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.:	**311-8278**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**DCD Tier 2 Section 3.12**
Date of RAI Issue:	**11/16/2015**

Question No. 03.12-4

ASME Boiler and Pressure Vessel Code (BPV Code) Section III, as mandated by 10 CFR 50.55a, requires that the effects of seismic and thermal movements of pipe restraints such as equipment nozzles, pipe supports, pipe anchors, and pipe headers (in the case of decoupled pipe branches) are considered in the piping analysis. DCD Section 3.12.5.3.3 states the following: "Thermal anchor movements less than or equal to 1.6 mm (1/16 in) may be excluded from analysis since this represents the industry practice when acceptable gaps in pipe supports allow (Reference 29)." The applicant is requested to provide additional information on its approach to demonstrate that when the piping analysis has excluded pipe restraint movement(s), adequate gap(s) exist in the as-built pipe supports to accommodate the excluded from the analysis pipe restraint movement(s).

Response – (Rev. 1)

In general, anchor movements are included in the piping analyses; however, as indicated in DCD Section 3.12.5.3.3, thermal anchor movements less than or equal to 1.6 mm (1/16 in) are excluded from analysis when acceptable gaps of pipe supports allow. The gaps in pipe supports are identified on the piping drawings. By constructing the supports in accordance with the nuclear quality assurance program, it is ensured that the acceptable gaps indicated on the drawings are installed in the plant. If adequate gaps in the as-built pipe supports cannot be satisfied to the support drawings, either re-analysis will be performed to accept the as-built gaps or the piping supports will be re-constructed to meet the required gap.

DCD Tier 2, Section 3.12.5.3.3 and Section 3.12.5.3.4 state that thermal anchor movements (TAMs) and seismic anchor movements (SAMs) less than 1.6 mm (1/16 inch) may be excluded from the piping analysis when acceptable gaps in the pipe support allow. To adopt this criterion for the piping analysis, the 1/16 inch clearance should be assured. In addition, the piping systems within the scope of the graded approach in the containment building, of which the analyses include TAMs and SAMs, were analyzed adding 1/16 inch TAM and SAM in each of

the three global directions at the nozzles in order to identify the effects of TAMs and SAMs less than 1/16 inch. As shown in the table below, the increase in piping stress at the nozzles, based on ASME Section III, NC-3653.2 (a) and NC-3655 (b) (4) for TAMs and SAMs of 1/16 inch is less than 3%. Thus, the effects of TAMs and SAMs less than 1/16 inch are determined to be negligibly small.

Subsystem	Code Equation	Original (% of Code Allowable)	Adding 1/16 inch SAM and TAM (% of Code Allowable)	Deviation (%) (Note 1)
MS101	NC-3653.2(a)	21.73	21.73	0.00
	NC-3655(b)(4)	36.41	36.47	0.06
FW101	NC-3653.2(a)	76.12	78.68	2.56
	NC-3655(b)(4)	62.99	63.57	0.58
SI101	NC-3653.2(a)	118.45	118.50	0.05
	NC-3655(b)(4)	56.47	56.88	0.41
SI105	NC-3653.2(a)	72.46	75.05	2.59
	NC-3655(b)(4)	43.03	43.45	0.42

Note 1: Deviation (%) = Adding 1/16 inch SAM and TAM (% of Code Allowable) - Original (% of Code Allowable)

However, the sentence that TAMs and SAMs are excluded based on the pipe support gap will be deleted, since the as-built 1/16 inch clearance in the pipe support might not be assured. This response is also applicable to RAI 334-8373, Question No. 03.12-13, which requested similar information.

Impact on DCD

DCD Tier 2, Subsections 3.12.5.3.3 and 3.12.5.3.4 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.

3.12.5.3 Loadings and Load Combination

3.12.5.3.1 Pressure

Internal design pressure, P, is used in the design and analysis of ASME Class 1, 2, and 3 piping (Reference 1). Minimum pipe wall thicknesses are determined using the formulations of NB/NC/ND-3640 and the design pressure. The applicable design and maximum service level pressures are used in load combinations as identified in Tables 3.12-1 and 3.12-2.

3.12.5.3.2 Mechanical Loads

The weight of the piping system, its contents, any insulation and in-line equipment, and any other mechanical loads identified in the design specification are considered in the piping analysis. The weight of water during hydrostatic testing is considered for steam or air-filled piping systems.

3.12.5.3.3 Thermal Expansion

The effect of linear thermal expansion range during various operating modes is considered along with thermal movements of terminal equipment nozzles, anchors, or restraints (thermal anchor movements) corresponding to the operating modes. The stress-free temperature is taken as 21 °C (70 °F). The piping systems operating at a temperature of 65 °C (150 °F) (Reference 1) and below are not analyzed for the effects of linear thermal expansion.

~~Thermal anchor movements less than or equal to 1.6 mm (1/16 in) may be excluded from analysis since this represents the industry practice when acceptable gaps in pipe supports allow (Reference 29).~~

3.12.5.3.4 Seismic

The effects of seismic inertial loads and anchor movements are included in the design analysis. The ground motion of the operating basis earthquake (OBE) for the APR1400 is equal to one-third of the ground motion of the SSE. Per Appendix S to 10 CFR Part 50,

the OBE load case does not require explicit design analysis. In the event of an earthquake that meets or exceeds the OBE ground motion, plant shutdown is required and seismic Category I piping and supports are inspected to provide reasonable assurance that no functional damage has occurred. The design of the APR1400 seismic Category I piping and supports includes analysis of the inertial and anchor movement ~~(greater than 1.59 mm (1/16 inch))~~ effects of the SSE event. These loads are Service Level D loads.

Fatigue effects due to earthquake loads are addressed in Table 3.12-1. Tables 3.12-1 and 3.12-2 identify SSE inertial and displacement loads in various load combinations for ASME Class 1, 2, and 3 piping and piping supports.

3.12.5.3.5 Fluid Transient Loads

The relief/safety valve thrust loads for open or closed systems are functions of valve opening, flow rate, flow area, and fluid properties. The analysis of these loads is usually accomplished using static loads as input to the piping analysis with appropriate dynamic load factors. Dynamic analysis of relief valve thrusts is used when static analysis produces undesirably conservative results. These loads are considered in Service Level B or D load combinations.

The water hammer phenomenon involves the rapid change in fluid flow creating a “shock wave” effect in the piping system. They are usually set in motion by rapid actuation of control valves, relief valves, and check valves. Rapid start or trip of a pump or turbine can also initiate such a phenomenon. The water hammer phenomenon is analyzed using dynamic analysis methods. The water hammer loads are considered in Level B, or D service load combinations.

The fluid transient loads are identified as dynamic fluid loads in Tables 3.12-1 and 3.12-2.

3.12.5.3.6 Wind/Tornado Loads

ASME Class 1, 2, and 3 piping for the APR1400 within the DC scope is not exposed to wind or tornado loads. The COL applicant is to design those piping exposed to wind and/or tornado, if any, to the plant design basis loads (COL 3.12(2)).

28. IEEE Std. 344-2004 (R2009), "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2005.

~~29. Welding Research Council Bulletins 353, "Position Paper on Nuclear Plant Pipe Support," May 1990.~~ Deleted.

30. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water (ALWR) Designs," U.S. Nuclear Regulatory Commission, 1993.

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Question No. 03.12-8

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for seismic loads.

DCD Section 3.7.2.7 shows that the combination of modal responses is performed in accordance with the latest (2012) revision of RG 1.92, which is Revision 3. DCD Section 3.7.1.2 shows that damping values are based on the latest (2007) revision of RG 1.61, which is Revision 1. In contrast, DCD Section 3.12.3.2.4 states that RG 1.92 Revision 1 of 1976 and Revision 3 of 2012 are used for combination of modal responses. It also indicates that combination of modal responses with no closely spaced modes is obtained by the square root of the sum of the squares (SRSS). It further states that, for closely spaced modes within 10% of each other or less, the 1976 RG 1.92 Revision 1 NRC-Grouping method is used for combination of modal responses. Thus, the DCD implies that closely spaced modes are only those that are within 10% of each other. The design of APR1400 piping and supports includes loadings due to the safe shutdown earthquake (SSE) in their structural analysis and, because the OBE is set equal to 1/3 of the SSE, loads due to OBE are not required in the design analysis, as described in DCD Section 3.12.5.3.4. DCD Section 3.12.3.2.1 states that the response spectra analysis for piping will use damping values from the 2007 RG 1.61 Rev 1, which specifies 4% SSE damping for piping.

1. The paragraphs above show that guidance from more than one Regulatory Guide is utilized. In DCD Section 3.7, these guides are of comparable issue date, while an earlier version is used for one guide in DCD Section 3.12. The applicant is requested to provide a technical justification for the difference between DCD Sections 3.7.2.7 and DCD Section 3.12.3.2.4, and an explanation for the different combinations of revisions of RG 1.61 and RG 1.92.

2. According to RG 1.92 Revision 3, Section C.1.1.1(1) for critical damping ratios less than or equal to 2%, modes are considered closely spaced if their frequencies are

within 10% of each other. According to RG 1.92 Revision 3, Section C.1.1.1(2), for critical damping greater than 2%, modes are considered closely spaced if the frequencies are within five times the critical damping ratio (i.e. for damping of 4%, modes are considered closely spaced if the frequencies are within 4x5=20% of each other). From the above, it can be seen that the closely spaced modes definition of 10% is only applicable to 2% damping, which is reasonably consistent with the damping value for piping in the 1973 revision of RG 1.61. Also, for 4% damping (as specified for SSE piping damping in the 2007 revision of RG 1.61 and which APR1400 utilizes) closely spaced modes are considered those that are within 20% of each other. As shown above, in the APR1400 piping seismic analysis closely spaced modes are not grouped in accordance with the NRC regulatory guidance because for 4% damping, modes are considered closely spaced if the frequencies are only within 10% of each other instead of 20% that the NRC regulatory guidance specifies. Based on the justification provided in response to item 1, the applicant is requested to provide additional information to justify using a definition for closely spaced modes different from that provided in staff guidance, such that the requirements of 10 CFR 50.55a can be demonstrated to be met.

3. The Regulatory Positions section in RG 1.92 Revision 3 includes the following statement: "If applicants for new licenses choose to use RG 1.92 Revision 1 methods for combining modal responses, their analyses should address the residual rigid response of the missing mass modes discussed in Regulatory Positions C.1.4 and C.1.5 of RG 1.92-R3." Based on the justifications provided in response to items 1 and 2 above, the applicant is requested to provide additional information to describe how the piping analysis methodology described in the DCD is consistent with the regulatory positions C.1.4 and C.1.5 of RG 1.92 Revision 3, or to justify an alternative approach.

Response – (Rev. 1)

RG 1.92 Revision 3 will be applied to seismic analysis in the piping design. At present, the PIPESTRESS (Version 3.7.0) and APLPIPE (Version 3F10.1) computer programs are used for the analysis of piping systems in the APR1400. The programs do not implement the combination of modal responses in accordance with RG 1.92 Revision 3. The piping systems, with the exception of the surge line, are analyzed by PIPESTRESS. The surge line is analyzed by ADLPIPE. The PIPESTRESS computer program will be revised to include the method to combine the modal responses specified in RG 1.92 Revision 3 and will be used to analyze the piping systems. The applicant plans to release the revised computer program in September 2016. ANSYS (Version 14.0) is to be substituted for ADLPIPE for the analysis of the surge line, and is capable of implementing RG 1.92 Rev.3 methods for combining modal responses. Seismic analysis of the piping design will be performed in accordance with RG 1.92 Revision 3 and DCD Tier 2, Section 3.12.3.2.4 will be revised after the next version of PIPESTRESS is released and the analysis is complete.

Impact on DCD

DCD Tier 2, Section 3.12.3.2.4 will be revised after releasing the next version of PIPESTRESS.

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.