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Subject: Response to Portion of NRC Request for Additional Information Letter No. 210 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-167 S02

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the subject NRC RAI originally transmitted and supplemented via the Reference 1 and Reference 2 letters, and supplemented by an NRC request for clarification in Reference 3.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 07-327, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application*, May 30, 2007
2. MFN 08-138, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 156 Related to ESBWR Design Certification Application*, February 15, 2008
3. MFN 08-531, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 210 Related to ESBWR Design Certification Application*, June 19, 2008

Enclosure:

1. MFN 08-740 - Response to Portion of NRC Request for Additional Information Letter No. 210 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-167 S02

cc:	AE Cubbage	USNRC (with enclosure)
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Enclosure 1

MFN 08-740

Response to Portion of NRC Request for Additional Information Letter No. 210 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-167 S02

For historical purposes, the original text of RAI 6.2-167 and RAI 6.2-167 S01, and the GEH responses, are included.

NRC RAI 6.2-167:

In DCD, Tier 2, Revision 3, Section 6.2.3, the ESBWR reactor building (RB) should be subject to periodic functional testing. 10 CFR 50, Appendix J, Option A, states in IV.B that other structures of multiple barrier or subatmospheric containment (e.g. secondary containment for boiling water reactors and shield buildings for pressurized water reactors that enclose the entire primary reactor containment or portions there of) shall be subject to individual test in accordance with the procedure established in the technical specifications, or associated bases. Please provide information on the type of test that will be used to bound the RB leakage, the conditions under which the test would be run, the degree to which these conditions would reflect worst case accident conditions, the frequency of such test, and the establishment of a test criteria. This information may be coordinated with the response to RAI 6.2-165 regarding reactor building leakage.

GEH Response:

DCD Tier 2, Revision 4, Chapter 16 includes a Technical Specification Surveillance Requirement (SR) 3.6.3.1.4 that requires the following:

> "Verify Reactor Building exfiltration rate within limits."

This requires a periodic functional test of the reactor building for leakage rate. This testing is discussed in the responses to RAIs 15.4-26 and 16.2-50. In summary, the reactor building air volume will be pressurized with a fan located outside the reactor building pressure boundary using an existing pipe penetration. The specific details related to performance of these tests are still being developed, including the conditions under which the test would be run, and the degree to which these conditions would reflect worst case accident conditions. The test frequency, as required by SR 3.6.3.1.4, is 60 months. The acceptance criterion is a reactor building leakage rate of less than 50% by weight per 24 hours. Also, as discussed in the response to RAI 15.4-26, DCD Tier 1 Table 2.16.5-2 (Inspection, Tests, Analyses and Acceptance Criteria for the Reactor Building) was revised in Revision 4 to add this test as a design commitment and to specify the acceptance criteria.

DCD Impact:

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

NRC RAI 6.2-167 S01:

The staff understands that GEH may be revising the test method to demonstrate a maximum flow rate at a specified differential pressure for the reactor building (RB). Please describe your plans related to the RB test method and update the response to RAI 6.2-167 to reflect the test method you plan to use.

GEH Response:

DCD Tier 2, Chapter 16 includes a Technical Specification Surveillance Requirement (SR) 3.6.3.1.4 for performance of periodic functional testing of the Reactor Building to verify the Reactor Building exfiltration rate is less than the limit assumed in the radiological analyses. Reactor Building exfiltration testing is performed to satisfy this Technical Specification requirement. Reactor Building exfiltration testing will be a positive pressure test of the Reactor Building volume, confirming that the Reactor Building Contaminated Area HVAC Subsystem (CONAVS) leakage rate is less than that used in the radiological analyses for a loss-of-coolant accident (LOCA) inside containment. The Reactor Building exfiltration test will be conducted at a positive pressure of a magnitude bounding the worst-case differential pressure between the Reactor Building and surroundings credited in the radiological analyses.

The Reactor Building exfiltration boundary is tested by applying a positive ¼ inch w.g. differential pressure. Unlike existing secondary containment designs, the ESBWR Reactor Building will not have active ventilation or significant differential pressure generated in response to an accident condition. The differential pressure developed will be the result of effects of wind loading applied across a face of the Reactor Building, adiabatic building heatup, and design basis leakage from primary containment. Therefore, a positive pressure test for the ESBWR Reactor Building appropriately simulates accident conditions. The magnitude of the ESBWR Reactor Building exfiltration test (nominal ¼ inch w.g. differential pressure) bounds the effects of worst-case wind loading on the Reactor Building, and matches the differential pressure applied in testing of existing BWR secondary containment structures.

The Reactor Building exfiltration test will evaluate leakage from the contaminated areas of the Reactor Building (CONAVS) only. By design, the building potentially contaminated (radiological) areas, which include the CONAVS and Reactor Building Refueling and Pool Area HVAC Subsystem (REPAVS), are separated from the normally clean (nonradiological) areas of the Reactor Building, which are serviced by the Reactor Building Clean Area HVAC Subsystem (CLAVS). The differential pressure established during normal operation between subsystems is not needed or credited as part of the radiological analyses. There are no flow paths, door louvers, etc., where air travels between ventilation subsystems (radiological and nonradiological areas). The radiological and nonradiological areas are separated by the building compartmentalization. Also, direct leakage from the primary containment to the nonradiological areas of the Reactor Building (CLAVS) is not credible, because the primary containment penetrations are located in radiological areas (not nonradiological areas), and primary containment liner leakage through the concrete to CLAVS is precluded by design.

The ESBWR Reactor Building exfiltration test leak rate acceptance criteria ensures that leakage is less than 297 cfm, the total exfiltration leak rate used in the radiological analyses. This leakage rate is no longer stated as a percentage of Reactor Building volume. This accident acceptance flowrate is converted to standard conditions (scfm) based on the highest temperature (T_{RB}) in the CONAVS area in DCD Tier 2, Table 3H-9 (110°C) and the pressure in the CONAVS area (P_{RB}) equal to 14.7 psia. Using standard temperature and pressure (T_{STP} and P_{STP}) the exfiltration test leak rate acceptance criteria in scfm is calculated as follows:

$$V\text{ (scfm)} = V\text{ (cfm)} \times [(P_{RB})(T_{STP})/(P_{STP})(T_{RB})]$$

$$V\text{ (scfm)} = 297\text{ cfm} \times [273/383]$$

$$V\text{ (scfm)} = 211\text{ scfm}$$

This Reactor Building exfiltration test leak rate acceptance criteria will be adjusted based on the actual Reactor Building test differential pressure applied to ensure that the impact of test parameter uncertainties are minimized (flow instrument uncertainty, and Reactor Building temperature and pressure gradients). The actual test leak rate acceptance criteria applied in the Technical Specification implementing procedure is proportional to the actual differential pressure applied to the credited volume during the test:

$$Q \propto \sqrt{\Delta p}$$

Where:

Q = air flow rate, scfm

Δp = actual differential pressure applied to the credited volume during the test, inches w.g

DCD Impact:

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

NRC RAI 6.2-167 S02:

The GEH response to RAI 6.2-167 S01 states that it will perform in accordance with TS SR 3.6.3.1.4 a test of the "Reactor Building Volume confirming that the Reactor Building contaminated area HVAC subsystem (CONAVS) is less than that used in the radiological analysis."

A. *Standard technical specification specify testing the RB for maximum leakage rate every [18] months. Please provide the basis for the 60-month frequency of testing in the Technical Specification SR 3.6.3.1.4.*

B. *Please provide the volume of the contaminated area to be tested. This area should include all the rooms in the contaminated area, including stairwells and the portion of the contaminated HVAC system up to the safety related isolation dampers. Is the mixing volume listed in Table 15.4-5 Section B an equivalent volume?*

C. *The change in DCD Revision 5 applies to only testing the contaminated area of the reactor building. Technical Specification surveillances should be placed on all doors, hatches, vents or leak paths that separate the contaminated portion from the clean area, the refueling area, and the external environment. Please clarify in technical specification SR 3.6.3.1.1, SR 3.6.3.1.2, and SR 3.6.3.1.3 that the surveillances apply to the contaminated area volume which is being tested for leakage. These surveillances are needed to assure the contaminated area is being maintained in the isolated condition assumed in the design basis analysis.*

D. *The contaminated portion of the RB pressure test will provide a leakage flow out at the differential pressure, but it cannot identify where the flow goes. From the design basis analysis evaluation it is conservative that all the flow exits the building through the contaminated stairwells directly to the environment. The staff is concerned that some or all of the leakage could be released to the clean areas of the reactor building and concentrate to the point of impacting access for maintenance and surveillance activities. Do doorways that connect the contaminated area with the clean area and the refueling area have gaps for pressure equalization and thermal expansion, or are they fitted with seals that prevent the migration of contaminants between the three areas? The statement in DCD revision 5 section 6.2.3.2 second paragraph that "air flow is from clean to potentially contaminated areas" indicates that there are openings between the clean area and contaminated area. Is this correct?*

E. *Since the clean areas of the reactor building are not being tested for leakage and have been stated to be isolated from the contaminated area, they cannot be considered as being part of the volume used for mixing and dilution of the contaminated release. As such the 40 percent mixing assumption (revision 4) based on the total reactor building volume (2.1 million cubic feet) is no longer applicable. What level of mixing, if any, is being considered for the contaminated portion of the building? Please confirm that the GOTHIC analysis which is being performed to demonstrate that the mixing assumption is conservative, does not consider any dispersion to the clean areas of the RB.*

F. *In DCD revision 5 section 6.2.3.1 third bullet, "openings through the RB boundary." Since only the contaminated portion is being considered as containing and controlling leakage, the openings should be the contaminated area test boundary openings. Please consider clarifying the reference to RB in the DCD to reflect the difference between a requirement for the contaminated portion and a requirement for the RB as a whole.*

G. *The refueling area has been excluded from the contaminated area which is to be tested. Are there penetrations in the refueling area, such as the IC supply line penetrations, that could leak and permit contamination from the primary to enter the refueling area? How is this potential leakage evaluated in the design basis analysis? What values are assumed for leakage into the refueling area and for exfiltration from the refueling area?*

H. *In DCD revision 5 section 6.2.3.5, second item, "doors that form part of the RB boundary...." Does this refer to the RB contaminated area boundary which is being credited with containment of contamination or to the RB as a whole? Please revise as necessary.*

GEH Response:

A. As discussed in the response to resolved RAI 16.2-50 (MFN 07-022, dated January 19, 2007), the ESBWR Reactor Building leakage rate from potentially contaminated areas is not expected to be significant since there is no active ventilation nor significant differential pressure between these areas and the outside atmosphere generated in response to an accident condition. Because the Reactor Building provides an added holdup volume for fission products released from the containment in the event of an accident with the minimal use of active design features (i.e., ventilation isolation dampers), and with a low differential pressure between the Reactor Building and the outside atmosphere generated in response to an accident condition, general building integrity inspections along with a 60-month in-depth confirmatory evaluation are expected to provide adequate assurance that the Reactor Building leakage assumptions remain valid. In addition, there are other Surveillance Requirements in DCD Tier 2, Chapter 16, Technical Specification (TS) 3.6.3.1, that verify the most likely leakage paths from potentially contaminated areas are intact/closed as required on a 31-day frequency, and the automatic actuation of the ventilation isolation dampers is verified every 24 months.

B. The volume of the reactor building area to be tested, contained in the GOTHIC analysis transmitted to the NRC (MFN 08-630, dated August 14, 2008), is approximately 23,300 m^3 (the total Reactor Building Contaminated Area HVAC Subsystem (CONAVS) area free volume is 23,274 m^3 (821,999 ft^3)).

The volume assumed in the loss-of-coolant accident (LOCA) dose calculation, as documented in DCD Tier 2, Table 15.4-5, Loss-of-Coolant Accident Dose Consequence Analysis Parameters, was conservatively reduced from the value in the GOTHIC analysis.

C. DCD Tier 2, Chapter 16, Technical Specification (TS) 3.6.3.1, Reactor Building (CONAVS Area), was revised in DCD Revision 5 to clarify that the boundary being tested and maintained operable is the area served by CONAVS (i.e., CONAVS Area). This TS requires Surveillance Requirements (SRs) that apply to the boundary for the CONAVS Area that are needed to assure the contaminated area is being maintained in the isolated condition assumed in the design basis analysis:

- SR 3.6.3.1.1 verifies that all Reactor Building (CONAVS area) equipment hatches are maintained closed.
- SR 3.6.3.1.2 verifies that one Reactor Building (CONAVS area) access door in each access opening is closed, except when the access opening is being used for entry and exit.
- SR 3.6.3.1.4 verifies that the Reactor Building (CONAVS area) boundary isolation dampers actuate on an actual or simulated isolation signal.

These SRs apply to all the boundary penetrations, excluding the passive electrical and piping penetrations that are designed closed/intact.

D. The only viable means of communication between the contaminated (CONAVS and Refueling and Pool Area HVAC Subsystem (REPAVS)) and clean (Reactor Building Clean Area HVAC Subsystem (CLAVS)) subsystems is via the emergency exit doors at the clean area that connect to the contaminated stairwell. These doors are normally closed and sealed tightly. There are no flow paths, door louvers, etc., where air travels between ventilation subsystems (radiological and non-radiological areas).

Stair tower doorways will be specified to have minimal leakage for all operating conditions. The actual door design has not been specified at this time, but they will be fitted with seals that prevent the migration of contaminants between areas.

The statement that "air flows from clean to potentially contaminated areas" means that normal airflow within a reactor building HVAC subsystem has this design feature. This ensures that HVAC flow paths are designed such that flow is not directed from a volume with a higher potential for airborne radioactivity to one of lower potential. There are no openings or communication between the CONAVS, REPAVS, or CLAVS served areas.

E. The non-radiologically controlled areas (CLAVS) of the reactor building are not considered as being part of the volume used for mixing and dilution of the contaminated release. This is addressed in DCD Tier 2, Revision 5, Subsection 15.4.4.5.2.3, which states:

> "The RB credited mixing volume presented in Table 15.4-5 is the mixing volume that is assumed in the LOCA dose analysis. The LOCA dose analysis model produces uniform mixing within that volume. The GOTHIC computer code (Reference 15.4-19) is used for a detailed analysis of the RB and confirms that the mixing volume presented in Table 15.4-5 is a conservative characterization of the RB holdup and transport delay. The GOTHIC model assumes the same containment leakage rate and RB exfiltration rate as the LOCA dose analysis.

Several sub-volumes of the RB are modeled in GOTHIC. They include the CONAVS and CLAVS areas (Subsection 9.4.6), and stairwells. The CONAVS ventilation area envelopes all the containment penetrations, except those in the steam tunnel. Leakage from the steam tunnel penetrations is separately treated in the LOCA dose analysis. In some cases, the CLAVS areas are barriers between the CONAVS areas and the environment. The stairwells act as a transport path from the CONAVS areas to the environment. All the interior doors connecting the different rooms in the building, as well as the doors that connect to other buildings or to the environment, are modeled. Additionally, the HVAC ductwork connecting the appropriate volumes is also modeled in GOTHIC. Selected rooms within the CONAVS area are subdivided in the GOTHIC analysis. A comparison of the GOTHIC and LOCA dose analysis results confirms that the credited mixing volume (Table 15.4-5) is conservative relative to the radiological releases traversing through the highly compartmentalized ESBWR RB. The comparison is a ratio of exfiltration to the environment over leakage into the RB. The GOTHIC analysis shows that hypothetical release from multiple penetrations into multiple RB sub-volumes provides significant holdup. The hypothetical release has to traverse through multiple volumes, ductwork, door gaps, and stairwells. GOTHIC demonstrates that under design basis accident conditions for a LOCA concurrent with LOOP and fuel damage, the mixing volume assumed in the LOCA dose analysis is conservative. Additional detail of the GOTHIC analysis will be presented in Reference 15.4-13, Appendix B".

The total volume and mixing volume credited in the analysis and listed in DCD Tier 2, Table 15.4-5, is 23,274 m^3 and 16,000 m^3 respectively. This equates to 68.7% mixing of the CONAVS (contaminated) portion of the reactor building.

F. The "openings through the RB boundary." referenced in DCD Tier 2, Revision 5, Subsection 6.2.3.1 is correct as stated. The reactor building openings will all be treated similarly whether CONAVS, CLAVS, or REPAVS served areas.

G. Penetrations that would cause flow into the refueling area are included in the exfiltration from the contaminated area. All of the leakage from the contaminated area is considered in the design basis analysis. The exfiltration from the contaminated areas is conservatively assumed direct to the environment in the dose analysis and no credit is taken for additional hold up by the refueling area. If there is flow into the refueling area there would be less flow to the environment.

H. DCD Tier 2, Revision 5, Subsection 6.2.3.5, second item, "doors that form part of the RB boundary..." correctly refers to all reactor building doors whether CONAVS, CLAVS, or REPAVS served areas.

DCD Impact:

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