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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-10

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for dynamic loads. DCD Tier 2, Section 3.12.3.4, "Time-History Method," states that for the dynamic response of piping systems, the time-history analysis may be performed using the modal superposition method.

1. The applicant is requested to identify which piping systems are evaluated using time history analysis. In addition, the applicant is requested to indicate whether the analyses are linear or non-linear and specify the time-history analysis technique used (modal superposition method, direct integration method in the time domain, or the complex frequency response method in the frequency domain).

2. CD Tier 2, Section 3.7.2.1.2, “Time-History Methods,” for the modal superposition method refers to ASCE Standard 4-98. ASCE 4-98 discusses an alternate method for considering the number of modes in a modal superposition analysis and states that the number of modes included should be sufficient to ensure that inclusion of all remaining modes does not result in more than a 10 percent increase in the total response of interest. The current NRC technical position, as described in RG 1.92, Revision 2 and Revision 3, is that this approach is “non-conservative and should not be used.” The applicant is requested to verify that when modal superposition time history analysis is used, its use conforms to the guidance described in RG 1.92, Revision 2 or 3, or justify an alternative approach.

Response – (Rev. 1)

1. The specific time history analysis techniques and the dynamic load evaluated using time history analysis are as follows:

Piping System	Time-history analysis techniques	Dynamic load evaluated using time history analysis
Main Steam	Linear modal superposition method	Operation of the main steam atmospheric dump valve due to upset condition from 100% load
		Sudden closure of the turbine stop valve due to upset condition from 100% load
		Operation of the main steam safety valves due to upset condition from 100% load
		Pipe break transient due to postulated pipe break in the MS system inside and outside reactor containment
		RCS branch line break load
Feedwater	Linear modal superposition method	Transient due to trip of three (3) main feedwater pumps on a Valves Wide Open (VWO) condition
		Transient due to postulated line break in the FW System on a Valves Wide Open (VWO) condition (outside reactor containment)
		Transient due to trip of a startup feedwater pump
		RCS branch line break load
Safety Injection/Shutdown Cooling	Linear modal superposition method	Branch line pipe break loads
		Relief valve discharge loads
Reactor Coolant Loop (RCL) Piping	Linear complex frequency response method	Seismic loads
	Linear direct integration method	IRWST discharge loads
	Non-linear direct integration method	Branch line pipe break loads
Surge Line	Linear direct integration method	Branch line pipe break loads

DCD Tier 2 Subsection 3.12.3.4 will be revised to clarify the time history method used for the piping systems.

2. The linear modal superposition time history analysis used for the piping systems, (except the RCL piping and surge line), are performed with the PIPESTRESS program in the APR1400. The program uses the left-out-force (LOF) method to calculate the effects of the high frequency rigid modes. The linear modal superposition method to evaluate the piping systems is used in accordance with RG 1.92, Rev. 3 and is sufficient to ensure that inclusion of all remaining modes do not result in more than a 10 percent increase in the total response of interest.

Impact on DCD

Tier 2, Section 3.12.3.4 will be revised as indicated 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

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

Analyses performed using the ISM method are used for damping values identified in Table 3 of NRC RG 1.61 (Reference 7).

3.12.3.4 Time-History Method

The time-history method may be used for other types of dynamic analyses such as hydraulic transient loads caused by water or steam hammer, safety and relief valve discharge actuation loads, jet force loads, postulated pipe breaks, or any other dynamic loading associated with fluid flow transients. ~~The analysis for the reactor coolant loop (RCL) piping is described in Appendix 3.9B.~~

~~For the dynamic response of the piping system, the time-history analysis may be performed using the modal superposition method (Reference 13).~~

When the modal superposition method is used, the cutoff frequency for the determination of modal properties is selected to account for the principal vibration modes of the piping system based upon mass and stiffness properties, modal participation factors, and the frequency content of the input forcing function. As required on a case-by-case basis, the analysis is repeated with more modes to verify the cutoff frequency for the determination of modal properties.

The missing mass effects of high-frequency modes are included based on the same principles described in Subsection 3.12.3.2.4.

Alternatively, the cutoff frequency is determined so that the calculated number of modes produces dynamic analysis results within 10 percent of the results of the dynamic analysis, including the next higher mode.

Damping values are described in Subsection 3.12.5.4.

3.12.3.5 Inelastic Analysis Method

For the APR1400, inelastic analysis methods are not used for the design of the piping system and its supports.

The dynamic analysis methods used for the reactor coolant loop (RCL) piping are the direct integration method and the complex frequency response method as described in Appendix 3.9B. The surge line is evaluated using the direct integration method. For the dynamic response of the other piping systems, the time-history analysis is performed using the modal superposition method (Reference 13).