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

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.

Impact on DCD

There is no impact on the DCD.

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.

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Question No. 03.12-6

Standard Review Plan (SRP) Section 3.12 specifies that when a piping system is to be broken up into two parts with the input from the larger piping system used to analyze the smaller piping system, the decoupling criteria provided in SRP Section 3.7.2 are applicable. APR1400 DCD Tier 2, Subsections 3.7.2.3.2 and 3.7.2.3.3 specify decoupling criteria for piping similar to those in SRP Section 3.7.2. DCD Subsection 3.12.4.4 specifies a choice of two decoupling criteria for piping that are different from the guidance in SRP Section 3.7.2 and those specified in DCD Subsection 3.7.2.3.2.

The following is requested from the applicant:

1. If the branch piping geometry is known, the applicant should clarify whether the branch piping is included in the piping analysis model with the header. If it is not included, the applicant should provide a technical justification for decoupling the branch from the header.

2. For branch piping with known geometry for which decoupling is justified based on the item above, SRP Section 3.12 indicates that decoupling criteria from SRP Section 3.7.2 should be used. The applicant is requested to justify why the decoupling criteria in DCD Subsection 3.7.2.3.2 were not applied for piping.

3. DCD Section 3.12.4.4 includes as one of the decoupling criteria that, if only the size of the branch pipe is known, the branch pipe may be decoupled from the run pipe if the ratio of run to branch pipe moment of inertia is 25 to 1 or more. The Welding Research Council (WRC) Bulletin (BL) 300, “Technical Position on Damping and on Industry Practice,” provides the technical justification for using the moment of inertia ratio of 25 for decoupling with exceptions, which has been accepted by the NRC when justified in certain applications. Since this decoupling criterion is in DCD Section 3.12.4.4, the applicant is requested to refer to and add WRC BL 300 in the DCD Section 3.12 list of references and also show in DCD 3.12.4.4 that, as shown in WRC BL 300, if either of

the two factors listed below apply, piping cannot be decoupled. If an alternative approach is selected, the applicant is requested to provide a technical justification.

i. If an anchor or fixed restraint on the branch pipe is located near the run pipe and significantly restrains the movement of the run pipe, the branch pipe should be included with the model of the run pipe, up to the anchor (or up to and including the series of fixed restraints that effectively permits termination of the problem at some point remote from the run pipe).

ii. The branch pipe should be included in the computer model of the run pipe if more precise magnitudes of reactions are required at terminal points (i.e., equipment, penetrations, etc.) to determine their (the reactions) acceptability.

Response

In the APR1400, the graded approach is applied to the piping design. Since the branch piping geometry is known, the decoupling criteria specified in DCD Subsection 3.7.2.3.2 cannot be applied to the piping systems. The decoupling criteria used is based on the ratio of run to the branch pipe moment of inertia being 25 to 1 or more in accordance with the Welding Research Council (WRC) Bulletin (BL) 300, "Technical Position on Damping and on Industry Practice." The other criteria, the ratio of run to branch pipe diameter, is almost the same as the ratio of run to the moment inertia based on the schedule of the piping for the APR1400. To clarify the decoupling criteria, the ratio of diameter will be deleted.

Impact on DCD

DCD Tier 2, Subsection 3.12.4.4 will be revised as shown in the Attachment.

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.

In general, pipe supports are modeled as rigid with the rigidity verified by checking support deflection in the restrained direction, if springs with actual stiffness values for the restrained degrees of freedom. Pipe support hardware weight for snubbers, struts, and spring hangers supported by the piping system is considered in the piping analysis. The weight added by the component support is included in the piping analysis when it is greater than 10 percent of the total mass of the adjacent pipe span including pipes, contents, insulations, and in-line components.

In general, an entire piping system cannot be modeled and analyzed as a single model; the piping system is therefore conveniently divided into multiple, smaller piping subsystems that satisfy the analysis size limitations of the computer program used for the piping system analysis. Branch piping that does not have a significant effect on the run piping is decoupled from the run pipe analysis based on the branch decoupling criteria defined in Subsection 3.12.4.4. Intermediate pipe anchors such as wall or slab penetration sleeve anchors and structural anchor supports may also be used for subdividing the piping systems.

3.12.4.3 Piping Benchmark Program

The computer programs used for the piping system analysis are verified in accordance with NRC benchmark problems.

The piping benchmark problems prescribed in NUREG/CR-1677, Volumes 1 and 2 (Reference 16), are used to validate the PIPESTRESS and ADLPIPE computer programs used in piping system analysis.

3.12.4.4 Decoupling Criteria

Small branch lines including instrument connections may be decoupled from the analysis model of the larger run pipe provided that ~~either the ratio of the branch pipe mean diameter to the run pipe mean diameter (D_b/D_r) is less than or equal to 1/3 or~~ the ratio of the moments of inertia of the two lines (I_b/I_r) is less than or equal to 1/25~~.~~

, under such conditions that no restraints on the branch are located near the run pipe for the flexibility or no precise magnitudes of reactions are required at the terminal points (Reference 31).

In the run pipe analysis, the applicable stress intensification factors (SIFs) and/or stress indices are incorporated. The mass effects of the branch line, where the mass of half the span of the branch pipe is greater than 10 percent of the mass of the pipe run span, are also

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.

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

31. Welding Research Council Bulletin 300, "Part 4 : Technical Position on Industry Practice", December 1984.

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Question No. 03.12-7

ASME BPV Code Section III, as mandated by 10 CFR 50.55a, requires that the effects of deadweight and seismic loads be accounted for in the piping analysis. In some instances under deadweight and seismic (or any dynamic acceleration) loadings, the piping is supporting the mass of certain supports in the unrestraint direction of the support. During seismic or other type of dynamic accelerations, this pipe support mass moves in directions perpendicular to the axis of the pipe support and if it is not accounted for in the piping analysis model, the results of the piping analysis may not be valid. Examples for this situation are the double pinned type of pipe supports such as snubbers or struts (particularly on small bore lines) or trapeze supports, in which the trapeze mass is supported by the pipe. The applicant is requested to describe how this situation is accounted for in the analysis and design of the APR1400 piping and, if appropriate, revise DCD Section 3.12 to include associated methodology and criteria.

Response

As indicated in DCD 3.12.4.2, the weight added by the component support is included in the piping analysis as a lumped mass at the support point when it is greater than ten percent of the total mass of the adjacent pipe span including pipes, contents, insulation, and in-line components. The support weight is calculated by clamp weight plus one half the weight of the strut (e.g., snubbers).

Impact on DCD

There is no impact on the DCD.

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.

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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

The piping analyses are performed based on RG 1.92 Revision 3 of 2012 which is the latest issued by the NRC before the APR1400 was docketed. RG 1.92 Revision 3 states that the methods of combining modal responses described RG 1.92 Revision 1 of 1976 remain acceptable provided that the residual rigid response of the missing mass modes is addressed. Consistent with the Regulatory Positions C.1.4 and C.1.5 of RG 1.92 Revision 3, the missing mass methods used in the piping analysis codes are automated. PIPESTRESS and ADLPIPE, which are analysis programs of piping systems in the APR1400, use the left-out-force (LOF) method and missing mass correction (MMC) method to calculate the effects of the high-frequency rigid modes. To determine the overall responses as described in DCD Section 3.12.3.2.4, the response in the periodic modes and residual rigid modes is combined by absolute sum in PIPESTRESS. The response below the cut-off frequency is combined by the square-root-of-sum-of-squares (SRSS) method with the response over the cut-off frequency in ADLPIPE.

Four percent damping is used for the piping analysis as specified for SSE piping damping in the 2007 revision of RG 1.61. The grouping method specified in NRC RG 1.92 Revision 1 of 1976 is applied to combine the modal responses of the piping system with closely spaced modes. Since the grouping method and the definition of closely spaced modes defined in RG 1.92 Revision 1 for the piping analysis in the APR1400 are applied, the closely spaced modes defined in

RG 1.92 Revision 3 relating to the critical damping value are not necessary for the combination of modal responses.

Impact on DCD

There is no impact on the DCD.

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.

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Question No. 03.12-9

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for seismic loads. DCD Section 3.7B.7.3 shows that ASME Class 1, 2, and 3 piping systems are evaluated for the hard rock high frequency (HRHF) seismic response spectra. DCD Section 3.7B.1 identifies that the HRHF response spectra exceed the certified seismic design response spectra (CSDRS) for frequencies above approximately 10 Hz.

1. DCD Section 3.7B.7 discusses the HRHF evaluation of selected SSCs. DCD Sections 3.7B.1 and 3.7B6 show that piping is among the SSCs that were selected to be evaluated for the effects of HRHF as part of the design certification application. DCD 3.7B.7.3 though shows that HRHF effects are to be evaluated by the combined license (COL) applicant. The applicant is requested to provide a justification for this inconsistency.

2. For the piping that was selected to be evaluated in the graded approach identified in DCD Section 14.3.2.3, the applicant is requested to clarify whether both CSDRS and HRHF response spectra are included in the completed piping analyses. In the event that the HRHF response spectra was not included in the piping analysis, the applicant is requested to provide a technical justification for its exclusion from the scope of the design certification application.

Response

Since the graded approach is applied to the piping design, the HRHF evaluation of piping systems will be performed by KHNP in accordance with the scope of the graded approach; including, ASME Class 1 piping (RCS main loop, pressurizer surge line, direct vessel injection line, and shutdown cooling lines) and specific Class 2 and 3 piping systems (main steam and main feedwater piping located inside containment and in the main steam valve house). Technical report, APR1400-E-S-NR-14004-P, “Evaluation of Effects of HRHF Response Spectra on SSCs” and DCD Tier 2, Subsection 3.7B is being revised to include the HRHF evaluation of the listed piping systems and will be completed in the second quarter of 2016.

Impact on DCD

There is no impact on the DCD.

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.