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Subject: **Response to Portion of NRC RAI Letter No.s 385 and 389 Related to ESBWR Design Certification Application – PRA – RAI Numbers 19.1-180 through 19.1-185**

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) Numbers 19.1-180 (Reference 1) and 19.1-181 through 19.1-185 (Reference 2).

ESBWR Design Control Document (DCD) and Licensing Topical Report (LTR) markups are provided in Enclosure 2.

If you have any questions about the information provided, please contact me.

Sincerely,

FOR

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-682, Letter from the U.S. Nuclear Regulatory Commission to Jerald G. Head, Request for Additional Information Letter No. 385, Related to ESBWR Design Certification Application, dated October 27, 2009.
2. MFN 09-686, Letter from the U.S. Nuclear Regulatory Commission to Jerald G. Head, Request for Additional Information Letter No. 389, Related to ESBWR Design Certification Application, dated October 30, 2009.

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No.s 385 and 389 Related to ESBWR Design Certification Application – PRA – RAI Numbers 19.1-180 through 19.1-185.
2. Response to Portion of NRC Request for Additional Information Letter No.s 385 and 389 Related to ESBWR Design Certification Application – PRA – RAI Numbers 19.1-180 through 19.1-185 – ESBWR DCD and LTR Markups.

cc:	AE Cubbage	USNRC (with enclosures)
	J G Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
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	eDRF Sections	0000-0109-4267 (RAI 19.1-180)
		0000-0109-4279 (RAIs 19.1-181 through 19.1-185)

Enclosure 1

MFN 09-717

Response to Portion of NRC Request for

Additional Information Letter No.s 385 and 389

Related to ESBWR Design Certification Application

Probabilistic Risk Assessment

RAI Numbers 19.1-180 through 19.1-185

NRC RAI 19.1-180

The ESBWR PRA (NEDO-33201) does not clearly describe the manner in which events pertaining to plant-specific cooling tower designs/arrangements (e.g., dry, hybrid) were treated in the PRA. Please revise NEDO-33201 to clarify the cooling tower designs/arrangements included within the scope of the ESBWR PRA and describe how they are bounded with the design PRA model.

GEH Response

NEDO-33201 Section 4.9.9 will be revised to clarify the cooling tower configurations that are considered in the PRA model, and describe how they are bounded with the design PRA model.

DCD Impact

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

LTR NEDO-33201, Rev 4 will be revised as noted in the attached markup.

NRC RAI 19.1-181

In DCD Revision 6, Section 19.2.3.2.3, Evaluations of External Event High Winds, (with the reactor at power), the applicant states there are no important sequences identified in the high wind risk analysis. The staff surmises that the applicant may intend to imply that there are no additional sequences or insights beyond those already identified for internal events LOPP. If this is so, please clarify this in the DCD, because the estimated CDF for high winds at power is on the order of those from all at power internal events. If the high winds at power risk assessment produced different core damage sequences or insights than the internal events at power LOPP initiator, please modify Section 19.2.3.2.3 in the DCD to describe the additional sequences and additional insights.

GEH Response

DCD Tier 2, Section 19.2.3 will be revised to state that the high winds at-power risk assessment does not produce significant core damage sequences or insights that are different than the internal events at-power loss of preferred power results.

DCD Impact

DCD Tier 2, Section 19.2.3 will be revised as noted in the attached markup.

NRC RAI 19.1-182

In the DCD Revision 6, Section 19.2.4.1.4, Evaluations of External Event High Winds, (with the reactor shut down), the writeup on significant core damage sequences lists no important contributors, even though the CDF is comparable to internal events and the LRF is higher than internal events. The staff surmises that the applicant may intend to imply that there are no additional sequences or insights beyond those already identified for internal events shutdown LOPP initiator. If this is so, please clarify this in the DCD, because the estimated CDF and LRF for high winds during shutdown are greater than those from all other events (internal and external, at power and shut down) combined. If the high winds at power risk assessment produced different core damage sequences, large release sequences, or insights than for the internal events shutdown LOPP initiator, please modify Section 19.2.4.1.4 in the DCD to describe the additional sequences and additional insights.

GEH Response

DCD Tier 2, Section 19.2.4 will be revised to state that the high winds shutdown risk assessment does not produce significant core damage sequences or insights that are different than the internal events shutdown loss of preferred power results.

DCD Impact

DCD Tier 2, Section 19.2.4 will be revised as noted in the attached markup.

NRC RAI 19.1-183

In DCD Revision 6, Section 19.2.3.2.3, Evaluations of External Event High Winds, (with the reactor at power), the applicant states there is a high winds risk insight included in the shutdown risk discussion. However, Section 19.2.4.1.4 states there are no significant results or risk insights from shutdown external events. These statements are contradictory. Further, it is not clear the extent to which the high winds risk assessment is conservative. Please modify Sections 19.2.3.2.3 and 19.2.4.1.4 by including an appropriate discussion of risk insights, including equipment that is important in keeping CDF/LRF estimates low and equipment that has high Risk Achievement Worth values that if not properly designed, operated, or maintained could result in significant increases in the CDF/LRF.

GEH Response

The third paragraph in Section 19.2.4.1.4 discusses the high winds risk insight that is referred to in Section 19.2.3.2.3.

Section 19.2.4.1.4 does not state or imply that there are no significant results or risk insights from shutdown external events. It concludes that the shutdown risk results for high winds are similar to those from the at-power risk results for loss of preferred power events.

The appropriate discussion of risk insights will be included in these sections in response to RAI 19.1-181 and RAI 19.1-182.

DCD Impact

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

NRC RAI 19.1-184

Please correct Section 19.2.3.2.3 in the DCD Revision 6 where it states that large release frequencies are not analyzed for high wind-induced external events. Large release frequency estimates are reported in Table 14.6-1, "High Wind-Induced CDF and LRF" in NEDO-33201 Revision 4.

GEH Response

DCD Tier 2, Section 19.2.3.2.3 will be revised to state that high wind-induced external events do not result in any additional significant contributors to large release frequency.

DCD Impact

DCD Tier 2, Section 19.2.3 will be revised as noted in the attached markup.

NRC RAI 19.1-185

Please modify the first sentence in Section 14.7, Insights, NEDO-33201, Revision 4, to state that "The estimated CDF and LRF for all analyzed scenarios, while using a bounding analysis for most sites, are similar to the internal events results." The inclusion of "for most sites" is needed because the hurricane analysis may not be bounding for particular sites on the Gulf of Mexico or southern Atlantic Ocean from North Carolina south since the frequency of hurricanes used in the PRA is an average of loss of offsite power for plants along the coast in that region.

GEH Response

The first sentence in Section 14.7, Insights, NEDO-33201, Revision 4, will be revised to state that the estimated CDF and LRF for all analyzed scenarios, while using a bounding analysis for most sites, are similar to the internal events results.

DCD Impact

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

LTR NEDO-33201, Rev 4 will be revised as noted in the attached markup.

Enclosure 2

MFN 09-717

Response to Portion of NRC Request for Additional Information Letter No.s 385 and 389 Related to ESBWR Design Certification Application – Probabilistic Risk Assessment

RAI Numbers 19.1-180 through 19.1-185

ESBWR DCD and LTR Markups

The components on the bypass lines and the main lines (motor-operated isolation valves) are assumed to be not testable during operation. These components are assumed to have a two year (24 month) test interval.

Table 4.9-3 lists the components subject to test and their expected frequency of test.

4.9.7 System Maintenance

Maintenance of one branch at a time is allowed during normal operation for the feedwater, condensate, circulating water and TCCW systems. Table 4.9-3 shows the maintenance unavailabilities used in the model.

4.9.8 Common Cause Failures

Common Cause Failure (CCF) events are identified within the system and are listed in Table 4.9-4. Detailed common cause failure analysis is provided in Section 5.3.

4.9.9 Fault Tree Analysis

4.9.9.1 Top Event Definitions

The list of the top events defined for the condensate and feedwater system are shown in Table 4.9-6.

The following top events have been defined for the system:

(1) QT-TOPPCS represents the failure of PCS using the TBS to dump steam to the condenser, circ water to condense the steam with a condensate pump and a feedwater pump to reinject water into the reactor.

(2) UF-TOP1 represents the failure of PCS using the condensate storage tank to provide water to the condenser which is pumped forward using a condensate pump and a feedwater pump.

(3) UF-TOPATWS represents nearly identical logic to UF-TOP1. The only differences is an operator action required during an ATWS event to restart feedwater.

(4) P22-0001-_1 represents the failure of two out of three TCCWS pumps and two out of four TCCWS heat exchangers to provide cooling.

(5) N71-CIRC is the failure of all four circulating water pumps to provide cooling to the condenser.

4.9.9.2 Fault Tree Description

The fault tree for condensate and feedwater (N21) is shown in Figure 4.9-4. Typical circulating water cooling methods include:

- Natural draft cooling tower that utilizes buoyancy via a tall chimney;
- Mechanical draft cooling tower, which uses power-driven fan motors to force or draw air through the tower;
- Fan-assisted natural draft cooling tower, which is a hybrid type that appears like a natural draft though airflow is assisted by a fan; and

- Spray ponds that use pumps to spray the water above a pond for evaporative cooling.

The fault tree assumes a wet cooling tower with natural draft is used. A sensitivity study was performed assuming mechanical draft cooling towers are used. The hybrid configuration also requires fans, and therefore is bounded by the mechanical draft cooling tower configuration from a risk perspective. The sensitivity study assumed that eight mechanical draft cooling towers are used, and two cooling towers are required to operate to ensure successful post-scram heat removal. The sensitivity study concluded that the differences in cooling water configurations have no measureable effect on CDF.

As stated in the assumption section, the fault trees for the condensate, feedwater, and TCCW systems have flags in the model that are used to select the combinations of pumps or air handling units that are in service. With various flag and split fraction settings, any operating combination can be evaluated. For the combined PRA model quantification, the split fractions in these fault trees are set to either TRUE or FALSE associated with a specific alignment. For the system only evaluation and cutsets in this section (4.9) the split fraction values are left as the actual assumed fractions associated with the equipment. For example; in the combined model quantification, feedwater pumps A, B, and C are set as the running pumps, and pump D is set to standby. For the system only quantification and cutsets, the fault tree is evaluated with the split fractions associated with each pump set at 0.25 (indicating that each pump is in standby 25% of the time).

The fault tree for the circulating water system (N71) is shown in Figure 4.9-4.

4.9.9.3 Human Interaction

Human interactions are shown in Table 4.9-5.

4.9.9.4 Special Events

There are two special events associated with the condensate and feedwater system. Basic event P22-NSC-TM-HXS that represents multiple TCCW heat exchangers out for testing and/or maintenance at the same time and has a probability of 7.5E-5. Basic event P22-NSC-TM-PUMPS represents multiple TCCW pumps out for testing and/or maintenance at the same time also has a probability of 7.5E-5.

4.9.10 Results of Fault Tree Analysis

The quantification of core damage sequences implicitly includes the contribution of basic events for this system. This quantification process enables checking the global consistency of the system fault trees and their relationship with the rest of the systems modeled in the PRA.

A summary of the basic events included in the system fault tree and reported in Table 4.9-7.

The top cutsets from quantification of each of the system tops is provided in Table 4.9-8.

4.9.11 PRA Insights

The failure of condensate and feedwater is dominated by the failure of the condensate minimum flow recirculation valve closing. This event is a dominant contributor because it is a single failure point for the PRA modeled function. The rest of the system has redundancy. The common cause failure of the Turbine bypass valves is also a significant contributor when the turbine bypass system is used.

Significant Large Release Sequences of External Event Flood

The important flooding sequences do not impose additional challenges to any of the passive containment cooling systems or the BiMAC. Therefore the internal events containment performance insights can be directly used for external event flood sequences.

Significant Offsite Consequences of External Event Flood

The estimated offsite consequences due to external events under at-power and shutdown conditions are less than the defined individual, societal, and radiation dose limits.

Summary of Important Results and Insight of External Event Flood

Due to the low CDF and LRF values for flooding events, there are no additional results or insights.

19.2.3.2.3 Evaluation of External Event High Wind

Introduction to Evaluation of External Event High Wind

The ESBWR high wind analysis explicitly quantifies accident sequences initiated by hurricanes and tornado winds. Straight winds are lesser velocity winds that pose minimal challenges to the plant design. Due to the strength of construction of the ESBWR Category I buildings, the effects of high winds are limited to Loss of Preferred Power events with a potential loss of the Condensate Storage Tank. Overall risk from high winds is further minimized by design features such as the motor driven pump, powered by the ancillary diesel generator, for alternate RPV injection, and the direct current (DC) batteries with a 72-hour operational life.

Significant Core Damage Sequences of External Event High Wind

The high winds at-power risk assessment does not produce significant core damage sequences or insights that are different than the internal events at-power loss of preferred power results.

~~There are no important sequences identified in the high wind analysis.~~

Significant Large Release Sequences of External Event High Wind

Due to the low CDF value and because the high winds do not affect any containment systems, high wind-induced external events ~~are not analyzed~~ do not result in any additional significant contributors to~~for~~ large release frequency.

Significant Offsite Consequences of External Event High Wind

The estimated offsite consequences due to external events under at-power and shutdown conditions are less than the defined individual, societal, and radiation dose limits.

Summary of Important Results and Insights of External Event High Wind

Due to the low CDF and LRF values for high wind events, there are no additional results of significance. There is one insight from the analysis that is included below in the shutdown risk discussion.

~~failure to flood containment to above top of active fuel. The fourth sequence involves loss of preferred power, with failure to align fire protection system water for injection to the RPV.~~

The most important operator actions in the ESBWR shutdown analysis are to close the lower drywell hatches upon the detection of a break in the reactor coolant system (RCS), and failure to recognize the need for low pressure makeup after depressurization.

Random failures of individual SSCs are not significant contributors to internal events during shutdown CDF.

19.2.4.1.2 Fire During Shutdown

The most important fire-initiated shutdown events are loss of RWCU/SDC due to fire in Turbine Building – Modes 5, 5 Open and 6-Unflooded; and, loss of preferred power due to fire in the switchyard – Modes 5, 5 Open and Mode 6-Unflooded.

There are two additional operator actions that are important for Shutdown external events, both of which involve fire-initiated events. They involve failure to initiate CRD injection, and failure to open two SRVs for depressurization.

19.2.4.1.3 Flooding During Shutdown

The most important flood-initiated shutdown events are a break in the Makeup Water System at the Reactor Building elevation 17500 mm during Modes 5 and 5 Open; a break in the Fire Protection System in the Turbine Building; and, Service Water Building PSW Line Break. Similar to the at-power flooding PRA, operator actions are not significant contributors to the shutdown internal flooding risk profile. Accounting for this conservatism and the low CDF and LRF values, there are no significant PRA results or insights from flooding during shutdown.

19.2.4.1.4 High Winds During Shutdown

Similar to the full power risk profile, the shutdown risk for high winds are limited to Loss of Preferred Power events with a potential loss of the Condensate Storage Tank. The high winds shutdown risk assessment does not produce significant core damage sequences or insights that are different than the internal events shutdown loss of preferred power results.

Operator actions are non-significant contributors to the shutdown high wind risk profile. Random failures of systems, structures or components are not significant contributors to the internal events shutdown CDF.

It is assumed that the plant is not in a Mode 6 Unflooded condition when a hurricane strike occurs. There is sufficient time, prior to a hurricane strike, for transitioning to another mode so that long term cooling is more available. In Mode 6 Unflooded, the containment is open, the reactor vessel is open and the water above the core will not keep the core cool for an extended period of time without additional mitigating systems.

19.2.4.1.5 Seismic Events During Shutdown

Similar to the full power risk profile, seismic risk during shutdown is dominated by seismic-induced SSC failures, and not by random SSC failures or human actions.

14.7 INSIGHTS

The estimated CDF and LRF for all analyzed scenarios, while using a bounding analysis for most sites, are similar to the internal events results. If site-specific high wind frequencies are estimated to be greater than the frequencies in this analysis, then the COL Applicant would perform a departure analysis and apply the appropriate measures. The shutdown high wind non-TSL frequency is higher than the shutdown internal events non-TSL frequency. However, the shutdown high wind PRA model is developed with significant conservatism, which can be refined following the detailed designs. As an example, during a H345 high wind shutdown event, the Condensate Storage Tank (located in the yard) is failed with no consideration given to aligning an alternate source of water. The failure of the CST during the H345 high wind shutdown events is a major contributor to the shutdown CDF and LRF.

The following insights are generated from the high wind risk analysis:

- The ESBWR is inherently safe with respect to high wind events.
- In Mode 6 Unflooded the containment is open, the reactor vessel is open and the water above the core will not keep the core cool for an extended period of time without additional mitigating systems. It is assumed that there is sufficient time prior to a hurricane strike for the plant to transition to another mode so that long term cooling water is more reliable.