U.S. NUCLEAR REGULATORY COMMISSION REGULATORY AUDIT OF PROBABILISTIC RISK ASSESSMENT, SEVERE ACCIDENT EVALUATION, AND RELIABILITY ASSURANCE PROGRAM AS PART 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:	Yunho Kim (KHNP) Harry Chang (KHNP)
DURATION:	**Part 1** (at NRC Headquarters) April 15, 2015, 1:00 p.m. - 5:00 p.m. **Part 2** (Follow-up audits at NRC Headquarters, via KHNP's electronic reading room) Various times from establishment of electronic reading room through April 2017 when the staff will examine probabilistic risk assessment (PRA), severe accident (SA) evaluation, and reliability assurance program (RAP) documents remotely.
LOCATION:	NRC Headquarters Two White Flint North 11545 Rockville Pike Rockville, MD 20852-2738
AUDIT TEAM:	Hanh Phan (NRO, Audit Lead) Lynn Mrowca (NRO/SPRA Branch Chief) Alissa Neuhausen (NRO) Anne-Marie Grady (NRO) Courtney St. Peters (NRO) Donald Palmrose (NRO) Donnie Harrison (NRO) Hanry Wagage (NRO) Jason Schaperow (NRO) Malcolm Patterson (NRO) Marie Pohida (NRO) Odunayo Ayegbusi (NRO) Robert Roche (NRO) Tony Nakanishi (NRO) James Steckel (NRO, Project Manager)

I. BACKGROUND

KHNP and KEPCO submitted by a letter dated December 23, 2014, to the U.S. Nuclear Regulatory Commission (NRC) a Design Control Document (DCD) for its Design Certification (DC) application of the Advanced Power Reactor (APR) 1400 design, accessible by Agencywide Documents Access and Management System (ADAMS) Accession No. ML15006A059. The NRC staff initiated this design certification review on March 9, 2015. To facilitate the NRC staff's evaluation of PRA, SA, and RAP information and to complete its safety review of APR1400 DCD Chapters 19 and 17.4, the staff is planning an audit which includes:

- **Part 1:** A half-day regulatory audit, which will be carried out at the NRC Headquarters, on the afternoon of April 15, 2015 to examine the at-power and low-power and shutdown PRA (including Level 1 and Level 2 internal events, internal floods, internal fires), external events, PRA-based seismic margin assessment (SMA), PRA-related information (i.e., RAP list), and SA evaluation. Part 1 of the audit would include an orientation of these materials and a demonstration of the software (SAREX and FTREX) used to model and quantify the APR1400 PRA, by a member of the KHNP staff.

- **Part 2:** Follow-up audits via KHNP's electronic reading room, from establishment of the electronic reading room through April 2017, which will be carried out at the NRC Headquarters, to continue examining the PRA, PRA-based SMA, external events risk evaluation, key sources of uncertainty/assumptions, uncertainty and sensitivity analyses, importance rankings, SA evaluation, PRA maintenance and upgrade, and RAP. The PRA maintenance/update program including process for assessment of design changes for potential impact on the PRA will also be audited.

II. PURPOSE

The purpose of this audit is for the staff to: (1) gain an understanding of APR1400 PRA, SA and RAP development to reach a reasonable assurance finding, (2) review related documentation and non-docketed information to evaluate conformance with the SRP or technical guidance, and (3) evaluate the quality and programmatic control process/procedures used by KHNP for PRA and RAP.

III. REGULATORY AUDIT BASIS

An audit is needed to evaluate and identify detailed information related to the applicant's submittal in direct support of the safety conclusions that need to be made regarding APR1400 DCD Chapters 19 and 17.4.

10 CFR 52.47(a)(27) states that a DC application must contain a final safety analysis report (FSAR) that includes a description of the design-specific PRA and its results.

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).

IV. REGULATORY AUDIT SCOPE

The specific scope of this audit will include reviewing the following topics:

- Level 1 and Level 2 internal events PRA
- Level 1 and Level 2 internal floods PRA
- Level 1 and Level 2 internal fires PRA
- Level 1 and Level 2 low-power and shutdown PRA
- PRA-based SMA
- External events risk evaluation
- PRA maintenance
- RAP list and process
- Security target set
- Severe accident evaluations
- Risk insights

V. DOCUMENTS/INFORMATION NECESSARY FOR THE AUDIT

The following documents are to be made available to the NRC staff:

1) "PRA Summary Report," Rev. 0, APR1400-E-P-NR-13001-P
2) All PRA notebooks and documents (including digital I&C notebook)
3) Success Criteria calculations and MAAP and RELAP results supporting these success criteria calculations
4) APR1400 emergency operating guidelines (EOGs)
5) Peer reviews, independent reviews, and self assessments, and peer review resolution evaluation report
6) PRA input to design programs and processes
7) PRA input to the reliability assurance program
8) PRA input to the severe accident mitigation design alternatives
9) Room cooling analysis performed to support PRA development
10) Detailed failure modes and effects analysis (FMEA) performed to identify initiating events and support the development of system fault trees
11) Procedure(s) used to assess all APR1400 design changes for PRA impact (including documentation that implements the procedure)
12) List of sources of uncertainty and key assumptions, which drive the PRA models and results
13) "KHNP Quality Assurance Program Description (QAPD) for the APR1400 Design Certification," Rev. 4, March 2014, APR1400-K-Q-TR-11005-NP
14) RAP implementation procedure and/or instructions
15) RAP expert panel meeting minutes/summaries
16) RAP corrective actions issued
17) Description of calculation of corium spreading on the containment floor and drawings showing spreading area
18) CORQUENCH results for MCCI in the reactor cavity sump
19) WinMACCS computer code output files for source term categories, STC-3 and STC-19

20) Calculations of onsite doses for source term categories, STC-3 and STC-19
21) Supporting seismic fragility calculations, and basis and justification for assumed HCLPF values (including screened out components)
22) Procedure to ensure HCLPF of 1.67 times the CSDRS for equipment on the SEL qualified by seismic qualification tests
23) Related to the containment performance goal, supporting deterministic finite element evaluation that meets the Factored Load Category requirements of ASME Code, Section III, Division 2, Subarticle CC-3720
24) Documentation of the MAAP model and MAAP calculations used to develop the source terms in DCD Table 19.1-29 on Pages 19.1-391 through 19.1-393
25) List of key sources of uncertainty and key assumptions which drive the MAAP calculations and MAAP results
26) Verification and validation report (description, attributes, and associated activities for assessing the quality) of software (e.g., SAREX, FTREX, room heatup, etc.,) used to develop APR1400 PRA and SA
27) "Analyses of Hydrogen Distribution and DDT Potential in the APR1400 during LPSD Severe Accidents," Rev.0, KEPC-LPSD-NRCDC-H2
28) Distance from the top of RHR pipe flow area and vortex test procedure
29) Containment capacity evaluation on severe accident
30) Test report on hot leg levels and shutdown cooling system flow rates
31) Reactor cooling pump seal test and probability calculation
32) Fragility analysis performed to support PRA-based seismic margin assessment (SMA)
33) PRA-based SMA during low power and shutdown

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

VI. SPECIAL REQUESTS

The NRC staff requests the following:

- Searchable electronic copies of the documents listed above
- KHNP personnel to provide an overview of the PRA and related documents and a demonstration of the software used to model the APR1400 PRA.

VII. AUDIT ACTIVITIES AND DELIVERABLES

The NRC audit team is expected to consist of twelve individuals covering the technical areas identified in the PRA, SA, and RAP. The task assignments are shown in Table 1. 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 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 copy or electronic files from the audit site(s).

An audit report will be generated after completion of the audit and published in the NRC's ADAMS. The audit will assist the NRC staff in the issuance of RAIs (if necessary) for the licensing review of APR1400 DCD Chapters 19 and 17.4 and PRA-related information provided in other chapters and in preparation of the NRC staff's SER.

The agenda for Part 1 of the audit is presented in Attachments A of this audit plan. 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.

Table 1 – Reviewer Assignments

#	Technical Elements	Reviewers and Assignments									
		Hanh Phan	Marie Pohida	Tony Nakanishi	Odunayo Ayegbusi	Courtney St. Peters	Hanry Wagage	Jason Schaperow	Anne-Marie Grady	Robert Roche	Alissa Neuhausen
1	PRA Quality and Maintenance	**P**	**S**								
2	Use of PRA (ITAAC, security target set, human factor, Technical specifications, etc.)	**P**	**S**								
3	Level 1 - Internal Events • Initiating Events • Accident Sequence • Success Criteria				**P**	**S**					
4	Level 1 - Internal Events • Systems Analysis • Human Reliability • Data Analysis • Quantification				**S**	**P**					
5	Level 2 - Internal Events						**P**	**S**	**S**		
6	Level 1 - Internal Floods	**S**		**P**							
7	Level 2 - Internal Floods						**P**	**S**	**S**		
8	Level 1 - Internal Fires	**S**		**P**							
9	Level 2 - Internal Fires						**P**	**S**	**S**		
10	PRA-based SMA	**P**			**S**						
11	SMA Fragility Analysis									**P**	**S**
12	Other External Events	**P**				**S**					
13	Level 1 - Low-Power and Shutdown PRA • Internal Events • External Events		**P**	**S**							
14	Level 1 – Low-Power and Shutdown PRA • Internal Floods • Internal Fires		**S**	**P**							
15	Level 2 –Low-Power and Shutdown PRA		**P**	**S**							
16	Severe Accident Evaluations						**P**	**S**	**S**		
17	Containment Performance									**P**	**S**
18	Reliability Assurance Program	**S**			**P**						
19	Risk Insights	**S**		**P**							

P - Primary Responsibility; **S** - Secondary Responsibility

ATTACHMENT A

AUDIT AGENDA

Part 1 - APR1400 DCD Chapters 19 and 17.4 "PRA, SA, and RAP" Regulatory Audit

April 15, 2015

NRC Headquarters
Two White Flint North
11545 Rockville Pike
Rockville, MD 20850

Wednesday, April 15, 2015:

1:00 p.m. – 1:15 p.m.	Introduction/Entrance Meeting ……..…….	[NRC/KHNP]
1:15 p.m. – 2:45 p.m.	Orientation of PRA Models/Documents ……	[KHNP/NRC]
3:00 p.m. – 4:00 p.m.	Demonstration of PRA Software ……	[KHNP/NRC]
4:00 p.m. – 4:30 p.m.	NRC Staff Caucus ……..……	[NRC]
4:30 p.m. – 5:00 p.m.	Summary of the Day and Action Items	[NRC/KHNP]