SUPPLEMENTAL 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.:	**35-7955**
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:	**06/17/2015**

Question No. 03.12-2

DCD Tier 2, Sections 3.6.2 and 3.12 provide the design methodology for piping analysis and pipe rupture analysis. DCD Tier 2, Subsection 3.6.2.1.1 provides an outline of the pipe rupture analysis report. DCD Tier 2, Subsection 14.3.2.3, "ITAAC for Piping Systems and Components," describes the use of a graded approach in completing APR1400 piping analysis and pipe rupture hazards analyses at the design certification stage. It identifies the scope of the graded approach including ASME Class 1 piping (RCS main loop, pressurizer surge line, direct vessel injection line, and shutdown cooling line and Class 2 and 3 piping systems (main steam (MS) and main feedwater (FW) piping located inside containment)).

The concept of employing a graded approach for the piping analysis and pipe rupture hazards analysis for the design certification application is consistent with SECY-90-377, "Requirements for Design Certification under 10 CFR Part 52." The level of detail of the piping design (including the pipe rupture analysis) review is to be commensurate with the importance of the safety function to be performed. The staff will evaluate information provided in the design certification application (e.g., summary information on the analysis approach and results as well as methodology) to ensure that it is sufficient to support a final safety determination and meet the applicable requirements of 10 CFR52.47. If sufficient design information is provided, a design could be certified without the need for design acceptance criteria.

Specific to DCD Tier 2, Section 3.12, the following information is necessary to support the staff's safety determination.

A: To demonstrate that the piping, which has been structurally evaluated based on the graded approach described in DCD Tier 2, Section 14.3.2.3, conforms to the requirements of ASME Boiler and Pressure Vessel Code (BPV Code) Section III, mandated by 10 CFR 50.55a, provide the following information in response to this request. The information need not be included in the DCD unless the applicant chooses to do so.

1. A tabulated, quantitative summary of the calculated maximum stresses and fatigue usage factors (if applicable) with a comparison to ASME BPV Code allowable stress values for each code equation. Include only maximum stresses and data at critical locations, including anchors, flued head anchor penetrations, nozzles, penetrations, flanged connections, valve and relief valve connections, branching pipe connections and pipe supports. List all applicable loads in load combination cases for each service level and code equation.

2. For equipment nozzles, a tabulated quantitative summary of the calculated reaction loads compared to specific nozzle allowable values.

3. For containment penetrations, quantitative maximum calculated results compared to allowable values from the penetration structural qualifications which include loads from both sides of the penetration.

B: DCD Tier 2, Section 3.12, Revision 0, primarily addresses the methodology for piping analysis. To support the safety determination described above, DCD Section 3.12 should be revised to include additional information on the approach to the analyses and results of analyses completed at the design certification stage. This information should include:

1. Summary information on the piping analysis approach referencing DCD Tier 2 Subsection 14.3.2.3, for the selection of certain piping systems based on graded approach

2. A list of all ASME Class 1 piping that is not included in the scope for piping design and analysis discussed in DCD Subsection 14.3.2.3, with a justification for the exclusion that addresses the safety significance of these piping systems

3. A subsection in DCD Tier 2, Section 3.12 to discuss the results of the piping structural analyses performed, and a conclusion discussion that demonstrates that these results support the applicant's conclusion that safety-related APR1400 piping and their supports comply with the requirements of pertinent regulations (10 CFR 50.55a; 10 CFR Part 50, Appendix A, GDC-1, GDC-2, GDC-4, GDC-14, and GDC-15; and 10 CFR Part 50, Appendix S)

4. A reference to detailed analysis reports that are available for audit by the NRC staff.

<u>Response</u>

Technical reports based on a graded approach to piping systems are being developed that include maximum stresses and fatigue usage factors, applicable loads and load combinations, nozzle allowable values, and containment penetration loads from both sides. The pertinent information of the analyses and results of the piping systems in these reports will be referenced in DCD Sections 3.12 and 14.3.2.3 when the reports are completed. The technical reports and revision of the DCD will be available for audit, if desired, by March 2016 and subsequently submitted to the NRC.

Supplemental Response

A. The technical reports mentioned in the original response will include the following information.

- A tabulated, quantitative summary of the calculated maximum stresses and fatigue usage factors (if applicable) with a comparison to the ASME BPV Code allowable stress values for each code equation. It will include only the maximum stresses and data at critical locations, including anchors, flued head anchor penetrations, nozzles, penetrations, flanged connections, valve and relief valve connections, branching piping connections and pipe supports. It will also list all applicable loads in the load combination cases for each service level and code equation.

- For equipment nozzles, a tabulated quantitative summary of the calculated reaction loads compared to specific nozzle allowable values will be provided.

- For containment penetrations, KHNP will provide the quantitative maximum calculated results compared to allowable values from the penetration structural qualifications which include loads from both sides of the penetration.

B. DCD Tier 2 will be revised including additional information as follows:

B.1. For the summary information, DCD Tier 2 Subsection 14.3.2.3 will be referenced in DCD Tier 2 Subsection 3.12.7 since the summary information on the piping analysis approach is described in DCD Tier 2 Subsection 14.3.2.3.

B.2. A list of all ASME Class 1 piping will be included in DCD Tier 2, Subsection 14.3.2.3. DCD Tier 2, Subsection 14.3.2.3 will be referenced in DCD Tier 2 Subsection 3.12.7 as shown in the attachment since a justification for the exclusion that addresses the safety significance of ASME Class 1 piping is described in DCD Tier 2, Subsection 14.3.2.3.

B.3. The technical reports that include the results of the piping analysis will be referenced in DCD Tier 2 Subsection 3.12.7.

B.4. The applicable technical reports will be added as a reference document in DCD Tier 2 Section 3.12.

Impact on DCD

A new Subsection 3.12.7 will be added and the current DCD Tier 2, Table 1.6-2 (2 of 2), Chapter 3 Table of Contents, and Subsections 3.12.7, 3.12.8 and 14.3.2.3 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.

Table 1.6-2 (2 of 2)

Report Number [1]	Title	DCD Tier 2 Section
APR1400-F-A-NR-14002-P APR1400-F-A-NR-14002-NP	The Effect of Thermal Conductivity Degradation on APR1400 Design and Safety Analyses	15.4 15.6
APR1400-F-A-NR-14003-P APR1400-F-A-NR-14003-NP	Post-LOCA Long Term Cooling Evaluation Model	15.6
APR1400-H-N-NR-14012-P APR1400-H-N-NR-14012-NP	Mechanical Analysis for New and Spent Fuel Storage Racks	9.1.2
APR1400-K-I-NR-14005-P APR1400-K-I-NR-14005-NP	Staffing and Qualifications Implementation Plan	18.5
APR1400-K-I-NR-14009-P APR1400-K-I-NR-14009-NP	Design Implementation Plan	18.11
APR1400-Z-A-NR-14006-P APR1400-Z-A-NR-14006-NP	Non-LOCA Safety Analysis Methodology	15.0.2
APR1400-Z-A-NR-14007-P APR1400-Z-A-NR-14007-NP	LOCA Mass and Energy Release Methodology	6.2.1.3
APR1400-Z-J-NR-14001-P APR1400-Z-J-NR-14001-NP	Safety I&C System	7.1, 7.2, 7.3, 7.4, 7.5, 7.8, 7.9
APR1400-Z-J-NR-14003-P APR1400-Z-J-NR-14003-NP	Software Program Manual	7.1.4, 7.2.2.2, 7.3.1
APR1400-Z-J-NR-14004-P APR1400-Z-J-NR-14004-NP	Uncertainty Methodology and Application for Instrumentation	7.2.2.7, 7.3.2.7
APR1400-Z-J-NR-14005-P APR1400-Z-J-NR-14005-NP	Setpoint Methodology for Plant Protection System	7.2.2.7, 7.3.2.7
APR1400-Z-M-NR-14008-P APR1400-Z-M-NR-14008-NP	Pressure-Temperature Limits Methodology for RCS Heatup and Cooldown	5.2, 5.3

(1) P – denotes document is proprietary.
NP – denotes document is non-proprietary.

APR1400-E-B-NR-16001-P APR1400-E-B-NR-16001-NP	Evaluation of Main Steam and Feedwater Piping applied to the grade approach for the APR1400	3.12
APR1400-E-B-NR-16002-P APR1400-E-B-NR-16002-NP	Evaluation of Safety Injection and Shutdown Cooling Piping applied to the grade approach for the APR1400	3.12

3.12.6.11 Pipe Support Gaps and Clearances

For guide type pipe supports modeled as rigid restraints in the piping analysis, the typical industry design practice is to provide small gaps between the pipe and its surrounding structural members. These small gaps allow radial thermal expansion of the pipe as well as allow rotation of the pipe at the support. The normal design practice for the APR1400 is to use a nominal cold condition gap of 1.6 mm (1/16 in) on each side of the pipe in the restrained direction. The COL applicant is to determine maximum radial thermal expansion at its design temperature (COL 3. 12(7)).

3.12.6.12 Instrumentation Line Support Criteria

The design and analysis loadings, load combinations, and acceptance criteria to be used for instrumentation line supports are similar to those used for pipe supports. The applicable design loads include deadweight, thermal expansion, and seismic loadings where appropriate. The applicable loading combinations similarly follow those used for the ASME Section III Levels in Table 3.9-10 using the design loadings mentioned above. The acceptance criteria are in accordance with ASME Section III, Subsection NF for seismic Category I instrumentation lines, AISC 360-05 (Reference 14) for non-seismic instrumentation lines.

3.12.6.13 Pipe Deflection Limits

For standard component pipe supports using standard manufactured hardware components, the manufacturer's recommendations for limitations in its hardware are followed. The limitations are travel limits for spring hangers; stroke limits for snubbers; swing angles for rods, struts, and snubbers; alignment angles between clamps or end brackets with their associated struts and snubbers; and the variability check for variable spring supports. In addition to the manufacturer's recommended limits, allowances are made in the initial designs for tolerances on such limits. This is especially important for snubber and spring design in which the function of the support may be changed by an exceeded limit.

3.12.7 Graded Approach of Piping Systems

The scope of piping systems which apply the graded approach is described in DCD 14.3.2.3. Based on the safety function, integrity, piping size and layout, the RCS main loops, Pressurizer Surge Line, DVI and SC lines are selected as ASME Code Class 1 for the graded approach. The DVI and SC lines are selected as the representative RCS branch piping systems based on size; other lines are smaller diameter and have no significant impact on RCS integrity. Considering the symmetrical arrangement of the DVI and SC lines, one out of four SI lines and one out of two SC lines were chosen as representative cases. The results of the piping analyses are documented in Technical Reports, APR1400-E-B-NR-16001-P and APR1400-E-B-NR-16002-P, (References 33 and 34), and are commensurate with the requirements of ASME Section III as mandated by 10 CFR 50.55a.

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3.12.~~7~~ Combined License Information

COL 3.12(1) The COL applicant is to prepare design reports for ASME Class 1, 2, and 3 piping system in accordance with ASME Section III.

COL 3.12(2) The COL applicant is to design the piping exposed to wind and/or tornado, if any, to the plant design basis loads.

COL 3.12(3) The COL applicant is to perform fatigue evaluations of ASME Class 1 piping.

COL 3.12(4) The COL applicant is to perform stress evaluations for ASME Class 2 and 3 piping.

COL 3.12(5) The COL applicant is to perform fatigue evaluations of environmental impact on ASME Class 1 piping, using methods acceptable to the NRC at the time of evaluation.

COL 3.12(6) The COL applicant is to perform the piping stress analysis including the thermal stratification effect on the SCS suction line.

COL 3.12(7) The COL applicant is to determine maximum radial thermal expansion at its design temperature.

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3.12.~~8~~ References

1. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

2. ASME B31.1, "Code for Pressure Piping, Power Piping," The American Society of Mechanical Engineers, the 2010 Edition.

3. ASME B31.3, "Code for Pressure Piping, Process Piping," American Society of Mechanical Engineers, the 2010 Edition.

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.

33. APR1400-E-B-NR-16001-P, "Evaluation of Main Steam and Feedwater Piping applied to the grade approach for the APR1400," Rev.0, KHNP, March 2016.

34. APR1400-E-B-NR-16002-P, "Evaluation of Safety Injection and Shutdown Cooling Piping applied to the grade approach for the APR1400," Rev.0, KHNP, March 2016.

14.3.2.3 ITAAC for Piping Systems and Components

Section 2.3 of Tier 1 involves piping system and components and includes treatment of motor-operated valves (MOVs), power-operated valves (POVs), and check valves as well as dynamic qualification, welding, fasteners, and safety classification of SSCs in accordance with the guidance in NRC RG 1.206 (Reference 1), SRP 14.3 (Reference 2), and SRP 14.3.3 (Reference 5).

The scope of piping systems and components covers piping design criteria, structural integrity, and functional capability of ASME code Class 1,2 and 3 piping systems included in the APR1400 design. A graded approach is taken to the scope of piping systems and components design. More of the ASME code Class 1 piping systems and components are designed than Class 2 and 3 due to their high safety significance. The scope of design for ASME code Class 1 piping includes RCS main loop, pressurizer surge line and two RCS branch line piping, i.e., the direct vessel injection line (12 inch) and shutdown cooling line (16 inch). The other branch line over 2.5 inches includes pressurizer spray line (4 inch). This line is smaller in size and has no significant impact to RCS integrity. Out of the four direct vessel injection lines and the two shutdown cooling lines, which have symmetric arrangements, only one line for each system is analyzed as a representative case. The scope of design for ASME code Class 2 and 3 piping includes main steam and main feedwater piping located inside the containment building. Main steam and main feedwater piping is the largest ASME Class 2 and 3 piping connected to the steam generators and has the highest structural load. The other major Class 2 and 3 piping of concern is SG blowdown piping (4 inch). However, this piping is connected to the SG at around the same elevation as the main feedwater piping (economizer line, 14 inch) and has much less impact to the SG. In addition, the scope includes analysis methods, modeling techniques, pipe stress analysis criteria, pipe support design criteria, high-energy line break criteria, and the leak-before-break (LBB) approach, as applicable to the APR1400 design. Graded approach is also taken to the scope of piping hazards analysis and LBB analysis. Piping hazards analysis includes main steam and main feedwater piping inside the containment building since it is most safety significant in terms of pipe break hazard as well as impact on the RCS structural analysis. LBB analysis includes pressurizer surge line as a representative case in consideration of the thermal stratification expected during the normal operation.

The ASME Code Class 1 piping systems include RCS main loops, pressurizer surge line and 13 piping subsystems of RCS branch piping which include 4 DVI lines, 2 SC lines, and 4 RCS drain lines (letdown, charging, RG and spray lines).

APR-1400 has one design ITACC for piping systems and components design. This design ITACC is for the completion of the environmental fatigue analysis for ASME Code Class 1 piping systems and components in accordance with NRC Regulatory Guide 1.207, Rev 0.

RG 1.207 provides two distinct methods for incorporating LWR environmental effects into the fatigue analysis of ASME Class 1 piping systems and components. The first method involves developing new fatigue curves that are applicable to LWR environments. Given that the fatigue life of ASME Class 1 piping systems and components in LWR environments is a function of several parameters, this method necessitates the development of several fatigue curves to address potential parameter variations. Alternatively, a single bounding fatigue curve could be developed. This second method involves using an environmental correction factor (F_{en}) to account for LWR environments by correcting the fatigue usage calculated with the ASME "air" curves. Either method may be The second method is used to meet this requirement.

As-built ITAAC are developed to verify the following:

a. A report that documents the results of an as-built reconciliation confirming that the piping systems have been built in accordance with the design report

b. The welding quality of as-built pressure boundary welds for ASME Class 1, 2, and 3 SSCs

c. The pressure integrity of ASME Code Class 1, 2, and 3 SSCs by specifying hydrostatic testing

d. The dynamic qualification records (e.g., seismic, loss-of-coolant accident [LOCA], and pilot-operated safety relief valve [POSRV] discharge loads) of seismic Category I mechanical and electrical equipment (including connected instrumentation and control [I&C]) and associated equipment anchorages

e. The vendor test records that demonstrate the ability of pumps, valves, and dynamic restraints to function under design conditions