GE Hitachi Nuclear Energy

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US Nuclear Regulatory Commission
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Washington, DC 20555-0001

Subject: **Request for Additional Information Letter Number 8 Related to Chapter 2 for GE-Hitachi Nuclear Energy Advanced Boiling-Water Reactor Design Certification Rule Renewal Application – GEH Response to RAI 02.05.04-1**

References:

1. Letter from USNRC to Jerald G. Head, GEH, Subject: Request for Additional Information Letter Number 8 related To Chapters 2 for GE-Hitachi Nuclear Energy Advanced Boiling Water Reactor Design Certification Rule Renewal Application, June 10, 2015

In regard to the Requests for Additional Information transmitted in your June 10, 2015 letter (Reference 1), please find attached the requested response to RAI 02.05.04-1.

Enclosure 1 contains the complete responses, while Enclosure 2 contains the Design Control Document markups associated with the responses.

If you have any questions concerning this letter, please contact Hugh Upton at 408-314-8499.

I declare under penalty of perjury that the foregoing information is true and correct to the best of my knowledge, information, and belief.

Sincerely,

Jerald Head

Jerald G. Head
Senior Vice President, Regulatory Affairs

Commitments: No additional commitments are made in the responses.

D106
NRO

Enclosures:
1. GEH Responses to RAI 02.05.04-1
2. GEH Responses to RAI 02.05.04-1 - ABWR DCD DRAFT Revision 6 Markups

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DBR – 0011958

Enclosure 1

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GEH Responses to RAI 02.05.04-1

NRC Request for Additional Information 2.05.04-1

10 CFR 52.59(a) (2015) requires, in pertinent part, a finding of compliance with the regulations in effect at the time of the original certification in order to issue a renewed design certification. In 1997, 10 CFR 52.47(a)(1)(iii) required design certification applicants to provide postulated site parameters, and an analysis and evaluation of the design in terms of such parameters. Also, as relevant to the ABWR design, Appendix A to 10 CFR Part 100, section V.(d) requires that each applicant determine other design conditions, which include soil stability under the Safe Shutdown Earthquake.

The ABWR DCD Tier 1 Table 5.0 "ABWR Site Parameters" and Tier 2 Table 2.0-1 "Envelope of ABWR Standard Plant Site Design Parameters" provided some standard design site parameters, but no dynamic bearing capacity and differential settlement site parameters are specified. Dynamic bearing capacity is an important site parameter that requires that the soil under the foundation be able to withstand, with certain safety margins, the foundation dynamic pressure resulting from the combination of all possible loadings, including seismic loading corresponding to the site SSE. In some cases, the maximum foundation dynamic pressure can be several times the static foundation pressure, therefore a site which meets the static bearing capacity requirement may not be stable under dynamic loading conditions. Also, the requirement of differential settlement of the foundation not to exceed certain limits under the combination of all possible loadings is another important site parameter needed to maintain foundation and structural integrity, and the normal operation of nuclear power plant facilities. Because the ABWR design is certified for plants founded on soil deposits up to 91.5 m (300 ft), in addition to rock sites, there is a potential that larger differential settlements may occur for a deep soil site due to the geologic variation of subsurface materials and non-uniform loading distribution. Therefore, the NRC requests the applicant to provide the following information or justify how its alternative approach complies with NRC regulations:

1. *Clearly define the dynamic bearing capacity (based on the maximum foundation pressure on foundation with adequate safety margin) and differential settlement requirements for safety related structures in proper sections and tables of the ABWR DCD to ensure foundation stability and safety of the structures for sites applying the ABWR technology. Associated COL information items should be specified in the DCD.*

2. *Provide details on how the dynamic bearing capacity and differential settlement requirements are determined, including the model(s), assumptions and input parameters used in analyses, calculations and justifications for site parameter determination.*

GEH Response:

There are three seismic category 1 buildings that make up the ABWR; Reactor Building, Control Building, and Radwaste Building Foundation. Of these three, the Reactor Building is the heaviest. The current ABWR interface requirement for static bearing capacity is based on the calculated static bearing pressure of the Reactor Building times a factor of safety. To stay consistent with that methodology the ABWR interface requirement for dynamic bearing pressure will also be based on the Reactor Building dynamic bearing pressure times a factor of safety.

The ABWR Reactor Building calculated dynamic bearing pressure is 2336 kPa and can be found in ABWR DCD Tier 2 Section 3H.1.5.6.

GEH will revise Tier 1 Table 5.0-1 and Tier 2 Table 2.0-1 to add 2700 kPa as the minimum dynamic bearing capacity as an ABWR standard plant site parameter. This will provide approximately 15% margin over the calculated value. GEH will revise COL Action Item 2.3.1.2 (2) to add a confirmation of the dynamic bearing capacity.

Buildings that are constructed of Reinforced Concrete on a mat or raft foundation can tolerate total settlements on the order of 125mm without damage (Reference 1 and 2). In commercial buildings to prevent problems with interfacing components that connect to a building the total allowable settlement is usually limited to 50mm (Reference 1 and 3). If a building is allowed to settle prior to installing the interfacing components a larger allowable total settlement can be used.

Based on ABWR construction experience with an aggressive 39 month construction schedule (first safety concrete to fuel load), mechanical and electrical components are installed at least 12 months after the completion of the basemat. This allows sufficient time for the building to settle justifying the relaxation of the allowable total settlement value.

Based on the above discussion, GEH will add a total long term (post construction) settlement of 75mm to Tier 1 Table 5.0-1, and Tier 2 Table 2.0-1. GEH will add an additional COL Action Item 2.3.1.2 (3) to add a confirmation of the total long term (post construction) settlement.

Angular distortion is another important foundation criterion that is needed to prevent damage to a building founded on soil. Angular distortion in this context is defined as the slope between two adjacent column lines. Buildings that are constructed of reinforced concrete on a mat foundation can tolerate angular distortion on the order of 1/500 (Reference 1, 2 and 3). For buildings that contain machinery sensitive to settlement, it is recommended that angular distortion be limited to 1/750 (Reference 1).

Based on the above discussion, GEH will add an angular distortion (post construction) limit of 1/750 to Tier 1 Table 5.0-1, and Tier 2 Table 2.0-1. GEH will revise COL Action Item 2.3.1.2 (2) to add a confirmation of the angular distortion limit.

References:

1. EM 1110-1-1904, Engineering and Design Settlement Analysis, US Army Corps of Engineers, September 30, 1994.
2. Principles of Foundation Engineering - Seventh Edition, Das, Braja M., 2011
3. EN 1997-1, Eurocode 7: Geotechnical Design – Part 1: General Rules, 2004

Impact on DCD:

The DCD Tier 1 Table 5.0-1, DCD Tier 2 Table 2.0-1, and DCD Tier 2 Section 2.3.1.2 are revised as shown. The ABWR DCD Rev 5 marked up pages are provided in Enclosure 2.

Enclosure 2

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GEH Responses to RAI 02.05.04-1

ABWR DCD DRAFT Revision 6 Markups

Table 5.0 ABWR Site Parameters

Maximum Ground Water Level:
61.0 cm below grade

Maximum Flood (or Tsunami) Level:
30.5 cm below grade

Precipitation (for Roof Design):
- Maximum rainfall rate: 49.3 cm/h(3)
- Maximum snow load: 2.394 kPa

Ambient Design Temperature:
1% Exceedance Values
- Maximum: 37.8°C dry bulb
  25°C wet bulb (coincident)
  26.7°C wet bulb (non-coincident)
- Minimum: –23.3°C–

0% Exceedance Values (Historical Limit)
- Maximum: 46.1°C dry bulb
  26.7°C wet bulb (coincident)
  27.2°C wet bulb (non-coincident)
- Minimum: –40°C

Exclusion Area Boundary (EAB): An area whose boundary has a Chi/Q less than or equal to $1.37 \times 10^{-3} s/m^3$.

Extreme Wind: Basic Wind Speed:
177 km/h(1)/197 km/h(2)

Tornado
- Maximum tornado wind speed: 483 km/h
- Maximum pressure drop: 13.827 kPaD
- Missile spectra: Spectrum I(4)

Soil Properties:
- Minimum static bearing capacity: 718.20 kPa
- Minimum shear wave velocity: 305 m/s(6)
- Liquefaction potential: None at plant site resulting from site specific SSE ground motion

Minimum Dynamic Bearing Capacity
2700kPa
Maximum Settlement (8)
75mm
Maximum Foundation Angular Distortion
1/750 (9)

Seismology:
- SSE response spectra: See Figures 5.0a and 5.0b(7)

Meteorological Dispersion (Chi/Q):
- Maximum 2-hour 95% EAB $1.37 \times 10^{-3} s/m^3$
- Maximum 2-hour 95% LPZ $4.11 \times 10^{-4} s/m^3$
- Maximum annual average
  (8760

(1) 50-year recurrence interval; value to be utilized for design c

(2) 100-year recurrence interval; value to be utilized for design

(3) Maximum value for 1 hour over 2.6 km^2 probable maximum
hour PMP of 0.32. Maximum short-term rate: 15.7cm/5 min

(4) Spectrum I missiles consist of a massive high kinetic energy missile which deforms on impact, a rigid missile to test penetration resistance, and a small rigid missile of a size sufficient to just pass through any openings in protective barriers. These missiles consists of an 1800 kg automobile, a 125 kg, 20 cm diameter armor piercing artillery shell, and a 2.54 cm diameter solid steel sphere, all impacting at 35% of the maximum horizontal windspeed of the design basis tornado. The first two missiles are assumed to impact at normal incidence, the last to impinge upon barrier openings in the most damaging directions.

(5) At foundation level of the reactor and control buildings.

(6) This is the minimum shear wave velocity at low strains after the soil property uncertainties have been applied.

(7) Free-field, at plant grade elevation.

(8) Settlement is long term (post construction) value.

(9) Angular distortion is defined as the slope between two adjacent columns. Angular distortion is long term (post construction) value.

Table 2.0-1
Envelope of ABWR Standard Plant Site Design Parameters (Continued)

Seismology:	– SSE Peak Ground Acceleration: – SSE Response Spectra: – SSE Time History:	0.30g*ff* per RG 1.60 Envelope SSE Response Spectra
	- Maximum Dynamic Bearing Capacity - Maximum Settlement - Maximum Foundation Angular Distortion	2700kPa 75mm*** 1/750†††
Hazards in Site Vicinity:	– Site Proximity Missiles and Aircraft – Toxic Gases – Volcanic Activity	$\leq 10^{-7}$ per year None None
Exclusion Area Boundary: (EAB)	– An area whose boundary has a Chi/Q less than or equal to 1.37 x 10^{-3} s/m^3	
Meteorological Dispersion (Chi/Q):	– Maximum 2-hour 95% EAB – Maximum 2-hour 95% LPZ – Maximum annual average (8760 hour) LPZ	1.37×10^{-3} s/m^3 4.11×10^{-4} s/m^3 1.17×10^{-6} s/m^3

* 50–year recurrence interval; value to be utilized for design of non-safety-related structures only.

† 100–year recurrence interval; value to be utilized for design for safety-related structures only.

‡ Probable maximum flood level (PMF), as defined in ANSI/ANS-2.8, "Determining Design Basis Flooding at Power Reactor Sites."

f Spectrum I missiles consist of a massive high kinetic energy missile which deforms on impact, a rigid missile to test penetration resistance, and a small rigid missile of a size sufficient to just pass through any openings in protective barriers. These missiles consists of an 1800 kg automobile, a 125 kg, 20 cm diameter armor piercing artillery shell, and a 2.54 cm diameter solid steel sphere, all impacting at 35% of the maximum horizontal windspeed of the design basis tornado. The first two missiles are assumed to impact at normal incidence, the last to impinge upon openings in the most damaging directions.

** Maximum value for 1 hour over 2.6 km^2 probable maximum precipitation (PMP) with ratio of 5 minutes to 1 hour PMP of 0.32 as found in National Weather Source Publication HMR No. 52. Maximum short term rate: 15.7 cm/5 min.

†† At foundation level of the reactor and control buildings.

‡‡ This is the minimum shear wave velocity at low strains after the soil property uncertainties have been applied.

ff Free-field, at plant grade elevation.

**** Settlement are long-term (post-construction) values*

††† Angular distortion is defined as the slope between two adjacent columns. Angular distortion is long term (post construction) value.

2.3 COL License Information

2.3.1 Envelope of Standard Plant Design Parameters

2.3.1.1 Non-Seismic Design Parameters

Compliance with the envelope of standard plant site non-seismic design parameters of Table 2.0-1 shall be demonstrated for design bases events (Subsection 2.2.1).

2.3.1.2 Seismic Design Parameters

To confirm seismic design adequacy of the standard plant, COL applicants shall demonstrate that the site-specific conditions meet the following site envelope parameters considered in the standardized design.

(1) SSE Ground Motion

The site-specific SSE ground response spectra of 5% damping at plant grade in the free-field are enveloped by the design ground spectra shown in Figures 3.7-1 and 3.7-2 for the horizontal and vertical components, respectively, which are based on Regulatory Guide 1.60 anchored to 0.3g peak ground acceleration. When the site-specific control ground motion is determined to locate at the rock outcrop or a hypothetical rock outcrop according to SRP 3.7.1 guidelines (e.g., shallow soil site), the site-specific soil free-surface motion through soil layer amplification shall be calculated and the resulting ground surface response spectra shall be bounded by the design ground spectra.

The site soil dynamic bearing capacity at the foundation level of the reactor and control building is 2700 kPa minimum.

(2) Bearing Capacity

The site soil static bearing capacity at the foundation level of the reactor and control building is 718.20 kPa minimum.

2.3.2 Standard Review Plant Site Characteristics

Identification and description of all differences from SRP Section II Acceptance Criteria for site characteristics (as augmented by Table 2.1-1) shall be provided. Where such differences exist, the evaluation shall discuss how the alternate site characteristic is acceptable. In addition, the COL applicant will provide/address the following:

2.3.2.1 Site Location and Description

COL applicants will provide site-specific information to site location, including political subdivisions, natural and man-made features, population, highways, railways, waterways, and other significant features of the area.

(3) Settlement

The maximum settlement of the reactor and control building foundations is 75mm.
The maximum angular distortion of the reactor and control building is 1/750.