U.S. NUCLEAR REGULATORY COMMISSION REGULATORY AUDIT OF CONTROL ELEMENT DRIVE MECHANISM AND REACTOR PRESSURE VESSEL INTERNALS AS PART OF THE APR1400 DESIGN CONTROL DOCUMENT AUDIT REPORT

Korea Hydro and Nuclear Power Co., Ltd. (KHNP) and Korea Electric Power Corporation (KEPCO)

APR1400 DESIGN CERTIFICATION
Docket No. 52-046

NRC Audit Team

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1.0 SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) staff conducted a regulatory audit of detailed design documents to facilitate the review of portions of the Advanced Power Reactor (APR) 1400 design certification document (DCD) Tier 2, Revision 0 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15006A042). The review included the following:

- Section 3.9.2, “Dynamic Testing and Analysis of Systems, Structures, and Equipment”;
- Section 3.9.4, “Control Element Drive Mechanisms [CEDMs]”; and
- Section 3.9.5, “Reactor Pressure Vessel Internals.”

The NRC staff audited the design documents in the applicant’s electronic reading room (ERR) between June 29, 2015, and July 2, 2015. The purpose of this audit was to: (1) gain a more detailed understanding of APR1400 supporting documents to support the staff’s future decision regarding reasonable assurance of adequate protection of public health and safety associated with the APR1400 design; (2) review related documentation and non-docketed information to evaluate conformance with the Standard Review Plan (SRP) or technical guidance; and (3) verify that the APR1400 dynamic testing of structures, systems and components (SSCs), CEDMs, and reactor internals are designed in accordance with the methodology and criteria described in the APR1400 final safety analysis report (FSAR), in support of the KHNP design certification (DC) application.

2.0 BASIS

The basis of this audit was to review the design documentation, including design specifications, design reports, and testing documents, for the CEDMs and reactor pressure vessel internals.

3.0 OBSERVATIONS AND RESULTS

Section 3.9.2, "Dynamic Testing and Analysis of Systems, Structures and Equipment"

The staff audited the hydraulic model and the computer programs used (if any) to calculate the forcing function applying to the reactor internals. The following document was provided by KHNP for audit:

1. KHNP Report 0000-PS-VV-010, Revision 0, which documents the computer code DPVIB.

The following observations resulted in RAIs in parallel with the staff's review of the DCD.

1. The report states the DPVIB code is used for the calculation of pump induced acoustic loads. The DPVIB can calculate sonic velocity, pump induced pressure distributions, and Fourier coefficients which define the pump induced pressure distribution. The report also states that DPVIB was approved for use in the design of NSSS. As such, the computer code DPVIB should be included in DCD Tier 2, Section 3.9.1 where computer codes are listed for use in designing the safety related SSCs.

   The computer code DPVIP was passed forward for staff review in DCD Tier 2, Section 3.9.1 where the staff issued request for additional information (RAI) 73-8025, Question 03.09.01-4.

2. The KHNP Report 0000-PS-VV-010, Revision 0 does not document the hydraulic model nor the translation of acoustic pump-induced pressure fluctuations to loads on the reactor internals as the staff original planned to audit. The staff requested information for the analytical methodology and the hydrodynamic model to show how the pump induced pulsation pressure loading to be translated for loads on RVI components. This resulted in RAI 151-8078, Question 03.09.02-9.

Section 3.9.4, "Control Element Drive Mechanisms"

The staff audited the following documents:

1. Summary Stress Report for Control Element Drive Mechanism, APR1400-H-N-NR-14006-P, Revision 1.

2. Design Specification for Control Element Drive Mechanisms and CEA Extension Shaft Assemblies, 11A60-ME-DS240-00, Revision 3.

3. Test Report TR-ESE-259, Double Step CEDM Scram Time Qualification.

4. TSSA Technical Evaluation Report Structural Damping and CEA/ESA Insertion Criteria for CEDM Shin-Kori, Units 3 and 4, Revision 1.

The following observations resulted in RAIs in parallel with the staff's review of the DCD.

1. Sections 6.2.2.2, 6.2.2.3, and 6.2.3 of the Design Specification for Control Element Drive Mechanisms and CEA Extension Shaft Assemblies, discuss duty requirements for the CEDM like design weight min and max, [ ], respectively; movement speed between [ ] in/min, minimum [ ] lb. upforce to lift CEDM, and the capability for [ ] full height drops. These are functional requirements that should be added to the DCD. This resulted in RAI 85-7949, Question 03.09.04-1.

2. On page 13-14 of the TSSA report, Section 1.5, "Shin-Kori CEDMs" states that changes made such as seismic supports in upper portions of CEDM shroud, shroud tube wall thickness increase, and outside diameter increase of longer CEDM nozzle. Are the test CEDMs identical to APR1400 production CEDMs, if not please clarify the exact differences between them in regards to supports, structural, material, and any other measurable differences? This resulted in RAI 85-7949, Question 03.09.04-2.

The following observations were closed.

1. On page 38 of the CEDM summary stress report, the end of the first sentence states that "…except the CEAs do not have to be inserted following a loss of coolant accident having break area greater than $0.5ft^2$." This exception is not mentioned in the DCD and it is not clear which references are referred to for insert ability requirements (references 3 and 6). The staff requested that these supporting reference documents be made available in the electronic reading room.

   The applicant uploaded the insert ability requirements (references 3 and 6) in the ERR.

2. Page 38 of the CEDM summary stress report, "Deformations and deflections," states that this summary specifies limits to insert ability based on drop tests with SSE loadings, but those SSE loadings and details on the effect of deformation and deflection on drop times do not appear in this summary report.

   The applicant clarified this item during the July 1, 2015, status briefing stating that details of the SSE loadings and details on the effect of deformation and deflection on drop times are described in Test Report TR-ESE-259, Double Step CEDM Scram Time Qualification and TSSA Technical Evaluation Report Structural Damping and CEA/ESA Insertion Criteria for CEDM Shin-Kori, Units 3 and 4, Revision 1.

3. Page 62 of the CEDM summary stress report, Table 10-26, “Upper Pressure Housing,” shows 0 CUF for the upper pressure housing at the upper end fitting, threads, and omega seal. Can you explain how these results were obtained?

   The applicant clarified this item during the July 1, 2015, status briefing.

4. The staff requested that “Test Report TR-ESE-259, Double Step CEDM Scram Time Qualification,” be added to the reading room as it is an important reference document in reviewing the TSSA Technical Evaluation Report Structural Damping and CEA/ESA Insertion Criteria for CEDM Shin-Kori, Units 3 and 4.

   The applicant uploaded this document in the ERR.

The following observations resulted in audit open items.

1. Dead weight is listed as 350 lbs in DCD Tier 2, Section 3.9.4.4, page 3.9-77. However in the CEDM Summary Stress Report, the ESA and 12 finger CEA sum up to only 345 lbs. What accounts for the weight discrepancy?

   The applicant confirmed that the 345 lbs. value is from the design specifications and will revise the CEDM report to correct the inconsistency.

2. On page 14 of the CEDM Summary Stress Report, Code Case N-4-12 is referred to for the material specification for the motor housing. However, in DCD Tier 2, Section 4.5.1, page 4.5-1, the motor housing is stated as using Code Case N-4-13, in accordance with NRC Regulatory Guide 1.84, Rev.36, which is reference no. 6 on page 4.5-14 of the DCD. Why are the code cases not consistent?

   The applicant confirmed that Code Case N-4-13 referred in the DCD is correct and will revise the CEDM report to correct the inconsistency.

3. On page 5 of the CEDM Summary Stress Report, Table 2-3, “Summary of simplified elastic plastic evaluation of the CEDM.” Can you explain the basis of the Ke factor evaluation.

   The applicant will provide a letter to address this item.

4. Section 6.2.1.6 of the Design Specification for Control Element Drive Mechanisms and CEA Extension Shaft Assemblies discusses safety-related non-pressure boundary components as being rated only for 40 years. However, in DCD 3.9.4.4 the design duty requirement of 100,000 ft is for 60

years based on the response to Issue List 3.9.4, Question 1 and includes non-pressure boundary components like the motor assembly and ESA. Please clarify this discrepancy.

The applicant will provide a letter to address this item.

5. On page 22 of the TSSA report, it states that the traces in Figure B were shifted with respect to their true positions to facilitate comparison between the two curves. Please clarify the process of converting the displaced shape from Figure A to B.

   The applicant will provide a letter to address this item.

6. On Figure 13 of the TSSA Report, limiting displacements are 1.0 inch at reference point 1 and .85 inch at reference point 2. What is the basis for these limiting displacements?

   The applicant will provide a letter to address this item.

7. In Section 2.5 of the TSSA report, page 23, it lists conditions where CEA insertion may become a problem. How are conditions 1 and 2 prevented from occurring?

   The applicant will provide a letter to address this item.

Section 3.9.5, "Reactor Pressure Vessel Internals"

The staff audited the following documents during the audit:

1. 11A60-ME-DS240-00-R02, DPL1, Rev. 2, "Design Specification for Reactor Vessel Core Support and Internal Structures."

The following observations resulted in RAIs in parallel with the staff's review of the DCD.

1. Design specification, Section 6.1.1.3 – The last sentence states that "The fuel assembly insert pins excluding the threaded portions are part of this structure." It is not clear to the staff why the threaded portions of the fuel assembly insert pins are excluded from the classification of the lower support structure. This resulted in RAI 92-8068, Question 03.09.05-2.

2. Design specification, Section 6.4.1.2 and Appendix VI – The service Level D limit is 80 percent. It is unclear to the staff the origin of this 80 percent. This resulted in RAI 92-8068, Question 03.09.05-19.

3. Design specification, Appendix III and summary stress report – contains loads and stress results for CEA guide tubes. It is unclear to the staff if there is any buckling analysis performed. This resulted in RAI 92-8068, Question 03.09.05-6.

The following observations were closed.

1. Design specification, Section 6.1.1, "Core Support Structure," states that "…[t]hese structures shall be designed in accordance with the requirements of Reference 3.1.1.2 (ASME Code Subsection NG) as delineated in this section and Section 6.5." Section 6.1.2, "Internal Structure" states that "The Internal Structures shall be designed in accordance with the requirements stipulated in Section 6.5 of this specification." It is unclear to the staff what "stipulated in Section 6.5 of this specification" means.

   The applicant explained that both the core support structures and internal structures are designed to ASME Code Subsection NG.

2. Design specification, Section 6.5.1.3 – Level B loading includes scram load, which is not in the DCD.

   The applicant explained that the DCD only describes the major loads, while the design specification lists all of the loads. Whenever there is discrepancy between the two, the design specification governs.

3. Design specification, Section 6.5.1.4 – Testing loading is not included in the DCD.

   The applicant explained that the DCD only describes the major loads, while the design specification lists all of the loads. Whenever there is discrepancy between the two, the design specification governs.

4. Design specification, Section 6.5.1.6 – Level D service loading includes scram load, which is not in the DCD.

   The applicant explained that the DCD only describes the major loads, while the design specification lists all of the loads. Whenever there is discrepancy between the two, the design specification governs.

5. Design specification, Section 6.5.2.5 – states that core support structure and internal structure have different requirement for Level D service limit. For core support structures, Appendix F to ASME Code is used. For internal structures, it only states the integrity of the core support structure is not impaired, but no commitment was made for design codes.

The applicant explained that for Levels A, B, and C service loadings, both core support structures and internal structures are designed to ASME Code Subsection NG. The same methodology is used for Level D service loading, but is not specifically stated in the design specification. It is also noted that the ASME Code Subsection NG does not specify requirement for internal structures under Level D service loading.

6. Design Specification, Appendix II – Level A service loading includes refueling (normal event – 10), which is not in the DCD.

   The applicant explained that the DCD only describes the major loads, while the design specification lists all of the loads. Whenever there is discrepancy between the two, the design specification governs.

7. Design Specification, Appendix II – Level B service loading includes upset event - 9, which is not in the DCD.

   The applicant explained that the DCD only describes the major loads, while the design specification lists all of the loads. Whenever there is discrepancy between the two, the design specification governs.

The following observations resulted in audit open items.

1. Design Specification, Appendix II – There is no information for Level C and Level D events.

   The applicant will provide a letter to address this item.

2. ASME Code Section III Subsection NCA-3252 includes three provisions for the contents of a design specification. Provisions a) and c) apply to the design specification, 11A60-ME-DS240-00-R02. However, provision c), which entails pre-service examination, is not mentioned in the design specification.

   The applicant will provide a letter to address this item.

4.0 CONCLUSION:

This summary audit report is to be referenced in Sections 3.9.2, 3.9.4, and 3.9.5 of the final safety evaluation report for the AP1400 DCD review. Based on the audit observations, the staff issued several RAIs. In addition, the applicant committed to provide a letter addressing the observations that resulted in audit open items. The NRC staff will review the RAI responses and the applicant's letter during the Phase 2 review.

5.0 REFERENCES:

1. 10 CFR Parts 50, “Domestic Licensing of Production and Utilization Facilities,” and 52 “Licenses, Certifications, and Approvals for Nuclear Power Plants.”

2. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition”, Chapter 3, “Design of Structures, Components, Equipment, and Systems.”

3. KHNP APR1400 Design Control Document – Tier 2 Chapter 03 – Design of Structures, Systems, Components, and Equipment (ADAMS Accession No. ML15006A059).