RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**252-8299**
SRP Section:	**03.07.02 – Seismic System Analysis**
Application Section:	**3.7.2**
Date of RAI Issue:	**10/19/2015**

Question No. 03.07.02-14

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the safe shutdown earthquake (SSE) ground motion through design, testing, or qualification methods. In accordance with 10 CFR 50 Appendix S, the staff reviews the adequacy of the seismic analysis methods used to demonstrate that SSCs can withstand seismic loads and remain functional. Per SRP Section 3.7.2.II.8, to ensure an adequate evaluation of the seismic Category I SSCs in a DC application, it is necessary to determine that they are not vulnerable to collapse or interaction with adjacent non□seismic Category I structures. Consequently, DC applicants should provide sufficient analysis and design information concerning interaction of the non□seismic Category I structures with seismic Category I SSCs for staff review.

DCD Section 3.7.2.7.1, describes three alternate criteria related to providing reasonable assurance that the failure of non□seismic Category I structure under the effect of a seismic event does not impair the integrity of an adjacent seismic Category I structures. Additionally, this DCD section references APR1400□E□S□NR□14005, which contains the details of the structure□soil□structure interaction (SSSI) analysis of the NI structures, EDGB/DFOT, the seismic Category II turbine generator building (TGB), and the seismic Category II compound building (CB). Staff review did not find a clear description of the specific criterion out of the three aforementioned criteria that apply to the evaluation of interaction effects of the TGB and CB with the seismic Category I structures. The staff needs additional information regarding these buildings, to ensure that the NI and EDGB/DFOT are not vulnerable to damage caused by collapse of the TGB or CB. As a minimum, the staff requests the applicant to provide the specific criteria out of the three criteria mentioned above that applies to the TGB and CB; a definition of the seismic input used for the design of these structures, and how the SSSI effects are accounted for in such seismic input; a description of the method of seismic design and analysis applicable to these structures: the maximum relative displacements between these structures and adjacent seismic Category I structures considering out□of□phase motion; and a description of how the potential effects of sliding and uplift have been considered for these structures.

Response

DCD Tier 2, Section 3.7.2.8 (Section number 3.7.2.7.1 has been changed to 3.7.2.8 in the response of RAI 249-8323, Question 03.08.01-16), criterion b which is equivalent to the SRP Section 3.7.2 II.8 criterion C is applied to the turbine generator building and compound building to provide reasonable assurance that failure of the structures under the effects of a seismic event do not impair the integrity of the nuclear island (NI). To describe what criterion is specifically applied to the turbine generator building and compound building, a description will be added in Section 3.7.2.8. In addition, the last phrase of criterion b, “in such a manner that the margins of safety of these structures are equivalent to those of seismic Category I structures,” will be removed.

The seismic analysis procedure, including soil-structure interaction analysis, which is applied to the NI structures is also applied to the turbine generator building and compound building. The same CSDRS based seismic input motions and the nine generic site profiles are applied to the seismic analysis of the NI and the turbine generator building and compound building. The SSSI effects are not accounted for in the seismic input for the turbine generator building and compound building.

The COL applicant is to check and consider the potential effects of sliding and uplift for the turbine generator building and compound building using the same approach that is used in the stability check for the NI common basemat, as described in APR1400-E-S-NR-14006-P. The DCD Tier 2, Section 3.7.2.8 and the corresponding COL information item (COL 3.7(4)) in Section 3.7.5 will be revised.

Impact on DCD

DCD Tier 2, Subsections 3.7.2.8, 3.7.5, and Table 3.2-1 will be revised, as indicated in the Attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

$$R_{rI} = \sum_{i=1}^{n} R_{\mathrm{ri}} + R_{missmassI}$$

where $R_{missmassI}$ is the residual rigid response of the missing mass modes for the I_{th} component of seismic input motion. The effect of missing mass modes not included in the analysis is accounted for by using the method given in NRC RG 1.92.

Finally, the combined response is calculated as follows:

$$R_I = \left[R_{rI}^2 + R_{pI}^2 \right]^{1/2}$$

3.7.2.8

RAI 249-8323 - Question 03.08.01-16

~~3.7.2.7.1~~ Interaction of Non-Seismic Category I Structures with Seismic Category I Structures

The interfaces between seismic Category I and non-seismic Category I structures are designed for the dynamic loads and displacements produced by both the seismic Category I and non-seismic Category I structures.

To provide reasonable assurance that the failure of a non-seismic Category I structure under the effect of a seismic event does not impair the integrity of an adjacent seismic Category I structure, one of the following ~~procedures~~ is used:

criteria

a. Maintenance of sufficient separation between non-seismic Category I structures and seismic Category I structures

b. Analysis and design of non-seismic Category I structures to prevent their failure under SSE conditions ~~in such a manner that the margins of safety of these structures are equivalent to those of seismic Category I structures~~

"Deleted"

c. Design of seismic Category I structures to withstand loads due to the collapse of the adjacent non-seismic Category I structures if sufficient spatial separation is not achieved

The seismic Category II turbine generator building and compound building are analyzed and designed to prevent their failure under SSE conditions (criterion b). Since the seismic Category II alternate alternating current gas turbine generator building is located at a considerable distance from the seismic Category I structures, as shown in Figure 1.2-1, criterion a is applies to the alternate alternating current gas turbine generator building.

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The turbine generator building and compound building are ~~classified as non-seismic Category I structures and are~~ located on the west side and south side of nuclear island with a ~~1.0 m~~ (3 ft) gap on each side. Figures 3.7-40 and 3.7-41 show the FEMs of the turbine generator building and compound building, respectively. To evaluate the structure-soil-structure interaction effects on the nuclear island structures due to presence of adjacent non-seismic Category I structures, the structure-soil-structure interaction analysis using the coupled model for entire structures is performed. The interaction effects of these non-seismic Category I structures on the nuclear island are negligible as provided in Technical Report, APR1400-E-S-NR-14005-P (Reference 20).

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~~The COL applicant is to confirm that the any site-specific non-seismic Category I SSCs are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction (COL 3.7(4)).~~

3.7.2.8 Effects of Parameter Variations on Floor Response Spectra

To consider variations in the structural frequencies due to the uncertainties in material properties of the structure and approximations in modeling, the peaks of the computed floor response spectra are broadened by ± 15 percent and smoothed in accordance with NRC RG 1.122, as described in Subsection 3.7.2.5.

The effects of potential concrete cracking on the structural stiffness of reinforced concrete structures are considered as enveloping the floor response spectra for cracked concrete properties with 7 percent damping for the reinforced concrete structures and those for uncracked properties with 4 percent damping for the reinforced concrete structures.

Both uncracked and cracked concrete stiffnesses are considered separately in the seismic analysis models of the seismic Category I structures. For consideration of potential concrete cracking, the cracked concrete stiffness in horizontal and vertical seismic analysis models is reduced by half of the uncracked concrete stiffness except prestressed concrete containment structure and reinforced concrete columns and walls in the vertical models described in ASCE/SEI 43-05 (Reference 21). Therefore, for nine soil profiles and one fixed-base condition, a total of 20 analysis cases are performed in the seismic analysis to generate the floor response spectra of the seismic Category I structures.

A

The COL applicant is to confirm that any site-specific non-seismic Category I structures are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction. The relative displacements calculated by the COL applicant are not to exceed the gaps between seismic Category I and non-seismic Category I structures.

For the seismic analysis of the seismic Category II structures, the site-specific FIRS are applied as seismic input motions and a site-specific soil profile is to be established as a supporting media. The same seismic analysis procedure which is applied to the seismic Category I structures is also applied to the seismic Category II structures.

The design codes used by the COL applicant for the structural design of the seismic Category II structures are as follows:

a. The design of the turbine generator building is performed using ACI 318 or AISC 360 as described in Table 3.2-1.

b. The compound building is designed according to RW-IIa criteria in RG 1.143. Hence, the design of the compound is performed using ACI 349 or AISC N690 as described in Table 3.2-1.

c. The design of the alternate alternating current gas turbine generator building located on the southwest side of the plant is performed using ACI 318 as described in Table 3.2-1.

The potential effects of sliding and uplift for the seismic Category II structures are checked using the same approach applied in the stability check for the seismic Category I structures (COL 3.7(4)).

2) The pre-shutdown inspection procedure supports determination of the effects of the earthquake on essential safe shutdown equipment. Following the earthquake, the equipment must be inspected for any needed resets or repairs, as well as for readiness prior to initiating shutdown activities.

3) The post-event inspection procedure supports determination of the degree of damage to equipment and equipment acceptability for continued operation.

3.7.5 Combined License Information

COL 3.7(1) The COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and the basis for the plant shutdown. The COL applicant is also to verify the appropriateness of the site-specific SSE and OBE.

COL 3.7(2) The COL applicant is to confirm that the horizontal components of the site-specific SSE ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1g.

COL 3.7(3) The COL applicant is to provide the seismic design of the seismic Category I SSCs that are not part of the APR1400 standard plant design. The seismic Category I structures are as follows:

a. Seismic Category I essential service water building

b. Seismic Category I component cooling water heat exchanger building

COL 3.7(4) The COL applicant is to confirm that the any site-specific non-seismic Category I SSCs are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction.

COL 3.7(5) The COL applicant is to perform any site-specific seismic design for dams that is required.

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B

COL 3.7(3) The COL applicant is to provide the seismic design of the seismic Category I SSCs and seismic Category II structures that are not part of the APR1400 standard plant design. The seismic Category I and II structures are as follows:

a. Seismic Category I essential service water building

b. Seismic Category I component cooling water heat exchanger building

c. Seismic Category II turbine generator building

d. Seismic Category II compound building

e. Seismic Category II alternate alternating current gas turbine generator building

COL 3.7(4) The COL applicant is to confirm that any site-specific non-seismic Category I structures are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction. The COL applicant is to confirm that the calculated relative displacements do not exceed the gaps between seismic Category I and non-seismic Category I structures.
The COL applicant is to apply the site-specific FIRS as seismic input motions and to establish a site-specific soil profile as a supporting media for the seismic analysis of the seismic Category II structures. The COL applicant is to apply the same seismic analysis procedure as the seismic Category I structures to the seismic Category II structures. The COL applicant is to perform the structural design of the seismic Category II structures using the design codes described in Subsection 3.7.2.8 and Table 3.2-1. The COL applicant is to check the potential effects of sliding and uplift for the seismic Category II structures using the same approach applied in the stability check for the seismic Category I structures.

Table 3.2-1 (1 of 86)

Classification of Structures, Systems, and Components[1]

Item No. / Principal SSCs	Location[2]	Safety Class	Quality Group	Codes and Standards	10 CFR 50, App. B[3]	Seismic Category	Remarks
I. Major Structures							
1. Containment Building (including mechanical and electrical penetrations)		SC-2	B	ASME Sec. III NE-2007 with 2008 addenda, ASME Sec. III CC-2001 with 2003 Addenda	Yes	I	
2. Containment Building Internal Structures (including radiation shield)		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
3. Auxiliary Building (including TSC)		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	(4)
4. Turbine Generator Building		NNS	N/A	ACI 318-2008 AISC 360-2005	A	II	(3)(d)
5. Compound Building		NNS	N/A	~~ACI 318-2008 AISC 360-2005~~	A	II	(3)(d), (4)
6. Emergency Diesel Generator Building		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
7. ~~Alternate AC Generator Building~~		NNS	N/A	ACI318-2008	A	II	(3)(d)
8. Essential Service Water Building		SC-3	N/A	ACI349-1997, ANSI/AISC N690-1994 incl. supp. 2(2004)	Yes	I	

Alternate Alternating Current Gas Turbine Generator Building

ACI 349-1997, ANSI/ AISC N690-1994 incl. Supp. 2 (2004)

Table 3.2-1 (85 of 86)

(4) Designed in accordance with NRC RG 1.143. The radwaste facilities, including the structures, systems, and components, are designed to meet the design basis loads, including the natural phenomena and internal and/or external man-induced hazards design criteria, in accordance with NRC RG 1.143.

- The radwaste safety classifications for the radioactive waste management systems: LWMS, GWMS, SWMS, and the SGBD systems and components, are presented in Sections 11.2, 11.3, 11.4, and 10.4.8, respectively.
- The radwaste safety classification for the compound building, in which the LWMS, GWMS, and SWMS are housed, is RW-IIa in accordance with the guidance in RG 1.143. ~~Radwaste treatment structure classified as Class RW-IIa is designed and constructed to meet the requirements of ACI 349 and AISC N690.~~ "Deleted"
- The components for the SGBD system are housed in the auxiliary building. The seismic design requirements for the auxiliary building exceed those for the radwaste safety classification. The seismic design loads for the building housing the SGBD system shall follow those for the auxiliary building.

(5) Designed based on guidance contained in NRC NUREG-0696 and NUREG-0737, Supplement 1.

(6) Security system requirements per 10 CFR 73.

(7) IEEE 497 endorsed by NRC RG 1.97 post-accident monitoring parameters. Instrumentation meets qualification and quality requirements of this NRC RG and IEEE 497.

(8) Guidance per NUREG-0718 and NRC RG 1.47.

(9) Earthquake monitoring is per NRC RG 1.12.

(10) Design guidance per NRC RG 1.13.

(11) Design guidance per NRC RG 1.13, NUREG-0554, and NUREG-0612.

(12) Design guidance per NRC RG 1.189.

(13) The entire crane, including the bridge and trolley, is designed and constructed in accordance with NRC RG 1.29.

(14) Non-safety-related diverse protection system per 10 CFR 50.62 and GL 85-06.

(15) Non-safety-related ACUs and components, including fan/motor and associated isolation dampers, are designed and constructed per NRC RG 1.140.

(16) Design guidance per NRC RG 1.45.

(17) These codes and standards are applied to requirements of interface design.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**252-8299**
SRP Section:	**03.07.02 – Seismic System Analysis**
Application Section:	**3.7.2**
Date of RAI Issue:	**10/19/2015**

Question No. 03.07.02-15

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the safe shutdown earthquake (SSE) ground motion through design, testing, or qualification methods. In accordance with 10 CFR 50 Appendix S, the staff reviews the adequacy of the seismic analysis methods used to demonstrate that SSCs can withstand seismic loads and remain functional.

(a) COL Items 3.7(3) and 3.8(1) in DCD Sections 3.7.5 and 3.8.4 respectively, identify the seismic Category I essential service water building and the seismic Category I component cooling water heat exchanger building as site□specific structures. However DCD Section 1.2.14 and Figure 1.2□1 identify these structures as being within the scope of the design certification for APR1400. The staff finds the information in DCD Section 1.2.14 and Figure 1.2□1 to be inconsistent with the aforementioned COL Items. Therefore, the staff requests the applicant to confirm that the aforementioned structures are site□specific and correct any inconsistencies presented in any other sections of the DCD.

(b) DCD Section 1.2.14 and Figure 1.2□1 identify the seismic Category II alternate alternating current (AAC) gas turbine generator building as being within the scope of the design certification for APR1400. However the staff did not find information in Section 3.7.2.7.1 concerning the seismic analysis and design methods for this building, or the treatment of seismic Category I and non□seismic Category I interaction considerations. Therefore, the staff requests the applicant to clarify which of the interaction criteria from DCD Section 3.7.2.7.1 applies to this building, and to provide a description of the applicable seismic analysis and design methods, consistent with the applicable criterion from DCD Section 3.7.2.7.1.

Response

(a) The seismic Category I essential service water building and component cooling water heat exchanger building are site-specific structures, as described in COL Items 3.7(3) and 3.8(1). DCD Tier 2, Sections 1.2 and 1.2.14, Figure 1.2-1, and Table 1.8-1 will be revised, as indicated in the attachment associated with this response.

(b) Since the seismic Category II alternate alternating current (AAC) gas turbine generator building is located at a considerable distance from the seismic Category I structures, as shown in DCD Tier 2, Figure 1.2□1, the interaction criterion of DCD Tier 2, Section 3.7.2.8 (Section 3.7.2.7.1 was changed to Section 3.7.2.8 by the response to RAI 249-8323 Question No. 03.08.01-16) which applies to the AAC gas turbine generator building is criterion (a) as indicated in the attachment associated with the response to RAI 252-8299 Question No. 03.07.02-14. The structure-soil-structure interaction effect between seismic Category I structures and the AAC gas turbine generator building is not significant.

The COL applicant is to confirm that the site-specific, seismic Category II AAC gas turbine generator building is designed not to degrade the function of a seismic Category I structure. The seismic analysis and design methods applicable to the seismic Category II AAC gas turbine generator building are described in the attachment associated with the response to RAI 252-8299 Question No. 03.07.02-14.

Impact on DCD

DCD Tier 2, Section 1.2 and 1.2.14, Figure 1.2-1, and Table 1.8-1 will be revised, as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

1.2 General Plant Description

This section contains a summary of the principal design criteria, operating characteristics, safety considerations, and major structures and systems. This section also includes a site plan and the general arrangement of major structures and equipment. ~~The scope of the certified design is described in Section 1.2.14 and is shown on the site plan in Figure 1.2-1. The site plan also shows site-specific structures and features.~~

The combined license (COL) applicant is to prepare a complete and detailed site plan.

1.2.1 Principal Design Criteria, Operating Characteristics, and Safety Considerations

1.2.1.1 Principal Design Objectives

The following subsection provides the principal design objectives for the safety, reliability, and performance of the plant. These objectives are the basis of the principal design criteria for the APR1400.

1.2.1.1.1 Safety Design Objectives

The safety design objectives of the APR1400 are as follows:

a. Simplify plant design and operation, as described in Subsection 1.2.1.2.1.

b. Provide the proper safety margin for a more forgiving and resilient plant, as described in Subsection 1.2.1.2.2.

c. Improve the human-system interface system to promote error-free normal operations and quick, accurate diagnosis of off-normal conditions.

d. Meet applicable NRC requirements related to engineered safety system design and analysis of plant and engineered safety system responses to regulatory transients and accidents.

The scope of the certified design is shown on the typical site arrangement plan in Figure 1.2-1; the figure includes site specific structures and features. The

c. Turbine generator building

d. Compound building

e. Emergency diesel generator building with two emergency diesel generator rooms , including the DFOT room

f. Alternate alternating current gas turbine generator building

g. Essential service water intake structure and ultimate heat sink related structure

h. Component cooling water heat exchanger building

~~A standard plot of the APR1400 is shown in Figure 1.2-1, and the~~ general arrangement drawings are shown in Figures 1.2-2 through 1.2-49.

See page 3.

1.2.14.1 Reactor Containment Building

The reactor containment building is designed using a post-tensioned concrete containment wall with a reinforced concrete internal structure. The reactor containment building houses a reactor, two steam generators, a pressurizer, reactor coolant loops, an IRWST, and portions of the auxiliary systems. The reactor containment building is designed to provide biological shielding and external missile protection, as well as to sustain all internal and external loading conditions that are reasonably expected to occur during the life of the plant.

The interior arrangement of the reactor containment building is designed to meet the requirements for all anticipated conditions during operation and maintenance, including new and spent fuel handling.

The equipment hatch is located at the operating floor level. The hatch is sized to accommodate the one-piece replacement of a steam generator. A polar bridge crane is supported from the wall of the reactor containment building. The polar bridge crane has the capability to install and remove the steam generators. Personnel access from the auxiliary building to the reactor containment building is through two hatches: one at the operating floor and the other one at the ground floor.

For seismic analysis and structural design, the certified design scope is limited to the reactor containment building, the auxiliary building, and the emergency diesel generator building including the diesel fuel oil tank room, which are seismic Category I buildings. The other seismic Category I buildings, including the component cooling water heat exchanger building and the essential service water building, and the seismic Category II buildings, such as the turbine generator building, the compound building, and the AAC gas turbine generator building, are designed by the COL applicant.

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 1.2-1 Typical APR1400 Site Arrangement Plan

Table 1.8-1 (1 of 2)

Index of System, Structure, or Component Interface Requirements for APR1400

System, Structure, or Component	Interface Type	DCD Tier 2 Section
Structures		
Switchyard	COL	8.2
Emergency operations facility	COL	13.3.3.2
Ultimate heat sink, including ESWS intake/discharge	CDI	9.2.5.2
Domestic water and sanitary system structure	CDI	9.2.4
Circulating water pump house	CDI	10.4.5.2
Normal plant heat sink, including CW system intake/discharge	CDI	10.4.5
Systems		
Offsite power system, including switchyard	COL	8.2
Domestic water and sanitary systems, including sanitary water treatment facility	CDI	9.2.4
Security system	COL	13.6.1
Communication system (offsite)	COL	9.5.2.2.2
UHS	CDI	9.2.5
Seismic Category II buildings described in Table 3.2-1	COL	3.7.5
Component cooling water heat exchanger building	COL	3.7.5 3.8.6
Essential service water building	COL	3.7.5 3.8.6