

**RADIATION SHIELDING CALCULATIONS AS PART OF CHAPTER 12 OF THE
APR1400 DESIGN CONTROL DOCUMENT – AUDIT PLAN**

February 12, 2016 – March 4, 2016

**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

Purpose:

The purpose of this audit is to review and resolve technical issues related to radiation shielding and dose calculations associated with APR1400 Chapter 12, "Radiation Protection," including radiation shielding and dose calculations associated with normal operation and refueling, vital area access, and equipment qualification and to assist staff in resolving various requests for additional information.

Background:

On March 4, 2015, the U.S. Nuclear Regulatory Commission (NRC) accepted the design certification application for docketing for the APR1400 submitted by Korea Electric Power Corporation (KEPCO) and Korea Hydro & Nuclear Power Co., Ltd. (KHNP) (Reference 1). The NRC staff initiated Phase 1 of the application design certification review on March 9, 2015.

In RAI 8098, Question 12.03-8, the staff requested that the applicant provide shield wall thicknesses for sources in several plant areas which were initially missing from the Design Control Document (DCD), as well as make additional clarifications and editorial corrections. In its response to this question, the applicant provided the requested information. However, the applicant also indicated that, in determining the shielding thicknesses provided in the DCD, they did not consider access to vital areas during an accident. 10 CFR 50.34(f)(2)(vii) and 10 CFR 50.34(f)(2)(viii) require that the licensee consider the vital area dose rates and this is discussed in Standard Review Plan Sections 12.2 and 12.3-12.4. In addition, the applicant indicated that there were other discrepancies between the shielding calculations and the information in the DCD which were corrected in the response to RAI 8098, Question 12.03-8. As a result of not considering vital area access and because of apparent errors, the applicant proposed revising DCD Table 12.3-4, changing approximately 200 shield thicknesses throughout the plant, with about 70 of those thicknesses decreasing.

Enclosure

In its response to RAI 8098, Question 12.03-10, KHNP/KEPCO provided information indicating that Room 077-P01, in the Compound Building, contains multiple different wall and floor thicknesses, while the initial DCD only specifies four wall thicknesses and a ceiling and floor thickness.

Due to the large number of shielding changes in the DCD and errors identified in the original DCD information, it is necessary to review the applicant's shielding calculations to ensure that the current information in the DCD is accurate and acceptable. In particular, it is unclear to the staff, if the vital area access dose calculations are accurate, since this information appears to have been based on the original shielding thicknesses, which did not consider vital area access. The purpose of this audit is to review the applicant's methodology and calculations for determining the shielding thicknesses and dose rates throughout the plant during normal operating conditions and accidents. During the audit and interactions with the applicant, the NRC staff may develop detailed requests for information, which would be part of a future formal correspondence.

Regulatory Audit Basis:

The audit basis is to ensure that the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52.47(a)(5), 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 61, "Fuel Storage and Handling and Radioactivity Control," 10 CFR 50.34(f)(2)(vii), and 10 CFR 50.34(f)(2)(viii) are met. 10 CFR 52.47(a)(5) requires that the FSAR contain the kinds and quantities of radioactive material and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in 10 CFR Part 20, "Standards for Protection Against Radiation." 10 CFR 20 includes radiation dose limits, as well as the requirement to keep radiation exposure to workers and members of the public as low as is reasonably achievable (10 CFR 20.1101(b)). 10 CFR 50.34(f)(2)(vii) requires that the applicant perform radiation and shielding design reviews of spaces around systems that may, as a result of an accident, contain accident source term and design as necessary to permit adequate access to important areas and to protect safety equipment from the radiation environment. 10 CFR 50.34(f)(2)(viii) requires that samples may be taken during an accident without exceeding 5 rems to the whole body or 50 rems to the extremities. GDC 61 requires, in part, that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions, with suitable shielding for radiation protection, and with appropriate containment, confinement, and filtering systems. This audited information provides an additional level of detail that will support the NRC staff's availability to determine the acceptability of the APR1400 design certification application.

To ensure that the above requirements are met, the plant includes radiation shields to attenuate radiation from radiation sources in the plant. Radiation sources include the reactor core and spent fuel as well as fission and corrosion products that escape from the reactor coolant and accumulate in various systems and components located throughout the plant during normal operations.

During design basis accidents, dose rates inside containment and in fuel handling areas will increase significantly (dependent on the accident), therefore dose rates from systems designed to circulate post-accident fluid may also increase significantly. Therefore, additional shielding (beyond that which would be necessary for normal operation) is needed for certain areas so that

the necessary equipment can withstand accident conditions and so that operators can access the areas of the plant that may require access during and following an accident.

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 SER.

Regulatory Audit Scope:

The primary scope of this audit is to review the applicant's methodology, assumptions, and calculations used in determining radiation shielding thicknesses, as well as the resultant plant dose rates, including those associated with normal operation, outages, and accident conditions (including dose rates associated with vital area access) to determine if the radiation shielding and associated dose rate information provided in the DCD meet with the above mentioned requirements and are based on reasonable assumptions. This includes reviewing the necessary MICROSIELD, RUNT-G, MCNP, ANISN, and other computer code calculation input and output files. In addition, the staff will review the applicant's calculations for radiation shielding and zoning for normal operation to ensure that they are based on the assumed 0.25 percent failed fuel source terms specified in the DCD, as appropriate, and to ensure that the shielding, zoning, and vital area access calculations for post-accident conditions are consistent with Regulatory Guide 1.183 and other applicable guidance, and the information in the DCD. The NRC staff will focus its review on the general methodology and assumptions used by the applicant in determining shielding thicknesses and dose rates throughout the plant, both during normal operation and accident conditions and the detailed calculation for determining the thicknesses of a number of selected radiation shields, such as those associated with the more significant radiation sources during normal operation, outages, and accident conditions. This audit will not be of sufficient detail to verify that all aspects of the applicant's calculations are adequate. Instead, the staff will base its final conclusion of the general plant shielding design as a whole in the final safety evaluation report, based on the staff's review of these calculations, the staff's general shielding analysis performed by staff, and the results of RAI responses. Since this audit will focus on high level assumptions and the detailed shielding review for several selected areas, the staff will base the conclusions of this audit only on the areas reviewed by the staff during the audit.

The 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:

The NRC staff will review shielding calculations, dose calculations for access to vital areas, as well as shielding calculations which include relevant features such as shielding walls and floors in various locations.

Audit Team:

Edward Stutzcage, NRO Health Physicist, Audit Lead
John Vera, NRO Project Manager

Applicant Contacts:

Christopher Tyree (AECOM)
Harry Chang (KHNP)

Special Requests:

The NRC staff has requested that KHNP provide searchable electronic copies of the documents to be provided for NRC review.

Audit Activities and Deliverables:

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

This audit will not be a face-to-face audit, therefore communications and discussions will be conducted over the telephone during the audit time period. The audit is scheduled between February 12, 2016, and March 4, 2016. The audit will conclude with an exit conference call on March 4, 2016. Teleconferences with the applicant will be scheduled as needed during the audit time period.

The audit will be conducted from the NRC Headquarters through digital copy or via KHNP's electronic reading room.

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, and the information will be handled appropriately throughout the audit.

At the completion of the audit, the audit team will issue an audit summary within 45 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 12, 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 conduct of the audit may be communicated to John Vera (NRC) at 301-415-5790 or John.Vera@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.