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.:	**533-8718**
SRP Section:	**03.09.02 – Dynamic Testing and Analysis of Systems, Structure, and Components**
Application Section:	**3.9.2**
Date of RAI Issue:	**12/22/2016**

Question No. 03.09.02-17

10 CFR 50 Appendix S IV(a)(1)(iii) 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 the response to RAI 267-8301 Question 03.07.03-1, dated June 13, 2016 (ML16165A512), the applicant revised DCD Tier 2 with an addition of Section 3.9.2.2.14, Seismic Analysis of Mechanical Tanks. In accordance with 10 CFR 50 Appendix S, the staff reviewed the adequacy of methods for seismic analysis of mechanical tanks, as described in DCD Section 3.9.2.2.14 for the structural integrity of tanks such as the fire water tank, fuel tanks for the emergency diesel generator, and other mechanical tanks that are classified as seismic Category I.

In DCD Section 3.9.2.2.14, the applicant stated that the seismic analyses of the mechanical tanks are performed using a separate (decoupled) finite element model to determine their natural frequencies and mode shape. Depending on the natural frequency results from the finite element analysis, seismic loads are calculated either by using the equivalent static method or the dynamic method, if the tanks are considered flexible (i.e., frequency less than 33 Hz). The staff requests the applicant to (1) provide the basis of using 33 Hertz while Zero Period Acceleration frequency is 50 Hertz for the certified seismic design response spectra in DCD Tier 2 Figures 3.7-1 and 3.7-2 and (2) confirm whether and how the fluid (water, fuel..) was considered in the finite element model for tanks, i.e. fully or partially liquid filled, including the effects of fluid-structure interaction and the slushing effects in the calculation of natural frequency and stresses during a seismic event. This information is required for staff review to make the safety determination of mechanical tanks during the SSE event.

Response

(1) In general, flexible equipment is defined as equipment which has the lowest resonant frequency that is less than the cutoff frequency of the associated response spectrum. Cutoff frequency is the frequency in the response spectrum where the zero period acceleration asymptote begins. In the case of the APR1400, the cutoff frequency is 50 Hz in accordance with the certified seismic design response spectra in DCD Tier 2 Figures 3.7-1 and 3.7-2. Therefore, the cut off frequency of 50 Hz is applied to the APR1400 as a criterion to distinguish whether equipment is rigid or flexible. The response to RAI 267-8301 Question 03.07.03-1 will be revised to reflect the cut off frequency of 50 Hz.

(2) The seismic analysis of liquid storage tanks accounts for the hydrodynamic forces exerted by the fluid on the tank walls. Evaluation of the hydrodynamic forces requires suitable modeling and dynamic analysis of the tank-liquid system, to support the complex nature of the system. However, the available mechanical tank models have simplified the analysis considerably by converting the tank-liquid system into an equivalent spring-mass system. In these mechanical models, it is recognized the vibrating fluid inside the container has two components, one that moves in unison with the tank (impulsive component) and another which undergoes sloshing motion (convective component). The Haroun method (1983) is a representative simplified equivalent spring-mass model of a flexible tank-liquid system that reflects the evaluation of hydrodynamic forces.

In the APR1400 tank cases, the most conservative configuration of a tank filled with fluid was considered in the tank structural analysis. The effects of fluid-structure interaction and sloshing were also considered using the Haroun (1983) method.

During the procurement process, the tank vendor will determine the structural acceptability of tank, including the sloshing effects using the site specific input spectra for each COL site. Therefore, the COL applicant will be responsible for reviewing the detailed analysis of the mechanical tank structural integrity. To ensure that the tank seismic analysis is adequately performed, a COL item will be added to DCD Section 3.9.2.2.14.

Impact on DCD

DCD Tier 2, Section 3.9.2.2.14 will be revised in accordance with RAI 267-8301 Question 03.07.03-1 Revision 1, which is attached to this response for information.

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.

Table 1.8-2 (5 of 29)

Item No.	Description
COL 3.8(7)	The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.
COL 3.8(8)	The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.
COL 3.8(9)	The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.
COL 3.8(10)	The COL application is to provide the following soil information for APR1400 site: 1) Elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) Consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) Moisture content, Atterberg limits, grain size analyses, and soil classification, 4) Construction sequence and loading history, and 5) Excavation and dewatering programs.
COL 3.9(1)	The COL applicant is to provide the inspection results for the APR1400 reactor internals classified as non-prototype Category I in accordance with RG 1.20.
COL 3.9(2)	The COL applicant is to provide a summary of the maximum total stress, deformation, and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components except for ASME Code Class 1 nine major components. For those values that differ from the allowable limits by less than 10 percent, the contribution of each loading category (e.g., seismic, deadweight, pressure, and thermal) to the total stress is provided for each maximum stress value identified in this range. The COL applicant is to also provide a summary of the maximum total stress and deformation values for each of the component operating conditions for Class 2 and 3 components required to shut down the reactor or mitigate consequences of a postulated piping failure without offsite power (with identification of those values that differ from the allowable limits by less than 10 percent).
COL 3.9(3)	The COL applicant is to identify the site-specific active pumps.
COL 3.9(4)	The COL applicant is to confirm the type of testing and frequency of site-specific pumps subject to IST in accordance with the ASME Code.
COL 3.9(5)	The COL applicant is to confirm the type of testing and frequency of site-specific valves subject to IST in accordance with the ASME Code.
COL 3.9(6)	The COL applicant is to provide a table listing all safety-related components that use snubbers in their support systems.
"Add" COL 3.9(8)	The COL applicant is to review the detailed analysis of mechanical tanks, including the effects of fluid sloshing.

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3.9.2.2.14 Seismic Analysis for Mechanical Tanks

The structural integrity of tanks such as fire water tank, fuel tanks for the emergency diesel generator, and other mechanical tanks that are classified as seismic category I is demonstrated by analysis. Structural analysis without testing is used if the structural integrity of such tanks can verify the intended design function.

The seismic analyses of the mechanical tank are performed using a separate (decoupled) finite element model to determine its natural frequencies and mode shape. Seismic loads are calculated, depending on the natural frequency results from the finite element analysis, either by using the equivalent static method or dynamic method if the tanks are considered flexible (frequency less than ~~33~~ 50 Hz). The impulsive and convective forces are also considered in the tank analyses. The stress evaluation of the mechanical tanks, bolts, tank plates, and tank supports are performed to ensure that the calculated stresses at all investigated locations are less than their corresponding allowable values.

The COL applicant is to review the detailed analysis of mechanical tanks, including the effects of fluid sloshing (COL 3.9(8)).

COL 3.9(2) The COL applicant is to provide a summary of the maximum total stress, deformation, and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components except for ASME Code Class 1 nine major components. For those values that differ from the allowable limits by less than 10 percent, the contribution of each loading category (e.g., seismic, deadweight, pressure, and thermal) to the total stress is provided for each maximum stress value identified in this range.

The COL applicant is to also provide a summary of the maximum total stress and deformation values for each of the component operating conditions for Class 2 and 3 components required to shut down the reactor or mitigate consequences of a postulated piping failure without offsite power (with identification of those values that differ from the allowable limits by less than 10 percent).

COL 3.9(3) The COL applicant is to identify the site-specific active pumps.

COL 3.9(4) The COL applicant is to provide an IST program including the type of testing and frequency of site-specific pumps subject to IST in accordance with the ASME Code.

COL 3.9(5) The COL applicant is to provide an IST program including the type of testing and frequency of site-specific valves subject to IST in accordance with the ASME Code.

COL 3.9(6) The COL applicant is to provide a table listing all safety-related components that use snubbers in their support systems.

COL 3.9(8) The COL applicant is to review the detailed analysis of mechanical tanks, including the effects of fluid sloshing.

3.9.10 References

1. EPRI-NP-2230, "ATWS: A Reappraisal, Part 3: Frequency of Anticipated Transients," Electric Power Research Institute, January 1982.

2. NUREG/CR-3862, "Development of Transient Initiating Event Frequencies for Use in Probabilistic Risk Assessment," U.S. Nuclear Regulatory Commission, May 1985.