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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 344 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.2-19 S03**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) 12.2-19 S03 sent by NRC Letter 344, Reference 1. The response to RAI Number 12.2-19 S02 was previously submitted to the NRC via Reference 2 in response to Reference 3.

GEH response to RAI Number 12.2-19 S03 is addressed in Enclosure 1. Enclosure 2 contains the DCD markups associated with this response.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-336, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 344 Related to ESBWR Design Certification Application*, May 18, 2009
2. MFN 06-528 Supplement 3, Response to Portion of NRC Request for Additional Information Letter Number No. 218 Related to ESBWR Design Certification Application – Radiation Protection - RAI Number 12.2-19 S02, January 20, 2009
3. MFN 08-561, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 218 Related to ESBWR Design Certification Application*, July 1, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 344 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.2-19 S03
2. Response to Portion of NRC Request for Additional Information Letter No. 344 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.2-19 S03 – DCD Markups

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Enclosure 1

MFN 09-498

Response to Portion of NRC Request for Additional Information Letter No. 344 Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.2-19 S03

NRC RAI 12.2-19 S03:

The response to RAI 12.2-19 S02 stated that GEH had recalculated the estimated dose rate to a worker in the Reactor Building at elevation +21000 from a dropped fuel bundle resting on the reactor vessel shield/seal ring. GEH stated that the resulting worker dose rate from a 35 GWd/MTU burnup fuel bundle at the worst position would be 7.06 Sv/hr (706 Rem/hr) and 8.25 Sv/hr (825 Rem/hr) for a 58 GWd/MTU burnup fuel bundle.

a. *Describe your bases and assumptions for increasing the maximum estimated worker dose rate from a dropped fuel bundle by a factor of 50% (from 4.7 Sv/hr to 7.06 Sv/hr for a 35 GWd/MTU burnup fuel bundle).*

The following staff questions pertain to GEH's analysis of the total dose to a person in the Reactor Building at elevation +21000 located close to a dropped fuel element.

b. *In GEH's response to item 2(3) of RAI 12.2-19 S02, GEH calculated that a person evacuating the grating platform on elevation +21000 in the upper drywell and exiting the drywell would receive a total dose of approximately 42 mSv (4.2 Rem) from the dropping of the maximum burnup fuel element at the worst location on the shield/seal ring. GEH states that a person would be able to leave the drywell within one minute once personnel are alerted to the situation. The staff notes that the time to alert the person of the situation of a dropped fuel element does not seem to be factored into GEH's assumption of the time needed to evacuate the drywell. At a dose rate of 2.29 mSv/second (229 mrem/second) (8.25 Sv/hr (825 Rem/hr)) at the maximum dose rate location, the time necessary to notify the worker to vacate the area can be a significant factor to consider in minimizing the total dose to the worker. Perform a time-motion analysis or use an alternative analysis method(s), (e.g., simulation, comparable operating experience, use of ANSI/ANS 58.8, "Time Response Design Criteria for Nuclear Safety-Related Operator Actions," or some other comparable analytic tool) to evaluate the integrated exit time and dose to a person evacuating the platform on elevation +21000 and exiting the drywell as a result of a dropped maximum burnup fuel bundle resting on the reactor vessel shield/seal ring in the worst position. The results of this analysis should be presented in a similar fashion to how GEH documented the postaccident doses to workers accessing vital areas (in DCD Tier 2, Tables 12.3-13 through 12.3-16). GEH should verify that this analysis considers, at a minimum, the following factors; 1) the time needed to alert a person on the upper drywell platform on elevation +21000 to evacuate the area, 2) the time needed for the worker to safely disengage himself from the work being performed, 3) the extra time that may be necessary to exit the area if the worker is wearing anti-c clothing and respiratory protection equipment, 4) the distances between the worker's work position and the drywell exit, including stairs that would have to be traversed, 5) the extra time that may be required if there are several workers in the area who are all trying to exit the drywell at the same time, 6) time delays in personnel exit times caused by obstructions (such* *as tool boxes, equipment, airlines, portable monitors, hoses) on the platforms on elevations +21000 and +18500, and 7) the time required to open the personnel airlock (if closed) and to exit from the drywell on elevation +18500.*

c. *In GEH's response to RAI 12.2-19, GEH stated that one of the anticipated maintenance activities of personnel on the platform on elevation +21000 during refueling operations is to access the platform located at elevation +19910 (located inside the Reactor Shield Wall between the Reactor Pressure Vessel (RPV) and the Reactor Shield Wall) to perform maintenance on and/or inspect the operations of the RPV stabilizer and RPV stabilizer supports. To do this, a person would have to pass through one of the two doors in the Reactor Shield Wall located above elevation +21000 and climb down by means of a foot iron on the Shield Wall to the platform on elevation +19910. Using an analysis similar to the one performed in response to part b. above, describe how a worker located on the platform on elevation +19910 inside the Reactor Shield Wall would exit the drywell in the event of a fuel drop on the reactor vessel shield/seal ring. In addition, evaluate the integrated exit time and dose to a person evacuating the platform on elevation +19910 and exiting the drywell as a result of a dropped maximum burnup fuel bundle resting on the reactor vessel shield/seal ring in the worst position.*

In the event that the calculated integrated dose to a worker exiting the drywell following the dropping of a fuel bundle on the shield/seal ring exceeds 50 mSv (5 person-rem) for either of the scenarios described in part b. or c. above, describe what precautions (such as restricting access to these areas during fuel movement or increasing the shielding to lower the potential dose rates in the upper drywell in the event of the fuel bundle drop on the reactor vessel shield/seal ring) that GEH or the COL applicant would implement to ensure that this dose limit is not exceeded.

d. GEH's response to item 2(1) of RAI 12.2-19 S02 states that personnel in the drywell would be alerted to anomalous radiation conditions by means of portable radiation instrumentation.

1. *GEH should describe what is meant by the use of "portable radiation instrumentation" to monitor workers (i.e., is GEH referring to the use of personal electronic dosimeters or other detection devices?).*
2. *With the potential for dose rates exceeding 8 Sv/hr (800 Rem/hr) in this area (making this a Very High Radiation Area) following a fuel drop accident, verify that you will have a reliable means (e.g., a dedicated fixed or portable radiation monitor(s) (with local alarm and flashing lights, as well alarm in the control room)) in place to monitor dose rates to personnel working in the drywell on elevation +21000 during fuel handling operations. Verify that the monitors used will have the capability to accurately detect dose rates of this magnitude. In addition, verify that the local alarm(s) associated with these*

monitors are sufficient to notify all personnel in the area to evacuate the area in the event of a fuel bundle drop.

3. *In accordance with 10 CFR 20.1602, describe the design measures to ensure that an individual is not able to gain unauthorized or inadvertent access to this area.*

e. *GEH's response to item 2(3) of RAI 12.2-19 S02 states that a worker would take 15 seconds to disengage from their work and an additional minute to evacuate the area (for a total of 1 minute, 15 seconds). However, GEH's response to item 2(2) of RAI 12.2-19 S02, as well as GEH's worker dose calculation, assumes that a worker would take a total of one minute to leave the drywell once alerted of a fuel element drop (i.e., 15 seconds to disengage from their work and an 45 seconds to exit the drywell). Clarify this apparent inconsistency in estimated evacuation times.*

In response to the original staff RAI 12.2-19, GEH calculated the estimated dose rates in the upper drywell for the worst case normal fuel handling scenario (when a fuel element, during refueling, is moved in the normal position closest to the internal vessel wall and the element is on the centerline of the RPV nozzle with the largest diameter). GEH calculated that the maximum dose rates would occur in the drywell on the platform at elevation +21000, room 1570, close to the shield wall penetration. GEH calculated that the maximum dose rates in this location would be 58.93 mSv/hr (5.9 Rem/hr) with the shield wall penetration open and 34.9 mSv/hr (3.5 Rem/hr) with the shield wall penetration closed. In GEH's response to RAI 12.2-19 S02, GEH stated that many of the values provided in response to RAI 12.2-19 have been superseded based on the sensitivity study performed by GEH in response to RAI 12.2-19 S01 to assess the impact of 58 GWd/MTU burnup fuel.

f. *If the dose rates listed above for the worst case normal fuel handling scenario have changed based on this recent GEH sensitivity study, provide the revised maximum dose rates close to the shield penetration corresponding to both an open and closed shield wall penetration.*
g. *Since this worst case dose rate would result from the movement of a fuel element past the RPV nozzle, state the expected transient time that this dose rate would exist in the area based on moving the fuel element past the RPV nozzle.*
h. *DCD Tier 2 Figure 12.3-10 indicates that the platform at elevation +21000 is designated as Zone E (< 1mSv/hr (< 100 mRem/hr)) during plant shutdown. Justify the use of this Zone designation for this area when the movement of fuel elements past the RPV nozzle could result in dose rates as high as 58.93 mSv/hr (5.9 Rem/hr) for the worst case normal fuel handling scenario (with the shield wall penetration open) and when a fuel bundle drop accident could result in potential dose rates as high as 8.25 Sv/hr (825 Rem/hr).*

GEH Response:

a. The increased dose rates were caused by a change in energy group structure. The dose rates calculated prior to the response to RAI 12.2-19 S02 used the average photon energy instead of the maximum photon energy for each energy group when converting fluence outputs from ORIGEN to be compatible with MCNP input requirements.

The change in dose rates also required a change to the radiation zone for Room 1570 from Zone E to Zone G during spent fuel transfer activities.

b-h. Based on a review of the responses to RAI 12.2-19, 12.2-19 S01, and 12.2-19 S02, the crediting of "…the reactor pressure vessel shield wall in the upper drywell extends to within half a meter of the upper drywell ceiling, thus permitting continued operations in the upper drywell during refueling and providing shielding in the case of a refueling accident" in DCD Tier 2 Subsection 12.1.2.3.2, Bullet #2 as a ALARA facility design feature has been reevaluated.

The calculated dose rates in the response to RAI 12.2-19 S02 indicated a very high radiation area is possible under certain conditions that would necessitate stringent controls be implemented to allow entry. To preclude additional design requirements to allow entry to the upper drywell in order to credit this as a facility design feature, the COL applicant's operational radiation protection program (COL 12.5-3-A) will be used to evaluate the need for entry to these areas during spent fuel transfers and will establish the necessary access controls to maintain radiation exposures ALARA.

The second sentence from Subsection 12.1.2.3.2 Bullet #2 related to upper drywell access during refueling operations will be deleted and clarification of entry requirements to potential high radiation areas during transient conditions will be added to Subsection 12.3.1.3.

By implementing these changes, answers to questions b-h are not necessary and will not be provided.

DCD Impact:

DCD Tier 2, Figures 12.3-7, 12.3-10, and 12.3-11 have been revised in Preliminary DCD Revision 6 (Letter MFN 09-410, June 19, 2009) to include a note that indicates a radiation zone G during spent fuel transfer operations for Room 1570.

DCD Tier 2, Subsections 12.1.2.3.2 and 12.3.1.3 have revised as shown in the attached markups and will be included in the Final DCD Revision 6.

Enclosure 2

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Radiation Protection

RAI Number 12.2-19 S03

DCD Markups

- Locating equipment, instruments, and sampling stations, that require routine maintenance, calibration, operation, or inspection, for ease of access and minimum required occupancy time in radiation areas;
- Laying out plant areas to allow remote or mechanical operation, service, monitoring, or inspection of highly radioactive equipment; and
- Providing, where practicable, transportation of equipment or components requiring service to a lower radiation area. As an example, the ESBWR design includes a dedicated room for maintenance of the Hydraulic Control Units (HCUs). Room 1107 is designed for HCU maintenance, and its radiation zone classification in Figure 12.3-1 is lower than the radiation zone designation where the HCUs normally reside (Rooms 1110, 1120, 1130, and 1140).

12.1.2.3.2 Minimizing Radiation Levels in Plant Access Areas and Vicinity of Equipment

Facility general design considerations directed toward minimizing radiation levels in plant access areas and in the vicinity of equipment requiring personnel attention include the following:

- Separating radiation sources and occupied areas where practicable (e.g., pipes or ducts containing potentially high radioactive fluids not passing through occupied areas).
- Providing adequate shielding between radiation sources and access and service areas. ~~Of special note, the reactor pressure vessel shield wall in the upper drywell extends to within half a meter of the upper drywell ceiling, thus permitting continued operation in the upper drywell during refueling and providing shielding in the case of a refueling accident.~~
- Locating equipment, instruments, and sampling sites in the lowest practicable radiation zone.
- Providing central control panels to permit remote operation of all safety-related instrumentation and controls from the lowest radiation zone practicable. For example, the Remote Shutdown Control Panels (Rooms 1313 and 1323) reside in a Radiation Zone "A" environment, per Figure 12.3-3; the Control Rod Drive Maintenance Control Panel (Room 2202) resides in a Radiation Zone "B" environment, per Figure 12.3-2.
- Where practicable for package units, separating highly radioactive equipment from less radioactive equipment, instruments, and controls.
- Providing adequate space for utilizing moveable shielding for sources within the service area when required.
- Providing means to control contamination and to facilitate decontamination of potentially contaminated areas where practicable.
- Providing means for service area decontamination.
- Providing space for pumps and valves outside of highly radioactive areas.
- Providing remotely-operated centrifugal discharge and/or back-flushable filter systems for highly radioactive radwaste and cleanup systems.
- Providing labyrinth entrances to radioactive pump, equipment, and valve rooms.

considered in determining the appropriate zoning for a given area. The relationship between radiation zone designations and accessibility requirements is presented in the following tabulation:

Zone Designation	Dose Rate µSv/hr	Access Description
A	D≤ 6 µSv/hr	Uncontrolled, unlimited access
B	6 µSv/hr <D≤ 10 µSv/hr	Controlled and unlimited access. (No or very low radiation sources are present)
C	10 µSv/hr<D ≤ 50 µSv/hr	Controlled and limited access (20 hr/wk). (Low radiation sources are present)
D	50 µSv/hr <D ≤ 250 µSv/hr	Controlled and limited access (4 hr/wk). (Low to moderate radiation sources are present)
E	250 µSv/hr <D ≤ 1 mSv/hr	Controlled and limited access (1 hr/wk). (Moderate radiation sources are present)
F	1 mSv/hr <D ≤ 10 mSv/hr	Limited and controlled access with special authorization permit required. (High radiation sources are present)
G	10 mSv/hr <D ≤ 100 mSv/hr	(Same as zone F above)
H	100mSv/hr<D≤ 1 Sv/hr	(Same as zone F above)
I	1 Sv/hr <D≤ 5 Sv/hr	(Same as zone F above)
J	D > 5 Sv/hr	Inaccessible during power and shutdown operations. (Very High radiation sources are present)

The dose rate applicable for a particular zone is based on operating experience and represents design dose rates in a particular zone. They should not be interpreted as the expected dose rates which would apply in all portions of that zone, or for all types of work within that zone, or at all periods of entry into the zone. Large BWR plants have been in operation for three decades, and operating experience with similar design basis numbers shows that only a small fraction of the 10 CFR 20 maximum permissible dose is received from radiation sources controlled by equipment layout or the structural shielding provided. Therefore, on a practical basis, a radiation zoning approach as described above accomplishes the ALARA objectives for doses as required by 10 CFR 20 Subpart C. The radiation zone maps for this plant, with zone designations as described in the preceding tabulations, are contained in Figures 12.3-1 through 12.3-22b.

Access to areas in the plant is controlled and regulated by the zoning of a given area. Areas with dose rates such that an individual would receive a dose in excess of 1000 µSv (100 mrem) in a period of one hour are locked and posted with "High Radiation Area" signs. Areas in which an individual would receive a dose in excess of 5 Gy (500 rads) within a period of one hour at 1 meter from a radiation source or 1 meter from any surface that the radiation penetrates are posted with "Very High Radiation Area" signs. In addition, several areas have been identified with transient conditions that occur during specialized activities like spent fuel transfer. These activities may create short-term high radiation areas. Controlled access to these areas is provided in accordance with the Radiation Protection Program that is provided by the COL Applicant (see Subsection 12.5.3 and COL Applicant action item 12.5-3-A).by the COL holder (COL 12.3-3-H).