CONTROL ELEMENT DRIVE MECHANISM AND REACTOR PRESSURE VESSEL INTERNALS AS PART OF THE APR1400 DESIGN CONTROL DOCUMENT AUDIT PLAN

JUNE 29, 2015 – JULY 2, 2015

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

APR1400 DESIGN CERTIFICATION
Docket No. 52-046

Location: NRC Headquarters
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2738

KHNP Washington DC Center
8100 Boone Blvd. Suite 620
Vienna, VA 22182

Purpose**:**

The purpose of this audit is for the staff to: (1) gain an understanding of the Advanced Power Reactor 1400 (APR1400) supporting documents to reach a reasonable assurance finding; (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 systems, structures and components (SSCs), control element drive mechanism (CEDM), and reactor internals are designed in accordance with the methodology and criteria described in the APR1400 design control document (DCD), in support of the KHNP design certification (DC) application.

Background:

On March 5, 2015, the U.S. Nuclear Regulatory Commission (NRC) accepted the DC application for docketing for the APR1400 submitted by KHNP (Reference 1). The staff initiated Phase 1 of the application DC review on March 9, 2015.

The NRC staff determined efficiency gains would be realized by auditing the documents supporting the following areas presented in the DCD, in lieu of requesting in requests for additional information (RAI):

1. Dynamic testing and analysis of SSCs.
2. Design of the CEDM.
3. Design of reactor pressure vessel (RPV) internals.

The purpose of this audit is to allow the NRC technical staff to gain an understanding of the supporting documents to better focus staff inquiries to the applicant. During the audit and interactions with the applicant, there may be detailed NRC requests for information developed, which would be part of future formal correspondence.

Regulatory Audit Basis:

Title 10 of the *Code of Federal Regulations* (10 CFR), Paragraph 52.47(a)(3)(i) states that a DC application must contain a final safety analysis report (FSAR) that includes a description of principal design criteria for the facility. A regulatory audit is needed to evaluate the safety conclusions that need to be made regarding Chapter 3, "Design of Structures, Components, Equipment, and Systems," of the APR1400 DCD, and to identify detailed information related to the applicant's principal design criteria. The NRC staff must have sufficient information to document its safety findings in the NRC staff's safety evaluation report (SER).

This regulatory audit is based on the following:

- General Design Criterion (GDC) 1 of Appendix A to 10 CFR Part 50, and 10 CFR 50.55a, "Codes and standards," as they relate to the testing of SSCs and the design of CEDM and reactor internals, require that the SSCs, CEDM and reactor internals be designed to quality standards commensurate with the importance of the safety functions to be performed.

- GDC 2, as it relates to the testing of SSCs and the design of CEDM and reactor internals, requires that the SSCs, CEDM and reactor internals be designed to withstand the effects of an earthquake without loss of capability to perform its safety functions.

- GDC 4, as it relates to the testing of SSCs and the design of reactor internals, requires that the SSCs and reactor internals be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operations, maintenance, testing, and postulated pipe ruptures, including loss of coolant accidents.

- GDC 10, as it relates to reactor internals, requires that the reactor internals be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences (AOOs).

- GDC 14, as it relates to the testing of SSCs and the design of CEDM, requires that the reactor coolant pressure boundary be designed, constructed, and tested for the extremely low probability of leakage or gross rupture.

- GDC 15, as it relates to the testing of SSCs, requires that the design of the reactor coolant system to have sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during normal operating conditions, including AOOs.

- GDC 26, as it relates to the CEDM, requires that the CEDM be one of the independent reactivity control systems that is designed with appropriate margin to assure its reactivity control function under conditions of normal operation, including AOOs.

- GDC 27, as it relates to the CEDM, requires that the CEDM be designed with appropriate margin, and in conjunction with the emergency core cooling system,

be capable of controlling reactivity and cooling the core under postulated accident conditions.

- GDC 29, as it relates to the CEDM, requires that the CEDM, in conjunction with reactor protection systems, be designed to assure an extremely high probability of accomplishing its safety functions in the event of AOOs.

- 10 CFR 52.47, "Contents of applications; technical information in final safety analysis report."

- Additional detailed acceptance criteria in Sections 3.9.2, 3.9.4, and 3.9.5, of the SRP, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants."

Regulatory Audit Scope:

The NRC staff intends to review design specifications, design (stress) reports, and supporting documents related to the evaluation of the following three areas:

1. Dynamic testing and analysis of SSCs (SRP Section 3.9.2).
2. Design of CEDM (SRP Section 3.9.4).
3. Design of reactor internals (SRP Section 3.9.5).

Specifically for the dynamic testing and analysis of SSCs, the NRC staff plans to audit detailed information on the hydrodynamic model that was used to obtain the pump pulsating loads, as stated in DCD Tier 2, Section 3.9.2.3.1.1. This information was discussed during the public meeting on April 14-15, 2015 (ADAMS Accession No. ML15120A538), and KHNP responded that references in the DCD provided additional information. Therefore, the staff intends to audit detailed information to address the following technical topics:

A. How the acoustic pump-induced pressure fluctuations are translated to loads on the reactor internals, including the damping used (e.g., in the structural analysis in DCD Tier 2 Sections 3.1.2 and 3.2, SRP Section 3.9.2, and Reference 7).

B. The flow path, the hydraulic model, and the computer programs used (if any) to calculate the differential pressure on the internals.

C. A comparison of analysis results to Palo Verde startup test data at the selected locations of reactor internals.

For the design of the CEDM, DCD Tier 2, Section 3.9.4.3, states that the deformation of the CEDM under seismic conditions is evaluated to verify scramability as presented in DCD Tier 2, Subsection 3.9.2.7.3. However DCD Tier 2, Subsection 3.9.2.7.3 does not provide any details on the verification established by analysis or test. SRP Section 3.9.4, "Control Rod Drive Systems," Item I.1 provides guidance that the staff performs a review of applicable design loads and their appropriate combinations, the corresponding design stress limits, and the corresponding allowable deformations is performed. The deformations are of interest in the present context only in those instances where a failure of movement due to excessive deformation could be postulated and such movement would be necessary for a safety-related function.

For the design of reactor internals, the NRC staff will review the design specifications, design reports and any supporting documents for all reactor internals components, with focus on core support structures.

The NRC staff will conduct this audit in accordance with the guidance provided in NRO-REG-108, “Regulatory Audits” (Reference 2).

Documents and Information Necessary for the Audit:

Detailed design documents for the dynamic testing and analysis of SSCs, the design of CEDM, and reactor internals should be made available to the NRC staff. Specific documents of interest include:

1. Design specifications and design reports for the reactor internals.

2. The CEDM stress report, drop testing report, and any other supporting documentation relating to scramability of the CEDM under seismic condition.

3. Computer code information related to Item A on page 3 above (including methods, flow charts, verification and validation, manuals, etc.), if these are not already addressed in a parallel audit related to DCD Tier 2, Section 3.9.1.

4. CEN-267-(V)-P, “Final Report on the Performance Evaluation of the Palo Verde Control Element Assembly Shroud,” Combustion Engineering, Inc., Rev. 1-P, 1984.

5. CEN-263(V)-P, “A Comprehensive Vibration Assessment Program for Palo Verde Nuclear Generating Station Unit 1 (System 80 Prototype),” Combustion Engineering, Inc., Rev. 1-P, January 1985 (Proprietary).

6. CENPD-178, “Structural Analysis of Fuel Assemblies for Seismic and Loss-of-Coolant Accident Loading,” Combustion Engineering, Inc., Rev. 1, August 1981.

7. Other documents that the applicant deems as necessary to support the NRC staff’s audit, outlined in the audit scope section of this audit plan.

This is not a comprehensive list of documents the staff will be reviewing as part of the audit, as there may be a need to review additional data and calculations supporting the basis for these documents.

Appropriate handling and protection of proprietary information shall be acknowledged and observed throughout the audit.

Audit Team:

Cheng-Ih (John) Wu, NRO Mechanical Engineer
Jason Huang, NRO Mechanical Engineer
Yiu Law, NRO Mechanical Engineer
Luis Betancourt, NRO Project Manager

Applicant Contacts:

Yunho Kim (KHNP)
Harry Chang (KHNP)

Special Requests:

The NRC staff requests that KHNP provide:

- searchable electronic copies of the documents listed above, and
- any necessary overviews of the dynamic testing and analysis of SSCs, the design of CEDM and reactor internals.

Audit Activities and Deliverables:

The NRC audit team review will cover the technical areas identified in the documents and information section of this audit plan. Depending upon how much effort is needed in a given area, NRC team members may be reassigned to ensure adequate coverage of important technical elements.

The audit will be conducted from NRC Headquarters via KHNP's electronic reading room; however the audit may also be carried out at KHNP's facilities in Vienna, VA, if the technical information is only retained in hard copy.

Follow up audits at the NRC Headquarters via KHNP's electronic reading room (or at KHNP's facilities in Vienna, VA) may be necessary at various times through September 2016, and will be addressed through separate audit plans.

The NRC Project Manager will coordinate with KHNP in advance of audit activities to verify specific documents and identify any changes to the audit schedule and requested documents.

The NRC staff acknowledges the proprietary nature of the information requested. It will be handled appropriately throughout the audit. While the NRC staff will take notes, the NRC staff will not remove hard copies or electronic files from the audit site(s).

At the completion of the audit the audit team will issue an audit summary within 90 days that will be declared and entered as an official agency record in the NRC's Agencywide Documents Access and Management System (ADAMS) records management system. The audit outcome may be used to identify any additional information to be submitted for making regulatory decisions, and it will assist the NRC staff in the issuance of RAIs (if necessary) for the licensing review of APR1400 DCD Chapter 3 and any related information provided in other chapters, in preparation of the NRC staff's SER.

If necessary, any circumstances related to the conductance of the audit will be communicated to Luis Betancourt (NRC) at 301-415-6146 or Luis.Betancourt@nrc.gov.

References:

1. "Letter to Korea Hydro and Nuclear Power Co., Ltd., and Korea Electric Power Corporation – Acceptance of the Application for Standard Design Certification of the

Advanced Power Reactor 1400," ADAMS Accession Number ML15041A455, issued March 4, 2015.

2. NRO-REG-108, "Regulatory Audits," ADAMS Accession Number ML081910260, issued April 2, 2009.

3. APR1400 Design Control Document, Revision 0, issued December 2014.

4. SRP Section 3.9.2, "Dynamic Testing and Analysis of Systems, Structures, and Components," Revisions 3, 2007.

5. SRP Section 3.9.4, "Control Rod Drive Systems," Revision 3, issued March 2007.

6. SRP Section 3.9.5, "Reactor Pressure Vessel Internals," Revision 3, issued March 2007.

7. APR1400-Z-M-NR-14009-P, Rev. 0, "Comprehensive Vibration Assessment Program for the Reactor Vessel Internals." Issued November 2014 (Proprietary).

8. KHNP letter dated June 1, 2015, "Submittal of APR1400 Responses to Action Items from April 14-15 MEB Public Meeting."

   - Submittal of the APR1400 Action Item Tracking List (ML15138A466), dated May 18, 2015.

   - APR 1400 DCA Action Item Tracking List – 30 day Look Ahead Pages 1-22 (ML15138A467), dated May 18, 2015 (Item 3-28 on 8 of 22) (Proprietary).

   - APR 1400 DCA Action Item Tracking List – 30 day Look Ahead Pages 1-4 (ML15138A468), dated May 18, 2015 (Proprietary).