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Subject: **Supplemental Response to Portion of NRC Request for Additional Information Letter No. 59 Related to ESBWR Design Certification Application ESBWR - RAI Numbers 19.5-3 through 19.5-14**

Enclosure 1 contains supplemental GE responses to the subject NRC RAIs transmitted via the Reference 1 letter. The original RAI responses were submitted via the Reference 2 letter. The RAI responses in Enclosure 1 replace the original responses in their entirety. Additional information has been provided to supplement previous responses.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

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References:

1. MFN 06-329, Letter from NRC to David Hinds, *Request for Additional Information Letter No. 59 Related to ESBWR Design Certification Application*, dated September 13, 2006
2. MFN 06-429, Letter from David Hinds to NRC, *Response to Portion of NRC Request for Additional Information Letter No. 59 Related to ESBWR Design Certification Application – ESBWR Probabilistic Risk Assessment and Chapter 19 – RAI Numbers 19.5-3 through 19.5-14*, dated October 29, 2006

Enclosures:

1. MFN 06-429 S1, Supplemental Response to Portion of NRC Request for Additional Information Letter No. 59 Related to ESBWR Design Certification Application ESBWR - Probabilistic Risk Assessment - RAI Numbers 19.5-3 through 19.5-14

cc: AE Cubbage USNRC (with enclosures)
David Hinds GE/Wilmington (with enclosures)
eDRF 0000-0063-4238

ENCLOSURE 1

MFN 06-429 Supplement 1

Supplemental Response to Portion of NRC Request for

Additional Information Letter No. 59

Related to ESBWR Design Certification Application

ESBWR Probabilistic Risk Assessment

RAI Numbers 19.5-3, 19.5.4, 19.5-5, 19.5-6, 19.5-7, 19.5-8, 19.5-9, 19.5-10, 19.5-11, 19.5-12, 19.5-13 and 19.5-14

NRC RAI 19.5-3

DCD Tier 2, Section 19.2.2.4 provides a seismic margin analysis result of 0.6g for the High Confidence Low Probability of Failure (HCLPF). A seismic margins analysis to determine that the plant HCLPF for a certified design should be at least equal to 1.67 times the safe shutdown earthquake (SSE), based on criteria in SECY 93-087,"Policy, Technical and Licensing issues Pertaining to Evolutionary and Advances Light-Water Reactor (ALWRs) Designs," April 2, 1993. The seismic margins analysis addressing the criteria in SECY 93-087 should be located in this section of the DCD. The associated structural calculations and assumptions need to be presented in DCD Tier 2,Chapter 19, showing all relevant assessments of the critical elements necessary to maintain plant performance during and after the SSE. References applicable to HCLPF calculations should be presented in Chapter 19.

GE Response

Table 19.2-4 of DCD Tier 2 Chapter 19 Rev. 2 will be revised in the next update.

DCD Impact

Table 19.2-4 of DCD Tier 2 Chapter 19 Rev. 2 will be revised.

NRC RAI 19.5-4

All the certified design components important for the plant HCLPF analysis should be presented in a tabluar form in the DCD Tier 2,Chapter 19. Also, the table of HCLPF values in the ESBWR Probabilistic Risk Assessment (PRA) Report (NEDO-33201) should be incorporated into Tier 1 of the DCD as a part of an ITAAC item to ensure and verify that the as-built plant HCLPF is equal to or greater than the certified plant HCLPF value.

GE Response

Seismic categorizations of SSCs are part of the standard inputs within the Tier 1 Design Descriptions and ITAAC HCLPF margins information will not be included as ITAAC items in Tier 1 because existing ITAAC items for various SSCs ensure that the plant has adequate seismic margin beyond the design basis SSE due to the various conservatism introduced in the normal design process as explained in response to RAI 19.5-5.

DCD Impact

Table 19.2-4 of DCD Tier 2 Chapter 19 Rev. 2 will be revised in the next update.

NRC RAI 19.5-5

Provide the essential elements of a procurement specification and associated installation criteria that would ensure that Structures, Systems and Components (SSCs) are procured and installed to develop the necessary HCLPF capacities.

GE Response

HCLPF capacity depends on the seismic margins in the structural response, equipment response and equipment capacity.

Conservatisms in the design and current practices in design and qualification procedures typically provide for HCLPF capacities exceeding 1.67 times SSE ground motion. These include anchorage design per ACI-349, seismic qualification per IEEE-344 requirements and dynamic analysis per ASCE 43-05 (including the load factor of 1.4 on testing). In addition, designers typically optimize the design effort by enveloping the floor spectra at different floor locations for specification of required response spectra and by designing standard piping and cable tray supports that cover a number of system configurations and loading conditions. These considerations are used in assigning what are deemed "reasonably achievable" fragilities.

It is not practical to specify the HCLPF capacity of structures and equipment for the vendors to meet as target values. The responsibilities for design and qualification are distributed among the architect-engineer, reactor manufacturer and equipment vendors. The equipment vendor is only responsible for qualification testing; the anchorage design is by the architect-engineer and the structural analysis that develops the floor spectra is typically by another group within the AE. Therefore, inclusion of the HCLPF capacities as an element of the procurement specifications is not feasible.

Instead, the procurement specification and associated installation criteria will have the following:

- Required Response Spectra (RRS) for qualification by analysis and testing
- Requirements for anchorage design per ASME/ACI-349 code
- Conformance to IEEE requirements for qualification testing
- Conformance to ASCE 43-05 requirements on dynamic analysis and load combinations.

GE will apply load factors on SSE demands in the procurement specifications when it is deemed necessary in order to assure that the HCLPF capacity will equal or exceed 1.67 times the SSE.

DCD/LTR Impact

Table 19.2-4 of DCD Tier 2 Chapter 19 Rev. 2 will be revised in the next update.

NEDO-33201 Section 15.3 will be revised in the next update.

NRC RAI 19.5-6

In Section 15.3.3 of NEDO-33201, Rev. 1, it has been recognized that relative displacements limiting SSC operability frequently control their seismic capacity. The structural fragility assessment method in Reference 15-1, R.P. Kennedy, et al., "Assessment of Seismic Margin Calculation Methods", NUREG/CR-5270, Lawrence Livermore National Laboratory, March 1989, is somewhat dated, and is based on a PWR plant study. The ESBWR design is very different - it has a very tall reactor vessel and drywell functionality is very much dependent on proper functioning of all pressure suppression components. Simply because of the reactor vessel height, a small amount rotation at the pedestal would significantly scale up the displacement near the reactor vessel head and the top of the drywell. Please discuss individual elements of functionality limits for ensuring drywell and wetwell functionality and the integrity of components attached to the reactor vessel

GE Response

NUREG/CR-5270 is used as a guide for processes and procedures applicable to any type of plant. Any unique ESBWR features are addressed through the normal design process to ensure adequacy in withstanding the design basis earthquake, and their HCLPF capacities are in turn estimated from design basis information accordingly.

Please note that the methodology for seismic margin evaluation described in NUREG/CR-5270 has not changed significantly. However, ANS Standard ANS 58.21 refers to two documents EPRI Fragility Methodology report (EPRI TR -103959, Reference 19.5-6(1)) and EPRI seismic margin methodology report (EPRI NP-6041, Reference 19.5-6(2)). These were not referred to in the DCD since they were proprietary documents that have been made available to the public.

References:

19.5-6(1): Electric Power Research Institute, "*Methodology for Developing Seismic Fragilities*", prepared by R.P. Kennedy and J. W Reed, EPRI TR-103959, June 1994

19.5-6(2): Electric Power Research Institute, "A Methodology for Assessment of Nuclear Plant Seismic Margin", prepared by Jack R. Benjamin and Associated, Inc., et al, EPRI NP -6041, June 1991

DCD Impact

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

NEDO-33201 Section 15.3 will be revised in the next update.

NRC RAI 19.5-7

Provide a description of the failure modes used to determine the HCLPF values for category I structures, particularly the containment structure. Provide a description of the extrapolation process supplemented by judgment.

GE Response

See the response to RAI 19.2-67 for the containment structure and the response to RAI 19.2-66 for the shear wall structures.

The analyzed failure modes for structures are based on the recommendations given in EPRI TR-103959 (Reference 19.5-6(1)). The extrapolation of the SSE elastic response to the ultimate strength of the component (depending on the failure mode and available ductility) followed the guidance of the above document.

DCD Impact

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

NRC RAI 19.5-8

Provide a description of how HCLPF values are determined for equipment and components qualified by testing, especially for the North Anna early site permit (ESP) site-specific ground motion spectrum.

GE Response

The ESBWR design certification is a generic plant licensing activity, and by definition, the DCD is not a site-specific licensing document. Therefore, North Anna site-specific analyses are not within the scope of the ESBWR design certification.

The overall approach for determining HCLPF capacities of equipment and components qualified by seismic testing is described in EPRI TR-103959 (Reference 19.5-6(1)). Since the detailed design information on the equipment is not available at this time, generic HCLPF capacities are assigned following the ALWR URD. These generic HCLPF capacities assumed for equipment and components are considered achievable because of the margins or safety factors introduced at different stages of equipment design and qualification. Equipment qualified for application in GE ESBWR plants have additional seismic margins in high frequencies because the design considers high-frequency hydrodynamic loads in combination with seismic loads. The other sources of margin are from conservatism in the ESBWR seismic response analysis, e.g., use of single enveloping design spectra and conservative treatment of soil-structure interaction and the use of enveloping responses of all site conditions for design.

The equipment and components of the GE ESBWR plant will be qualified to the required floor response spectra arising from the single envelope ground motion input rich in both low and high frequencies and following the ASCE, ASME and IPEEE procedures. Their seismic HCLPF capacities are expected to meet the required value of 1.67 times 0.5g peak ground acceleration for rock sites or 1.67 times 0.3 peak ground acceleration for soil sites.

Given the single enveloping design spectra of the ESBWR and the performance-based design spectra for new units, it becomes obvious that the rock sites are the most challenging for meeting the required HCLPF capacity if the building frequency is higher than 9 Hz. At 9 Hz and above, the single enveloping design spectra is the same as the North Anna ESP design spectra and the structural response factor is only slightly greater than unity when other variables that affect the seismic response of the structures are considered. In such a case, the required response spectra (RRS) is appropriately factored throughout the frequency range to assure that the HCLPF margin of 1.67 is met.

DCD Impact

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

NEDO-33201 Section 15.3 will be revised in the next update.

NRC RAI 19.5-9

Justify the use of both ductility (inelastic energy absorption factor) as well as damping (structural response factor) effects to determine the overall factor of safety.

GE Response

The factor representing the median and variability in ductility (inelastic energy absorption) factor, F_u is calculated according to the effective frequency/effective damping method and/or effective Riddell-Newmark method recommended in EPRI TR-103959 (Reference 19.5-6(1)). Similarly, the damping factor (F_d) based on the damping when the structure is "at or just below yield point". EPRI TR-103959 states "--- for structures whose fragilities are determined using the simplified response spectra methods, the exact damping is unimportant since assumptions concerning the ductility ratio and the damping ratio are self-correcting. In other words, the assumption of increased damping results in a lower (more conservative) factor of safety for the inelastic energy dissipation factor and balances the increased factor of safety in the elastic demand due to higher damping."

In the seismic fragility calculation of ESBWR structures, a median damping value of 7% of critical is conservatively assumed for the inelastic energy absorption factor calculation. For rock sites, 5% damping is assumed even when the calculated effective damping value is greater than 5% because the North Anna ESP design spectrum, on which the high frequency components of the single envelope design input spectrum is based, is available only for the 5% damped case. This assumption results in an inelastic energy absorption factor with slight conservative bias.

DCD Impact

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

NEDO-33201 Section 15.3 will be revised in the next update.

NRC RAI 19.5-10

Section 15.3.1 of NEDO-33201, Rev. 1, states that generic fragilities were chosen based on a review of prior PRAs and fragility data and that they are considered achievable for the ESBWRs with an evolutionary improvement in the seismic capacities of the components designed to a 0.3g SSE minimum. Provide a list of the prior PRAs and the bases for using their fragility values. If multiple fragility values for similar components were available, please describe the bases for the chosen value. Please describe where and how these generic fragility data were used to establish 0.6g HCLPF value for the ESBWR. Elaborate on the meaning of the phrase "evolutionary improvement" and how this ensures that these fragilities are achievable.

GE Response

As stated in NEDO-33210 Rev 1, Section 15.3.5, generic fragilities and corresponding HCLPF capacities are the same as those considered in the ABWR SSAR and ALWR recommendations (EPRI ALWR Utility Requirements Document, Appendix A PRA Key Assumptions and Ground rules); furthermore, it was shown that these HCLPF capacities were achieved for the Lungmen NPP Project in Taiwan, which has a 0.40g SSE.

The HCLPF capacities assigned are expected to be "reasonably achievable" for the ESBWR just as they were for the high seismic accceleration in Taiwan. As stated in response to RAI 19.5-5, GE applies load factors on SSE demands in the procurement specifications when it is deemed necessary to assure that the HCLPF capacity equals or exceeds 1.67 times the SSE.

The use of the term "evolutionary improvements" means that equipment may become more seismically rugged as vendors improve upon the design of their products. GE reviews the specific equipment design against the designs that form the basis of the ALWR URD recommendations.

DCD Impact

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

NRC RAI 19.5-11

Section 15.3.1 of NEDO-33201, Rev. 1, states that the peak ground acceleration (PGA) of the design earthquakes is 0.3g for the SSE while the North Anna specific SSE has a PGA value of 0.49g. Please clarify which PGA value was used in your analyses to compute the capacity factors, particularly the strength factor (Fs). A certified design for the North Anna ESP response spectra would put the plant HCLPF value at 1.67x0.49g or about 0.82g, please explain how you meet the HCLPF.

GE Response:

The HCLPF capacities currently shown in NEDO-33201 Rev. 1 are relative to 0.3g PGA of the RG 1.60 spectral shape. Two sets of HCLPF capacities will be developed: one for rock sites and another for soil sites. This approach provides consistentcy with the updated definition of SSE design ground motion which is a single envelope of the 0.3g RG 1.60 and North Anna specific SSE. As shown in Figure 19.5-13(1), the peak ground acceleration of the rock spectra is specified as 0.5g while it is 0.3g for soil sites.

DCD Impact

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

NEDO-33201 Rev 1, Section 15.3 will be revised in the next update.

NRC RAI 19.5-12

Justify the use of Equation 15.3-11 in NEDO-33201, Rev. 1, to determine the ultimate shear strength for short reinforced concrete shear walls, typical of nuclear power plants. Provide the equation used to determine the ultimate shear strength for the containment wall.

GE Response

See the response to RAI 19.2-66 for shear strength of shear walls and the response to RAI 19.2-67 for the ultimate seismic strength assessment of containment. The method of calculating ultimate shear capacity follows the guidance in EPRI NP-6041 (Reference 19.5-6(2)) for containment structures.

DCD Impact

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

NRC RAI 19.5-13

For the shape factor (Fsa), Section 15.3.3.1.2 of NEDO-33201, Rev. 1,states that for the purpose of seismic risk assessment, the median ground motion spectrum given in NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," is considered to be the realistic input ground motion definition. Considering the significant number of advancements in the field of seismic hazards since the development of this spectrum in the late 1970's, justify your consideration of the NUREG/CR-0098 spectrum as realistic input ground motion.

GE Response

The spectral shape factors are reevaluated for two site conditions: rock and soil. For rock sites, the North Anna ESP site SSE spectrum is compared to the ESBWR single envelope design spectrum to determine the shape factor. For soil sites, the bounding SSE spectrum of soil sites among the 28 sites (excluding Vogtle) included in the current EPRI study (Reference 19.5-13(1)) is compared to the ESBWR single envelope design spectrum to determine the shape factor. Figure 19.5-13(1) shows this spectra comparison.

DCD Impact

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

NEDO-33201 Section 15.3 will be revised in the next update.

References:

Reference 19.5-13 (1) Electric Power Research Institute "Assessment of Performance-Based Approach for Determining the SSE Ground Motion for New Plant Sites, V 1: Performance-Based Seismic Design Spectra", Product ID # 1012044, Final Report, June 2005.

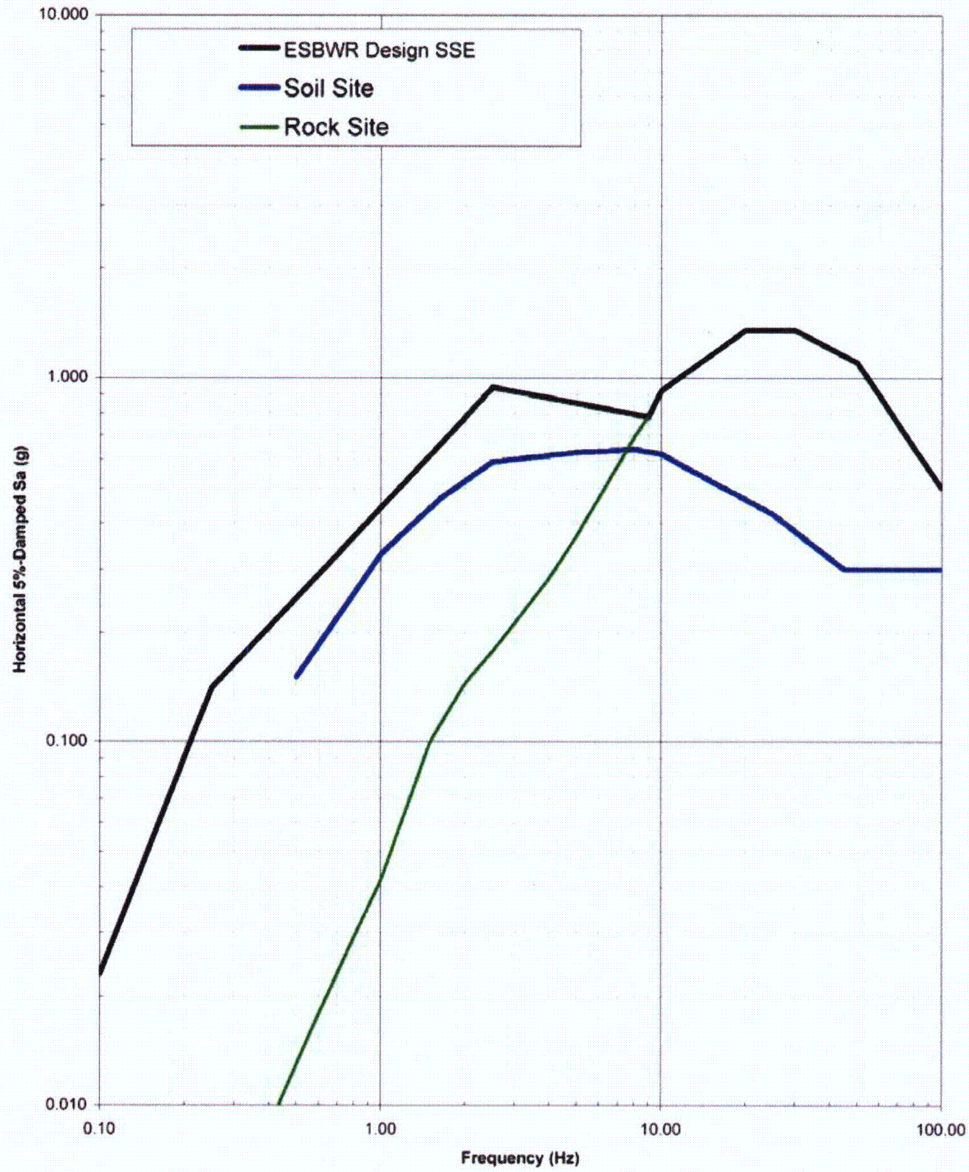

Figure 19.5-13 (1) Comparison of Design Ground Spectrum with Soil and Rock Spectra

NRC RAI 19.5-14

Provide a comparison showing ratios of the bounding (all site conditions) seismic responses of the containment structure at important locations to the critical functionality limits. Using the highest ratio determine the HCLPF value.

GE Response

See response to RAI 19.2-67 for the containment structure.

The HCLPF values are revised based on the new spectra discussed in the response to RAI 19.5-13. The highest ratio (calculated value divided by the allowable value) for the critical functional failure mode) is used to determine the HCLPF capacity in accordance with EPRI TR 103959 methodology (Reference 19.5-6(1)).

DCD Impact

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

NEDO-33201 Section 15.3 will be revised in the next update.