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

March 19, 2018

Dr. Han-Gon Kim, Project Manager
APR1400 Design Certification
Advanced Reactors Development Laboratory
Korea Hydro and Nuclear Power Co., Ltd.
70, 1312-gil Yuseong-daero, Yuseong-gu, Daejeon,
305-343 Korea (Republic of)

SUBJECT: THE KOREA HYDRO AND NUCLEAR POWER CO. LTD ADVANCED POWER REACTOR 1400 AIRCRAFT IMPACT ASSESSMENT INSPECTION FOLLOW-UP, NUCLEAR REGULATORY COMMISSION INSPECTION REPORT NO. 05200046/2016-202

Dear Dr. Han-Gon Kim:

On February 7, 2018, the U.S. Nuclear Regulatory Commission (NRC) conducted an inspection of the Korea Hydro and Nuclear Power Co, LTD. (KHNP) Aircraft Impact Assessment (AIA) related to implementation of corrective actions associated with Notice of Violation (NOV) 05200046/2016-202-01 citied in NRC Inspection Report No. 05200046/2016-202 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17226A082). The NRC staff performed this inspection at the KHNP office in Vienna, VA on February 7, 2018. The purpose of the inspection was to assess KHNP's compliance with the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.150, "Aircraft Impact Assessment." The enclosed report presents the results of this inspection.

Based on KHNP's implementation of corrective actions associated with NOV 05200046/2016-202-01, the NRC inspection team concluded the KHNP is in compliance with the requirements of 10 CFR 50.150. The NRC inspection team did not identify any new violations within the scope of this inspection and has closed NOV 05200046/2016-202-01.

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," which is part of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's Agencywide Documents Access and Management System, which is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. This letter and its enclosures will be withheld for 5 days from the date of issuance to allow you to identify any information you consider to be proprietary or sensitive. If you consider any information in this letter or its

enclosures to be proprietary or sensitive, you must submit a timely request for the NRC to withhold that information in accordance with 10 CFR 2.390.

Sincerely,

/RA/

Terry W. Jackson, Chief
Quality Assurance Vendor Inspection Branch-1
Division of Construction Inspection
and Operational Programs
Office of New Reactors

Docket No.: 05200046

Enclosure:
Inspection Report No. 05200046/2017-202
and Attachment

SUBJECT: THE KOREA HYDRO AND NUCLEAR POWER CO. LTD ADVANCED POWER REACTOR 1400 AIRCRAFT IMPACT ASSESSMENT INSPECTION FOLLOW-UP, NUCLEAR REGULATORY COMMISSION INSPECTION REPORT NO. 05200046/2016-202

Dated: March 19, 2018

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U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NEW REACTORS
DIVISION OF CONSTRUCTION INSPECTION AND OPERATIONAL PROGRAMS
VENDOR INSPECTION REPORT

Docket No.:	05200046
Report No.:	05200046/2017202
Inspection Locations:	Korea Hydro and Nuclear Power Co, LTD. (KHNP) office in Vienna, VA
Contact:	Dr. Kapsun Kim
Nuclear Industry Activities:	Korea Hydro and Nuclear Power Co., Ltd. (KHNP) completed their aircraft impact assessment (AIA) of the advanced power reactor 1400 (APR1400) design certification to comply with the U.S. Nuclear Regulatory Commission requirements in Title 10 of the *Code of Federal Regulations* Section 50.150, "Aircraft Impact Assessment." The NRC performed an inspection of the KHNP AIA in July 2017. The inspection resulted in one Notice of Violation documented in NRC Inspection Report No. 05200046/2016-202 (ADAMS Accession No. ML17226A082.)
Inspection Date:	February 7, 2018
Inspectors:	Stacy Smith, Team Leader, NSIR/DSO/SOSB Ryan Nolan, NRO/DSRA/SRSB Ata Istar, NRO/DEI/SEB
Approved by:	Terry W. Jackson, Chief Quality Assurance Vendor Inspection Branch-1 Division of Construction Inspection and Operational Programs Office of New Reactors

Enclosure

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) conducted this inspection to verify that Korea Hydro and Nuclear Power Co, LTD. (KHNP) had implemented the provisions of 10 CFR 50.150, "Aircraft Impact Assessment," and performed a design-specific assessment [1] of the effects on the facility of the impact of a large commercial aircraft. Specifically, this inspection verified corrective actions associated with Notice of Violation (NOV) 05200046/2016-202-01 citied in NRC Inspection Report (IR) No. 05200046/2016-202 (ADAMS Accession No. ML17226A082).

The NRC conducted the inspection of KHNP in Vienna, VA, on February 7, 2018.

The following served as the bases for the NRC inspection:

- 10 CFR 50.150

During this inspection, the NRC inspection team implemented Inspection Procedure (IP) 37804, "Aircraft Impact Assessment," dated February 9, 2012.

This inspection was performed to verify that KHNP's aircraft impact assessment (AIA) of the advanced power reactor 1400 (APR 1400) design complies with the requirements of 10 CFR 50.150. Revision 8 of NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," dated April 2011, has been endorsed by the NRC in Regulatory Guide (RG) 1.217, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts," as one means of performing an AIA acceptable to the NRC. Specifically, this inspection was performed to verify implementation of KHNP's corrective actions to determine whether full compliance has been achieved and maintained.

The NRC inspection team concluded that the portions of the KHNP AIA reviewed by the NRC inspection team comply with the applicable requirements of 10 CFR 50.150. The NRC inspection team did not identify any new violations within the scope of this inspection and has closed NOV 05200046/2016-202-01.

The results of the inspection are summarized below.

Corrective Actions Associated with NOV 05200046/2016-202-01

Based on KHNP's implementation of corrective actions associated with NOV 05200046/2016-202-01, the NRC inspection team concluded KHNP is in compliance with the requirements of 10 CFR 50.150. The NRC inspection team has closed Violation 05200046/2016-202-01.

[1] By a ''design-specific'' assessment, the NRC means that the impact assessment must address the specific design of the facility that is either the subject of a construction permit, operating license, standard design certification, standard design approval, combined license, or manufacturing license application (see 74 FR 28129; June 12, 2009).

REPORT DETAILS

1. Corrective Actions Associated with NOV 05200046/2016-202-01

   a. Inspection Scope

      The NRC inspection team reviewed corrective actions associated with the three examples of NOV 05200046/2016-202-01 documented in NRC IR 05200046/2016-202 (ML17226A082).

      - Example 1 – Identification of Key Design Features

        KHNP failed to identify or incorporate the following design features and functional capabilities:

        - ultimate heat sink;
        - cabling for the safety-related instrumentation and control in the A and B equipment rooms;
        - design and configuration of viewing areas in the A and B diesel generator control rooms;
        - design of the wall and the size of rebar used in the exterior walls of the main steam valve rooms;
        - design and configuration of the polar crane support bracers and girders; and,
        - design and configuration of auxiliary building (AB) interior and exterior walls.

        In addition, the AIA relied upon the design and configuration of the auxiliary building exterior walls to show how spent fuel pool (SFP) integrity is maintained. However, the design control document (DCD) does not identify or describe the design and configuration of the auxiliary building exterior walls, which contribute to the protection of the SFP.

      - Example 2 – Essential Chilled Water System & Remote Shutdown Room

        KHNP failed to perform a design specific assessment in certain portions of the AIA. Specially, the AIA credits component cooling water to provide room cooling for systems relied upon to support core cooling (such as the motor driven auxiliary feed water pumps and safety injection pumps). However, the essential chilled water system (ECWS) is the system designed to provide room cooling. The essential chilled water system was not identified nor considered as a key design feature in the assessment; and, as a result, it was not analyzed in the assessment nor identified or described in the DCD. In addition, the AIA incorrectly credits the remote shutdown room for controlling core cooling equipment for a number of aircraft impact scenarios.

      - Example 3 – Realistic Analyses of Concrete Strength

        KHNP failed to use realistic analyses in certain portions of the AIA. Specifically, KHNP used a non-realistic value of concrete strength gain to analyze aircraft

impacts. Specifically KHNP utilized 91-day test strength values for concrete and NEI 07-13 aging factors, but the NEI 07-13 aging factors are intended for use with 28-day test strengths. The resulted in non-realistic values for the aging strength gain of the concrete.

The NRC inspection team reviewed actions taken in Condition Report (CR) 11E47-CR-17-N-244, dated September 14, 2017, that addressed the three examples of NOV 05200046/2016-202-01 documented in IR 05200046/2016-202. The team also reviewed CR 11E47-CR-18-N-014, dated January 31, 2018, that addressed a self-assessment performed by KHNP to verify consistency between the AIA report and the DCD.

Furthermore, the NRC inspection team reviewed KHNPs response to the NOV submitted on September 29, 2017 (ADAMS Accession Nos. ML17272A600 & ML17272A602) and supplemental response in December 1, 2017 (ADAMS Accession Nos. ML17335A073 & ML17335A075).

b. Observations and Findings

b.1 Example 1 – Identification of Key Design Features

The NRC inspection team verified that the six design features identified in the first example of the NOV were appropriately identified and incorporated in the DCD.

Specifically, the NRC inspection team verified that the ultimate heat sink, cabling for the safety-related instrument and control rooms, and design and configuration of the A and B diesel generator control rooms were appropriately identified and incorporated in DCD mark-ups provided to the NRC in the September 29, 2017, and December 1, 2017, responses.

In addition, NRC inspection team verified that KHNP correctly provided required rebar areas in the exterior walls of the main steam valve rooms, which were tabulated and depicted in figures as the key design features of the assessment and in the DCD. In addition KHNP identified and described the polar crane bracket and rail girder in the DCD, tabulated the properties, and described them as key design features to protect the safety systems located inside containment from the drop of the polar crane due to the strike of a large commercial aircraft. The inspectors reviewed KHNP's structural assessment cases due to direct strike near the crane girder support with different parked positions of the crane in the Section 3.0, "Primary Integrity of Containment," in report APR1400-E-P-NR-P-SGI, Revision 3. The inspectors verified that KHNP used appropriate design inputs (including the structural analysis parameters), assumptions, and adequate documentation to analyze the damage to the polar crane bracket and rail girder resulting from direct strikes near the crane girder support of a large commercial aircraft.

The NRC inspection team verified that KHNP provided the required rebar areas in tabulated form and figures, showing interior and exterior walls in the DCD for the AB and diesel generator building, which were credited as the key design features against the strike of a large commercial aircraft. In addition, the NRC verified that KHNP described

the design and configuration of the AB exterior walls that contribute to the protection of the SFP in the DCD.

b.2 Example 2 –Essential Chilled Water System & Remote Shutdown Room

The NRC inspection team verified that the ECWS is now correctly credited for providing room cooling to equipment credited for core cooling. In addition, an assumption was added to the heat removal assessment which states that an aircraft strike cannot affect both headers of the ECWS. KHNP performed additional structural analysis and design changes to ensure the ECWS was protected. Since the final piping layout of the ECWS and component cooling water system are not complete at this time, KHNP added a combined license (COL) item to the DCD that requires a COL applicant to design the piping layout so that a piping failure from an aircraft impact will not cause a total loss of cooling capability. The NRC inspection team concluded the AIA properly assessed the ECWS, and the COL item identified in the DCD will ensure the AIA would not become invalidated.

In addition, the NRC inspection team reviewed and verified the heat removal assessment was revised to correctly identify the Remote Control Center (RCC) for providing control to the operators for certain strikes; specifically, Strikes 21, 110, 111, and 112. The inspectors noted the remaining strikes that originally identified the Remote Shutdown Room as providing control were also revised to identify the RCC as the credited means of control.

The NRC inspection team reviewed KHNP's structural assessment to demonstrate sufficient protection of the ECWS against the strike of a large commercial aircraft, as described in the new Section 7.0, "Protection of Essential Chilled Water Systems," in Report APR1400-E-P-NR-P-SGI, Revision 3. KHNP found the ECWS is vulnerable to physical damage from single aircraft strikes. KHNP performed modeling and analyses to assess these vulnerabilities and identified structural strengthening measures to protect the ECWS. KHNP's assessment included four analysis cases of aircraft strikes. The NRC inspectors verified that KHNP provided the required rebar areas in the walls and slabs in the AB and diesel generator buildings, which were tabulated and depicted in a figure as the key design features of the assessment and in the DCD. Furthermore, the NRC inspection team verified that KHNP used appropriate design inputs, including the structural analysis parameters and assumptions, in each analysis cases. Lastly, the NRC inspector's verified that KHNP adequately documented and analyzed the damage to walls protecting the ECWS from the strike of a large commercial aircraft.

b.3 Example 3 – Realistic Analyses of Concrete Strength

The NRC inspection team reviewed the material properties of concrete for the AB and reactor containment buildings used in the structural analyses. The inspectors determined and concluded that KHNP met the guidance provided of NEI 07-13, Revision 8, for the compressive test strengths of concrete at 28 days used in the analyses and by identifying them as the key design features in the DCD.

c. Conclusions

Based on KHNP's implementation of corrective actions associated with NOV 05200046/2016-202-01, the NRC inspection team concluded the KHNP is in compliance with the requirements of 10 CFR 50.150. The NRC inspection team has closed Violation 05200046/2016-202-01.

2. Entrance and Exit Meetings

On February 7, 2018, the NRC inspection team discussed the scope of the inspection with representatives from KHNP. At the end of the day, the NRC inspection team presented the inspection results during an exit meeting with representatives from KHNP.

ATTACHMENT

1. PERSONS CONTACTED

Name	Affiliation	Entrance	Exit	Interviewed
James Steckel	NRC	X	X	
Ata Istar	NRC	X	X	
Ryan Nolan	NRC	X	X	
Stacy Smith	NRC	X	X	
Randy James	SIA	X	X	X
Ilhwan Moon	KEPCO E&C	X	X	X
Jimkyoo Yoon	KEPCO E&C	X	X	X
Kapsun Kim	KHNP	X	X	X
Jungho Kim	KHNP	X	X	X
Jiyong Oh	KHNP	X	X	X
Daejoong Kim	KEPCO E&C		X	
Sunghoon Kang	KEPCO E&C		X	

2. Inspection Procedures Used

Inspection Procedure 37804, “Aircraft Impact Assessment,” dated February 9, 2012.

3. List of Items Opened, Closed, and Discussed

Item Number	Status	Type	Description
05200046/2016-202-01	CLOSED	NOV	10 CFR 50.150(a)(1)

4. Documents Reviewed

Condition Reports

CR 11E47-CR-17-N-244, dated September 14, 2017
CR 11E47-CR-18-N-014, dated January 31, 2018

Letters

MKD/NW-17-0321L, “Subject: Reply to a Notice of Violation Report No. 05200046/2016-202,” dated September 29, 2017

MKD/NW-17-0372L, “Subject: Supplemental Reply to a Notice of Violation Report No. 05200046/2016-202,” dated December 1, 2017 (ML17335A073)

Procedures

EP-3.06, “Corrective Action Program,” Revision 4
EP-6.07, “Engineering Drawing,” Revision 3

5. ACRONYMS USED:

AB	auxiliary building
APR1400	advanced power reactor 1400
ADAMS	Agencywide Documents Access and Management System
AIA	aircraft impact assessment
ADAMS	Agencywide Documents Access and Management System
CFR	Code of Federal Regulations
COL	Combined license
CR	Condition Report
DCD	design control document
DCIP	Division of Construction Inspection and Operational Programs
DEI	Division of Engineering and Infrastructure
DSO	Division of Security Operations
DSRA	Division of Safety Systems, Risk Assessment, and Advanced Reactors
ECWS	essential chilled water system
IP	inspection procedure
IR	inspection report
KHNP	Korea Hydro and Nuclear Power Co, LTD
NEI	Nuclear Energy Institute
NOV	Notice of Violation
NRC	(U.S.) Nuclear Regulatory Commission
NRO	Office of New Reactors
NSIR	Nuclear Security and Incident Response
QA	quality assurance
RCC	Remote Control Center
RG	Regulatory Guide
SFP	spent fuel pool
SEB	structural engineering branch
SIA	Structural Integrity Association
SOSB	security oversight and support branch
SRSB	Reactor Systems, Nuclear Performance & Code Review
U.S.	United States (of America)