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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 88 Related to ESBWR Design Certification Application, RAI Numbers 19.1-68, 19.1-70 through 19.1-80, 19.1-109 and 19.1-116.**

The purpose of this letter is to submit the GE-Hitachi Nuclear Energy Americas LLC (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated December 26, 2006 (Reference 1). The responses to those questions are addressed in Enclosure 1 as RAI Numbers 19.1-68, 19.1-70 through 19.1-80, 19.1-109 and 19.1-116.

Please contact me if you have any questions.

Sincerely,

Kathy Sedney for

James C. Kinsey
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 07-357, 06-551, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, *Request for Additional Information Letter No. 88 Related to ESBWR Design Certification Application,* December 26, 2006.

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 88 Related to ESBWR Design Certification Application ESBWR Probabilistic Risk Assessment RAI Numbers 19.1-68, 19.1-70 through 19.1-80, 19.1-109, 19.1-116.

cc:	AE Cubbage	USNRC (with enclosures)	
	GB Stramback	GEHNEA/San Jose (with enclosures)	
	RE Brown	GEHNEA/Wilmington (with enclosures)	
	eDRF Section	0000-0075-1319	19.1-68 through 19.1-73,
		0000-0073-5870	19.1-74
		0000-0073-5883	19.1-75
		0000-0073-5897	19.1-76
		0000-0073-5907	19.1-77
		0000-0073-5916	19.1-78
		0000-0073-5926	19.1-79
		0000-0073-5932	19.1-80
		0000.0074-9060	19.1-109
		0000.0074-1319	19.1-116.

Enclosure 1
MFN 07- 507

Response to Portion of NRC Request for Additional Information Letter No. 88 Related to ESBWR Design Certification Application ESBWR Probabilistic Risk Assessment RAI Numbers 19.1-68, 19.1-70 through 19.1-80, 19.1-109 and 19.1-116

NRC RAI 19.1-68

Discuss the dominant accident sequences and associated major contributors and interpretation of results (Section 7). Section 7 of the PRA documents the results of core damage frequency (CDF) due to internal initiating events that occur when the plant is operating at power. This documentation is mostly in tabular form without much discussion and interpretation of the results. A discussion of the dominant accident sequences and associated major contributors to CDF, as well as an interpretation of the results in terms of important design and operational features, should be included. Such information is one of the inputs to the integrated process used to gain insights about the design and identify design and operational requirements. The discussion should include:

(1) a characterization of the dominant accident sequences and associated major contributors to the sequence CDF;

(2) a characterization of the major contributors to the uncertainty associated with the estimated CDF; and

(3) a characterization of the major design and/or operational features that contribute to the reduced CDF risk of the proposed design as compared to operating designs (e.g., less reliance on offsite and onsite power, and divisional separation). Since the ESBWR design has evolved from current BWR technology, through the incorporation of several features intended to make the plant safer, more available and easier to operate, the results of the risk evaluation should indicate that the design represents a reduction in risk over existing plants. For this purpose, a generic qualitative comparison of risks, by initiating event category,between the proposed design and operating BWR plants helps identify major design features that contribute to the reduced risk of the proposed design as compared to operating designs. Please provide this information.

GEH Response

NEDO 33201 Revision 2 incorporates the information in this request. The dominant accident sequences and associated major contributors to the sequence CDF are discussed in Section 7. The major contributors to the uncertainty associated with the estimated CDF are discussed in Section 11. Section 18 discusses the major design and operational features that contribute to the reduced CDF risk of the proposed design as compared to operating designs. This Section also indicates that the ESBWR design represents a reduction in risk over existing plants. Furthermore, it contains a qualitative comparison of risks, by initiating event category, between the ESBWR design and currently operating BWR plants and identifies major design features that contribute to the reduced risk of the proposed design as compared to operating designs.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19 R4.

NEDO-33201 Sections 7, 11 and 18, Rev.2 addresses the questions raised in this RAI.

NRC RAI 19.1-70

Address sensitivity analysis regarding 72-hour mission time and core cooling vulnerability event trees (Section 11). The staff needs additional information, related to Section 11.3.1 (Mission Time), as follows:

(A) It is stated (page 11.3-2) that for accident sequences, resulting from the core cooling vulnerability (CCV) event trees and which are grouped into the "ok" category, core damage can be avoided for much longer than the 72-hour mission time. If the means used in the CCV event trees are intended to prolong core cooling until other means become available or actions are taken

(B) It is stated (page 11.3-2) that the CCV event trees for transients include mainly the Fuel and Auxiliary Pool Cooling System (FAPCS) and the Fire Protection System (FPS) as additional active cooling systems to be used in sequences involving class II accidents after successful water injection from GDCS and the suppression pool (top event VLFL). However, these sequences already include failure of the FAPCS in the suppression pool cooling mode. Therefore, it is likely that the FAPCS will not be available for injection. Please explain.

(C) It is stated (page 11.3-2) that in the CCV event tree for loss of preferred power (LOPP) credit is taken for recovery of offsite power within 24 hours assuming failure to recover power at 30 minutes. A conditional failure probability to recover offsite power within 24 hours of about 10 percent is assumed. Please justify this assumption.

GEH Response

A. A major update of the event trees has been performed as part of the update of NEDO-33201. The core cooling vulnerability (CCV) event tress are not applicable to the new revision of the PRA model. The event trees have been updated to explicitly address sequences beyond 24 hours, up to 72 hours. These longer term sequences are Class II sequences. The contribution from Class II sequences is included in the CDF and LRF results.

B. The Level 1 PRA model uses the small event tree/ large fault tree approach where the fault trees are appropriately linked to the event tree structure. This methodology accounts for prior failures of systems or components that may be used in more than one event tree node. As discussed in response to part (A), the event trees have been updated and the results include the contributions of Class II sequences. Some of these sequences involve both functions of FAPCS (injection and suppression pool cooling), but the fault tree linking approach ensures that any prior failures of components that are required by either or both functions are properly addressed.

C. The updated PRA model does not include any recovery of offsite power.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19, Rev 4.
There is no impact to NEDO-33201, Rev 2.

NRC RAI 19.1-71

Address sensitivity analysis associated with non-safetyrelated systems (Section 11). The staff needs additional information, related to Section 11.3.2 (Importance of Non-Safety Systems), in the following areas:

(A) It appears that the cutsets provided in Section 11-5 are based on a mission time of 24 hours and important failures occurring after 24 hours from the initiation of the accident are not considered. For example, the successful post 24-hour operation of ICS and PCCS require the opening of a pair of MOVs to replenish the IC/PCC pools. The staff could not find any cut sets including common cause failure of these MOVs. If such failures are considered, the calculated CDF and LRF values in the "focused PRA" sensitivity study, which are used to identify non-safety-related systems that are candidates for regulatory oversight, could be much higher than those reported in the PRA. Please explain.

(B) The systems that are considered unavailable in the "focused PRA" sensitivity study are listed on page 11.3-3. This list does not include any support systems, such as onsite power, cooling water and non-safety-related I&C. Please explain.

(C) The results of the "focused PRA" sensitivity study include significant uncertainties (related to both modeling assumptions and data) that need to be addressed and taken into account in identifying candidate systems for regulatory oversight. Please discuss.

GEH Response

A. In Revision 2 of NEDO-33201, the event trees have been updated to explicitly address sequences beyond 24 hours, up to 72 hours. This includes adding an event tree node to account for replenishing the water level in the IC/PCC pools. Valves B32-F104A and F104D open to replenish the water level in IC/PCC pool AB. Each valve has a diverse operator. Likewise, valves B32-F104B and F104C open to replenish the water level in IC/PCC pool CD. Common cause valve failures are modeled for common valve operators. In this case, a common cause valve failure does not prevent the pool refilling function.

B. The focused PRA does not exclude support systems because they support the active systems that are assumed failed in the analysis.

C. In order to account for uncertainties in modeling assumptions and data, the FAPCS low pressure coolant injection function and the suppression pool cooling function were classified as RTNSS. Also, the BiMAC device was classified as RTNSS to account for severe accident phenomenological uncertainty.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19, Rev 4.

There is no impact to NEDO-33201, Revision 2.

NRC RAI 19.1-72

Address results and insights from the uncertainty,importance and sensitivity analyses (Section 18). Section 11 includes the results of sensitivity analyses. Additional sensitivity analyses may be needed to address open issues identified by the staff's review or due to changes in the design or the PRA. Section 18 includes the results of the importance analyses in tabular form without much discussion, interpretation or explanation of how these results have been used in an integrated fashion to support the design certification process. A discussion is needed to explain how the results and insights from the uncertainty, importance and sensitivity analyses have been used systematically, in an integrated fashion, to gain insights about the design and identify appropriate requirements to ensure that important assumptions made in the risk evaluation will remain valid in a future plant referencing the certified design and that uncertainties have been appropriately addressed. Please discuss.

GEH Response

NEDO 33201 Section 11, Revision 2 addresses uncertainty and additional sensitivity analyses. NEDO 33201 Sections 17 and 18, Revision 2 discuss how the results and insights from the uncertainty, importance and sensitivity analyses have been used. The results are used systematically, and in an integrated fashion, to gain insights about the design and to identify appropriate requirements to ensure that important assumptions made in the risk evaluation remain valid in a future plant referencing the certified design.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19, Revision 4.

NEDO-33201 Sections 7,11and 18, Revision 2 addresse the questions raised in this RAI.

NRC RAI 19.1-73

Address uses of PRA in the design process (Section 18). Please include a discussion on the use of PRA in the design process, with representative examples, of ways in which the ESBWR design was enhanced by adding or modifying design features or operational requirements. Please provide at least one example in each of the following three categories, if available. • Use of PRA to identify and introduce features and requirements in the ESBWR design that reduce or eliminate known vulnerabilities (or weaknesses) in operating BWR designs. • Use of PRA to quantify the effect of new design features and operational strategies on plant risk to confirm the risk reduction credit for such improvements. • Use of PRA to select among alternative features, operational strategies, or design options.

GEH Response

NEDO 33201 Section 18, Revision 2 includes a discussion on how the ESBWR PRA has been used to evaluate design features that reduce or eliminate known weaknesses in operating BWR designs and evaluate the effect of new design features and operational strategies on plant risk to confirm the risk reduction credit for such improvements. For example, the fire suppression piping in the Control Building has been moved, based on PRA input, to significantly reduce the probability of internal flooding in the building. An example of using the ESBWR PRA to select among alternative features, operational strategies, or design options is the analysis of Severe Accident Mitigation Alternatives, which is contained in NEDO 33306 Revision 1.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19 R4.
NEDO-33201 Section 18, Revision 2 addresses the questions raised in this RAI.

NRC RAI 19.1-74

Provide plant layout drawings for fire areas and fire boundaries and identify equipment (Section 12). Please provide (1) plant layout drawings showing fire area boundaries and equipment located in each fire area, and (2) list of equipment located in each fire area (including cables routed through the fire area). This information is needed to clarify certain statements and assumptions made in the fire risk analysis (Section 12 of the PRA). For example, it is stated that the pumps and the heat exchangers of each RWCU train are located in different fire areas without stating in what fire areas they are located and through which fire areas the cabling to the RWCU pumps are routed. Also, please provide a list of any fire areas that were screened out from detailed analysis and discuss the basis. For example, it appears that fires in the yard area causing loss of offsite power (frequency 1.5E-2/year) and the remote shutdown panels were not addressed. Please clarify.

GEH Response

The following information are provided:

(1) The plant layout drawings for fire areas and fire boundaries are included in DCD Section 9A (Figures 9A.2-1 through 9A.2-47), which are referred in revision 2 of NEDO-33201 Section 12. Table 9A.5-1 through 9A.5-7 in DCD Section 9A list additional information for these fire areas.

(2) The list of equipment located in each fire area and the cable routing information are included in NEDE/NEDO-33386, Section 4 Revision 0.

   a. The mapping from fire areas to rooms, then to components and basic events are based on the current detailed design drawings, which could be subject to changes. However, the separation criteria are implemented and no significant changes are expected in future modifications to the detailed designs.

   b. The cable routing is assumed for PRA fire model under the guideline for separation criteria. Although the final cable routing could be different from the ones assumed in the PRA model, the assumed cable routing in the PRA model is conservative.

As shown in NEDE/NEDO-33386 Section 4, the components of the two trains of RWCU are separated in two fire areas F1152 and F1162.

The remote shutdown panels will be located in separate fire areas in the reactor building (DCD section 9A.4.3). Since the fire PRA model does not take credit for the remote shutdown panels for conservatism, the location of the remote shutdown panels is not critical to the current PRA model. Such conservatism can be removed when the detailed design provides the necessary information.

A fire in the switchyard could result in a plant trip if it results in loss of preferred power. Such scenario has been included in the fire PRA model with a conservative assumption that any fire in the switchyard would result in a reactor trip. For consistency and conservatism, a fire frequency of 1.8E-2/yr and 5.2E-2/shutdown-year based on RES/OERAB/S01-01 has been used. The fire frequency that could result in a plant trip has been included in the loss of preferred power initiator (the switchyard-related portion of initiator %T-LOPP) in the baseline 1 PRA models. Therefore, include these fire scenarios in fire PRA model is conservative.

The qualitative process was used to screen out a list of fire areas based on the guidelines in NUREG/CR-6850 Task 4. The qualitative screening results are included in revision 2 of NEDO-33201 Section 12.

DCD/NEDO-33201 Impact

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

NEDO-33201 Section 12, Rev. 2 has been revised to include screening information.

NEDE/NEDO-33386 Rev. 0 was transmitted by MFN 07-485, Supplement 1, dated September 28, 2007.

NRC RAI 19.1-75

Address propagation of smoke to areas beyond the postulated fire (Section 12). Smoke damage of advanced digital I&C system components can prevent actuation of multiple components. This issue has not been addressed in the fire PRA (Section 12). The propagation of smoke (e.g., through the ventilation system) to certain areas of the plant could impact equipment divisions supporting redundant functions and result in significant risk increases. Please address this issue by:

(1) searching for potential smoke propagation paths;

(2) identifying design and operational features that are available to prevent or minimize smoke propagation; and

(3) assessing the associated risk or showing (e.g., through bounding assumptions) that such risk is insignificant. Smoke propagation paths between safety-related areas as well as between a safety-related and a non-safety related area should be investigated. Please discuss.

GEH Response

(1) Potential Smoke Propagation Paths

Detailed HVAC system design information is not available. Based on the simplified system diagrams (Figures 9.4-1 through 9.4-13) included in DCD Section 9.4, the potential smoke propagation paths are identified as follows:

- **Control Room**: The control room ventilation system is separate from other rooms in the control building. Therefore there is no potential smoke propagation path between the control room and other rooms.
- **Control Building**: There are two trains of control building ventilation. With the failure of the smoke removal mode, smoke can potentially propagate among N-DCIS room A (fire area F3301), Div I and IV Q-DCIS rooms (fire areas F3110 and F3140), or among N-DCIS room B (fire area F3302), Div II and Div III Q-DCIS rooms (fire areas F3120 and F3130).
- **Fuel Building**: With the failure of exhaust fans, smoke could potentially propagate among all fuel building elevations. However, the FAPCS components are the only modeled PRA components in the fuel building. All components are assumed to be located in one fire area F2100. Therefore, the potential smoke propagation paths have no impact on fire analysis.
- **Turbine Building**: With the failure of exhaust fans, smoke could potentially propagate among all turbine building elevations. However, the turbine building covers very large open areas and should not result in high concentration of particles that can result in component failure. The RCCW system components are housed in separate fire areas and are designed with separation criteria that no single fire can fail both trains. RCCW rooms

have their own fan coil units that are cooled by the nuclear-island chilled water system. Therefore, the RCCW rooms can be isolated from the rest of the turbine building to ensure its operability after a postulated fire in the turbine building general area (i.e., not the RCCW rooms).

- **Reactor Building**: Three reactor building HVAC systems (CLAVS for clean areas, CONAVS for contaminated areas, and REPVAS for the refueling and pool area) are designed for the reactor building. With the failure of the smoke removal mode, certain reactor building levels can have smoke propagation. The drywell/containment ventilation system is not connected to the reactor building HVAC systems.
- **Electrical Building**: With the failure of the smoke removal mode, the electric and electronic rooms can have smoke propagation. The two trains are separated since there are two HVAC sub-systems for redundancy. Diesel generator rooms have their own ventilation systems. There are no smoke propagation paths between the two diesel generator rooms and between the diesel generator rooms and the electrical building rooms.

(2) Design and Operational Features

The following design and operational features are used to mitigate the potential risk associated with smoke propagation. Per DCD Section 9.5.1.11, Fire protection/smoke control provisions for ventilation for the various building areas are designed as follows:

- Smoke control in accordance with NFPA 92A guidelines is provided for unsprinklered areas where the FHA identifies a potential for heavy smoke or heat conditions. Additionally, safe egress and safe smoke refuge areas during a fire incident are provided in accordance with NFPA 92A guidelines for building occupants and the fire brigade. NFPA 101 guidelines are utilized for the design and labeling of safe egress routes.
- Smoke removal meets NFPA 804 with exception to NFPA 804 Sections 8.4.3 (3) and 8.4.3.2. Automatic sprinkler protection is provided for the high density cable tunnels, fuel oil tank rooms, diesel-generator rooms and a significant portion of the turbine building to limit heat and smoke generation. The COL Holder will establish provisions for manual smoke control by manual actions of the fire brigade for all plant areas in accordance with NFPA 804 guidelines.

The exceptions discussed in the second bullet above involve provisions from smoke removal in areas not completely protected by the automatic sprinkler system, which have no impact on this evaluation.

Smoke removal from areas containing equipment required for safe shutdown is provided by the Heating, Ventilating, and Air-Conditioning (HVAC) systems operating in smoke removal mode. Smoke will be removed from rooms containing equipment required for safe shutdown by the normal HVAC system in smoke removal mode.

All ventilation duct openings in fire barriers will be protected by fire dampers as required by NFPA 90A.

In the detailed design stage, balanced HVAC and Q-DCIS system designs will be implemented to address both heat dissipation and smoke removal issues. The impact of a failure of the smoke removal system can be significantly mitigated if more separation is considered in the detailed HVAC design. Some of the safety-related Q-DCIS circuit boards may be conformably coated for protection or protected by other equivalent methods (e.g., hermetically sealing equipment or qualifying with tests for smoke). Use of any of the methods described above would significantly reduce the potential of smoke damage to the Q-DCIS circuit boards. In revision 2 of NEDO-33201 section 12, coating of Q-DCIS circuit boards is credited as a reasonable approach to address the smoke propagation issue. The subject section will be revised to document the final detailed design features to mitigate the smoke damage.

(3) Assessing Smoke Propagation Risk

Based on the above discussions, the following is the risk evaluation on the potential smoke propagation paths if the smoke removal mode fails and fire dampers fail to isolate the subject area:

- **N-DCIS room A (fire area F3301), Div I and IV Q-DCIS rooms (fire areas F3110 and F3140):** The risk increase due to the additional failures for the postulated smoke damage is not significant since the ESBWR plant has N-2 redundancy in the safety system design. With the additional failure probability of the smoke removal mode and the failure of fire dampers to isolate, the risk contribution due to smoke propagation is negligible.
- **N-DCIS room B (fire area F3302), Div II and Div III Q-DCIS rooms (fire areas F3120 and F3130):** Same as above. The risk increase due to smoke propagation is negligible.
- **Electric and electronic rooms in the electric building for each train of the electrical distribution system:** The risk increase due to the additional failures for the postulated smoke damage is not significant since only one train of the electric system is impacted. With the additional failure probability of the smoke removal mode and the failure of fire dampers to isolate, the risk contribution due to smoke propagation is negligible.
- **Different levels in the reactor building**: The risk increase due to smoke damage, if assumed, combined with the failure of the smoke removal mode and the fire damper isolation is not significant with a balanced detailed HVAC system design (i.e., implementing separation criteria of reactor building HVAC subsystems, or coating some of the Q-DCIS circuit boards, or using other equivalent methods to protect them from the postulated smoke damages). Per NUREG/CR-6850 Appendix T, smoke damage, only one mode of component failure was found to be of potential risk significance, which is circuit bridging. By coating some of the Q-DCIS circuit boards or protected by other equivalent methods, the potential smoke damage could be significantly reduced. On the other hand, a detailed HVAC design could implement separation criteria for different fire

areas with safety-related equipment, which would result in negligible risks associated with smoke damage even without crediting coating of the Q-DCIS circuit boards.

In summary, the risk associated with postulated smoke propagation is negligible with balanced HVAC and Q-DCIS system designs implemented to address smoke removal issues

DCD Impact

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

LTR NEDO-33201 Section 12, Rev 3 will be revised to document the final detailed design features to mitigate the smoke damage

NRC RAI 19.1-76

Address risk importance of nonsafety-related systems in the fire PRA (Section 12). Please provide the risk importance measures for non-safety-related systems that were credited in the fire risk assessment. The conservative assumptions used in the fire risk analysis do not provide insights regarding the importance of non-safety-related systems to mitigate accident sequences initiated by fire events. Reviewer Summary Full Text -8-

GEH Response

The importance of nonsafety-related systems in the fire analyses is demonstrated in the sensitivity studies for the focused full-power and shutdown fire cases. The results are included in revision 2 of NEDO-33201 Section 11.

DCD/NEDO-33201 Impact

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

NEDO-33201 Section 11, Revision 2 has been revised to show the importance of nonsafety-related systems.

NRC RAI 19.1-77

Investigate fire-induced spurious valve actuations causing LOCA or incorrect valve lineup (Section 12). The staff believes that a systematic search of potential fire-induced spurious valve actuations (single and multiple) causing LOCA or incorrect valve lineup is needed and should be addressed in Section 12 of the PRA. Fires have the potential to cause spurious valve actuations. Smoke damage of advanced digital I&C components can prevent actuation of multiple components. Although smoke-induced scenarios are not routinely treated in conventional PRAs, they should be investigated in this case because of the potential vulnerability of advanced electronics to smoke damage. If such failures are found to be believable, based on frequency estimates, their risk impact should be assessed. Also, the spurious opening of containment isolation valves as well as the opening of valves in paths between the reactor coolant system and low pressure systems (leading to interfacing system LOCAs) should be investigated. Please discuss any ESBWR features that prevent or mitigate spurious actuation and smoke damage (and their impacts, as necessary) of I&C components.

GEH Response

In the internal event PRA model, the following additional events contribute to the LOCA frequencies in addition to pipe breaks for LOCA inside containment:

	Event	Contribution To
a.	Spurious actuation of one DPV	Medium Steam LOCA
b.	Spurious actuation two or more SRVs/DPVs	Large LOCA
c.	Spurious actuation of one GDCS Squib	Medium Liquid LOCA

A single fire in any fire area will not result in spurious actuation of the subject valves and result in a LOCA. The ESBWR design features as described in DCD Tier 2 Section 7.1.3 help minimize the adverse affect on safe shutdown from fire-induced spurious actuations. The ESBWR instrumentation and control system is digital. A spurious signal cannot be induced by fire damage 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 is used up to the Remote Multiplexing Units (RMUs) in the plant. Hard wires then are used to control the subject components. Typically, two or three load drivers are actuated simultaneously in order to actuate the component. To eliminate spurious actuations, these multiple load drivers are located in different fire areas. Therefore, a fire in a single fire area cannot cause spurious actuation.

The existence of fire detection and suppression systems, fire barriers, and adequate monitoring and supervision means that it can be assumed that fire propagation to neighboring zones separated by those barriers is a relatively negligible contribution to risk. Nevertheless, the potential propagation of a fire started in one of the divisions of the building and propagating to another area is considered in the Fire PRA.

The squib valves used in ADS, GDCS, and SLCS are located inside primary containment, and their firing mechanisms are not vulnerable to direct contact with a fire during at-power operations. Furthermore, the sensing and actuation circuitry is primarily digital with fiber-optic connections, and they are immune to the hot-shorting phenomena. A relatively minor amount of copper wiring exists from the Remote Multiplexing Units in the Reactor Building to the firing circuits inside the primary containment such that concurrent hot-shorts caused by a fire are considered to be negligible. Moreover, the primary containment is inerted during at-power operations so there is no possibility for a fire-induced spurious actuation inside the containment during at-power operations.

For intersystem LOCA (ISLOCA), there are two systems with penetration lines that did not screen.

1. Main Steam Line Drains Upstream of the MSIVs
2. Feedwater System (Line A)

The main steam line drains upstream of the MSIVs have multiple, normally closed valves including two containment isolation valves (one normally closed and the other normally open). The safety-related DCIS system is designed so that no single fire can spuriously actuate the containment isolation valves. Moreover, if spurious actuation were to occur on both valves, the drain is still isolated. The other normally closed valve downstream on the drain line is normally closed and it is unlikely that a fire can propagate across multiple fire areas and cause spurious actuations on both the containment isolation valves and the downstream valve.

For the high/low pressure interfaces on the feedwater system line A, multiple check valves are included, which prevent the opening of the path even if a spurious actuation should occur after a fire. DCD Tier 2 section 7.6.1 describes the HP/LP system interlock function. Moreover, the detailed design has added the monitoring and alarm functions on the line between the check valve and the normally closed isolation valves to check for potential leakage to detect valve failure upstream. Therefore, the spurious actuation due to a postulated fire has negligible impact on the ISLOCA evaluations.

As discussed in the response to RAI 19.1-75, design and operational features are used to mitigate the potential risk associated with smoke propagation.

DCD/NEDO-33201 Impact

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

NEDO-33201 Section 12, Revision 2 has been revised to address fire induced LOCAs.

NRC RAI 19.1-78

Address probability of fire barrier failure and propagation of fire to an adjacent area (Section 12). It is stated that "A value of 7.4E-03 is taken as the fire propagation probability from one divisional fire area to another. This probability represents failure of a fire door and is obtained from Reference 12-4." However, there may be more than one fire door separating the two fire areas and additional fire propagation pathways, such as piping or cable penetrations and ventilation ducts (especially in large "fire areas" assumed in order to simplify the analysis). Reference 12-4 (listed in the submitted fire risk analysis) provides fire barrier failure probabilities associated with such fire propagation pathways. In addition, fire doors in some fire areas can be open to perform online maintenance. Please provide additional justification of the assumed probability of fire barrier failure by addressing each of these staff concerns.

GEH Response

New fire propagation scenarios for full-power scenarios have been postulated based on the plant general arrangement drawings, which are included in Table 12.3-2 in the revision 2 of NEDO-33201 Section 12. Although the fire analysis conservatively assumes that a postulated fire can cause damage to all components and cabling in the subject fire area, it is reasonable to assume that the fire will not propagate to all directions. Therefore, it is reasonable to postulate a fire propagation scenario based on the most limiting path between two adjacent fire areas through a failed fire door, a fire damper, or walls and penetration seals.

More conservative assumptions have been used in the shutdown fire analysis to consider multiple propagation paths.

The failure probabilities of fire barriers are taken from Table 11-3 of NUREG/CR-6850 Vol. 2.

Fire doors may be open to perform online maintenance. However, this is not modeled in the revision 2 of the ESBWR fire PRA model. The risk increases associated with the open fire doors will be controlled by the plant's risk management program of 10CFR50.65(a)(4) when the plant is in operation.

DCD/NEDO-33201 Impact

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

NEDO-33201 Table 12.3-2, Revision 2 has been revised to show new fire propagation scenarios.

NRC RAI 19.1-79

Verify, explain and/or clarify the following assumptions regarding main control room (MCR) fires:

(A) Verify that if MCR evacuation is necessary, the remote shutdown panels provide complete redundancy in terms of control and monitoring for safe shutdown functions.

(B) Explain how the transfer of operations from the MCR to the remote shutdown panels is controlled (e.g., is there a transfer switch and associated analog-to-digital converter?). Explain why a fire-induced short or flash lightning cannot generate spurious actuation signals. Please list the features of the proposed optical fiber design that prevent spurious actuations, given a fire in the MCR or the remote shutdown panels. Reviewer Summary Full Text -9-

(C) Verify that the MCR and remote shutdown panel are in separate fire areas and each has its own dedicated ventilation system.

(D) List any design and operational features that limit MCR fire ignition frequency (e.g., low voltage, low current equipment, fiberoptic cables, and administrative procedures).

(E) List any design and operational features that prevent or limit the propagation of smoke from MCR fires to adjacent areas (including the remote shutdown panels).

(F) Discuss the potential of spurious actuations associated with hard-wired controls.

GEH Response

(A) If the MCR evacuation is necessary, the remote shutdown panels provide complete redundancy in terms of control and monitoring for safe shutdown functions. Although not all the detailed designs are available, the remote shutdown panels are designed to be located in the reactor building.

(B) The transfer of operations from the MCR to the remote shutdown panels is not required since the remote shutdown panels are designed to have all the function available at the MCR. 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.

(C) The MCR is located in the control building (fire area F3270) and remote shutdown panels are located in separate fire areas in the reactor building. The MCR has its own dedicated ventilation system (CRHAVS) and the remote shutdown panels ventilation system will be using the reactor building ventilation system (CONAVS and CLAVS).

(D) The ESBWR MCR design does not have main control boards as in a traditional nuclear power plant. The safety-related and nonsafety-related electrical cabinets are located in the separate DCIS rooms, which are in different fire areas. The MCR communicate with these DCIS rooms via fiber-optic cables. The cabinets in MCR are the control consoles and the wide display panels. Therefore only low voltage and low current equipment will be included in the MCR. Administrative procedures will be used to limit the amount of transient loads that can be brought into the MCR. Nevertheless, conservative assumptions have been used to evaluate the MCR fire ignition frequency. The main control boards are assumed to an applicable fire ignition source to ESBWR MCR. The weighting factor on transient ignition source is also increased for conservatism.

(E) The MCR and remote shutdown panels are located in totally different buildings. No smoke propagation from MCR to other fire areas is postulated since the MCR has its own ventilation system.

(F) The HFE process ultimately decides the hard-wired controls in the MCR. At this time, the SCRAM and MSIV closure will have hard-wired controls in the MCR, which does not affect the PRA model. The HFE group has been recommended not to include other hard-wired controls because of the potential for spurious operations due to fires. One PRA assumption is that there will be no controls in the MCR that can induce undesirable spurious operations that affect the PRA.

DCD/NEDO-33201 Impact

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

NEDO-33201 Section 12, Revision 2 has been revised to discuss assumptions regarding main control room fires.

NRC RAI 19.1-80

Please explain why a fire in the Reactor Building Divisional Zones is not likely to cause the inadvertent opening of multiple SRVs. Describe the actuation mechanism of SRVs, their power sources and the separation of power and control cables associated with the various SRVs (Section 12).

GEH Response

The reactor building is divided into four divisions for the safety-related system. For each division, multiple fire areas on different elevations are assigned to house multiple load drivers that are required to actuate the safety relief valves. Typically two load drivers are actuated simultaneously in order to actuate the component. This arrangement eliminates spurious actuations due to a postulated fire in a single fire area. Therefore, a fire in a single fire area cannot cause spurious actuation. DCD Section 7.3.1.1.2 states as follows:

> *Each of the trains (per division) of ADS start signals are sent to the load drivers/discrete outputs for the ADS SRVs and DPVs operated by that division. The load drivers/discrete outputs are wired in series for each valve such that each is required for operation. This scheme makes the logic single failure proof against inadvertent actuation.*

Per DCD Section 7.3.1.1.2, each of the SRVs is equipped with four solenoid-operated pilot valves. Three solenoids receive Q-DCIS signal, the fourth is part of the DPS. The solenoid-operated pilot valves are powered by 250 VDC buses. The divisional safety-related power sources are located in the divisional batteries rooms. The power and control cables are physically separated from other divisions.

DCD/NEDO-33201 Impact

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

No changes to NEDO-33201, Revision 2 will be made in response to this RAI.

NRC RAI 19.1-109

The PRA (Section 13) does not include modeling of post 24-hour failures and actions in the flooding risk analysis. The staff believes such modeling is important in sensitivity studies, such as the focused PRA used to identify non-safety-related systems that are candidates for regulatory oversight. Please include post 24-hour modeling or discuss the rationale for excluding.

GEH Response

Revision 2 of the PRA includes modeling of post 24-hour failures and actions. These have been included in the event tree.

DCD/NEDO-033201 Impact

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

NEDO-33201 Section 13, Revision 2 has been revised to include post 24 hour flooding.

NRC RAI 19.1-116

In Table 19.2-3 (Risk Insights and Assumptions) of Design Control Document (DCD) Tier 2, Chapter 19, please include a list of the design and operational requirements (e.g., ITAACs, Technical Specifications, reliability assurance program, COL action items) that can be identified through a systematic search of risk insights and assumptions in the PRA. Identification of such requirements is one objective pertaining to use of the PRA. The staff recognizes that identification of such requirements is an iterative process and the list cannot be finalized until all analyses, and staff review/evaluation, are completed and open issues are resolved. Please discuss.

GEH Response

DCD Chapter 19 Revision 4 Table 19.2-3 has been revised to identify design and operational requirements based on PRA risk insights and assumptions. A systematic method is used to identify the significant insights and assumptions of the PRA model. Sections 1.0 through 16.0 of NEDO-33201 are reviewed to identify instances where parametric, modeling and completeness uncertainties have required the use of assumptions. This provides a comprehensive accounting for assumptions from each phase of the PRA development. The final result is a list of assumptions that have a significant effect on the PRA model and its insights, and their dispositions. The dispositions are as follows:

- Design Requirement: an assumption that requires specific design details be preserved to maintain its validity.
- Operational Program: an assumption that requires specific operational procedures or training be served to maintain its validity.
- Insight: an assumption that provides significant information about the PRA model or its results that should be maintained in PRA model development, updates, and risk-informed applications.

Design Requirements are maintained through the design control process. Proposed design changes that affect the PRA are required to receive a PRA review to ensure that design requirements remain valid. Operational Program issues are incorporated into the human factors engineering program.

DCD/NEDO-33201 Impact

There is no impact to DCD Tier 2 Chapter 19 R4.

NEDO-33201 Table 19.2-3, Revision 2 has been revised to identify design and operational requirements based on PRA risk insights and assumptions