



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 29, 2017

MEMORANDUM TO: Michael McCoppin, Chief
Licensing Branch 2
Division of New Reactor Licensing
Office of New Reactors

FROM: Tomeka Terry, Project Manager */RA/*
Licensing Branch 2
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: AUDIT REPORT FOR STRUCTURAL AND SEISMIC DESIGN
SUPPORTING CHAPTER 3, "DESIGN OF STRUCTURES, SYSTEMS,
COMPONENTS, AND EQUIPMENT," OF THE ADVANCED POWER
REACTOR 1400 DESIGN CONTROL DOCUMENT

The U.S. Nuclear Regulatory Commission staff conducted an audit for structural and seismic design supporting Chapter 3, "Design of Structures, Systems, Components, and Equipment" on Section 3.8.5 "Foundations." The Korea Electric Power Corporation and Korea Hydro & Nuclear Power Co., Ltd. (KHNP) submitted an application for a design certification of the Advanced Power Reactor (APR1400). The audit was held in Vienna, Virginia at KHNP Washington DC on August 24-25, 2017 and August 28-29, 2017. The purpose of the audit is to review the seismic analysis and structural design of the APR1400 foundation and to confirm the design approach in the APR1400 design control document.

The audit plan can be found in the Agencywide Documents Access and Management System under Accession No. ML17228A832 dated August 22, 2017. Enclosed is the audit report.

Docket No.: 52-046

Enclosures:

1. Audit Report
2. List of Attendees

cc w/encls.: See next page

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SUBJECT: AUDIT REPORT FOR STRUCTURAL AND SEISMIC DESIGN SUPPORTING
CHAPTER 3, "DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND
EQUIPMENT," OF THE ADVANCED POWER REACTOR 1400 DESIGN
CONTROL DOCUMENT DATED: 11/29/2017

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SUMMARY AUDIT REPORT OF APR1400 FOUNDATIONS

1.0 BACKGROUND

Title 10 of the *Code of Federal Regulations* Part 52, Section 47, "Contents of applications; technical information," states that:

The application must contain a level of design information sufficient to enable the Commission to judge the applicant's proposed means of assuring that construction conforms to the design and to reach a final conclusion on all safety questions associated with the design before the certification is granted. The information submitted for a design certification must include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the [U. S. Nuclear Regulatory Commission] NRC, and procurement specifications and construction and installation specifications by an applicant. The Commission will require, before design certification, that information normally contained in certain procurement specifications and construction and installation specifications be completed and available for audit if the information is necessary for the Commission to make its safety determination.

In conducting the review of the Advanced Power Reactor (APR1400) design control document (DCD) application, the U.S. Nuclear Regulatory Commission (NRC) staff requested that the applicant make available documentations for the seismic analysis and structural design of the APR1400 foundations.

The APR1400 foundation for the nuclear island (NI) common basemat supports the Reactor Containment Building which consists of the Pre-stressed Concrete Containment Vessel, Containment Internal Structures, and Auxiliary Building. Other APR1400 foundations consist of the Emergency Diesel Generator Building and the Diesel Fuel Oil Tank building.

The NRC staff performed an audit of the applicant's design, analysis reports and request for additional information (RAI) responses of its foundations to gain a better understanding of the foundation design and analysis approach used by KHNP. This audit also assisted the NRC staff in completing its technical review of Section 3.8.5 of the application. The staff reviewed the related documentation and supporting documents for the seismic analysis and structural design of the APR1400 foundations in order to address the following outstanding technical issues:

- (1) The consideration of construction sequence and settlements.
- (2) The different methods of analysis used (response spectra analysis and equivalent static).
- (3) The loads and load combinations used and how the transition region is designed.
- (4) The determination of differential displacements.

Subsequently, the NRC staff will also confirm that the markups in RAI responses are incorporated into the APR1400 DCD.

NRC Audit Team:

Ata Istar, NRC, Structural Design
 Vaughn Thomas, NRC, Structural Design
 Joseph Braverman, NRC, Structural Design, Consultant
 Luisette Candelario, NRC Geotechnical Engineer
 Ricardo Rodriguez, NRC Geotechnical Engineer
 Tomeka Terry, NRC, Project Manager

2.0 AUDIT RESULTS

During this audit, the NRC staff performed the review of seismic analyses and structural designs of the APR1400 foundations against the information described in Section 3.8.5 of the DCD application. The NRC staff reviewed design reports (e.g.; TR APR1400-E-S-NR14006-P, Revision 3) along with calculations supporting the following applicant’s RAIs responses:

RAIs	Questions	Subject	Results/Conclusions
255-8285	03.08.05-7	Construction sequence and settlement evaluation	The staff finds the response acceptable because the applicant performed a construction and post-construction sequence analysis and developed four types of settlement criteria in accordance with Standard Review Plan (SRP) 3.8.5.II.4.
255-8285	03.08.05-8	Load combinations, phasing of seismic loading from superstructures, linear and nonlinear (considering uplift) analysis, and directional combination method for seismic	The staff finds the response acceptable because the applicant used accelerations from the SSI analyses and conservatively enveloped member forces from the linear analysis cases, based on three soil profiles (S01 [soft], S04 [medium] and S08 [stiff]), and the nonlinear analysis cases (allowing for uplift) for the design of the NI basemat. The applicant further described that the enveloped results of the linear case (SRSS combination method) and the nonlinear case (100-40-40 combination method) are used in the design of the NI basemat.
255-8285	03.08.05-12	Seismic analysis approach for NI basemat design and calculation of maximum soil bearing pressure	The staff finds the response acceptable because the analysis approach for the basemat design and the calculation of maximum soil bearing pressures were performed in accordance with SRP 3.8.5.II.4. Also, these bearing pressures are lower than the allowable static and dynamic bearing pressure capacities specified as interface criteria for the site.

255-8285	03.08.05-13	Loads and load combinations for design of the foundation	The staff finds the response acceptable because the applicant provided the technical basis for the set of loads and load combinations used for design of the foundations.
255-8285	03.08.05-16	Soil media modeling for seismic analyses and stability evaluation	The staff finds the response acceptable because the applicant addressed the issues related to soil modulus values of E_{static} and $E_{dynamic}$, and revised COL 3.8(20) for performing site-specific evaluations of the NI foundation design and settlements.
255-8285	03.08.05-17	Calculation of settlements for developing settlement criteria	The staff finds the response acceptable because the applicant referred to RAI 255-8285, Question 03.08.05-7 for the detailed explanation and analysis of the effects from construction sequence on design and the various types of settlements during the construction sequence and post-construction phases of the NI.

During the audit, the NRC staff also reviewed drawings (plan and section views) and descriptions that reflect the design results, including reinforcing steel bars of the foundations, assumptions of the analysis and design methods used to reach the design results.

3.0 CONCLUSION

The NRC staff has the following conclusions:

The NRC staff finds that all of the RAI responses are acceptable as described in the table above. In addition, the applicant provided markups of the required changes to the APR1400 DCD and KHNP technical report on stability evaluation that were necessary for the NRC staff to reach its safety findings on the APR1400 foundation designs in support of the APR1400 DCD review.

Shortly after the audit, KHNP submitted official responses to the RAIs that included the markups to the APR1400 DCD and KHNP technical report for verification by the NRC staff.

List of Attendees

<u>Name</u>	<u>Affiliation</u>
Tomeka Terry	U.S. Nuclear Regulatory Commission (NRC)
Ata Istar	NRC
Vaughn Thomas	NRC
Luisette Candelario	NRC
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