
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.: 151-8078
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems, Components, and Equipment
Application Section: 3.9.2
Date of RAI Issue: 08/10/2015

Question No. 03.09.02-1

The initial test program is implemented to demonstrate that the piping systems, restraints, components, and supports have been designed to withstand flow-induced dynamic loading under the steady-state and operational transient conditions anticipated during service, to confirm that proper allowance for thermal contraction and expansion is provided, and to demonstrate that piping vibrations are within the acceptable level such as those caused by an in-line component trip. The applicant stated in DCD Tier 2 Section 3.9.2.1 that the supports and restraints necessary for operation during the life of the plant are considered to be parts of the piping system. Therefore, to meet the GDC 1, the staff requests the applicant to justify the applicability of the stress limits in the referenced guidance of ASME OM-S/G-1990 during steady state vibration are to be based for the 60-year life.

Response

ASME OM-S/G-1990, Part 3, indicates that the criterion used for steady- state vibration is to limit the vibrational stresses to a value below the endurance limit of the piping material. The allowable stress values are determined from the ASME Section III, Division 1, Appendix I design fatigue curve (S-N Curve) at 10^{11} stress cycles. For example, 50 hertz vibration occurring continuously over the 60-year plant design life, which is only applied to major SCCs such as the RCS, SI/SC, etc., results in 9.5×10^{10} stress cycles which is below 10^{11} stress cycles of an effective endurance limit. If the steady state vibration is over 10^{11} stress cycles, a detail evaluation of the vibration will be performed to ensure that the vibration will be acceptable for the design life of piping system.

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 Reports.

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.: 151-8078
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems, Components, and Equipment
Application Section: 3.9.2
Date of RAI Issue: 08/10/2015

Question No. 03.09.02-5

In review of DCD Tier 2 Subsection 3.9.2.1.1, the applicant's vibration criteria appear to be based on ASME OM-S/G-2007, Part 3, Paragraph 3.2.1.2; for austenitic stainless steels, the stress limits are obtained from Figures I-9.2.1 and I-9.2.2 of the Mandatory Appendix I to Section III of the ASME BPV Code. In addition, the DCD states that the allowable stress reduction factor provides reasonable assurance that the alternating stress S_{alt} is based on the number of cycles during the design life. In accordance with GDC 1, the applicant is requested to provide a justification whether the fatigue strength at 1E6 cycles with the reduction factor would be conservative for a 60 years operation life running at 1E11 cycles.

Response

ASME OM-S/G-1990, Part 3 is applied to vibration criteria for the APR1400. For austenitic stainless steels, the stress limits are obtained with allowable stress reduction factor 1.0 from I-9.2.2 of the Mandatory Appendix I to ASME Section III, which provide the stress limits up to 10¹¹ cycles.

The vibration cycles are evaluated based on the specific piping design life in accordance with ASME OM-S/G-1990, Part 3. For the APR1400, the 60- year design life is for major SCCs such as the RCS, SI/SC, etc.

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 Reports.

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.: 151-8078
SRP Section: 03.09.02 – Dynamic Testing And Analysis of Systems, Structures, And Components
Application Section: 3.9.2
Date of RAI Issue: 08/10/2015

Question No. 03.09.02-8

In the case of multiple-supported equipment in a single structure and/or spanning between structures, an alternate method that can be used is the independent support motion (ISM)

approach consistent with guidance given in Section 2 of NUREG-1061, Volume 4.

If the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method should be followed.

Therefore, the applicant is requested to specify in DCD Section 3.9.2, consistent with SRP Section 3.7.3 in combining the final structural response from each ISM, multiple-support excitation methods should be implemented in accordance with the staff recommendations

on response combinations given in NUREG-1061, Volume 4, Section 2.

In addition, the staff notes that in lieu of the response spectrum approach, time histories of support motions may be used as input excitations to the subsystems. The time history approach is considered to provide more realistic results as compared to the more conservative USM or ISM methods.

Response

DCD Section 3.9.2.2.8 will be revised to reflect that KHNP will follow the guidance provided in NUREG-1061, Volume 4, Section 2 for instances when the independent support motion is used as an alternate method for the multiple supported excitation cases.

Impact on DCD

DCD Section 3.9.2.2.8 will be revised as indicated 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 Reports.

APR1400 DCD TIER 2**3.9.2.2.8 Multiple-Supported Equipment Components with Distinct Inputs**

When the equipment or component is supported at points with different elevations within a building and between buildings, either the envelope of these elevation response spectra or multiple supports excitation is used for the seismic qualification of the equipment.

For analyzing the piping systems supported at multiple locations within a single structure or multiple structures, the method used is described in Subsection 3.12.3.2.

If ISM (Independent Support Motion) method is utilized for alternate method of multiple supports excitation, the criteria for the use of ISM method will be followed in accordance with NUREG -1061, Volume 2, Section 4.

3.9.2.2.9 Use of Constant Vertical Static Factors

A constant static factor is not used for the seismic design of seismic Category I structures, systems, and components specified in Subsections 3.7.2.10 and 3.7.3.6.

3.9.2.2.10 Torsional Effects of Eccentric Masses

All concentrated loads in a piping subsystem, such as valves and valve operators, are modeled as massless members with the mass of each component lumped at its center of gravity. Massless members are modeled by connecting the center of gravity of components to the centerline of piping so that the torsional effects of the eccentric masses are considered.

Torsional effects of eccentric masses are also considered in the analysis of seismic Category I subsystems other than piping.

3.9.2.2.11 Buried Seismic Category I Piping Conduits, and Tunnels

The seismic criteria and methods used to analyze buried seismic Category I piping, conduit, and tunnels are addressed in Subsections 3.7.3.7 and 3.12.3.8.

3.9.2.2.12 Interaction of Other Piping with Seismic Category I Piping

Interaction of other piping with seismic Category I piping is addressed in Subsection 3.12.3.7.

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.: 151-8078
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems, Components, and Equipment
Application Section: 3.9.2
Date of RAI Issue: 08/10/2015

Question No. 03.09.02-16

SRP Section 3.9.2, SRP acceptance criterion 7 recommends the use of ASME OM-S/G-1990, Part 3 for vibration testing. In accordance with 10 CFR 52.47, the applicant is requested to clarify the edition of ASME OM-S/G being used for the APR1400 design throughout DCD Tier 2 (referenced as the 2007 edition in some locations) and justify any differences from the guidance in SRP Section 3.9.2. In addition, the reference to "OM Part 7" (as well as other similar references to other parts) should be clarified in the DCD to give the complete reference (e.g., OM-S/G-2007, Part 7).

Response

The piping system tests are performed in accordance with ASME OM-S/G-1990. DCD Tier 2 section 3.9.2 will be revised to clarify the code edition and to provide the complete reference.

Impact on DCD

DCD Tier 2, Sections 3.9.2 and 3.9.10 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 Reports.

APR1400 DCD TIER 2

- d. Seismic Category I portions of moderate-energy piping systems located outside the containment

ASME OM-S/G-1990

The ITP is conducted in accordance with the ~~ASME OM~~ (Reference 34).

The ITP is implemented to demonstrate that these piping systems, restraints, components, and supports have been designed to withstand flow-induced dynamic loading under the steady-state and operational transient conditions anticipated during service, to confirm that proper allowance for thermal contraction and expansion is provided, and to demonstrate that piping vibrations are within the acceptable level. The supports and restraints necessary for operation during the life of the plant are considered to be parts of the piping system.

The ITP includes a list of systems, flow modes, and selected locations for visual inspections and other measurements, the acceptance criteria, and possible corrective actions if excessive vibration or indications of thermal motion restraint occur.

The proper installation and operation of snubbers is verified through visual inspections, hot and cold position measurements, and observation of thermal movements during the ITP. The list of snubbers on systems that are subjected to sufficient thermal movements from cold to hot position is provided as part of the ITP to measure snubber travel. In addition, the ITP includes the procedure necessary to verify the snubber operability when snubber travel is not measured.

3.9.2.1.1 Steady-State Vibration

The above piping systems in Subsection 3.9.2.1 with the potential to exhibit significant vibration are monitored for steady-state vibration.

ASME OM-S/G-1990

The details relating to this test are described in the test procedure prepared in accordance with ~~ASME OM~~, Part 3. The piping is monitored for normal operating and test modes along with operating modes expected to result in the most severe vibration. The piping is visually inspected and vibration movements are measured using portable instrumentation at locations where the vibration is determined to be the most severe. The piping, if necessary, is instrumented and monitored remotely.

APR1400 DCD TIER 2

The measured piping displacements are compared with allowable displacement limits that are based on the allowable stress amplitudes, S_{alt} , calculated in accordance with ASME OM, Part3. S_{alt} is limited as defined below.

ASME OM-S/G-1990



- a. For ASME Section III Class 1 piping systems

$$S_{alt} = \frac{C_2 K_2}{Z} M \leq \frac{S_{el}}{\alpha}$$

Where:

- C_2 = secondary stress index as defined in ASME Section III
- K_2 = local stress index as defined in ASME Section III
- M = maximum zero to peak dynamic moment loading due to vibration only, or in combination with other loads, as required by the system design specification
- S_{el} = 0.8 S_A , where S_A is the alternating stress at 10^6 cycles in psi from ASME Section III, Appendices, Figure I-9.1; or S_A at 10^{11} cycles from the ASME Section III, Appendices, Figure I-9.2.2. The user considers the influence of temperature on the modulus of elasticity.
- Z = section modulus of the pipe
- α = allowable stress reduction factor: 1.3 for materials covered by the ASME Section III, Appendices, Figure I-9.1; or 1.0 for materials covered by the ASME Section III, Appendices, Figure I-9.2.1 or I 9.2.2

- b. For ASME Section III Class 2 and 3 piping systems and ASME B31 piping systems

$$S_{alt} = \frac{C_2 K_2}{Z} M \leq \frac{S_{el}}{\alpha}$$

Where:

- $C_2 K_2$ = $2i$
- i = stress intensification factor, as defined in ASME Section III, Subsections NC and ND or ASME B31

APR1400 DCD TIER 2

The piping is instrumented to measure the system response during the dynamic transient events. The measured responses are compared with analytically predicted values from the piping stress reports.

If excessive system vibration is apparent during the dynamic transient events, an evaluation is performed to determine the cause and to identify the corrective action.

Alternatively, an analysis may be performed to demonstrate that the measured dynamic transient vibration does not cause the piping system in question to exceed stress or fatigue acceptance criteria.

3.9.2.1.3 Thermal Expansion

For piping systems expected to be subjected to significant thermal movements, the thermal expansion test is performed to verify that the piping system expands and contracts within the acceptable limits based on analytically predicted movements from the piping stress analyses during the ITP and is performed in accordance with the requirements of ~~ASME OM~~, Part 7.

↑ ASME OM-S/G-1990

Prior to heatup, the locations of potential thermal interferences are identified and appropriate corrective restraints are installed through a pre-heatup walkdown. One complete thermal cycle (i.e., cold to hot position and back to cold position) is monitored.

The piping and components are visually inspected and piping displacements are monitored at predetermined locations. The measurement locations are based on those of snubbers, hangers, and expected large displacements.

3.9.2.2 Seismic Analysis and Qualification of Seismic Category I Mechanical Equipment

3.9.2.2.1 Seismic Qualification Testing

The recommended guidance and requirements in NRC RG 1.100 (Reference 35) and IEEE Std. 344-2004 (Reference 36) are used for the development and implementation of methods and procedures for seismic qualification of mechanical and electrical equipment. The

APR1400 DCD TIER 2

28. CENPD-252-P-A, "Method for the Analysis of Blowdown Induced Forces in a Reactor Vessel," Combustion Engineering, Inc., July 1979 (Proprietary).
29. CENPD-133P, "CEFLASH-4A: A Fortran-IV-Digital Computer Program for Reactor Blowdown Analysis," Combustion Engineering, Inc., August 1974 (Proprietary).
30. CENPD-133P, "CEFLASH-4A: A Fortran-IV Digital Computer Program for Reactor Blowdown Analysis (Modifications)," Combustion Engineering, Inc., Supplement 2, February 1975 (Proprietary).
31. Scherer, A. E., Licensing Manager, (C-E), Letter to D. F. Ross, Assistant Director of Reactor Safety Division of Systems Safety, LD-76-026, March 1976 (Proprietary).
32. Parr, O. D., Chief Light Water Reactor Project Branch 1-3, Division of Reactor Licensing (NRC), Letter to F. M. Stern, Vice President of Projects (C-E), June 1975.
33. Kniel, K., Chief Light Water Reactors Branch No. 2, Letter to A. E. Scherer, Licensing Manager (C-E), August 1976 (Staff Evaluation of CENPD-213).

34. ASME OM Code, "Code for Operation and Maintenance of Nuclear Power Plants," American Society of Mechanical Engineers, the 2004 Edition with the 2006 Addenda.

35. Regulatory Guide 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," Rev. 3, U.S. Nuclear Regulatory Commission, September 2009.
36. IEEE Std. 344-2004 (Reaffirmed 2009), "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (IEEE), June 2005.
37. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," U.S. Nuclear Regulatory Commission, 1993.
38. Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," Rev. 3, U.S. Nuclear Regulatory Commission, October 2012.

34. ASME OM-S/G-1990, "Standards and Guides For Operations of Nuclear Power Plants," Part 3, "Requirements for Preoperational and Initial Start-Up Vibration Testing of Nuclear Power Plant Piping Systems," and Part 7, "Requirements for Thermal Expansion Testing of Nuclear Power Plant Piping Systems."