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.:	**344-8407**
SRP Section:	**03.10 - Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.**
Application Section:	**03.10**
Date of RAI Issue:	**12/22/2015**

Question No. 03.10-7

In RAI 8360 Question 03.09.03-4, the NRC staff requested that KHNP address how the hard rock high frequency ground motion response spectra exceedance of the certified seismic design response spectra discussed in DCD Tier2, Appendix 3.7B was considered in the evaluation of component dynamic qualification in other DCD sections including DCD Tier 2, Section 3.10, “Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.” DCD Tier 2, Appendix 3.7B.7.4 and Technical Report APR1400-E-S-NR-14004-P, “Evaluation of Effects of HRHF Response Spectra on SSCs,” Revision 0, Section 6, “Evaluation,” Subsection 1.18 “Safety-Related Equipment” state that safety-related equipment is evaluated for the effect of high frequency input motion for safety of the plant. However, the purpose and details of the evaluation are not clear.

Interim Staff Guidance DC/COL-ISG-01, “Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion,” Section 4.0, “Identification and Evaluation of HF Sensitive Mechanical and Electrical Equipment/Components” provides guidance for the identification and evaluation of high frequency sensitive equipment. The guidance includes the need to provide a basis for the criteria used for each screening step that is used to identify equipment/components with potential for high frequency sensitivity, describe the process for evaluating the equipment and components that are screened in, and explain the method of generating the required response spectra at the location of support or attachment point.

To the extent that Technical Report APR1400-E-S-NR-14004-P and the information presented in DCD Tier 2, Appendix 3.7B is proposed to be approved as part of the design certification application (information on which was requested in RAI 8360 Question 03.09.03-4), the NRC staff requests that KHNP describe the evaluation process fully and provide the information discussed in DC/COL-ISG-01, and update the DCD and technical report.

Response

The process for evaluating exceedance of the certified seismic design response spectra with respect to hard rock high frequency ground motion response spectra and the effects on the dynamic qualification of components is provided in the attached description. The described process includes the information discussed in DC/COL-ISG-01 and will be incorporated into Technical Report APR1400-E-S-NR-14004-P/NP, “Evaluation of Effects of HRHF Response Spectra on SSCs,” Revision 1, Subsection 6.4 “Safety-Related Equipment” and into DCD Section 3.7B.7.4 “Safety-Related Equipment.”

Impact on DCD

DCD Appendix 3.7B.7.4 will be revised as shown in the attached markup.

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

Technical Report APR1400-E-S-NR-14004-P/NP, Rev. 1 will be revised as shown in the attached markup.

Table 1.8-2 (4 of 29)

Item No.	Description
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.
COL 3.7(6)	The COL applicant is to perform seismic analysis of buried seismic Category I piping, conduits, and tunnels.
COL 3.7(7)	The COL applicant is to perform seismic analysis for the seismic Category I above-ground tanks.
COL 3.7(8)	The COL applicant that references the APR1400 design certification will determine whether essentially the same seismic response from a given earthquake is expected at each unit in a multi-unit site or each unit is to be provided with a separate set of seismic instruments.
COL 3.7(9)	The COL applicant is to confirm details of the locations of the triaxial time-history accelerograph.
COL 3.7(10)	The COL applicant is to identify the implementation milestones for the seismic instrumentation implementation program based on the discussion in Subsections 3.7.4.1 through 3.7.4.5.
COL 3.7B(1)	The COL applicant is to evaluate the HRHF response spectra.
COL 3.7B(2)	~~The COL applicant is to evaluate the representative items listed in Table 3.7B-2.~~
COL 3.8(1)	The COL applicant is to provide the design of site-specific seismic Category I structures such as the essential service water supply structure and the component cooling water heat exchanger building.
COL 3.8(2)	The COL applicant is to identify any applicable site-specific loads such as site proximity explosions and missiles, potential aircraft crashes, and the effects of seiches, surges, waves, and tsunamis.
COL 3.8(3)	The COL applicant is to determine the environmental condition associated with the durability of concrete structures and provide the concrete mix design that prevents concrete degradation including the reactions of sulfate and other chemicals, corrosion of reinforcing bars, and influence of reactive aggregates.
COL 3.8(4)	The COL applicant is to determine construction techniques to minimize the effects of thermal expansion and contraction due to hydration heat, which could result in cracking.
COL 3.8(5)	The COL applicant is to monitor the safety and serviceability of seismic Category I structures during the operation of the plant and provide the appropriate maintenance.
COL 3.8(6)	The COL applicant is to provide reasonable assurance that the design criteria listed in Table 2.0-1 are met or exceeded.

The COL applicant is to verify the applicability of evaluation of the items potential to HF sensitivity

COL 3.7B(3) The COL applicant is to perform the HRHF evaluation of safety related equipment.

APPENDIX 3.7B – EVALUATION FOR HIGH FREQUENCY SEISMIC INPUT

TABLE OF CONTENTS

b. Reactor coolant system (RCS)

1) Reactor vessel internals (RVI) and core

2) Component supports and nozzles of the RCS

c. Piping system

d. Safety-related ~~electrical~~ equipment

3.7B.7 Evaluation

3.7B.7.1 Building Structures

Maintaining the structural integrity of the nuclear island structures is important to the safety of the plant. Representative portions of the building structures that were evaluated for the effect of high frequency input were selected based on the areas with the potential to experience high seismic shear and moment loads in a seismic event.

The evaluation consisted of a comparison of the seismic loads and equivalent acceleration from high frequency input to those obtained from the APR1400 design-basis CSDRS for the representative building structures. The nuclear island structures were considered to be qualified for high frequency input if the seismic loads and equivalent acceleration from the CSDRS enveloped those from the high frequency input.

3.7B.7.2 Reactor Coolant System

The RVI support the core and are therefore important to safety. RVI consist of complicated components whose natural frequencies are in the relatively high frequency range.

RCS component supports were selected as one of the evaluation items because they help maintain the capability of RCS components to perform their intended safety-related functions.

Nozzles were evaluated because piping failures generally occur at high stress locations, such as at the nozzles of a component, and they represent the sensitivity of the reactor coolant loop piping to high frequency excitation.

In the APR1400 plant, the design acceptance criteria are applied to the piping design area. The combined license (COL) applicant is to evaluate the HRHF response spectra (COL 3.7B(1)).

3.7B.7.4 Safety-Related ~~Electrical~~ Equipment

~~Safety-related electrical equipment was evaluated for the effect of high frequency input motion for safety of the plant. Representative items were selected for the evaluation because they are susceptible to high frequency seismic inputs. Susceptibility to excitation caused by high frequency input depends on the presence of the following factors:~~

a. ~~The local HRHF ISRS exceed the APR1400 CSDRS ISRS in the high frequency range~~.

b. ~~Safety related equipment has modes or natural frequencies in the high frequency range~~.

c. ~~Safety-related components have potential failure modes involving a change of state, chatter, signal change/drift, and/or connection problems~~.

~~Equipment with modes in the range of the high frequency response excitation is expected to experience higher loads and amplifications than equipment with modes outside a high frequency range. To support this expectation and determine the effect of high frequency seismic motion on the APR1400 safety related electrical equipment, the equipment configuration, location, stress analysis methodology, and equipment qualification testing procedures were reviewed~~.

~~The COL applicant is to evaluate the representative items listed in Table 3.7B-3 (COL 3.7B(2))~~.

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3.7B.8 Combined License Information

COL 3.7B(1) The COL applicant is to evaluate the HRHF response spectra.

COL 3.7B(2) ~~The COL applicant is to evaluate the representative items listed in Table 3.7B-3~~.

The COL applicant is to verify the applicability of evaluation of the items potential to HF sensitivity

COL 3.7B(3) The COL applicant is to perform the HRHF evaluation of safety related equipment.

A (1/2)

3.7B.7.4. Safety-related equipment

As a result of the high frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. The use of prior testing results should be justified by demonstrating that the frequency content of the PSD of the test waveform is sufficient.

Safety-related equipment is evaluated for the effect of high frequency input motion to demonstrate their safety-related functionality.
For the evaluation of the equipment and components functionality for those cases where the GMRS/FIRS-based ISRS exceed the CSDRS-based ISRS below 50 Hz, further equipment and component functionality evaluations are needed. The screening process is applied for identification and evaluation of high-frequency sensitive mechanical and electrical equipment/components. For the new qualification test of equipment and components, the RRS that is generated to meet GMRS/FIRS-based ISRS as well as the CSDRS-based ISRS are applied.

Evaluation process for evaluating equipment and components that are screened in is described in Technical Report APR1400-E-S-NR-14004-P (Reference 3) with a basis for the criteria used for each screening step that is used to identify equipment/components with potential to HF sensitivity.

The HRHF evaluations of the safety equipment shall be performed by the COL Applicants (COL 3.7B(3)). The seismic qualification test/analysis will be performed for the components to envelop the in-structure response spectra resulting from the entire set of certified seismic design response spectra (CSDRS), including ground motions for the COL sites with high frequency content.

3.7B.7.4.1 Evaluation process steps and description

Identification and evaluation process of HF sensitive mechanical and electrical equipment and components is performed for safety-related equipment and components before performing seismic qualification.

3.7B.7.4.1.1 Potentially high-frequency sensitive equipment

Safety-related equipment and components that have been undergone prior qualification testing/analysis are classified to either HF sensitive or HF insensitive. The potentially HF sensitive equipment and components are evaluated for the HF sensitivity.
The concern with potentially HF-sensitive components is related to the functionality of the devices when subjected to HF motions.

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The component types suggested in Table 3.7B-3 are considered potentially sensitive to HF motions and should be screened based on the procedures and criteria provided in Technical Report APR1400-E-S-NR-14004-P (Reference 3). For all safety-related equipment that is designed to have part(s) of its assembly with components classified to be potentially sensitive to HF motions are to be evaluated for the adequacy in accordance with the procedures described in APR1400-E-S-NR-14004-P (Reference 3).

List of HF sensitive equipment is provided to Technical Report APR1400-E-X-NR-14001-P, "Equipment Qualification Program"(Reference 13), Table 3, "Equipment Qualification Equipment List". The COL applicant is to verify the applicability of evaluation of the items potential to HF sensitivity (COL 3.7B(2)).

3.7B.7.4.1.2 Items not potentially HF sensitive

In case that items are not potentially sensitive to HF, the confirmation that the natural frequency of the equipment or components is at the region where CSDRS-based ISRS exceedance occurs is required. When the natural frequency is at the CSDRS exceedance region, the higher seismic load based on the HRHF-based ISRS is imposed to the equipment compared to the CSDRS-based ISRS. Therefore additional evaluation to ensure that HRHF-based ISRS does not affect any structural integrity and functional requirement is required although the equipment is potentially classified to be insensitive to HF. The method of additional evaluation could be evaluating the existing data to envelop the RRS that is prepared for HRHF-based ISRS including margins HRHF-based ISRS, conduct screening test if necessary or any analysis to verify acceptability.

3.7B.9 References

1. Regulatory Guide 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” Rev. 2, U.S. Nuclear Regulatory Commission, July 2014.

2. EPRI Draft White Paper, “Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions,” Transmitted to NRC, March 2007.

3. APR1400-E-S-NR-14004-P, “Evaluation of Effects of HRHF Response Spectra on SSCs,” Rev. 0, KHNP, November 2014.

4. EPRI TR-1023389, “Evaluation of Seismic Hazards at Central and Eastern U.S. Nuclear Power Sites,” Electric Power Research Institute, June 2011.

5. NUREG/CR-6728, “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-consistent Ground Motion Spectra Guidelines,” U.S. Nuclear Regulatory Commission, March 2007.

6. NUREG-0800, Standard Review Plan, Section 3.7.1, “Seismic Design Parameters,” Draft Rev. 4, U.S. Nuclear Regulatory Commission, December 2012.

7. EPRI TR-102631, “Soil-Structure. Interaction Analysis Incorporating Spatial Incoherence of Ground Motions,” Electric Power Research Institute, October 1997.

8. EPRI TR-1015110, “Effects of Spatial Incoherence on Seismic Ground Motions,” by Electric Power Research Institute, November 2007.

9. Regulatory Guide 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants,” Rev. 3, U.S. Nuclear Regulatory Commission, September 2009.

10. EPRI TR-1015108, “Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components, and Equipment in Nuclear Power Plants,” Electric Power Research Institute, June 2007.

11. EPRI TR-1015109, “Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory Motions,” Electric Power Research Institute, October 2007.

12. Interim Staff Guidance DC/COL-ISG-01, "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications," U.S Nuclear Regulatory Commission, 2009.

13. APR1400-E-S-NR-14001-P, "Equipment Qualification Report," Rev.0, KHNP, November 2014.

6.4 Safety-related Equipment

Safety-related equipment is evaluated for the effect of high frequency input motion for safety of the plant. Representative items are selected for the evaluation because they are susceptible to high frequency seismic inputs. Susceptibility to excitation caused by high frequency input requires the following factors to be present:

- The local HRHF-based ISRS need to exceed CSDRS-based ISRS in the high frequency range.
- Safety-related equipment must have modes or natural frequencies in the high frequency range.
- Safety-related components must have potential failure modes involving change of state, chatter, signal change/drift, or connection problems.

It is expected that equipment with modes in the range of the high frequency response excitation will experience higher loads and amplifications than equipment with modes outside this range. To support this expectation and determine the effect of high frequency input ground motion on the APR1400 safety-related equipment, a review of the equipment configuration, location, stress analysis methodology, and equipment qualification testing procedures is required.

The evaluation of representative items shown in Table 6-9 is to be accomplished by the COL applicant.

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6.4 Safety-related equipment

In some situations the site specific spectra may exceed the certified design spectra in the high-frequency range. As a result of the high frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. The vast majority of prior existing seismic qualification tests used input frequencies up to only 33 Hz. The use of these prior testing results should be justified by demonstrating that the frequency content of the PSD of the test waveform is sufficient.

Safety-related equipment is evaluated for the effect of high frequency input motion to demonstrate their safety-related functionality.
For the evaluation of the equipment and components functionality for those cases where the GMRS/FIRS-based ISRS exceed the CSDRS-based ISRS below 50 Hz, further equipment and component functionality evaluations are needed. The screening process is applied for identification and evaluation of high-frequency sensitive mechanical and electrical equipment/components. If a new test is planned for the qualification of equipment and components, the RRS that is generated to meet GMRS/FIRS-based ISRS as well as the CSDRS-based ISRS are applied.

Evaluation process for evaluating equipment and components that are screened in is described in this report with a basis for the criteria used for each screening step that is used to identify equipment/components with potential to HF sensitivity. The method of generating the RRS at the location of support or attachment point within a structure or a cabinet that will be used in the evaluation is described.

The HRHF evaluations of the safety equipment shall be performed and the seismic qualification test/analysis will be performed for the components to envelop the in-structure response spectra resulting from the entire set of certified seismic design response spectra (CSDRS), including ground motions for the specific sites with high frequency content.

6.4.1 Evaluation process steps and description

Identification and evaluation process of HF sensitive mechanical and electrical equipment and components is performed for safety-related equipment and components before performing seismic qualification. Refer to Figure 6-11 for the High Frequency Screening Process.

6.4.1.1 Potentially high-frequency sensitive equipment

Safety-related equipment and components that have been undergone prior qualification testing/analysis are classified to either HF sensitive or HF insensitive. The potentially HF sensitive equipment and components are evaluated for the HF sensitivity.
The concern with potentially HF-sensitive components is related to the functionality of the devices when subjected to HF motions. Concerns over functionality of components due to HF motions have been focused on:

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1) devices that have inadvertently changed state, permanently or temporarily (i.e., chattered) or had their output signals affected as a result of vibratory motions. This group is characterized as having bi-stable contacts or other mechanisms loaded by springs and/or electromagnetic forces which can be actuated/moved by inertial forces. Bi-stable devices such as relays, contactors, switches, potentiometers and similar devices, and those components whose output signal or settings (set-points) could be changed by HF vibratory motion are observed from seismic qualification tests and operating experience during which HF impact excitation (and likely high accelerations) caused relays to actuate resulting in inadvertent actions. From the industry experience, relays, contact devices, pressure transducers, and potentiometer are observed to be sensitive to high frequency motion.

2) non-ductile components such as ceramic insulators and cast iron components that have failed due to HF shock-type loads. The latter group of devices has been screened by either avoiding use of brittle materials, or by seismic and operational qualification testing of components (such as breakers and switchgear) whose operation involves impact loads and also requires potentially brittle insulating materials.
   Non-ductile components and internal parts include those made of such materials as cast iron and ceramics. Standard commercial components which require non-ductile parts for function (e.g., circuit breakers) will be tested in accordance with traditional test standards; components otherwise fabricated of brittle materials should be avoided or justified on a case-by-case basis.

Based on the above considerations, the component types suggested in Table 6-9 are considered potentially sensitive to HF motions and should be screened following the procedures and criteria provided in this report. For all safety-related equipment that is designed to have part(s) of its assembly with components classified to be potentially sensitive to HF motions are to be evaluated for the adequacy in accordance with the procedures described in this report. List of HF sensitive equipment is provided to Technical Report APR1400-E-X-NR-14001-P, “Equipment Qualification Program”, Table 3, “Equipment Qualification Equipment List”. The items potential to HF sensitivity listed in Table 6-9 shall be verified for its applicability of evaluation in accordance with site specific condition and/or equipment supplier’s design characteristics.

HF insensitive equipment and components are also evaluated for the adequacy of the qualification in terms of their natural frequency. Detail evaluation process for HF insensitive equipment is described in 6.4.1.2.

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6.4.1.1.1 Use of Existing Qualification Data
Safety-related equipment and components have been seismically qualified in accordance with IEEE Standard 344 random multi-frequency type test. Input motions containing additional HF content which is greater than specified for low frequency (LF) design motions were included in seismic testing either intentionally or unintentionally. Also HF content has been combined with seismic test motions for some equipment to demonstrate equipment intended function for concurrent seismic and non-seismic loads (e.g. hydrodynamic loads) during a seismic event. In order to define HF sensitivity vulnerability, test result could be confirmed to envelop the RRS generated for both HRHF-based ISRS and CSDRS-based ISRS including proper margins. However, proper frequency contents with sufficient energy which were used for input to the shaking table shall be demonstrated to allow use of existing test data.

6.4.1.1.2 Screening test
HF vibration screening tests can be conducted to identify any HF sensitivities or abnormalities of the components in case when only the RRS based on CSDRS-based ISRS are confirmed to be satisfied. A high frequency screening test can also be used to demonstrate lack of component sensitivity to high frequency vibration. The procedures for screening test prepared by the equipment manufacturer shall be reviewed to identify the adequacy of the criteria used for the test. The RRS for the screening test shall be used to envelop HRHF based ISRS. Upper limit for the HF screening evaluation is set to 50 Hz since majority of HRHF based ISRS show this limit is appropriate. However, if there is any ISRS that shows HF content above 50 Hz, this frequency content will also be evaluated.

6.4.1.2 Items not potentially HF sensitive
In case that items are not potentially sensitive to HF, the confirmation that the natural frequency of the equipment or components is at the region where CSDRS-based ISRS exceedance occurs is required. When the natural frequency is at the CSDRS exceedance region, the higher seismic load based on the HRHF-based ISRS is imposed to the equipment compared to the CSDRS-based ISRS. Therefore additional evaluation to ensure that HRHF-based ISRS does not affect any structural integrity and functional requirement is required although the equipment is potentially classified to be insensitive to HF. The method of additional evaluation could be evaluating the existing data to envelop the RRS that is prepared for HRHF-based ISRS including margins, conduct screening test if necessary or any analysis to verify acceptability.

17. Center for Engineering Strong Motion Data (CESMD), (http://strongmotioncenter.org/).

18. NUREG-0003, “Statistical Studies of Vertical and Horizontal Earthquake Spectra,” U.S. Nuclear Regulatory Commission, January 1976.

19. Regulatory Guide 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” Rev. 1, U.S. Nuclear Regulatory Commission, December 1973.

20. M. K. Kaul, “Spectrum-Consistent Time-History Generation,” Journal of the Engineering Mechanics Division, American Society of Civil Engineer, Vol. 104, No. EM4, pp. 781-788, August 1978.

21. K. Lilhanand, K and W. S. Tseng, “Generation of Synthetic Time Histories Compatible with Multiple-Damping Design Response Spectra,” SMiRT-9, Lausanne, K2/10, 1987.

22. K. Lilhanand, K and W. S. Tseng, “Development and Application of Realistic Earthquake Time Histories Compatible with Multiple-Damping Design Spectra,” Proceedings of 9th World Conference on Earthquake Engineering, Tokyo-Kyoto, Japan, August 1988.

23. Computer Program, “SYNQKE-R,” PC Version 1.0, “User’s and Theoretical Manual,” Rev. 1, Paul C. Rizzo Associates, Inc., December 2009.

24. NUREG/CR-5347, “Recommendations for Resolutions of Public Comments on USI A-40, 'Seismic Design Criteria',” Brookhaven National Laboratory, Prepared for U.S. Nuclear Regulatory Commission, June 1989.

25. D. A. Gasparini and E. H. Vanmarcke, “SIMQKE – A Program for Artificial Motion Generation, User’s Manual and Documentation; Simulated Earthquake Motions Compatible with Prescribed Response Spectra,” Department of Civil Engineering, Massachusetts Institute of Technology, Publication No. R76-4, November 1976.

26. EPRI TR-1015110, “Effects of Spatial Incoherence on Seismic Ground Motions,” Electric Power Research Institute, November 2007.

27. Interim Staff Guidance (ISG) 01, “Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications,” U.S. Nuclear Regulatory Commission, May 2008.

28. APR1400 Document No. 1-310-C305-002, “Seismic Analysis of NI Structures Using Incoherent Ground Motion,” Rev. 0, KEPCO Engineering & Construction Company, Inc. and KHNP, July 2013.

29. Ghiocel Predictive Technologies, Inc., “ACS SASSI Version 3.0 Including Options A, AA and FS,” User Manuals, Revision 1, Pittsford, NY, October 2014.

30. APR1400 Document No. 1-350-C305-001, “Emergency D/G BLDG Seismic Analysis,” Rev. 3, KEPCO Engineering & Construction Company, Inc. and KHNP, September 2013.

31. APR1400 Document No. 1-350-C305-002, “Seismic Analysis of EDGB Using Incoherent Ground Motion,” Rev. 1, KEPCO Engineering & Construction Company, Inc. and KHNP, February 2015.

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32. Regulatory Guide 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Rev. 3, U.S. Nuclear Regulatory Commission, September 2009.
33. EPRI TR-1015108, "Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components, and Equipment in Nuclear Power Plants," Electric Power Research Institute, June 2007.
34. EPRI TR-1015109, "Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory Motions," Electric Power Research Institute, October 2007.
35. APR1400-E-S-NR-14001-P, "Equipment Qualification Report," Rev.0, KHNP, November 2014.

Added

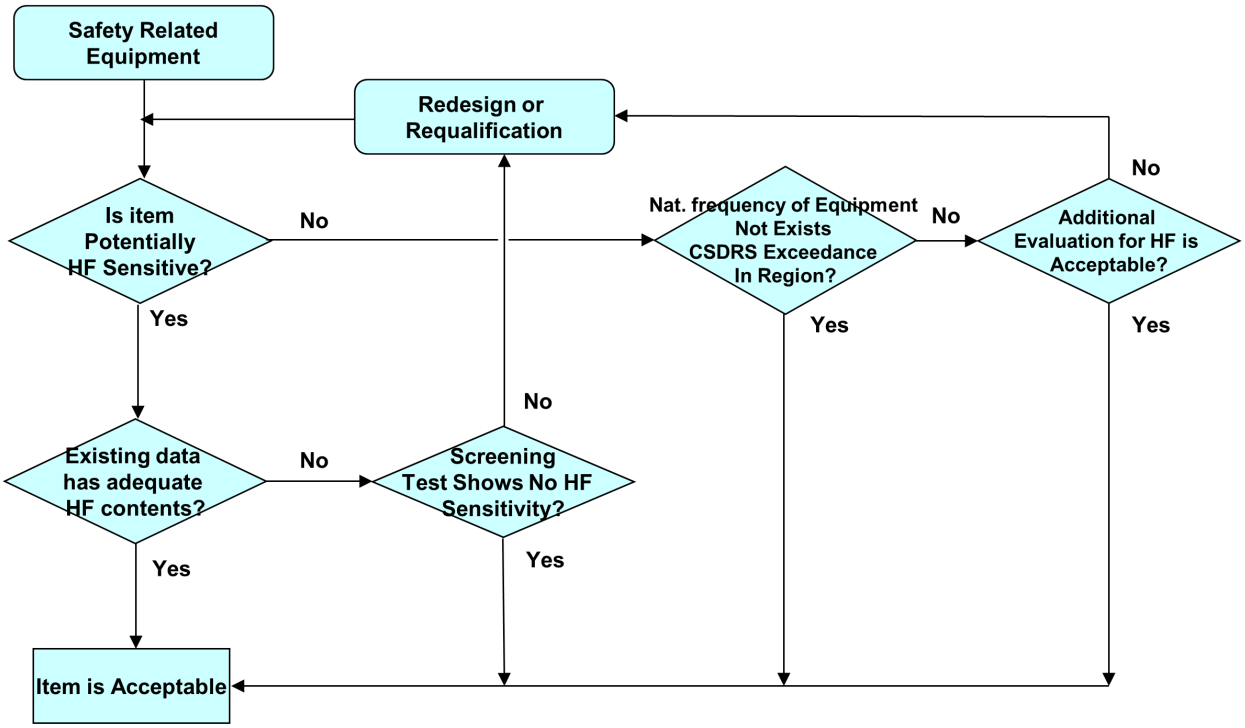

Figure 6-11 High-Frequency Screening Process

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.:	**344-8407**
SRP Section:	**03.10 - Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.**
Application Section:	**03.10**
Date of RAI Issue:	**12/22/2015**

Question No. 03.10-8

Technical Report APR1400-E-S-NR-14004-P, Table 6-8, “List of Potential Equipment to Evaluate Against High

Frequency Seismic Input” lists the electrical equipment sensitive to high frequency seismic input by category. However, Interim Staff Guidance DC/COL-ISG-01 states that for the evaluation of high frequency sensitive equipment, provide a table containing the list of high frequency sensitive mechanical and electrical equipment that will be qualified by testing or analysis. To the extent that Technical Report APR1400-E-S-NR-

14004-P, is proposed to be incorporated by reference as part of the design certification application, the NRC staff requests that the applicant provide a complete list of mechanical and electrical equipment sensitive to high frequency seismic input in Technical Report APR1400-E-S-NR-14004-P. Alternatively, the applicant can modify Technical Report APR1400-E-X-NR-14001-P, “Equipment Qualification Program”, Table 3, “Equipment Qualification Equipment List” to indicate equipment that is sensitive to high frequency.

Response

Technical Report APR1400-E-X-NR-14001-P/NP, “Equipment Qualification Program”, Table 3, “Equipment Qualification Equipment List” will be modified to indicate equipment that is sensitive to high frequency seismic input. The table will include the mechanical and electrical equipment that is sensitive to high frequency in accordance with the classification set forth in Table 6-9 of Technical Report APR1400-E-S-NR-14004-P/NP, “Evaluation of Effects of HRHF Response Spectra on SSCs” and Table 3.7B-3 of the DCD. However, Table 3 in Technical Report APR1400-E-X-NR-14001-P/NP is currently being revised to incorporate information requested in RAI 115-8066 Question 03.11-4. KHNP will include the requested information pertaining to this RAI with the submittal of the response to RAI 115-8066 Question 03.11-4 scheduled for

May 31, 2016.

Impact on DCD

DCD Table 3.7B-3 will be revised as shown in the attached markup.

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

Technical Report APR1400-E-S-NR-14004-P/NP, Rev. 1 will be revised as shown in the attached markup. Technical Report APR1400-E-X-NR-14001-P/NP will be revised with the response to RAI 115-8066 Question 03.11-4.

LIST OF TABLES

Potentially HF Sensitive Component

Potentially HF Sensitive Component

Table 3.7B-3 ~~(1 of 2)~~

~~Equipment List of Evaluation for High Frequency Seismic Input~~

Equipment	Description
125V DC 1E Battery	Battery
1E Battery Charger	Battery Charger
1E DC Control Center	Distribution Panels
Non-1E DC Control Center	
Ground Fault Monitoring Cabinet	
125V DC Distr. PNL	
480V 1E MCC	Motor Control Center
1E Regulating TR.	Transformer
1E Inverter	Inverter
1E AB 4.16KV SWGR	Switchgear
Spent Fuel Pool Level	Level Switches and Transfer
Floor Drain Sump Flooding Level	
CCW Sump Flooding Level	
SI Pump Room Flooding Level	
SC Pump Room Flooding Level	
CS Pump Room Flooding Level	
BOP RMS Cabinet (SRDC)	Radiation Monitor
MMIS-BOP MCR Consoles	Main Control Room
MMIS-BOP ESF-CCS (LCC and GCC)	
MMIS-BOP QIAS-N	
Flexible Hose	Active Hose
Reactor Trip Switchgear	Switchgear
RCP Pump Speed	Speed Sensor
RCS Hot Leg Water Level	Transmitters
PZR Level	
PZR Wide Range Pressure	
PZR Narrow Range Pressure	

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- Electro-mechanical relays (e.g., control relays, time delay relays, protective relays)
- Electro-mechanical contactors (e.g., Motor Control Center(MCC) starter)
- Circuit breakers (e.g., molded case and power breaker – low and medium voltage)
- Auxiliary contacts (e.g., for Molded Case Circuit Breaker (MCCBs), fused disconnects, contactors/starters)
- Control switches (e.g., benchboard panel, operator switches)
- Transfer switches (e.g., low and medium voltage switches with instrumentation)
- Process switches and sensors (e.g., pressure/diff. pressure, temperature, level, limit/position, and flow)
- Potentiometers
- Digital solid-state devices (mounting and connections only)
- Microprocessors-based components
- Connectors and connections (including circuit board connections for digital and analog equipment)
- Unrestrained components

APR1400 DCD TIER 2

~~Table 3.7B-3 (2 of 2)~~

Equipment	Description
POSRV Motor Operated Isolation Valve	Active Valves
Pilot Operated Safety Relief Valve	
SIT Discharge Isolation	
PZR Level Reference Leg Temperature	Resistance Temperature Detector
SIT N2 Vent	Non Active Valve
SCS Heat Exchanger	Heat Exchanger
Safety Injection Tank	Tank

LIST OF TABLES

Potentially HF Sensitive Component

Potentially HF Sensitive Components

Table 6-9

List of Potential Equipment to Evaluate Against High Frequency Seismic Input

Equipment	Description
125V DC 1E Battery	Battery
1E Battery Charger	Battery Charger
1E DC Control Center	Distribution Panels
Non-1E DC Control Center	
Ground Fault Monitoring Cabinet	
125V DC Distr. PNL	
480V 1E MCC	Motor Control Center
1E Regulating TR.	Transformer
1E Inverter	Inverter
1E AB 4.16KV SWGR	Switchgear
Spent Fuel Pool Level	Level Switches and Transfer
Floor Drain Sump Flooding Level	
CCW Sump Flooding Level	
SI Pump Room Flooding Level	
SC Pump Room Flooding Level	
CS Pump Room Flooding Level	
BOP RMS Cabinet (SRDC)	Radiation Monitor
MMIS-BOP MCR Consoles	Main Control Room
MMIS-BOP ESF-CCS (LCC & GCC)	
MMIS-BOP QIAS-N	
Flexible Hose	Active Hose
Reactor Trip Switchgear	Switchgear
RCP Pump Speed	Speed Sensor
RCS Hot Leg Water Level	Transmitters
PZR Level	
PZR Wide Range Pressure	
PZR Narrow Range Pressure	
POSRV Motor Operated Isolation Valve	Active Valves
Pilot Operated Safety Relief Valve	
SIT Discharge Isolation	
PZR Level Reference Leg Temperature	Resistance Temperature Detector
SIT N2 Vent	Non Active Valve
SCS Heat Exchanger	Heat Exchanger
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Replace with Next Page

- Electro-mechanical relays (e.g., control relays, time delay relays, protective relays)
- Electro-mechanical contactors (e.g., Motor Control Center(MCC) starter)
- Circuit breakers (e.g., molded case and power breaker – low and medium voltage)
- Auxiliary contacts (e.g., for Molded Case Circuit Breaker (MCCBs), fused disconnects, contactors/starters)
- Control switches (e.g., benchboard panel, operator switches)
- Transfer switches (e.g., low and medium voltage switches with instrumentation)
- Process switches and sensors (e.g., pressure/diff. pressure, temperature, level, limit/position, and flow)
- Potentiometers
- Digital solid-state devices (mounting and connections only)
- Microprocessors-based components
- Connectors and connections (including circuit board connections for digital and analog equipment)
- Unrestrained components

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.:	**344-8407**
SRP Section:	**03.10 - Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.**
Application Section:	**03.10**
Date of RAI Issue:	**12/22/2015**

Question No. 03.10-9

General Design Criterion 2 in Appendix A to Title 10 of the Code of Federal Regulations (10 CFR) Part 50 requires structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes. DCD Tier 2, Appendix 3.7B.7.4 states that representative items selected for the evaluation because they are susceptible to high frequency seismic inputs. It goes on to state that susceptibility to excitation caused by high frequency input depends on the presence of the following factors:

a. The local hard rock high frequency (HRHF) in-structure response spectra (ISRS) exceed the APR1400 certified seismic design response spectra (CSDRS) ISRS in the high frequency range.

b. Safety-related equipment has modes or natural frequencies in the high frequency range.

c. Safety-related components have potential failure modes involving a change of state, chatter, signal change/drift, and/or connection problems

The NRC staff recognizes that equipment with natural frequencies in the high frequency range is expected to experience higher loads and amplification than equipment with natural frequencies outside the high frequency range. However, equipment sensitive to high frequency that have natural frequencies outside the high frequency range may still be affected by the high frequency exceedance. Therefore, to the extent that Technical Report APR1400-E-S-NR-14004-P and the information presented in DCD Tier 2 Appendix 3.7B is proposed to be approved as part of the design certification application, the NRC staff requests that the applicant provide the basis for not performing an evaluation of equipment with natural frequency outside the high frequency range (i.e.,low frequency) for exceedance of CSDRS.

Response

For screening of equipment sensitive to high frequency, test results can be confirmed to envelop both HRHF-based ISRS and CSDRS-based ISRS in order to define HF sensitivity vulnerability in cases when using exiting qualification data. HF vibration screening tests can be conducted to identify any HF sensitivities or abnormalities of the components in cases when only the CSDRS-based ISRS are confirmed to be satisfied.

Technical Report APR1400-E-S-NR-14004-P/NP, “Evaluation of Effects of HRHF Response Spectra on SSCs,” Rev. 1, Subsection 6.4 “Safety-Related Equipment” and DCD Section 3.7B.7.4 “Safety-Related Equipment” will be revised to describe the evaluation process of equipment with natural frequency outside the high frequency range for exceedance of CSDRS.

Impact on DCD

DCD Sections 3.7B.7.4 will be revised as shown in Attachment 1 associated with the response to Question 03.10-7.

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

Technical Report APR1400-E-S-NR-14004-P/NP, Rev. 1 will be revised as shown in Attachment 2 associated with the response to Question 03.10-7.