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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 121 Related to ESBWR Design Certification Application, RAI Number 19.2-24 S02**

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) sent by NRC letter dated December 5, 2007 (Reference 1). Previous RAIs and responses were transmitted in References 2 and 3. The GEH response to RAI Number 19.2-24 S02 is in Enclosure 1.

Verified DCD changes associated with this RAI response are identified in the enclosed DCD markups by enclosing the text within a black box. The marked-up pages may contain unverified changes in addition to the verified changes resulting from this RAI response. Other changes shown in the markup(s) may not be fully developed and approved for inclusion in DCD Revision 5.

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

Sincerely,

R.E. Brown for/

James C. Kinsey
Vice President, ESBWR Licensing

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NRO

References:

1. MFN-07-658, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request For Additional Information Letter No. 121 Related To ESBWR Design Certification Application,* dated December 5, 2007

2. MFN 06-323, Supplement 1, Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application, RAI Numbers 19.2-22S01 and 19.2-24S01, dated July 5, 2006

3. MFN 06-323, Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application – ESBWR Probabilistic Risk Assessment – RAI Numbers 19.2-22 and 19.2-24, dated September 18, 2006

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 121 Related to ESBWR Design Certification Application, ESBWR Probabilistic Risk Assessment, RAI Number 19.2-24 S02

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRF	0000-0079-2070

Enclosure 1

MFN 06-323, Supplement 2

Response to Portion of NRC Request for

Additional Information Letter No. 121

Related to ESBWR Design Certification Application

ESBWR Probabilistic Risk Assessment

RAI Number 19.2-24 S02

Verified DCD changes associated with this RAI response are identified in the enclosed DCD markups by enclosing the text within a black box. The marked-up pages may contain unverified changes in addition to the verified changes resulting from this RAI response. Other changes shown in the markup(s) may not be fully developed and approved for inclusion in DCD Revision 5.

NRC RAI 19.2-24 (Original)

Provide additional details regarding the BiMAC cover plate/lid arrangement, which is said to serve a dual purpose of providing a work surface during plant maintenance and trapping core debris during a high pressure melt ejection event. (The lid is indicated to be a stainless steel top plate over a zirconium oxide mat over a normal floor grating.) Include information regarding the lid materials, properties, thickness, and any seal provisions to prevent normal reactor coolant system (RCS) leakage from entering the BiMAC cavity, if applicable. Discuss the potential for the cover plate/lid to impede debris transport to the BiMAC cavity, particularly if the high velocity debris/gas jet is disrupted/dispersed by the substantial control rod drive (CRD) structures below the RPV, which appear to be neglected in the ESBWR analysis.

GE Response (Original)

Upon further evaluations of the potential DCH threat we are now of the opinion that the "trapping" quality of the plate on top of the BiMAC cavity is not needed (recall that the original concept was to provide some additional relief, even though such could not be, and was not counted on), and that this floor plate could better be used for the physical protection of BiMAC (see Section 21 of NEDO-33201 Rev 1). There is no "impedance" issue, speculated by this question, whatever is the material/structure used to cover the BiMAC. Any non-coolable geometry would penetrate such a structure, and any coolable geometry would be retained by it without further a due. The disruption of a jet from the RPV due to the CRDs and the motors at the lower ends is a good point that we ignored in Rev 1, but it is now discussed in the full ROAAM review version relative to the new purpose and design of this plate (see addenda on Basemat Melt Penetration (BMP) in full ROAAM review Severe Accident Treatment (SAT) report provided as the "Attachment to the GE's response to RAI 19.2-5").

NRC RAI 19.2-24 S01

The response to RAI 19.2-24 did not describe any provisions to prevent normal reactor coolant system leakage from entering the BiMAC cavity. Describe any such provisions, as well as provisions for preventing core debris from entering the LDW sumps prior to melt-through of the cover plate.

GEH Response, Supplement 1

The BiMAC cavity will drain through many narrow channels into the sumps, as required for leakage detection. As a design assumption (the detailed design is yet to be completed) these channels are sufficiently long to plug by freezing any melt that enters, prior to it reaching the sumps.

Normal reactor coolant system leakage is designed to enter the BiMAC cavity and be directed to the LDW sumps by a channeling system in the BiMAC layer itself. The width and number of the channels will be selected so that the required water flow rate during normal reactor operation is achievable. The cover plate (or personnel plate) above the BiMAC is solely for personnel activities and will not completely cover the area of the LDW floor; it is not designed as a provision to keep leakage flow out of the BiMAC cavity. Additionally, the channels are designed to arrest corium flow such that freezing will occur and prevent corium entry to the LDW sumps.

As discussed in NEDO-33201, Section 21, the BiMAC will function to shield the LDW sumps from the corium ejection. Immediately following RPV failure, the corium will come into contact with the personnel plate. The personnel plate is designed such that virtually no hold-up of the corium occurs; as such, any corium deflection by the personnel plate that could re-direct the ejection toward the sumps is prevented.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.
No changes to NEDO-33201 will be made in response to this RAI.

NRC RAI 19.2-24 S02

The response to Supplement 1 of RAI 19.2-24 states that a design assumption is that narrow drain channels into the sump would be sufficiently long to be plugged by freezing melt prior to reaching the sump. Upon completion of the detailed design, please provide an analysis that demonstrates that the melt would indeed freeze and plug the channels, and that no molten core debris would reach the sumps. In addition, please explain how, if molten core debris would reach the sump, radioactivity would be released to the environment.

GEH Response, Supplement 2

The analysis for the narrow drain channels will be referenced in DCD Subsection 19.3.2.6 as noted in the attached markup. Additionally, DCD Subsection 6.2.1.1.10.2, which describes the lower drywell floor in moderate detail will reference DCD Subsection 19.3.2.6

There are measures inherent to the design of the ESBWR safety systems that will prevent the possibility of radioactivity release in the event of molten core debris entering the sump. The containment isolation valves (2) on the sump pump drain line will automatically close during a design basis accident (see RAI 6.2-157 MFN 08-193, dated March 5, 2008 for further details). This will prevent any possibly contaminated material from reaching the radwaste building. Additionally, the sump is designed to flood with water in the event of a lower drywell flood/deluge. This water will cool the debris before it is able to melt through the sump liner, lower drywell liner, and insulating concrete.

DCD Impact

DCD Subsections 6.2.1.1.10.2 and 19.3.2.6 will be changed as shown in the attached markup.

DCD Table 19.2-3 will be changed as shown in the attached markup.

There will be no changes made to NEDO-33201 as a result of this RAI.

Attachment 1

MFN 06-323, Supplement 2

DCD Tier 2, Revision 5 Markup

Section 6.2.1.1.10.2 ESBWR Design Features for Severe Accident Control

DCD Tier 2, Revision 5 Markup

Section 19.3.2.6 Basemat Internal Melt Arrest and Coolability Device (BiMAC)

DCD Tier 2, Revision 5 Markup

Table 19.2-3 Risk Insights and Assumptions

Using this layered defense-in-depth approach, the following are the main elements in the design against severe accidents:

- Accident prevention;
- Accident mitigation; and
- Containment performance including design features to address containment challenges during a severe accident.

6.2.1.1.10.2 ESBWR Design Features for Severe Accident Control

Several features are designed into the ESBWR that serve either to prevent or mitigate the consequences of a severe accident. Key ESBWR features, their design intent, and the corresponding issues are summarized in Table 6.2-9. For each feature listed in Table 6.2-9, brief discussion is made below.

(1) Isolation Condenser System (ICS)

The Isolation Condensers (ICs) supports both reactor water level and pressure control and are the first defense against a SA. The ESBWR is equipped with four ICs, which conserve RPV inventory in the event of RPV isolation. Basically, the ICs take steam from the RPV and return condensate back to the RPV. The ICs begin operation when the condensate lines open automatically on diverse signals including RPV level dropping to Level 2. After operation begins, the ICs are capable of keeping the RPV level above the setpoint for ADS actuation. The design mitigates noncondensable buildup in the ICs (that can impair heat removal capacity) by temporarily opening a small vent line connecting the ICs to the suppression pool. The vent line is operated automatically when high RPV pressure is maintained for more than a set time. The vent line valves re-close automatically when RPV pressure is decreased below the setpoint pressure.

The RPV depressurizes in the event of a break in the primary system or after ADS actuation. Furthermore, the ESBWR design does not require the operation of the ICs to prevent containment pressurization and containment pressure control function is served by the Passive Containment Cooling System (PCCS).

(2) Automatic Depressurization System

The ESBWR reactor vessel is designed with a highly reliable depressurization system. This system plays a major role in preventing core damage. Furthermore, even in the event of core damage, the depressurization system can minimize the potential for High-Pressure Melt Ejection and lessen the resulting challenges to containment integrity. If the reactor vessel fails at elevated pressure, fragmented core debris could be transported into the upper drywell. The resulting heatup of the upper drywell atmosphere could overpressurize the containment or cause over temperature failure of the drywell head seals. The RPV depressurization system decreases the uncertainties associated with this failure mechanism by minimizing the occurrences of high pressure melt ejection.

(3) Compact Containment Design

The RB volume is reduced by relocating selected equipment and systems to areas outside of the RB. The major portion of this relocation is to remove nonsafety items from the Seismic Class 1 structure and to place them in other structures that are classified as Non-Seismic. Along with other system design simplifications and the above described relocation of non-safety items, a compact containment design is achieved with the characteristic of having a minimum number of penetrations. This reduces the leakage potential from the containment.

(4) PCC Heat Exchangers

The basic design of the ESBWR ensures that any fission products that are generated following an accident are not released outside the plant. One such removal mechanism is the PCC heat exchanger tubes. These tubes act like a filter for the aerosols. They essentially 'filter out' any aerosols that are transported into the PCC units along with the steam and non-condensable gas flow. Aerosols that are not retained, in the drywell or the PCC heat exchangers, get transported via the PCCS vent line to the suppression pool where they are efficiently scrubbed.

The PCC heat exchanger not only cools the containment by removing decay heat during accident, but also provides fission product retention within the containment.

(5) Lower Drywell Configuration

The floor area of the lower drywell has been maximized to improve the potential for ex-vessel debris cooling. There is a drain sump incorporated into the lower drywell floor intended to prevent water buildup on the floor. The location of the sump has been maximized to place it as far away from the RPV as possible, and is described in further detail in DCD Subsection 19.3.2.6 and Table 19.2-3.

(6) Manual Containment Overpressure Protection Subsystem (MCOPS)

In the event that containment heat removal fails or core-concrete interaction continues unabated, the Containment Inerting System lines are used to manually vent the containment to control pressure, preventing the overpressure failure of containment.

(7) Deluge Lines Flooder System

The lower drywell deluge lines flooder system has been included in the ESBWR to provide automatic cavity flooding in the event of core debris discharge from the reactor vessel. This system is actuated on high lower drywell floor temperature. The system consists of multiple lines that connect each of the GDCS water pools to the drywell connecting vents. The volume of water in the GDCS pools is capable of flooding the RPV and lower drywell to the top of active fuel.

The deluge flooder lines from the GDCS pools provide sufficient water to quench all core debris. The deluge lines originating from the GDCS provide water to the Basemat-Internal Melt Arrest and Coolability (BiMAC) device embedded into the lower drywell floor to cool the ex-vessel core-melt debris from top and bottom sides. By flooding the lower drywell after the introduction of core material, the potential for energetic fuel-coolant interaction is minimized. Additionally, covering core debris provides for debris cooling and scrubbing of fission products released from the debris due to core-concrete interaction. From an overall containment performance point of view, the flooder provides a significant benefit for accident mitigation.

(8) Passive Containment Cooling System (PCCS)

The PCCS system is designed to remove decay heat from the containment. The PCC heat exchangers receive a steam-gas mixture from the drywell atmosphere, condense the steam and

19.3.2.5 GDCS Deluge Subsystem

The lower drywell deluge subsystem of GDCS provides automatic flow to the lower drywell if core debris discharge from the reactor vessel is detected. This subsystem is actuated on a high lower drywell floor temperature profile that is unique to a core debris discharge. Supply lines connect each of the GDCS water pools to the deluge headers, which are isolated by squib valves. The deluge headers provide water to the Basemat-Internal Melt Arrest and Coolability (BiMAC) device embedded into the lower drywell floor to cool the ex-vessel core-melt debris. Temperature sensors in the BiMAC device provide the actuation signal to open the squib valves. This permits flooding the lower drywell after there has been a discharge of core material, which is significant because it minimizes the consequences of steam explosions that would occur if the lower drywell floor had been flooded prior to core discharge. Subsequent coverage of the core melt provides for debris cooling and scrubbing of fission products released from the debris. The deluge lines are sized to accommodate a single line failure, so that flow from the functional lines would be sufficient to ensure proper BiMAC operation; that is, capable to operate in the natural circulation mode within 5 minutes from corium melt arrival on the LDW floor.

19.3.2.6 Basemat Internal Melt Arrest and Coolability Device (BiMAC)

The BiMAC device is a passively-cooled barrier to core debris on the lower drywell (LDW) floor. This boundary is provided by a series of side-by-side inclined pipes, forming a jacket, which is passively cooled by natural circulation when subjected to thermal loading. Water is supplied to the BiMAC device from the GDCS pools by squib valves that are activated on the deluge lines. The timing and flows are such that cooling becomes available immediately upon actuation, and the chance of flooding the LDW prematurely, to the extent that this opens up a vulnerability to steam explosions, is remote. Analyses have shown that the containment will not fail by basemat melt-through or by overpressurization as long as the BiMAC functions. The detection and activation system is designed as a two-train system that is completely independent of core damage prevention systems. The BiMAC device is illustrated in Figure 19.3-1. Important considerations in the design are as follows:

(1) Pipe inclination angle. The inclined pipes are designed with consideration of critical heat fluxes generated by the molten corium, to permit natural circulation flow.

(2) Sacrificial refractory layer. A refractory material is located on top of the BiMAC pipes to protect against melt impingement during the initial corium relocation event. This also allows an adequate, but short, time period for diagnosing that conditions are appropriate for flooding, which minimizes the chance of inadvertent, early flooding. The refractory material is selected to have high structural integrity and high resistance to melting.

(3) Cover plate. A supported steel plate above the LDW floor, and the BiMAC device, serves as a floor for refueling operations. The plate is made to sit on top of normal floor grating, which is supported from below by steel columns. The cover plate is designed so that debris will penetrate it in a short period of time while providing protection for the BiMAC from CRD housings falling from the vessel.

(4) Lower Drywell Cavity. The space available at the BiMAC device is sufficient to accommodate the full core debris. The entire volume available, up to a height of the vertical segments of the BiMAC pipes, amounts to approximately 400% of the full-core debris. Thus there is no possibility for the melt to remain in contact with the LDW liner. The two sumps, needed for detecting leakage flow during normal operation, are positioned: the Equipment Drain Sump is located above the LDW floor, the Floor Drain Sump is located in the LDW outside of the BiMAC pipes and protected in the same manner as the rest of the LDW liner (Figure 19.3-1). The Floor Drain Sump will have channels at floor level to allow water, which falls onto the LDW floor, to flow into the sump. The channels will be long enough that any molten debris which reaches the inlet will freeze before it exits and spills into the sump. The channels will be designed consistent with ABWR DCD Tier 2 Section 19ED. ~~These considerations are in the conceptual stage and may be revised in final design.~~

19.3.2.7 Containment Isolation

The ESBWR containment design minimizes the number of penetrations. This affects the severe accident response by minimizing the probability of containment isolation failure. Lines that originate in the reactor vessel or the containment have dual barrier protection that is generally obtained by redundant isolation valves. Lines that are considered nonsafety-related in mitigating an accident isolate automatically in response to diverse isolation signals. Lines which may be useful in mitigating an accident have means to detect leakage or breaks and may be isolated should this occur.

Because of the high consequence of a RWCU line break outside containment, this system is designed with a third, diverse isolation valve. This valve is controlled by the nonsafety-related DCIS system and closes on the same signals that provide the safety-related isolation.

19.3.3 Containment Vent Penetration

In accordance with the guidance in SECY-93-087, Section I, SECY-90-16 Issue K, Dedicated Containment Vent Penetration, "... passive plant design features that address the containment overpressure challenge include highly reliable, redundant, and diverse passive safety-grade decay heat removal, automatic depressurization, and containment cooling." Therefore, the NRC recommended that, "the containment performance criteria proposed in Section I.J of this enclosure will serve as the basis for the staff's review of containment integrity and the need for containment vent." The containment performance goal in SECY-93-087, Issue I.J is met. Details are found in NEDO-33201 Revision 1, Section 8.2, "Frequency of Overpressure and Bypass Release Categories," and Section 8.3 of the DCD, "Containment Performance Against Overpressure."

The ESBWR design includes highly reliable, redundant, and diverse passive safety-grade decay heat removal, automatic depressurization, and containment cooling functions. In addition, use of containment venting is not credited in the calculation of LRF. Therefore, the nonsafety-related, active vent is acceptable.

Table 19.2-3
Risk Insights and Assumptions

Insight or Assumption	Disposition
The exposure of the distributed control and information system (DCIS) equipment to heat and smoke caused by a fire in a single fire area does not cause spurious actuations that could adversely affect safe shutdown. The ESBWR design features as described in DCD Tier 2 Section 7.1.3 help minimize the adverse affect on safe shutdown due to fire-induced spurious actuations. First of all, the ESBWR instrumentation and control system is digital. A spurious signal cannot be induced by the fire damages in a fiber optic cable. The hard wires are minimized to limit the consequences of a postulated fire. Typically the main control room (MCR) communicates with the safety-related and nonsafety-related DCIS rooms with fiber optics. From the DCIS rooms to the components, fiber optics will also be used up to the Remote Multiplexing Units (RMUs) in the plant. Hard wires then are used to control the subject components. Typically two load drivers are actuated simultaneously in order to actuate the component. To eliminate spurious actuations, these two load drivers are located in different fire areas. Therefore, a fire in a single fire area cannot cause spurious actuation.	Design Requirement
The communication links between the main control room (MCR) and the DCIS rooms do not include any copper or other wire conductors that could potentially cause fire-induced spurious actuations that could adversely affect safe shutdown. Since the main control room communicates with the DCIS rooms via fiber-optic cables, no spurious actuations due to electrical shorting will be originated from a MCR fire.	Design Requirement
It is assumed that the doors that connect the Control and Reactor Buildings with the Electrical Building galleries are watertight, for flooding of the galleries up to the ground level elevation.	Design Requirement
The floor Drain Sump channels, which allow leakage on the lower drywell floor to flow into the sump, will prevent any molten debris, which reaches the inlet, from entering the sump.	Design Requirement
Closure of both the equipment hatch and the personnel hatch can be performed from outside the lower drywell/containment.	Design Requirement