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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 100 –Auxiliary Systems– RAI Number 9.1-40**

Enclosure 1 contains GEH's response to the subject NRC RAI transmitted via the Reference 1 letter.

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

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

DO68
NRO

Reference:

1. MFN 07-327, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 100 Related to the ESBWR Design Certification Application*, May 30, 2007.

Enclosure:

1. MFN 07-403 – Response to Portion of NRC Request for Additional Information Letter No. 100 – RAI Numbers 9.1-40.

cc:	AE Cubbage	USNRC (with enclosure)
	BE Brown	GEH/Wilmington (with enclosure)
	LE Fennern	GEH/San Jose (with enclosure)
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	eDRF:	0000-0070-0976 R1

Enclosure 1

MFN 07-403

Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application

Auxiliary Systems

RAI Number 9.1-40

NRC RAI 9.1-40:

DCD Tier 2, Rev. 3, Section 9.1.6 identified the following COL Holder items relating to Section 9.1.1 of the DCD Tier 2.

"The COL Holder shall provide the dynamic and impact analyses of the fuel storage racks. The COL Holder shall confirm that the fuel storage racks are designed to provide sufficient natural convection coolant flow through the rack and fuel to remove decay heat without reaching excessive water temperatures. The COL Holder shall provide the criticality analysis as required by "Criticality Control" of the Section 9.1.1.1 of the DCD Tier 2."

The staff found that the above three COL Holder Items are analysis and design issues that have to be reviewed by the NRC staff prior to issuing the combined license. The information for the COL Holder Items will be available for review only after the license is issued. This is not acceptable because the staff will not be able to conclude whether the design and analysis of the new fuel storage for the COL applicant satisfy the regulatory requirements at the time when the license is issued. The staff has determined that the above three COL Holder Items should be revised to COL Applicant Items.

GEH Response:

Fuel rack analyses (Dynamic and Impact, Thermal-Hydraulic, Criticality, Load-Drop) are performed by the rack designer. The results of analyses performed are documented in two separate Licensing Topical Reports (LTR); one addressing criticality, the other addressing the remainder of required analyses. These LTRs are noted as references 9.1-1 and 9.1-2 in the attached DCD Subsection 9.1.7 markup. As these LTRs satisfy pre-license requirements, COL Holder/Applicant items are no longer required.

The anticipated submittal dates for the LTRs are November 2007 for the Criticality Analysis and February 2008 for the Dynamic, Load-Drop, and Thermal-Hydraulic Analyses.

This response supersedes the response submitted for RAI 14.3-92 S01.

DCD Impact:

DCD Tier #2, Subsections 9.1.1, 9.1.2, 9.1.4, 9.1.6, and 9.1.7, Rev. 3, are to be revised as noted in the attached markup. This DCD markup supersedes the markup submitted for RAI 14.3-92 S01.

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

Storage Design

The new fuel storage racks in the buffer pool can store up to 60% of one full core fuel load.

Mechanical and Structural Design

The new fuel storage racks contain storage space in the Reactor Building buffer pool in the reactor for 60% of the RPV core capacity of fuel assemblies (with channels) or bundles (without channels). They are designed to withstand all credible static and seismic loadings.

The racks are designed to protect the fuel assemblies and fuel 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 being struck by fuel assemblies, fuel bundles or other equipment.

The racks are constructed in accordance with the Quality Assurance Requirements of 10 CFR 50, Appendix B.

The racks are classified as Nonsafety-Related and Seismic Category I

Thermal-Hydraulic Design

The fuel storage racks are will be designed to provide sufficient natural convection coolant flow through the rack and fuel to remove any heat present without reaching excessive water temperatures. A thermal-hydraulic analysis to evaluate the rate of naturally circulated flow and the maximum rack exit temperature has been will be performed, see Subsection 9.1.6, COL Information Reference 9.1-1.

Material Considerations

Structural material used in the fabrication of the fuel storage racks is in accordance with the latest issue of the applicable ASTM specification at the time of equipment order. Materials are chosen for their corrosion resistance and their ability to be formed and welded with consistent quality.

Dynamic and Impact Analysis

A standard dynamic analysis, using the appropriate response spectra, is shall be performed by the COL licensee to demonstrate compliance to design requirements. The input excitation for these analyses utilizes the horizontal and vertical response spectra provided in Section 3.7.

Vertical impact analysis is shall be performed by the COL licensee because the fuel assembly is held in the storage rack by its own weight without any mechanical hold-down devices. See Subsection 9.1.6 for COL information requirements for Dynamic and Impact Analysis See Reference 9.1-1, which provides the documentation for the dynamic and impact analyses.

9.1.1.2 Facilities Description (New Fuel Storage)

Pool Storage

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—effects caused by pool temperature changes occurring as a result of normal operating or abnormal conditions, as applicable;
- Seismic loads;
- Fuel drop load-effect of an accidental drop of the heaviest fuel assembly or bundle from the maximum possible height; and
- Stuck fuel load-upward force on the rack caused by a postulated stuck fuel assembly.

The load combinations considered in the rack design are as follows:

- Dead plus live loads;
- Dead plus live plus thermal loads
- Dead plus live plus thermal plus stuck fuel loads;
- Dead plus live plus thermal plus seismic loads; and
- Dead plus live plus fuel drop loads;

Stress analyses are performed by classical methods based upon shears and moments developed by the dynamic method. Using the given loads, load conditions and analytical methods, stresses are calculated at critical sections of the rack and compared to acceptance criteria referenced in ASME Code Section III, Subsection NF. In addition, the design of the spent fuel storage racks and associated support structures meet the requirements of Appendix D to SRP 3.8.4. See Reference 9.1-1 for the results of the stress analysis for the spent fuel racks.

9.1.2.5 Thermal-Hydraulic Design

During normal operation the fuel storage racks are designed to provide sufficient natural convection coolant flow through the rack and fuel to remove decay heat without reaching excessive water temperatures (100°C; 212°F).

In the spent fuel storage pool, the bundle decay heat is removed by FAPCS recirculation flow to maintain the pool temperature below 48.9°C (120°F) during normal conditions.

A thermal-hydraulic analysis to evaluate the rate of naturally circulated flow and the maximum rack exit temperature is ~~will be~~ performed. See ~~Subsection 9.1.6 for COL information~~ See Reference 9.1-1 for the thermal-hydraulic analysis results.

In the event of loss of FAPCS cooling trains boiling can occur, see Subsection 9.1.3.2. The structural acceptance criteria for the fuel storage racks is that the storage rack design shall not exceed the allowable stress levels given in the ASME B&PV Code, Section III, Subsection NF during boiling.

9.1.2.6 Material Considerations

Structural material used in the fabrication of the fuel storage racks is in accordance with the latest issue of the applicable ASTM specification at the time of equipment order. Materials are chosen for their corrosion resistance and their ability to be formed and welded with consistent quality.

The storage tube material is permanently marked with identification traceable to the material certifications. The fuel storage tube assembly is compatible with the environment of treated water and provides a design life of 60 years.

9.1.2.7 Facilities Description (Spent Fuel Storage)

There are two separate areas for storage of spent fuel assemblies. These are in a separate deep pit area in the buffer pool in the Reactor Building and in the Spent Fuel Pool in the Fuel Building.

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. The amount to be stored is equal to the amount of fuel that may be removed and subsequently returned to the RPV during a typical fuel shuffling activity. The deep pit for the storage of spent fuel in the rack is designed such that the depth of the cavity allows the fuel to be placed in the rack with sufficient margin below the rack for natural convection cooling to occur and that the top of the active fuel remains below the top of the cavity. The spent fuel storage racks are top entry racks designed to preclude the possibility of criticality under normal and abnormal conditions.

Spent fuel storage racks in the Spent Fuel Pool area provide storage in the fuel building Spent Fuel Pool for spent fuel received from the reactor vessel resulting from ten calendar years of operation plus one full core offload of fuel. The cavity for the storage of spent fuel in the rack is designed such that the depth of the cavity allows the fuel to be placed in the rack with sufficient margin below the rack for natural convection cooling to occur and that the top of the active fuel remains below the top of the cavity. The spent fuel storage racks are top entry racks designed to preclude the possibility of criticality under normal and abnormal conditions.

On a complete loss of the FAPCS active cooling capability and under the condition of maximum heat load associated with 20 years of fuel storage and a full core off load, sufficient quantity of water is available in the Spent Fuel Pool above the top of active fuel (TAF) level to allow boiling for 72 hours and still have the TAF submerged under water.

9.1.2.8 Safety Evaluation

Criticality Control

The spent fuel storage racks are designed to assure that the fully loaded array is sub critical by at least 5% Δk/k.

Monte Carlo techniques are employed in the calculations performed to assure that k_{eff} does not exceed 0.95 under all normal and abnormal conditions.

The assumption is made that the storage array is infinite in all directions. Because no credit is taken for neutron leakage, the values reported as effective neutron multiplication factors are, in reality, infinite neutron multiplication factors.

The biases between the calculated results, experimental results, and the uncertainty in the calculation, are taken into account as part of the calculative procedure to assure that the specific k_{eff} limit is met. Criticality analysis is documented in Reference 9.1-2.

Structural Design and Material Compatibility Requirements:

- The support structure allows sufficient pool water flow for natural convection cooling of the stored fuel and allows the rack material temperatures to stay within limits.
- The racks include individual solid tube storage compartments, which provide lateral restraints over the entire length of the fuel assembly or bundle.
- The racks are fabricated from materials used for construction and are specified in accordance with the latest issue of applicable ASTM specifications at the time of equipment order.
- The racks are designed to withstand the impact force generated by the vertical free-fall drop of a fuel assembly and its handling tool from the maximum height expected during normal fuel handling (See Reference 9.1-1 for analysis).
- The rack is designed to withstand a pull-up force in the event a fuel assembly should jam.
- The fuel storage pools have adequate water shielding for the stored spent fuel. See Subsection 9.1.3.

NRC Regulatory Guide 1.13 is applicable to spent fuel storage facilities. The Reactor Building, which contains the fuel storage facilities, including the storage racks and pool, is designed to protect the fuel from damage caused by:

- Natural events such as earthquake, high winds and flooding; and
- Mechanical damage caused by dropping of fuel assemblies, bundles, or other objects onto stored fuel.

Summary of Radiological Considerations

By adequate design and careful operational procedures, the design bases of the spent fuel storage arrangement are satisfied. Thus, the exposure of plant personnel to radiation is maintained well below published guideline values. Further details of radiological considerations, including those for the spent fuel storage arrangement, are presented in Chapter 12.

- Install equipment storage pool gate;
- Drain reactor cavity;
- Install and tighten reactor vessel head;
- Install reactor vessel insulation;
- Perform in-service leak test (ISLT - Equipment is tagged out and inoperable during this test, which is a critical path item);
- Remove tags and restore valve lineups;
- Install drywell head;
- Flood reactor cavity;
- Perform startup operations check; and
- Check final drywell closeout.

9.1.4.18 Safety Evaluation of Fuel Handling System

Fuel servicing equipment is discussed in Subsection 9.1.4.6 and refueling equipment is discussed in Subsection 9.1.4.5. In addition, the summary safety evaluation of the fuel handling system is described in the following paragraphs.

The refueling machine and fuel handling machine are designed to prevent them from becoming unstable and toppling into pools during a SSE, and interlocks, as well as limit switches, are provided to prevent accidental movement of the grapple mast into pool walls.

The grapple on both the refueling machine and fuel handling machine is hoisted to its retracted position by redundant cables inside the mast and is lowered to full extension by gravity. The retraced position is controlled by both interlocks and physical stops to prevent raising the fuel assembly above the normal stop position required for safe handling of the fuel. The operator can observe the exact grapple position over the core by a display screen at the operator console.

~~These racks requires the submittal of information pertaining to load drop analysis. See Subsection 9.1.6 for COL license information requirements under "Spent Fuel Racks Load Drop Analysis."~~ The results of the rack load drop analysis are contained in Reference 9.1-1.

The fuel handling system complies with General Design Criterion 61 of 10 CFR 50 as described in Subsection 3.1.6.2.

9.1.4.19 Inspection and Testing Requirements

Inspection

The fuel storage racks and refueling machine have additional "quality requirements" that identify features that require specific QA verification of compliance to drawing requirements.

Testing

Functional tests are performed on refueling and servicing in the shop prior to the shipment of most production units and generally include electrical tests, leak tests, and sequence of operations tests.

- QA Program to Monitor and Assure Implementation and Compliance of Heavy Load Handling Operations and Controls; and
- Personnel Qualifications, Training and Control Program.

9.1.5.9 Safety Evaluations

The arrangement of the refueling floor precludes transporting heavy loads, other than spent fuel handled by the refueling machine or fuel handling machine, over spent fuel stored in the spent fuel storage pool.

The separation (arrangement, equipment interlocks, and routing) of redundant safety-related components in relation to heavy load paths minimizes the potential to cause failure of safety-related components. Administrative procedures further minimize the potential hazard from heavy loads.

9.1.5.10 Inspection and Testing

Qualification load and performance testing, including nondestructive examination (NDE) and dimensional inspection on heavy load handling equipment, is performed. Tests may include load capacity, safety overloads, life cycle, sequence of operations, and functional performance.

When load handling equipment is received at the site, it is inspected to ensure no damage has occurred during transit or storage. Prior to use and at periodic intervals, each piece of equipment is tested again to ensure the electrical and/or mechanical functions are operational including visual inspection and, if required, NDE inspection.

Crane inspections and testing comply with ANSI B30.2.

9.1.5.11 Instrumentation Requirements

The majority of the heavy load handling equipment is manually operated and controlled by the operator based on visual observations. This type of operation does not necessitate the need for a dynamic instrumentation system.

Load cells may be installed to provide automatic shutdown whenever threshold limits are exceeded for critical load handling operations to prevent overloading.

9.1.6 COL Information

9.1.6-1-H Dynamic and Impact Analyses of Fuel Storage Racks (Deleted)

~~The COL Holder shall provide the NRC confirmatory dynamic and impact analyses of the fuel storage racks. Refer to Subsections 9.1.1.1, and 9.1.2.4, under subheading Dynamic and Impact Analysis.~~

~~The COL Holder shall confirm the fuel storage racks are designed to provide sufficient natural convection coolant flow through the rack and fuel to remove decay heat without reaching excessive water temperatures (100°C; 212°F), refer to Subsections 9.1.1.1 and 9.1.2.5.~~

9.1.6-2-H Fuel Storage Racks Criticality Analysis (Deleted)

~~The COL Holder shall provide the NRC confirmatory criticality analysis as required by *Criticality Control* refer to Subsections 9.1.1.1 and 9.1.1.2).~~

9.1.6-3-H Fuel Racks Load Drop Analysis (Deleted)

~~The COL Holder shall provide the NRC confirmatory load drop analysis as required by Subsection 9.1.2.4.~~

Handling of Light Loads (Fuel Handling)

The COL Holder shall provide the NRC the following for confirmatory review:

- Fuel handling procedures.
- Maintenance manuals and procedures for equipment used to move fuel.
- Equipment inspection and test plans for equipment used to move fuel.
- Personnel qualifications, training, and control programs for fuel handling personnel.
- QA programs to monitor, implement, and assure compliance to fuel handling operations.

Handling of Heavy Loads

The COL Holder shall provide the NRC the following for confirmatory review:

- A listing of all heavy loads, heavy load handling equipment, and their associated heavy load attributes;
- 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;
- Heavy load handling equipment maintenance manuals and procedures;
- Heavy load handling equipment inspection and test plans;
- Heavy load personnel qualifications, training, and control programs; and
- QA programs to monitor, implement, and assure compliance to heavy load handling operations.

9.1.7 References

~~None.~~

9.1-1 Licensing Topical Report NED-33373, "Dynamic, Load-Drop, and Thermal-Hydraulic Analyses for ESBWR Fuel Racks"

9.1-2 Licensing Topical Report NED-33374, "Criticality Analysis for ESBWR Fuel Racks"