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MFN 06-189
Supplement 3

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Subject: Response to Portion of NRC Request for Additional Information Letter No. 176 Related to ESBWR Design Certification Application – Seismic Design – RAI Number 3.7-52 S03

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated April 10, 2008 (Reference 1). The original RAI and previous supplements and the GEH responses are listed in References 2 through 7.

RAI Number 3.7-52, Supplement 3 is addressed in Enclosure 1.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 08-375, Letter from U. S. Nuclear Regulatory Commission to Mr. Robert E. Brown, *Request for Additional Information Letter No. 176 Related to ESBWR Design Certification Application*, April 10, 2008

2. MFN 06-189, Supplement 2, Letter from James C. Kinsey to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 109 Related to ESBWR Design Certification Application – Seismic Design – RAI Number 3.7-52 S02*, February 5, 2008

3. MFN 07-555 from the U.S. Nuclear Regulatory Commission, Chandu Patel, Senior Project Manager, ESBWR/ABWR Projects Branch 1, Division of New Reactor Licensing, Office of New Reactors, to Robert E. Brown, Senior Vice President, Regulatory Affairs, GEH, *Request for Additional Information Letter No. 109 Related to ESBWR Design Certification Application,* dated October 12, 2007

4. MFN 06-189 Supplement 1 from David H. Hinds to the U.S. Nuclear Regulatory Commission, *Response to Portion of RAI Letter No. 20 Related to ESBWR Design Certification Application - Seismic Design RAI Numbers 3.7-8 S01, 3.7-11 S01, 3.7-25, S01, 3.7-26 S01, 3.7-52 S01 and 3.7-55 S01- Supplement 1*, dated December 8, 2007

5. RAI 3.7-52 S01, resulting from seismic follow-up audit, dated November 2007

6. MFN 06-189 from David H. Hinds to the U.S. Nuclear Regulatory Commission, *Response to Portion of RAI Letter Number 20 Related to EWBWR Design Certification Application - Seismic Design – RAI numbers 3.7-7,3.7-8,3.7-11,3.7-12,3.7-25,3.7-26,3.7-29, 3.7-34, 3.752, and 3.7-55,* dated June 29, 2006

7. MFN 06-115 from Lawrence Rossbach, Project Manager, ESBWRIABWR Projects Branch, Division of New Reactor Licensing, Office of Nuclear Reactor Regulation, to David H. Hinds, *Request for Additional Information Letter No. 20 Related to ESBWR Design Certification Application*, dated April 24, 2006

Enclosure:

1. Response to Portion of NRC RAI Letter No. 176 Related to ESBWR Design Certification Application, DCD Tier 2 Section 3.7 – Seismic Design – RAI Number 3.7-52 S03

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF	0000-0084-3373 (RAI 3.7-52 S03)

ENCLOSURE 1

MFN 06-189
Supplement 3

Response to Portion of NRC RAI Letter No. 176
Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.7 – Seismic Design

RAI Number 3.7-52 S03

For historical purposes, the original text of RAI 3.7-52 and the GEH responses are included. The attachments (if any) are not included from the original responses to avoid confusion.

NRC RAI 3.7-52

DCD Section 3.7.3.13 does not provide any detail about the methods of analysis employed or the acceptance criteria used to determine structural design adequacy of buried conduits, tunnels, and auxiliary systems. In addition, the applicant did not provide the definition for the term "auxiliary systems." The staff requests the following additional information to complete its review:

(a) a description of the types of SSCs that are included under the category "auxiliary systems;"

(b) a description of the analysis method and acceptance criteria for buried conduits;

(c) a description of the analysis method and acceptance criteria for tunnels;

(d) a description of the analysis method and acceptance criteria for auxiliary systems.

GEH Response

(a) See DCD Table 3.2-1 for identification of components in "auxiliary systems". See DCD Chapter 9 for identification and description of "auxiliary systems."

(b) There are no Seismic Class I buried conduits.

(c) There are no C-I tunnels in the ESBWR design. Tunnels in the ESBWR are NS but since some tunnels in the ESBWR carry liquid radwaste, the structural acceptance and materials criteria for tunnels are in accordance with RG 1.143 – Safety Class IIa. The method of seismic analysis is the same as building embedded walls, taking into account the requirements described in DCD Section 3.7.3.13.

(d) Same analysis methods and acceptance criteria is used for Auxiliary systems for underground portions of Category I structures, as shown in DCD Sections 3.8.4 and 3.8.5 for analysis and acceptance criteria details. Refer to DCD Chapter 9 for list of auxiliary systems.

Markups of DCD Tier 2 Sections 3.7.3.13, 3.7.3.14 and 3.7.3.15 were provided in MFN 06-189.

NRC RAI 3.7-52, Supplement 1

NRC Assessment Following the November 2, 2006 Audit

Provide an explicit description of the design approach and acceptance criteria for buried C-I SSCs since there are electrical cable banks between the CB and RB.

GEH Response

The responses provided to RAI 3.7-52 (b) and (c) under MFN 06-189 are revised as follows:

(b) There are no Seismic Class I buried conduits. There are Seismic Class I conduits in two electrical duct banks from the CB to the RB.

(c) There are no C-I tunnels in the ESBWR design. The access tunnels between Seismic Category I or II buildings are C-II. Tunnels carrying liquid radwaste are NS but the structural acceptance and material criteria are in accordance with RG 1.143 – Safety Class IIa.

The electrical duct banks (See (b) above) and yard FPS lines are buried underground utilities with a Seismic Category I classification. The duct banks are located in a closed reinforced concrete trench (or tunnel) covered with backfill and the FPS lines will be located in covered reinforced concrete trenches near the surface with removable covers to facilitate maintenance and inspection access. These items are relatively short since they are routed directly between buildings.

The method of seismic analysis is the same as building embedded walls, taking into account the requirements described in DCD Tier 2 Subsection 3.7.3.13. The effect of wave propagation is accounted for in accordance with Section 3.5.2 and Commentary of ASCE 4-98.

No DCD change was made in response to this RAI Supplement.

NRC RAI 3.7-52, Supplement 2

(1) *Confirm that there is no buried Seismic Category I piping, and that no buried Seismic Category I piping will be added at the COL stage. Describe how GEH has communicated the restriction on buried piping in the DCD, and how it will ensure that this restriction will be enforced at the COL stage. Include this information in DCD 3.7.3.13.*

(2) *The staff understands that there are no Seismic Class I [same as Seismic Category I] conduits buried directly in the ground. There are Seismic Class I conduits in two electrical duct banks from the CB to the reactor building (RB). The electrical duct banks are buried underground utilities with a Seismic Category I classification. The duct banks are located in a closed reinforced concrete trench (or tunnel) covered with backfill. These items are relatively short since they are routed directly between buildings.*

Confirm the above information and include it in DCD 3.7.3.13.

(3) *The staff understands that yard Fire Protection System (FPS) lines are buried underground utilities with a Seismic Category I classification. The FPS lines will be located in covered reinforced concrete trenches near the surface with removable covers to facilitate maintenance and inspection access. These items are relatively short since they are routed directly between buildings.*

Confirm the staff's understanding related to FPS lines. Include this information in DCD 3.7.3.13

(4) *The staff understands that there are no C-I [same as Seismic Category I] tunnels in the ESBWR design. The access tunnels between Seismic Category I or II buildings are C-II. The method of seismic analysis is the same as building embedded walls, taking into account the requirements described in DCD Tier 2 Subsection 3.7.3.13. The effect of wave propagation is accounted for in accordance with Section 3.5.2 and Commentary of ASCE 4-98. The staff's understanding is that GEH's C-II designation denotes an SSC whose failure could negatively impact a safety-related SSC, and is seismically analyzed to the same criteria as a seismic C-1 SSC.*

Confirm the staff's understanding related to buried tunnels. Discuss adherence to the acceptance criteria in the latest revision of SRP 3.7.3 (Rev. 3, March 2007), with respect to acceptable methods for seismic analysis and evaluation of buried SSCs. Provide a technical basis for any deviations from the SRP guidance. Include this information in DCD 3.7.3.13.

(5) *Specifically identify and describe the buried components of Seismic Category I auxiliary systems. Describe in detail the analysis methodology employed to ensure they can withstand the design-basis seismic ground motion. Include this information in DCD 3.7.3.13.*

GEH Response

(1) GEH confirms that there is no buried Seismic Category I piping in the DCD scope.

DCD Tier 2 Subsection 3.7.3.13 will be clarified to incorporate the above response.

COL applicants referencing a certified design typically incorporate the DCD by reference, with supplements and deviations as appropriate. Deviations and supplements are documented in the COLA FSAR, and therefore are available for review by the NRC.

(2) The staff's understanding regarding buried conduits is correct except as clarified below. There are four Seismic Category I electrical duct banks from the Control Building (CB) to the Reactor Building (RB). DCD Tier 2 Figure 1.2-2 shows partial routing of the above duct banks.

DCD Tier 2 Subsection 3.7.3.13 will be clarified to incorporate the above response.

(3) The staff's understanding regarding Fire Protection System (FPS) lines in the yard is correct except as clarified below. The FPS lines are routed from Fire Water Service Complex (FWSC) to CB, and from FWSC to RB/FB. The routing between FWSC and RB/FB avoids interference with the access tunnel.

DCD Tier 2 Subsection 3.7.3.13 will be clarified to incorporate the above response.

(4) The staff's understanding regarding tunnels and design approach used is correct.

The Radwaste Tunnel (RT) provides for pipes that transport radioactive waste to the Radwaste Building from RB and TB. The RT is classified Non-Seismic (NS) but the structural acceptance criteria are in accordance with RG 1.143 – Safety Class RW-IIa.

The design of buried structures meet the requirements of SRP 3.7.3 (Rev. 3, March 2007) and no deviations are contemplated. The method of analysis and design is as follows:

- Lateral earth pressures are determined in the same manner as for embedded walls below grade for C-I structures. Effect of wave propagation is accounted in accordance with ASCE 4-98, Section 3.5.2 and Commentary.
- Longitudinal Forces and strains are treated as secondary forces and strains (displacement-controlled).
- Longitudinal compressive strains are limited to 0.3%. The reinforcing steel added to concrete addresses the effect of longitudinal tensile strains.

- Primary loadings are lateral earth pressures, hydrostatic pressures, dead loads, and live loads applied concurrently with seismic excitation. Resultant stresses due to wave propagation effects and those resulting from the dynamic anchor movement are combined by the SRSS method.
- Differential displacements in soils are included.
- Expansion joints are provided between the tunnel and the connecting building to provide seismic isolation.
- Expansion joints along the tunnel are located no more than 20 m (65.6 ft.) apart.

DCD Tier 2 Subsection 3.7.3.13 will be clarified to state the above.

(5) There are no buried Seismic Category I auxiliary system components.

DCD Tier 2 Subsection 3.7.3.13 will be clarified to incorporate the above response.

DCD Impact

A markup of DCD Tier 2 Subsection 3.7.3.13 was provided in MFN 06-189, Supplement 2.

NRC RAI 3.7-52, Supplement 3

The staff reviewed the GEH's response to RAI 3.7-52, Supplement 2, dated February 5, 2008. Based on its review of the response and the proposed revision to DCD Tier 2, Subsection 3.7.3.13, the staff identified the following issues that remain to be addressed:

(a) A clear statement of the seismic classification and the applicable seismic analysis/design methodology needs to be included in the DCD revision, for each concrete tunnel and trench; considering that the trenches protect and support Category 1 piping and conduit/duct banks, the trenches should be Seismic Category I; DCD Tier 2, Table 3.2-1 should identify all the trenches and tunnels, and their seismic classification.

(b) The DCD revision should include a description of the seismic analysis methodology for the Category I FPS yard piping, the Category I electrical conduits/duct banks, and the Safety Class RW-IIa radwaste piping, that are supported in the tunnels and trenches.

(c) The DCD revision should include a definition of the seismic input motion at the surface, consistent with the single envelope design spectrum defined at the bottom of the RB/FB foundation.

(d) The first sentence of the proposed revision to 3.7.3.13 states "There are no Seismic Category I (C-I) utilities i.e. piping, conduits, or auxiliary system components that are directly buried underground." However, a subsequent sentence in the proposed revision states "For seismic Category I (C-I) buried conduits, tunnels, and auxiliary systems, the following items are considered in the analysis and design in accordance with SRP 3.7.3 (Rev. 3, March 2007):" Explain why conduits and auxiliary systems are listed, but not piping. Should any of the three be listed? Should only "buried tunnels and trenches" be listed? The wording in the DCD revision needs to be corrected.

(e) The statement "..., the following items are considered..." needs to be clarified. Are all of these items evaluated for each tunnel and trench? If not, list and explain any exceptions. Are any of the items applicable to analysis of piping, conduit/duct banks, and auxiliary system components protected by and/or supported in the trenches and tunnels? This information should be included in the DCD revision.

GEH Response

(a) The access tunnel structure (U66) is classified as Seismic Category II in DCD Tier 2 Table 3.2-1. Its description and seismic analysis/design methodology is provided in Subsection 3.7.3.13.

The radwaste tunnel (U67) is classified as NS with the structural design acceptance criteria in accordance with RG 1.143, Safety Classification RW-IIa as stated in DCD Tier 2 Table 3.2-1. Since it is a buried structure, its seismic analysis/design methodology meets the special provisions delineated in DCD Tier 2 Subsection 3.7.3.13. This will be clarified in the next update to the DCD.

Closed concrete trenches containing FPS yard piping and safety-related duct banks are Seismic Category I. DCD Tier 2 Table 3.2-1 will be revised to show this in the next update to the DCD. This table will also be revised to identify the Seismic Category II duct banks between ancillary diesel generator building and other structures that were added in DCD Rev. 5 due to a design change. Since these are buried structures, their seismic analysis/design methodology meets the special provisions delineated in DCD Tier 2 Subsection 3.7.3.13. This will be clarified in the next update to the DCD.

(b) Seismic Category I piping, conduits/duct banks (when not embedded in reinforced concrete), and Safety Class RW-IIa radwaste piping are supported in tunnels and trenches and are not in direct contact with soil. Therefore, the standards methods of seismic analysis described in DCD Tier 2 Section 3.7.3 apply. Seismic Category I concrete duct banks that are in direct contact with soil are designed to the special provisions delineated in DCD Tier 2 Section 3.7.3.13.

(c) Seismic input motion is specified in DCD Tier 2 Table 3.7-2. Scale factors are also specified depending on the depth of embedment.

(d) The wording in DCD Tier 2 Subsection 3.7.3.13 will be corrected in the next update to the DCD to consistently address all buried items.

(e) See response to items (b) and (d) above.

DCD Impact

DCD Rev. 5 Tier 2 Table 3.2-1 and Subsection 3.7.3.13 will be revised as noted in the attached markup.

Table 3.2-1

Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
Y71 Piping Duct	~~N~~	~~OL~~	—	~~E~~	~~NS~~	~~Typical classifications for piping ducts in the yard area.~~ Classification of individual piping ducts match the highest classification of the pipe they carry.
1. FPS yard piping concrete trench	N	OL	--	E	I	
2. Other Piping Duct	N	OL	--	E	NS	
Y72 Cable Duct	~~N~~	~~OL~~	—	~~E~~	~~NS~~	~~Typical classifications for cable ducts in the yard area.~~ Classification of individual cable ducts match the highest classification of the cables they carry.
1. Concrete duct banks between RB and CB	3	OL	--	B	I	
2. Concrete duct banks between ancillary diesel generator building and other structures	N	OL	--	E	II	
3. Other Cable Duct	N	OL	--	E	NS	
Y86 Site Security	N	ALL	—	E	NS	

Notes:

(1) Principal components: A module is an assembly of interconnected components that constitute an identifiable device or piece of equipment. For example, electrical modules include sensors, power supplies, and signal processors; and mechanical modules include turbines, strainers, and orifices.

(2) Safety Class: 1, 2, 3 or N are designations for safety-related or nonsafety-related as discussed in Subsection 3.2.3.

(3) Location codes:

ALL	=	All locations			
CV	=	Containment Vessel	RW	=	Radwaste Building
CB	=	Control Building	CP	=	Circulating Water Pump House

resulting responses are combined with the inertia effects by the SRSS method. Because the OBE design is not required, the displacement-induced SSE stresses due to seismic anchor motion are included in Service Level D load combinations.

In place of the response spectrum analysis, the ISM time history method of analysis is used for multi-supported systems subjected to distinct support motions, in which case both inertial and relative displacement effects are already included.

3.7.3.10 Use of Equivalent Vertical Static Factors

Equivalent vertical static factors are used when the requirements for the static coefficient method in Subsection 3.7.2.1.3 are satisfied.

3.7.3.11 Torsional Effects of Eccentric Masses

Torsional effects of eccentric masses are included for subsystems similar to that for the piping systems discussed in Subsection 3.7.3.3.1.

3.7.3.12 Effect of Differential Building Movements

In most cases, subsystems are anchored and restrained to floors and walls of buildings that may have differential movements during a seismic event. The movements may range from insignificant differential displacements between rigid walls of a common building at low elevations to relatively large displacements between separate buildings at a high seismic activity site.

Differential endpoint or restraint deflections cause forces and moments to be induced into the system. The stress thus produced is a secondary stress. It is justifiable to place this stress, which results from restraint of free-end displacement of the system, in the secondary stress category because the stresses are self-limiting and, when the stresses exceed yield strength, minor distortions or deformations within the system satisfy the condition which caused the stress to occur.

When the piping analysis is performed using USM analysis, per SRP Section 3.9.2, absolute sum method is used to combine the inertia results and the seismic anchor motion results for piping support design.

When the piping analysis is performed by ISM, the piping stresses and pipe support loads are increased by 10% when using the SRSS group combination method. With the additional 10% added to the piping stresses and the pipe support loads, the inertia and the seismic anchor motion are combined by SRSS for piping stresses and pipe support loads.

3.7.3.13 Seismic Category I Buried Piping, Conduits and Tunnels

~~There are no~~ All Seismic Category I utilities (i.e. piping, conduits, or auxiliary system components), that are ~~directly buried~~routed underground are installed in concrete trenches or in concrete duct banks in direct contact with soil.

Fire Protection System yard piping with a Seismic Category I classification is installed in covered reinforced concrete trenches near the ground surface with removable covers to facilitate maintenance and inspection access.

There are Seismic Category I conduits in four electrical duct banks from the CB to the RB. These electrical duct banks are ~~installed~~ embedded in ~~closed~~ reinforced concrete ~~trenches covered with backfill~~in direct contact with soil.

There are no buried Seismic Category I tunnels in the ESBWR design. The access tunnel, which includes walkways between and access to RB, CB, TB, SB, and Electrical Building is classified Seismic Category II. Since Seismic Category II structures are designed to the same criteria as Seismic Category I structures there is no impact to adjacent Seismic Category I structures.

The Radwaste Tunnel provides for pipes that transport radioactive waste to the Radwaste Building from RB and TB. The Radwaste Tunnel is classified non-seismic but the structural acceptance criteria are in accordance with RG 1.143 – Safety Class RW-IIa.

In accordance with SRP 3.7.3 (Rev. 3, March 2007), ~~The~~ the following items are considered in the analysis and design of trenches or concrete duct banks for Seismic Category I or II utilities and buried Seismic Category II and radwaste tunnels~~in accordance with SRP 3.7.3 (Rev. 3, March 2007)~~:

- Two types of ground shaking-induced loadings are considered for design:
  - Relative deformations imposed by seismic waves traveling through the surrounding soil or by differential deformations between the soil and anchor points.
  - Lateral earthquake pressures and ground-water effects acting on structures.
- When applicable, the effects caused by local soil settlements, soil arching, etc., are considered in the analysis.
- Lateral earth pressures are determined in the same manner as for embedded walls below grade for Seismic Category I structures. Effect of wave propagation is accounted in accordance with ASCE 4-98, Subsection 3.5.2 and Commentary.
- Longitudinal forces and strains are treated as secondary forces and strains (displacement-controlled).
- Longitudinal compressive strains are limited to 0.3%. The reinforcing steel added to the concrete addresses the effect of longitudinal tensile strains.
- Seismic input motions are based on the single envelope design response spectra as defined in Table 3.7-2 using the applicable scale factor.
- Primary loadings are lateral earth pressures, hydrostatic pressures, dead loads, and live loads applied concurrently with seismic excitation. Resultant stresses due to wave propagation effects and those resulting from the dynamic anchor movement are combined by the SRSS method.
- Expansion joints are provided between the tunnel and the connecting building to provide seismic isolation.
- Expansion joints along the tunnel are located no more than 20 m (65.6 ft.) apart.

Seismic Category I utilities and Safety Class RW-IIa radwaste piping installed in trenches or tunnels are analyzed in accordance with the standard requirements of Subsection 3.7.3. Seismic input motions for the portions located below ground are based on the single envelope design response spectra as defined in Table 3.7-2 using applicable scale factor.

3.7.3.14 Methods for Seismic Analysis of Seismic Category I Concrete Dams

There are no Seismic Category I concrete dams in the ESBWR design.

3.7.3.15 Methods for Seismic Analysis of Above-Ground Tanks

The seismic analysis of Seismic Category I above ground tanks considers the following items:

- At least two horizontal modes of combined fluid-tank vibration and at least one vertical mode of fluid vibration are included in the analysis. The horizontal response analysis includes at least one impulsive mode in which the response of the tank shell and roof is coupled together with the portion of the fluid contents that move in unison with the shell, and the fundamental sloshing (convective) mode.
- The fundamental natural horizontal impulsive mode of vibration of the fluid-tank system is estimated giving due consideration to the flexibility of the supporting medium and to any uplifting tendencies for the tank. The rigid tank assumption is not made unless it can be justified. The horizontal impulsive-mode spectral acceleration, S_{a1}, is then determined using this frequency and damping value for the impulsive mode. This is the same as that for the tank shell material in accordance with NUREG/CR-1161. Alternatively, the maximum spectral acceleration corresponding to the relevant damping is used.
- Damping values used to determine the spectral acceleration in the impulsive mode are based upon the system damping associated with the tank shell material as well as with the SSI. The SSI system damping takes into account soil damping in the form of stiffness-weighted damping in accordance with Equation 3.7-14 or complex stiffness matrix in accordance with Equation 3.7-16.
- In determining the spectral acceleration in the horizontal convective mode, S_{a2}, the fluid damping ratio is 0.5% of critical damping unless a higher value can be substantiated by experimental results.
- The maximum overturning moment, M_o, at the base of the tank is obtained by the modal and spatial combination methods discussed in Subsections 3.7.2.7 and 3.7.2.6, respectively. The uplift tension resulting from M_o is resisted either by tying the tank to the foundation with anchor bolts, etc., or by mobilizing enough fluid weight on a thickened base skirt plate. The latter method of resisting M_o, when used, must be shown to be conservative.
- The seismically induced hydrodynamic pressures on the tank shell at any level are determined by the modal and spatial combination methods discussed in Subsections 3.7.2.7 and 3.7.2.6, respectively. The maximum hoop forces in the tank wall are evaluated with due regard for the contribution of the vertical component of ground shaking. If the effects of SSI results in higher response then an appropriate SSI method of analysis comparable to Reference 3.7-16 is used. The hydrodynamic pressure at any level is added to the hydrostatic pressure at that level to determine the hoop tension in the tank shell.