection of the FAPCS to include two parallel valves in the makeup water supply line from FPS to FAPCS for both the IC/PCC and spent fuel pools. This change insures that an on-site water source remains available as makeup for the IC/PCC and spent fuel pools for the first seven days even if a single active failure were to occur. Passive failures in the piping of the common header need not be considered for low pressure, low temperature piping that is seldom used.

The source of long term makeup to the IC/PCCS pools (post 7 days) is determined by the COL holder on a plant specific basis. After 7 days, offsite sources of makeup are assumed to be available and can be brought to the site as needed. DCD section 1D.4 will be modified as described in the response to RAI 9.1-12 to clarify the responsibility of the COL holder to identify sources of long-term makeup water for the IC/PCC and spent fuel pools.

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

NRC RAI 9.1-22

DCD Tier 1, Section 2.1.4 states that the IC/PCC pool subcompartments on each side of the reactor building communicate at their lower ends to enable full use of the collective water inventory, but that section also states that there is no cross connection between the IC/PCC pools. DCD Tier 1, Figure 2.6.2-1 indicates that a single emergency makeup line provides water to a single, interconnected IC/PCC pool. Clarify how the IC/PCC pools are configured and how subcompartments communicate to share inventory. Clarify how a single emergency makeup line provides water to an adequate number of IC and PCC heat exchangers to satisfy the accident analyses, assuming a single failure of any active valves.

GE Response

The arrangement of these pools is shown more clearly in DCD Tier 2, Figure 6.2-2. In addition to the IC/PCCS expansion pools, this figure shows the arrangement of the auxiliary pools.

There are two large expansion pools on either side of the Reactor Building, which are normally isolated from each other. These two pools are themselves divided into three separate compartments. The three compartments of both expansion pools are interconnected by valves, which are locked open, and the three compartments of each pool communicate and are treated as a single pool volume. The two expansion pools are connected to each other and can share water inventory with each other through normally closed, parallel redundant valves connecting to the Dryer/Separator Pool and Reactor Well. The valves are designed to open on receiving a low level signal from either of the two expansion pools, and allow the IC/PCC pools to utilize the inventory in the Dryer/Separator Pool and Reactor Well.

Contained within both expansion pools are five smaller subcompartments – three for PCC heat exchangers, and two for IC heat exchangers. Each of these subcompartments also contains a locked-open maintenance valve that allows for communication to the larger expansion pool. When water in the subcompartments is drawn down by boil off, makeup water from the expansion pool will flow in through these maintenance valves. If a heat exchanger requires service, these valves can be closed, and the subcompartment can be pumped dry. FAPCS suction is taken from each of the ten subcompartments into a common header, pumped through the cooling / cleaning train, and then discharged back through a common header that branches into the two expansion pools.

The emergency makeup line is being revised as described in the response to RAI 9.1-13 such that there are now two parallel valve connections to the FPS to avoid single failures. A clarification will be added to DCD section 9.1.3.2 to explain how the entire IC/PCC pool volume can be connected with the auxiliary pools through the Dryer/Separator Pool, and a second clarification will be added to better explain the flow path used to cool the IC/PCC pool water.
A DCD markup describing these changes is attached

NRC RAI 9.1-23

DCD Tier 1, Figure 2.6.2-1 does not show any flow paths to reject excess water or radioactive waste (e.g., resin) to liquid and solid radioactive waste systems, respectively.

Describe how the FAPCS is used to manage pool water inventory and how waste from the water treatment subsystem is handled. Update DCD Tier 1, Figure 2.6.2-1 to show these capabilities.

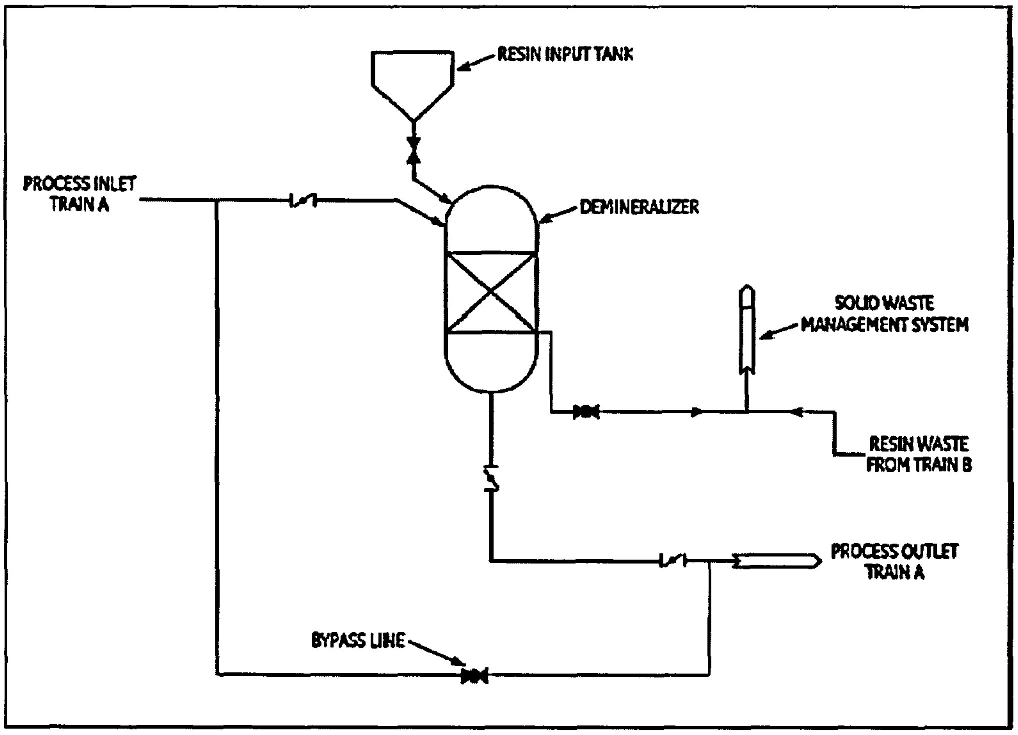
GE Response

DCD Tier 1 Rev. 1, Figure 2.6.2-1 does indicate the capability to discharge water to the Liquid Waste Management System (abbreviated as LWS on figure) by way of the overboarding lines connected to valves F016 and F017.

The filter/demineralizer units are shown in an extremely simplified form, and do not include details such as a discharge path for the spent resin. The full P&ID includes a complete process flow path for the resin to be discharged to the Solid Waste Management System. A simplified drawing of the demineralizer units is included with this response to supplement the figure in the DCD.

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

Simplified Demineralizer Sketch (RAI 9.1-23)



NRC RAI 9.1-24

DCD Tier 2, Section 9.1.4.1 states that both the refueling machine and the fuel handling machine have telescoping masts with integral grapples mounted from a trolley structure. Section 9.1.4.1 also states that the machines are also equipped with auxiliary hoists and jib cranes to which other grapples are attached when required. Both have redundant safety features and indicators that ensure positive engagement with fuel bundles.

Describe the design of grapples used to handle fuel and how the design reduces the probability of a fuel assembly drop. Identify any loads handled over stored fuel which could have greater kinetic energy that a fuel assembly dropped from its normal handling elevation.

GE Response

The fuel grapple is designed with dual interlocking deep "J" shaped hooks. The hooks open, the first hook to one side of the bail handle, and the second hook to the other side of the bail handle. When closed, each hook passes under the bail handle. As the fuel assembly is raised the bail handle rests down in radius the "J" hooks. The "J" hooks and the bail handle are captured inside the grapple head. The fuel bail handle is completely captured. In the event that a grapple open signal is sent and the "J" hook actuator is energized, the hook cannot move due to the fact that the bail handle is capture down inside the pair of "Js" and they can not pull apart. At the same time the bail is capture in part by the grapple head. The hooks cannot move.

If one "J" does not close, the second will capture the bail handle providing a level of redundancy.

For normal refueling and RPV maintenance operation there are no components that are raised and transferred over spent or new fuel. The layout of the building pools is such that components (like a control blade) can be moved in the RB from the RPV to the IFTS and in the FB from the IFTS to a storage position without passing over fuel. Interlocks are in place on the refueling and fuel handling machines such that when a heavy load is sensed on an auxiliary hoist, pre-established heavy load boundary zones are enforced by the fuel handling machine controls limiting the travel of the refueling and fuel handling machines.

No identified DCD changes

NRC RAI 9.1-25

DCD Tier 2, Section 9.1.6 states that the COL Holder shall develop fuel handling procedures and administrative controls. In order to address review guidance contained in paragraphs III.1 and II.6 of SRP Section 9.1.4, Revision 2, July 1981, describe the necessary scope of the administrative controls with regard to restrictions on loads handled over stored fuel and monitoring light load handling system components for degradation.

GE Response

Administrative controls are applied to the tabulated listing of the cranes and refueling equipment provided in Table 9.1-6.

The development of the site specific procedures to govern these administrative controls is a COL Holder action item. At this stage of design the documentation [specifications, drawings, manuals, procedures, etc] is not available until completion of the procurement activities for the respective equipment. Additionally, the QA program as well as the training and control programs can be unique to a COL Holder. As a result, the COL Holder shall provide the following information:

1) Load handling system operating and equipment maintenance procedures;
2) Load handling system and equipment maintenance procedures and/ or manuals;
3) Load handling system and equipment inspection and test plans, NDE, visual, etc.;
4) Load handling safe load paths and routing plans;
5) QA program to monitor and assure implementation and compliance of load handling operations and controls; and;
6) operator qualifications, training and control program.

No identified DCD changes

NRC RAI 9.1-26

DCD Tier 2, Section 9.1.4.1 states that, where applicable, DCD Tier 2,Table 9.1-5 provides the appropriate ASME, American National Standards Institute (ANSI), Industrial and Electrical Codes are identified. Describe how industry codes and standards Identified in DCD Tier 2,Table 9.1-5 apply to specific components in the light and overhead heavy load handling systems.

GE Response

Specific standards are selected as appropriate for the device or piece of equipment and are invoked in the associated design or procurement documents. The standard is used in part or in total depending upon the equipment and application. See attached Table 9.1-5 for a more comprehensive cross reference and or examples of major equipment components and applicable standards.

Table 9.1-5 will be revised in a future DCD revision.

Table 9.1-4

Classification of Equipment

Principal Component	Safety Designation	Location	QA Requirement	Seismic Category	Notes
Fuel Servicing Equipment					
1. Fuel Preparation Machine	N	FB/RB	E	II	
All other equipment	N	FB/RB	E	NS	
Miscellaneous Servicing Equipment	N	FB/RB	E	NS	
RPV Servicing Equipment	N	RB	E	NS/I	
RPV Internal Servicing Equipment	N	RB	E	NS	
Refueling Equipment					
1. Fuel Handling machine	N	FB	E	II	
2. Refueling Machine	N	RB	E	II	
3. Refueling Bellows	N	CV	E	NS	
Fuel Storage Facility					
1. Fuel Storage Racks (new and spent)	N	FB/RB	E	I	
Under RPV Servicing Equipment	N	CV	E	NS	

The biases between the calculated results and experimental results, as well as the uncertainty involved in the calculations, are taken into account as part of the calculative procedure to assure that the specific k_{eff} limit is met.

9.1.2.3 Storage Design

The fuel storage racks provided in the Spent Fuel Pool in the Fuel Building provide for storage of irradiated fuel assemblies resulting from 10 calendar years of plant operation plus one full core off load. The fuel storage racks in the Reactor Building buffer pool deep pit can hold a total of 154 spent fuel assemblies.

9.1.2.4 Mechanical and Structural Design

The spent fuel storage racks in the Reactor Building buffer pool and in the Spent Fuel Pool in the Fuel Building contain storage space for fuel assemblies (with channels) or bundles (without channels). A standard dynamic analysis using the appropriate response spectra is performed to demonstrate compliance to design requirements. They are designed to withstand all credible static and seismic loadings. The racks are designed to protect the fuel assemblies and bundles from excessive physical damage which may cause the release of radioactive materials in excess of 10 CFR 20 and 10 CFR 100 requirements, under normal and abnormal conditions caused by impact from fuel assemblies, bundles or other equipment.

The Spent Fuel Pool and buffer pool are reinforced concrete structures with stainless steel liners. Fuel storage racks and pool liner embedments are designed to meet Seismic Category I requirements. Pool liner and anchorage are designed to the same loads and load combinations as the pool concrete structure in accordance with DCD Table 3.8-15, except that load factors for all cases are equal to 1.0 and the acceptance criteria follow ASME Section III, Division 2, CC-3700. The bottoms of the pool gates are higher than the minimum water level required over the spent fuel storage racks to provide adequate shielding and cooling. Pool fill and drain lines enter the pool above the safe shielding water level. Redundant anti-siphon vacuum breakers are located at the high point of the pool circulation lines to preclude a pipe break from siphoning the water from the pool and jeopardizing the safe water level.

The racks include individual solid tube storage compartments, which provide lateral restraints over the entire length of the fuel assembly or bundle. The weight of the fuel assembly or bundle is supported axially by the rack fuel support. Lead-in guides at the top of the storage spaces provide guidance of the fuel during insertion.

Materials used for construction are specified in accordance with the latest issue of applicable ASTM specifications. The racks are constructed in accordance with a quality assurance program that ensures the design, construction, and testing requirements are met.

The structural integrity of the rack is demonstrated for the loads and load combinations described below using linear elastic design methods.

The applied loads to the rack are as follows:

- Dead loads, weight of rack and fuel assemblies plus the hydrostatic loads
- Live loads—effect of lifting an empty rack during installation
- Thermal loads—the uniform thermal expansion caused by pool temperature changes

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, portion or all of the water may bypass the water treatment unit.

IC/PCCS Pool Cooling and Cleanup Mode –The FAPCS-IC/PCCS pool C/C 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 IC/PCCS pools. Water is cooled and cleaned by the IC/PCC pool C/C subsystem and is then returned to the pool through a common line that branches and discharges deep in the pool.

GDCS Pool Cooling and Cleanup Mode – One train of the FAPCS C/C 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 C in this mode of operation. The water is cooled and cleaned and is then returned to GDCS pool B. The water level in the GDCS pool B rises and the water is cascaded and discharged at a submerged location in the adjacent GDCS pools A and C during this mode of operation.

Suppression Pool Cooling and Cleanup Mode – One of the FAPCS C/C 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 initiated following an accident to cool the suppression for accident recovery.

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 supply of emergency makeup water to the Spent Fuel Pool and IC/PCCS pools following an accident and the systems containment isolation function.

The SFP is designed to dissipate fuel decay heat through heat up and boiling of the pool water. 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 (the ultimate heat

sink) 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.

The FAPCS piping and components that provide the flow paths for the emergency makeup water supply are designed to meet the requirements contained in Table 9.1-3, Item 3. No active valves are required to operate for establishing emergency makeup water supply flow paths.

Two containment isolation valves are provided on the FAPCS lines that penetrate the containment, except the suppression pool suction line, which has one containment isolation valve.

The use of two containment isolation valves meets NRC GDC 56 requirement. The use of one pneumatic power assisted containment isolation valve also satisfies GDC 56 based on the allowable exception (Case 2 discussed in 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. Two exception cases are quoted in the SRP 6.2.4:

Case 1 Both valves may be located outside containment, if it is not practical to locate a valve inside the containment (e.g. the valve may be under water as a result of an accident).

Case 2 Use of a single containment isolation valve is acceptable if it can be shown that:

- the reliability of an ESF or ESF-related system is greater with only one isolation valve,
- closed system outside containment which is designed to Seismic Category I, Safety Class 2 and design temperature and pressure at least equal to that for the containment, and is protected from missiles, and
- a single active failure can be accommodated with only one isolation valve.

Case 2 is applicable to the use of only one isolation valve on the suppression pool suction line for the following reasons:

- An isolation valve inside the drywell would be submerged under water under severe accident conditions.
- 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. Because the suppression pool suction line isolation valves are normally closed, opening of the suction line

and components, which remain in the focused PRA model, based on their risk significance are included within Table 1D-1.

4. Selection of Important Nonsafety-Related Systems

Combinations of nonsafety-related SSCs that are necessary to meet NRC regulations, safety goal guidelines, and the containment performance goal objectives have been determined. These combinations are determined for both scope Criteria A and E where NRC regulations are the bases for consideration, and scope Criteria C and D where PRA methods are the bases for consideration. To address the long-term safety issue in scope Criterion B, PRA insights, sensitivity studies, and deterministic methods are used to establish the ability of the design to maintain core cooling and containment integrity beyond 72 hours. Non-safety SSC functions required to meet beyond design basis requirements (Criterion A), to resolve the long-term safety and seismic issues (Criterion B), and to prevent significant adverse interactions (Criterion E) are addressed in Table 1D-1.

The following steps are taken in using the focused PRA to determine the nonsafety-related SSCs important to risk:

a. Those nonsafety-related SSCs needed to maintain initiating event frequencies at the comprehensive baseline PRA levels are determined.

b. The necessary success paths with nonsafety-related systems and functions in the "focused PRA" to meet the safety goal guidelines, containment performance goal objectives, and NRC regulations are added. Systems are chosen by considering the factors for optimizing the overall design, and the effect and benefit to the particular systems. PRA importance studies assist in determining the importance of these SSCs.

5. Nonsafety-Related System Reliability/Availability Missions

From the focused PRA the functional R/A missions of active systems needed to meet the safety goal guidelines, containment performance goals, and other NRC performance requirements as described in Step 4 are determined. These systems and components have reliability/availability specifications, based on the importance to safety of their functional R/A missions (see Table 1D-1).

1D.3 CONCLUSION

All of the safety issues with regard to the RTNSS applicability criteria have been resolved for the design certification submittal for the ESBWR, and thus, no additional RNTSS process is needed.

1D.4 COL INFORMATION

The COL applicant shall review its plant against the RNTSS criteria in Table 1D-1. As needed, the COL licensee shall implement a RNTSS program that will provide the required level of reliability of system(s) required to keep the IC/PCC and Fuel Pools filled. This includes identifying other readily accessible and suitable volumes of water. Appropriate redundancy or a backup system for filling the pool from a reliable source, such as a lake, river, or onsite seismic Category I water-storage facility, should be provided as required by Paragraph C.8 of Regulatory Guide 1.13.

Table 3.2-1

Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
U39 Turbine Building HVAC	N	TB	—	E	NS	
U40 Reactor Building HVAC						
1. Building isolation dampers	3	RB	—	B	I	
2. Controls associated with the isolation dampers	3	RB	—	B	I	
3. Other system components	N	RB	—	E	II	
U41 Other Building HVAC	N	OL	—	E	NS	
U42 Potable Water and Sanitary Waste System	N	CB, SB, EB, RB, OO	—	E	NS	
U43 Fire Protection System (FPS)						
1. Non-seismic yard piping loop and valves including supports	N	OO, OL	D	E	NS	**Fire Protection System** — A quality assurance program meeting the guidance of NRC Branch Technical Position SPLB 9.5-1 (NUREG-0800) is applied to the protection system. Also, special seismic qualification requirements are applied.
2. Seismic category I piping loop and valves including supports	N	OO, RB, CB, FB	C	E	I	Same as above.
3. Fire water storage tank	N	OO	C	E	I	Same as above.
4. Fire pump enclosure	N	OO	—	E	II	Same as above.
5. Seismic category I pump including diesel-engine drive	N	OO	C	E	I	Same as above.
6. Booster pumps	N	RB	C	E	I	Same as above.
7. Motors for seismic category I pumps	N	OO,RB	—	E	I	Same as above.
8. Other pumps and motors	N	OO	D	E	NS	Same as above.

Table 2.16.3-1

ITAAC For The Fire Protection System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The basic configuration of the Fire Protection System is as described in Subsection 2.16.3.	1. Inspections of the as-built system will be conducted.	1. The as-built Fire Protection System conforms to the basic configuration contained in the Design Description of Subsection 2.16.3.
2. The motor driven pump described in the Design Description for the Fire Protection System is powered from the non-Class 1E bus.	2. A test of the power availability to the motor driven pump described in the Design Description in Subsection 2.16.3 will be conducted with power supplied from the permanently installed electric power busses.	2. The motor driven pump described in the Design Description for the Fire Protection System receives power from non-Class 1E busses only.
3. Two water supply tanks with a minimum volume of about 2000 m^3 (550,000 gal) each are provided.	3. Inspection of the as-built water supply sources and volumetric calculations using as-built dimensions will be performed.	3. As-built water supply sources meet the volumetric requirements specified in the Certified Design Commitment.
4. Fire water supply system pumps independently provide a minimum flow of [454.2 m^3/hr (2,000 gpm)] at a pressure of [689 kPa gauge (100 psig)] at the most hydraulically remote 65 mm (~2.5 in) hose connections station or [448 kPa gauge (65 psig)] at the most hydraulically remote 40 mm (~1.6 in) hose station in the Reactor Building and Control Building.	4. A test of the flow rate and pressure from each pump will be conducted.	4. The fire water supply system pumps independently provide the flow and pressure specified in the Certified Design Commitment.

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
5. No location within a fire area is more than [30.5 m (100 ft)] from a hose station.	5. Inspection of the as-built hose rack locations will be performed.	5. Standpipe and hose rack stations are located such that no location within a fire area is more than [30.5 m (100 ft)] from a hose station.
6. No safe shutdown equipment is more than [30.5 m (100 ft)] from two hose stations on separate standpipes.	6. Inspection of the as-built hose rack locations will be performed.	6. Standpipe and hose rack stations are located as such that no safe shutdown equipment is more than [30.5 m (100 ft)] from two hose stations on separate standpipes.
7. Automatic fire suppression is provided for all electrical areas exceeding that specified in codes NFPA 13 & 15.	7. Inspection of all electrical areas to identify areas requiring automatic fire suppression system per NFPA 13 & 15.	7. Confirm that an automatic fire suppression is provided for all electrical areas required per NFPA 13 & 15.
8. Automatic fire suppression is provided for all non-electrical areas exceeding that specified in codes NFPA 13 & 15.	8. Inspection of all non-electrical areas to identify areas requiring automatic fire suppression system per NFPA 13 & 15.	8. Confirm that an automatic fire suppression is provided for all non-electrical areas required per NFPA 13 & 15.
9. Automatic foam-water extinguishing systems are provided for the diesel generator and day tank rooms, per codes NFPA 11& 16.	9. Inspection of as-built systems and testing of automatic logic under simulated fire conditions will be conducted.	9. The automatic foam-water suppression systems exist and initiation logic is actuated under simulated fire conditions.
10. The fuel oil tanks for the diesel-driven fire pumps have sufficient capacity to allow diesel engine operation for approximately 8 hours as described in this Subsection 2.16.3.	10. Inspection of the fuel oil day tanks will be conducted.	10. The fuel oil tanks for the diesel-driven fire pumps have sufficient capacity to allow diesel engine operation for approximately 8 hours as defined in this Subsection 2.16.3.
11. Control room indications and controls for the Fire Protection System are as defined in Subsection 2.16.3.	11. Inspections will be performed on the control room indications and controls for the Fire Protection System.	11. Indications and controls exist or can be retrieved in the MCR as defined in Subsection 2.16.3.

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
12. The fire water supply system shall be capable of supplying a total makeup flow rate of ≥ 46 m^3/hr (200 gpm) to the IC/PCC and spent fuel pools.	12. A test of the flow rate from each pump will be conducted.	12. The fire water supply system pumps independently provide the flow and pressure specified in the Certified Design Commitment.

automatically closed, if open, upon receipt of a containment isolation signal from the LD&IS. The power-operated containment isolation valves on the suppression pool suction and return lines and the drywell spray line do not receive a containment isolation signal because these valves must be able to open when FAPCS is initiated to provide an accident recovery function.

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 to prevent unintended drainage of the pools. The anti-siphoning holes in the suppression pool suction line are at the elevation of minimum water level to prevent complete draining of the pool in case of a suction line break at a lower elevation.

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 are designed to close upon loss of its electric power or pneumatic (air or nitrogen) supply.

Provisions are provided to protect FAPCS components from fire, missile generating event, plant internal flooding, or seismic event of intensity up to and including a Safe Shutdown Earthquake (SSE) so that sufficient capability is retained for the fuel pool cooling function.

The FAPCS is designed to permit surveillance testing and in-service inspection of the safety-related components in accordance with ASME Section XI. Additionally, 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.

Piping and components completely separate from FAPCS pool cooling piping provide flow paths for post-accident make-up water transfer, from off-site water supply sources to the IC/PCCS pool and spent fuel pool. No active valves located inside the Reactor Building is required to operate to accomplish this makeup. This piping and components are designed to meet Quality Group C and Seismic Category I requirements.

The Dryer/Separator Pool and Reactor Well contains valves that, when opened, create a connection between the two IC/PCCS expansion pools through the Dryer/Separator Pool. These valves are designed to open on receiving a low level signal from either of the IC/PCCS expansion pools, and will allow the IC/PCCS Pools to utilize the inventory in the Dryer/Separator Pool and Reactor Well.

Containment isolations valves are provided on the FAPCS lines that penetrate the containments. The containment isolation valves on the GDCS pool suction and discharge lines that do not have post accident operation receive containment isolation signal.

FAPCS piping and components, relied upon for containment integrity, are designed to Quality Group B and Seismic Category I requirements.

System Operation

and cleaned and then returned to the Spent Fuel Pool. When necessary, a portion or all of the water may bypass the water treatment unit.

Fuel and Auxiliary Pool Cooling and Cleanup Mode - During a refueling outage, one or both FAPCS C/C 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.

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

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, portion or all of the water may bypass the water treatment unit.

IC/PCCS Pool Cooling and Cleanup Mode –The FAPCS-IC/PCCS pool C/C 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 C/C 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 C/C 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 C in this mode of operation. The water is cooled and cleaned and is then returned to GDCS pool B. The water level in the GDCS pool B rises and the water is cascaded and discharged at a submerged location in the adjacent GDCS pools A and C during this mode of operation.

Suppression Pool Cooling and Cleanup Mode – One of the FAPCS C/C 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 initiated following an accident to cool the suppression for accident recovery.

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.

Table 9.1-5

Reference Codes and Standards

Number	Title	Devise
ANS-N14.6	Standard for Special Lifting Devices for Shipping Containers Weighing (5 tons) or More for Nuclear Materials	Applicable to any item carrying a heavy load such as the RB and FB overhead cranes and the refueling and fuel handling machine
ANSI B30.9	Slings	Applicable to the RPV dryer strongback slings.
ANSI B30.10	Hooks	Applicable to the RB and FB overhead cranes.
ANSI B30.2	Performance Standards for Overhead Electric Overhead Traveling Cranes	Applicable to the RB and FB overhead cranes.
ANSI B30.11	Overhead and Gantry Crane	Applicable to the RB and FB overhead cranes.
CMAA70	Specifications for Electric Overhead Traveling Cranes	Applicable to the RB and FB overhead cranes and the refueling and fuel handling machines
NUREG-0612	Control of Heavy Loads at Nuclear Power Plants	Applicable to the RB and FB overhead cranes. A portion of the NUREG is applicable to the RPV strongback or dryer strongback interface with the lifting device. Applicable to the hoist on the refueling and fuel handling machines that handles the combined fuel support and control blade grapple. Typically the combined weight of the equipment and tooling exceeds the weight of a fuel assembly.
NUREG-0554	Single Failure Proof Cranes for Nuclear Power Plants	Applicable to the RB and FB overhead cranes. Applicable to the hoist on the refueling and fuel handling machines that handles the combined fuel support and control blade grapple. Typically the combined weight of the equipment and tooling exceeds the weight of a fuel assembly.