

August 5, 2015

MEMORANDUM TO: Samuel Lee, Chief
Licensing Branch 2
Division of New Reactor Licensing
Office of New Reactors

FROM: John McKirgan, Chief **/RA/**
Reactor Systems, Nuclear Performance, and Code Review
Division of Safety Systems and Risk Assessment
Office of New Reactors

SUBJECT: STAFF REGULATORY AUDIT PLAN REGARDING THE
REACTOR, REACTOR COOLANT SYSTEM AND CONNECTING
SYSTEMS, AND AUXILIARY SYSTEMS AS PART OF THE
REVIEW OF THE APR1400 DESIGN CONTROL DOCUMENT

The Reactor Systems, Nuclear Performance, and Code Review Branch prepared a regulatory audit plan for the audit of supporting design documentation related to the reactor, reactor coolant system and connecting systems, and auxiliary systems for the APR1400 design (Enclosure). The audit will help staff gain an understanding of APR1400 supporting calculations and analysis to reach a reasonable assurance finding and review related documentation and non-docketed information to evaluate conformance with the Standard Review Plan and other related guidance. This audit plan provides an overview of the Regulatory Audit activities the staff will perform.

Enclosure: As stated

CONTACT: Shanlai Lu, NRO/DSRA/SRSB
(301) 415-2869

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DATE	8/4/2015	8/4/2015	8/5/2015

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**U.S. NUCLEAR REGULATORY COMMISSION REGULATORY AUDIT OF THE REACTOR,
REACTOR COOLANT SYSTEM AND CONNECTING SYSTEMS, AND AUXILIARY SYSTEMS
AS PART OF THE REVIEW OF THE APR1400 DESIGN CONTROL DOCUMENT**

**APR1400 DESIGN CERTIFICATION
Docket No. 52-046**

AUDIT PLAN

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

APPLICANT CONTACTS: Christopher Tyree, KHNP
Harry Chang, KHNP

DURATION: An audit will be conducted for approximately three months from U.S. Nuclear Regulatory Commission (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 NRC Headquarters via KHNP's electronic reading room (or at KHNP's facilities in Vienna, VA) may be necessary at various times.

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

AUDIT TEAM: Shanlai Lu
Alexandra Burja
Matt Thomas
Boyce Travis
James Gilmer
Jeff Schmidt
Donald Carlson
James Steckel

I. BACKGROUND

On March 5, 2015, the U.S. Nuclear Regulatory Commission (NRC) accepted the design certification application for docketing for the Advanced Power Reactor 1400 (APR1400) submitted by Korea Hydro and Nuclear Power Co. (KHNP) (Reference 1). Staff initiated Phase 1 of the application design certification review on March 9, 2015.

NRC staff determined that efficiency gains would be realized by auditing the documents supporting the calculations presented in the design control document (DCD) in lieu of requests for additional information (RAIs) asking the applicant to docket the calculation files. The purpose of this audit is to allow NRC technical staff to gain an understanding of the supporting calculations to better focus staff inquiries to the applicant. During the audit and other interactions with the applicant, detailed RAIs may be developed, which would be part of future formal correspondence.

II. REGULATORY AUDIT BASIS

The purposes of this audit are for the staff to: (1) gain an understanding of APR1400 supporting calculations and analyses to reach a reasonable assurance finding and (2) review related documentation and non-docketed information to evaluate conformance with the Standard Review Plan (SRP) or technical guidance.

According to 10 CFR 52.47(a)(3)(i) a design certification application must contain a final safety analysis report (FSAR) that includes a description of principal design criteria for the facility. An audit is needed to evaluate the safety conclusions that need to be made regarding Chapters 4, 6, and 15 of the APR1400 DCD and identify detailed information related to the applicant's principal design criteria.

The NRC staff must have sufficient information to ensure that acceptable risk and adequate assurance of safety can be documented in the NRC staff's safety evaluation report (SER).

This regulatory audit is based on the following:

- 10 CFR Part 50 Appendix A, General Design Criteria (GDC):
 - GDC 10, "Reactor design": The reactor core and associated coolant, control, and protection systems shall 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.
 - GDC 13, "Instrumentation and control": Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.
 - GDC15, "Reactor coolant system design": The reactor coolant system and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.
 - GDC 17, "Electric power systems": An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel

design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

- GDC 26, “Reactivity control system redundancy and capability”: Two independent reactivity control systems of different design principles shall be provided. One of the systems shall use control rods, preferably including a positive means for inserting the rods, and shall be capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The second reactivity control system shall be capable of reliably controlling the rate of reactivity changes resulting from planned, normal power changes (including xenon burnout) to assure acceptable fuel design limits are not exceeded. One of the systems shall be capable of holding the reactor core subcritical under cold conditions.
 - GDC 31, “Fracture prevention of reactor coolant pressure boundary”: The reactor coolant pressure boundary shall be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state and transient stresses, and (4) size of flaws.
 - GDC 35, “Emergency Core Cooling”: A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that (1) fuel and clad damage that could interfere with continued effective core cooling is prevented and (2) clad metal-water reaction is limited to negligible amounts.
- RG 1.82, “Water Sources for Long-term Recirculation Cooling Following a Loss-Of-Coolant Accident.”
 - SRP Section 4.6, “Functional Design of Control Rod Drive System,” Review Procedure 3.
 - SRP Section 6.3, “Emergency Core Cooling System,” in general and Review Procedure 14.
 - SRP Sections from 15.2.1 to 15.2.5, “Loss Of External Load,” “Turbine Trip,” “Loss Of Condenser Vacuum,” “Closure Of Main Steam Isolation Valve (BWR),” and “Steam Pressure Regulator Failure (Closed).”
 - SRP Section 15.2.8, “Feedwater System Pipe Break Inside and Outside Containment (PWR).”

III. REGULATORY AUDIT SCOPE AND METHODOLOGY

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

documents and supporting calculations related to the reactor, reactor coolant system and connecting systems, and auxiliary systems described in APR1400 DCD Tier 2 Chapter 4, 6 and 15, specifically Subsections 4.4, 4.6, 6.3, 15.2.1-5, and 15.2.8. The following are areas the NRC staff intends to review on this audit:

- In Section 4.4, the staff needs information to assess minimum departure from nucleate boiling ratio (DNBR), FATES computer code fuel rod thermal performance, design vessel internal component loads and the method for statistical combination of uncertainties.
- In Section 4.6, the staff needs information to confirm that to ensure that the CEDM cooling subsystem capacity is sufficient to ensure reliable reactivity control during normal operation.
- In Section 6.3.2.2.3, the staff needs information to confirm that actual required net positive suction head (NPSH) does not exceed the maximum required NPSH of 6.1 m (20 ft) at pump runout flow, as stated by the applicant.
- In Section 6.3.2.2.5, the staff needs information to confirm that the safety injection tank (SIT) relief valves are sized to protect the tanks against the maximum fill rate of liquid or gas into the SITs.
- In Sections 15.2.1 to 15.2.5, the staff needs information to assess assumptions, input parameters and results of anticipated operational occurrences (AOOs) and one postulated accident (PA) that results in an unplanned decrease in heat removal by the secondary system.
- In Section 15.2.8, the staff needs information to review peak reactor coolant system (RCS) and steam generator pressure versus break sizes with offsite power available to ensure the limiting values were evaluated.

The NRC staff intends to review information, documents and supporting calculations related to the transient and accident analyses described on the Technical Report APR1400-F-C-NR-14003-P, Rev.0, "Functional Design Requirements for a Core Protection Calculator System for APR1400." The following is an area the NRC staff intends to review:

- The staff needs information to assess annealing process as the CPCS relies heavily on the power annealing factors/methodology.

The NRC staff also intends to review information, documents and supporting calculations related to the transient and accident analyses described on the Technical Report APR1400-F-C-NR-

12001-P, Rev.1, "Thermal Design Methodology." The following are areas the NRC staff intends to review:

- The staff needs information to assess capabilities of TORC and CETOP.
- The staff will review main approximations and operating experience in using TORC and CETOP methodology.
- The staff will review thermal margin calculations utilizing the TORC and CETOP computer codes

IV. INFORMATION AND DOCUMENTS NECESSARY FOR THE AUDIT

The following documents are to be made available to the NRC staff, either at the KHNP Washington D.C. Center, or in the electronic reading room. 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.

- Information, documentation and calculations in Section 4.4 related to (1) description and verification of the annealing process, (2) experimental data to perform a series of independent confirmatory calculations, (3) operating reactor experience with CPCS, and (4) CPCS validation documentation.
- Information, documentation and calculations in Section 4.4 related to (1) TORC and CETOP computer codes methods and capabilities, (2) main approximations used in CETOP, (3) TORC/CETOP code validation, (4) operating reactor experience in using the TORC/CETOP methodology, and (5) thermal margin calculations utilizing the TORC and CETOP computer codes.
- Documentations and calculations in Section 4.6 related to the required cooling capacity for the control element drive mechanisms (CEDM) to ensure that the capacity provided by the CEDM cooling subsystem is sufficient to ensure reliable reactivity control during normal operation.
- Documentations and calculations in Section 6.3 related to NPSH margins in accordance with RG 1.82 for the safety injection pumps, including vendor documents on pumps specifications; and minimum in-containment refueling water storage tank (IRWST) water volume and its incorporation in the safety analyses.
- Calculations in Section 6.3 related to sizing of the SIT relief valves and adequacy of its capacity so, that in the event of a maximum fill rate of liquid or gas into the SIT, the SIT's integrity is maintained.
- Calculations, assumptions, inputs, and results in Section 15.2.1-5 related to the events of loss of external load, turbine trip, loss of condenser vacuum and main steam isolation valve (MSIV) closure.
- Calculation in Section 15.2.8.4.3 related to peak RCS and steam generator pressure verses break sizes with offsite power available to ensure the limiting values were evaluated.

V. TEAM ASSIGNMENTS

The following table identifies the NRC staff and the review areas.

Table-1. NRC On-site Review Team

Review Area	NRC Staff Name
Transient and Accident Analyses	S. Lu / J. Schmidt
Computer Codes	Numark/ISL
Thermal Margins	J. Gilmer
Engineering Safety Features	M. Thomas/B. Travis
Reactor	D. Carlson/ A. Burja
Project \Support	J. Steckel

VI. LOGISTICS

The NRC staff and the applicant have agreed that the audit will be conducted via an electronic reading room and in the KHNP office in Vienna, VA. In support of this approach, the applicant has agreed to make knowledgeable staff available, along with relevant documentation, to support staff review and discussion of the material.

The audit is scheduled for a period of three months and onsite audits will be scheduled as needed. The staff requests that all document titles identified by NRC staff be available at the beginning of the audit in the electronic reading room and prior to any scheduled onsite audit. The NRC staff will have internal meetings throughout the audit to discuss preliminary findings. A summary of audit preliminary findings will be provided to the applicant for discussion. Document titles responsive to the audit areas listed in Section IV of this audit plan.

VII. SPECIAL REQUESTS

The NRC staff requests that KHNP provide:

- Document titles responsive to the audit areas listed in Section IV of this audit plan.
- Searchable electronic copies of the documents listed above.
- KHNP personnel to provide any necessary overviews of the APR1400 reactor, reactor coolant system and connecting systems, and auxiliary systems DCD information and related documents.

VIII. AUDIT ACTIVITIES AND DELIVERABLES

The NRC audit team review will cover the technical areas identified in Section III 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 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 Chapters 4, 6, and 15 and any related information provided in other chapters, in preparation of the NRC staff's Safety Evaluation Report.

If necessary, any circumstances related to the conductance of the audit will be communicated to James Steckel (NRC) at 301-415-1026 or James.Steckel@nrc.gov.

IX. 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," March 4, 2015, ADAMS Accession Number ML15041A455.
2. NRO-REG-108, "Regulatory Audits," April 2, 2009, ADAMS Accession Number ML081910260.
3. APR1400 Design Control Document, Revision 0, December 2014.