REVISED 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.:	**267-8301**
SRP Section:	**03.07.03 – Seismic Subsystem Analysis**
Application Section:	**3.7.3**
Date of RAI Issue:	**10/22/2015**

Question No. 03.07.03-3

In accordance with 10 CFR 50 Appendix S, the staff reviewed the seismic subsystem analysis for the APR1400 standard design. The applicant is requested to provide the following additional information to assist the staff review:

(a) DCD Section 3.7.3.6, Use of Constant Vertical Factors, states: “In general, seismic Category I subsystems are analyzed in the vertical direction using the methods specified in Subsection 3.7.3.1. No constant vertical static factors are used for subsystems.” The phrase “in general” suggests that methods other than those in Subsection 3.7.3.1 may be used. As such, the applicant is requested to explain whether methods other than those in Subsection 3.7.3.1 are used for the APR1400 standard design, and if so, to describe these methods in the DCD.

(b) DCD Section 3.7.3.10 references DCD Section 3.9.2.2.4, Basis for Selection of Frequencies, which states: “The stiffness of the restraints and supports system is designed to be greater than the zero-period acceleration (ZPA).” The staff has interpreted that the intent of this sentence is “The fundamental frequency of the restraints and supports system is designed to be greater than the ZPA frequency of the applicable ISRS, to ensure no additional amplification of the seismic loads on the restrained/supported equipment and components.” The applicant is requested to confirm the staff’s interpretation and if confirmed, to revise the DCD accordingly. If there is a different intent, provide a detailed explanation of the meaning of the quoted sentence from DCD Section 3.9.2.2.4.

Response - (Rev. 1)

(a) To state the use of constant vertical static factors more specifically, and provide the COL applicant the ability to incorporate the constant vertical static factors, DCD Tier 2, Subsection 3.7.3.6 will be revised to state the following:

3.7.3.6 Use of Constant Vertical Static Factors

The seismic analysis of seismic category I subsystems can be performed using the response spectrum analysis method, the time history analysis method, or the equivalent static load method, as specified in Subsection 3.7.3.1. When the equivalent static load method is employed, the constant vertical static factor can be used to calculate the vertical response loads for the seismic design of seismic Category I subsystems only if it can be demonstrated that the subsystems are rigid in the vertical direction or the acceptance criteria in SRP Subsection 3.7.2 II.1.B are satisfied.

In addition, the term "static seismic acceleration coefficient" will be changed to "constant static factor," in order to be consistent with DCD Tier 2, Subsection 3.7.3.6, and the term "g level" will also be changed to "spectral acceleration," to avoid possible confusion, in the markup to DCD Tier 2, Subsection 3.7.3.1.1 of the response to RAI 267-8301 Question 03.07.03-4, as indicated in the attachment associated with this response.

(b) For the restraints and supports system mentioned in DCD Section 3.9.2.2.4, the fundamental frequencies of equipment supports, which consist of the concrete foundation with anchor bolts, are to be greater than the ZPA frequency of the applicable ISRS. The other types of supports for cable trays, conduits, HVAC ducts, and piping must be adequately designed for the applicable loads because their fundamental frequencies are within the ranges where resonance can occur. For clarity, DCD Tier 2, Subsection 3.9.2.2.4 will be revised, as suggested by the staff, as indicated in the attachment associated with this response.

For general seismic subsystems identified in SRP 3.7.3, DCD Section 3.7.3.10 will be revised according to the response to Question 03.07.03-2 of RAI 267-8301 regarding Section 3.7.3.10.

Impact on DCD

DCD Tier 2, Subsection 3.7.3.1.1, 3.7.3.6, and 3.9.2.2.4 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.

3.7.3.3 Analysis Procedures for Damping

The analysis procedure used to account for the damping in subsystems conforms with Subsections 3.7.1.2 and 3.7.2.15.

3.7.3.4 Three Components of Earthquake Motion

Seismic responses resulting from analysis of subsystems due to three components of earthquake motions are combined in the same manner as the seismic response resulting from the analysis of building structures as specified in Subsection 3.7.2.6.

3.7.3.5 Combination of Modal Responses

When a response spectrum method of analysis is used to analyze a subsystem, the maximum responses such as accelerations, shears, and moments in each mode are calculated regardless of time. If the frequencies of the modes are well separated, the SRSS method of mode combination gives acceptable results; however, where the structural frequencies are not well separated, the modes are combined in accordance with NRC RG 1.92.

3.7.3.6 Use of Constant Vertical Static Factors

~~In general, seismic Category I subsystems are analyzed in the vertical direction using the methods specified in Subsection 3.7.3.1. No constant vertical static factors are used for subsystems.~~

See page 2.

3.7.3.7 Buried Seismic Category I Piping, Conduits, and Tunnels

During an earthquake, buried structures such as piping, conduits, and tunnels respond to various seismic waves propagating through the surrounding soil as well as to the dynamic differential movements of the buildings to which the structures are connected. The various waves associated with earthquake motion are P (compression) waves, S (shear) waves, and Rayleigh waves. The stresses in the buried structure are governed by the velocity and angle of incidence of these traveling waves. However, the wave types and their directions during an earthquake are very complex. For design purposes, the seismic-

The seismic analysis of seismic category I subsystems can be performed using the response spectrum analysis method, the time history analysis method, or the equivalent static load method, as specified in Subsection 3.7.3.1. When the equivalent static load method is employed, the constant vertical static factor can be used to calculate the vertical response loads for the seismic design of seismic Category I subsystems only if it can be demonstrated that the subsystems are rigid in the vertical direction or the acceptance criteria in SRP Subsection 3.7.2 II.1.B are satisfied.

3.7.3.1.1 Use of Equivalent Static Load Method of Analysis

spectral acceleration

constant static factor

In the seismic analyses of components, the equivalent static load method would be used if a dynamic analysis is not performed. The static seismic acceleration coefficient is equal to 1.5 times the peak g level in the applicable required response spectra. A value less than 1.5 times could be used if its conservatism and justification are verified. The equivalent seismic static load is the product of the equipment or component mass and the static seismic acceleration coefficient.

constant static factor

See page 2

3.7.3.1.2 Determination of Number of Earthquake Cycles

The procedure used to account for the fatigue effect of cyclic motion associated with seismic excitation recognizes that the actual motion experienced during a seismic event consists of a single maximum or peak motion and some number of cycles of lesser magnitude. The total or cumulative usage factor can also be specified in terms of a finite number of cycles of the maximum or peak motion. Based on this consideration, seismic Category I subsystems, components, and equipment are designed for a total of two SSE events with 10 maximum stress cycles per event (20 full cycles of the maximum SSE stress range). Alternatively, an equivalent number of fractional vibratory cycles to that of 20 full SSE vibratory cycles may be used (but with an amplitude not less than one-third [1/3] of the maximum SSE amplitude) when derived in accordance with Appendix D of IEEE Std. 344-2004 (Reference 23).

3.7.3.2 Procedure Used for Analytical Modeling

The criteria and bases described in Subsection 3.7.2.3 are used to determine whether a component or structure will be analyzed as a subsystem. The modeling techniques incorporate either a single- or multi-degree of freedom subsystem consisting of discrete masses connected by spring elements. The associated damping coefficients are consistent with Table 3.7-7. The degree of complexity of each model is sufficient to accurately evaluate the dynamic behavior of the component.

RAI 267-8301 - Question 03.07.03-4 Attachment (1/2)

When the equivalent static load method is used for the seismic analysis of components, i) justification of the adequacy of the analysis models and conservatism of the analysis results are to be provided by showing that the analysis results obtained from the equivalent static load method are more conservative than those of a dynamic analysis, such as response spectrum analysis method or time history analysis method, ii) the responses obtained from relative motion between points of support, if any, are combined with the response from the inertial loads, and iii) the…

seismic qualification testing methods for safety-related mechanical equipment are described in Subsection 3.10.2.2.

3.9.2.2.2 Seismic System Analysis Methods

The seismic system analysis methods (e.g., response spectra analysis, time-history analysis, equivalent static load analysis) are described in Subsections 3.7.2 and 3.7.3. The method of analysis for piping and supports is described in Section 3.12. Seismic analysis methods for mechanical equipment and supports use the guidelines in IEEE Standard 344-2004 and Subsection 3.10.2 and 3.10.3. The seismic analysis of mechanical equipment is performed by vendors to provide a seismic qualification report that demonstrates the structural integrity in accordance with the requirement of the design specification. The RCS seismic analysis is described in Appendix 3.9B.

3.9.2.2.3 Determination of Number of Earthquake Cycles

The OBE is chosen as 1/3 of the SSE for the APR1400 (see Section 3.7). When the OBE is less than or equal to 1/3 SSE, design or analysis is not required for the OBE.

With the elimination of the OBE, to account for fatigue in analysis and testing, the guidance for determination of the number of earthquake cycles described in SECY-93-087 (Reference 37) is used to account for fatigue in analysis and testing. For piping analysis, the number of earthquake cycles to be considered is defined in Subsection 3.7.3.1.

Alternatively, an equivalent number of fractional vibratory cycles to that of 20 full SSE vibratory cycles may be used (but with an amplitude not less than one-third of the maximum SSE amplitude) when derived in accordance with Appendix D of IEEE Standard 344-1987.

3.9.2.2.4 Basis for Selection of Frequencies

The seismic analysis is accomplished to account for the resonant frequencies and the seismic responses of structures, subsystems, and components in their design. ~~The stiffness of the restraints and supports system is designed to be greater than the zero-period acceleration (ZPA).~~ The fundamental frequency of restraints and supports system is designed to be greater than the ZPA frequency of the applicable ISRS, to ensure no additional amplification of the seismic loads on the restrained/supported equipment and components. The seismic responses of equipment and subsystems are maintained