May 14, 2015

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

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

William Ward, Sr. Project Manager ***/RA/***
Licensing Branch 2
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: SUMMARY OF APRIL 14 - 15, 2015, PUBLIC MEETING WITH KOREA HYDRO AND NUCLEAR POWER CO. LTD. TO DISCUSS TOPICS RELATED TO ADVANCED POWER REACTOR 1400 DESIGN

On April 14 and 15, 2015, a Category 1 public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) staff and Korea Hydro and Nuclear Power Co. Ltd. (KHNP) at the NRC offices in Rockville, Maryland. The business portion of the meeting on the morning of April 15, 2015, was closed to the public because of the discussion of proprietary presentation material. However, the remainder of the meeting was open to the public. The meeting notice was issued on March 25, 2015, and was documented in the NRC Agencywide Documents Access and Management System (ADAMS) under Accession Number (No.) ML15097A268. The notice included the meeting agenda.

The purpose of the meeting was to discuss various proprietary and non-proprietary topics related to the Advanced Power Reactor 1400 (APR1400) design certification application that was submitted to the NRC on December 23, 2014, and formally accepted for review on March 6, 2015. For the proprietary KHNP presentation used on the morning of April 15, 2015, non-proprietary versions have been received and entered into ADAMS. The four sets of non-proprietary slides from KHNP are available in ADAMS using the package Accession No. ML15117A674. Slides presented by the NRC staff under the title “APR1400 Design Certification Review Mechanical Engineering Topics,” Enclosure 1, are available in ADAMS using Accession No. ML15110A141.

The List of Attendees is provided as Enclosure 2.

The meeting discussion addressed five major topics, focusing on clarification of the APR1400 design certification applicant's approach and identification of issues with material presented in the design control document (DCD) and associated technical reports:

- Piping design
- Design and procurement specification development schedule
- Jet impingement evaluation methodology for APR1400
- Functional design, qualification, and inservice testing (IST) programs
- Additional mechanical engineering topics

Piping Design

In the discussion of piping design, the NRC staff described the historical background and highlights of the "graded approach" to the level of detail necessary for design certification that KHNP intends to follow in its application. Implementation of this approach eliminates the need for design acceptance criteria (DAC) that have been used in other design certifications, as well as for combined license (COL) applicant action, other than to address site-specific items, at the application stage. KHNP presented their approach and described the current status of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (BPV Code) Class 1 piping system design, as well as portions of the main steam and feedwater piping from the steam generators to the first anchor beyond the containment isolation valves. Most of these analyses will be complete and available for NRC staff audit by the end of August 2015, with certain segments of the main steam and feedwater piping not available until the end of December 2015. KHNP also described their plans for performing environmentally-assisted fatigue (EAF) analyses in accordance with Revision 0 of both Regulatory Guide 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor [LWR] Environment for New Reactors," and its associated NUREG/CR-6909, "Effect of LWR Coolant Environments on the Fatigue Life or Reactor Materials." These analyses will be complete by the end of March 2016.

The NRC staff also described five additional clarifications needed in the piping analysis methodology description in DCD Tier 2, Section 3.12, "Piping Design Review," related to thermal anchor movements, nominal cold gaps, decoupling criteria, stiff pipe clamps, and support mass consideration.

As a result of this discussion, KHNP voiced its intent to revise the DCD as follows:

1. Delete COL items 3.12(1), 3.12(3), 3.12(4), 3.12(5), 3.12(6), and 3.12(7), as they describe activities that are actually being performed by KHNP within the scope of the design certification. Detailed design implementation by the COL licensee will be addressed using ASME BPV Code-related inspections, tests, analyses, and acceptance criteria (ITAAC).
2. Confirm the wording in COL item 3.12(2) to focus on a revision to design certification stage analyses performed by KHNP if site-specific design basis loads exceed those assumed in the design.
3. Delete the DAC ITAAC associated with EAF analyses, as they will be performed at the design certification stage.

4. Provide summary information on the analysis approach (e.g., selection of certain piping systems based on the graded approach) and results (e.g., relationship to ASME BPV Code allowed stresses).
5. Update description of thermal anchor movement exclusion in DCD Tier 2, Section 3.12.5.3.3 to reflect exclusion only if necessary, depending on as-built verification of gap size.
6. Update discussion of nominal cold gap to clarify that the gap may not be in all directions (e.g., bottom side for vertical support of deadweight).
7. Clarify decoupling criteria used in DCD Tier 2, Section 3.12.4.4 to justify any differences from DCD Tier 2, Section 3.7.2.3.2. The NRC staff observed that the Section 3.12 criteria were different from the guidance in Standard Review Plan (SRP) Section 3.7.2, Seismic System Analysis, and that the use of more than one decoupling criteria in the DCD is likely unnecessary and should be justified. If the branch geometry is known, there is generally no need to decouple it from the header. If it is still needed to decouple the branch from the header, while the branch geometry is known, justify the need and apply consistent decoupling criteria in accordance with those in DCD Tier 2, Section 3.7.2.3.2. If only the size of the branch is known, then, as the NRC staff clarified, the Welding Research Council Bulletin 300, "Technical Position on Damping and on Industry Practice," provides a technical justification for using the moment of inertia ratio of 25 for decoupling with exceptions.
8. Describe how pipe support masses are considered in the piping stress analysis for deadweight and seismic loadings.

KHNP clarified that the APR1400 design does not use stiff pipe clamps and clamps of the type identified in NRC Information Notice 83-80, "Use of Specialized 'Stiff' Pipe Clamps," and Generic Safety Issue 89, "Stiff Pipe Clamps" (described in NUREG-0933, "Resolution of Generic Safety Issues"), and voiced its intent to providing this clarification in writing.

Design and Procurement Specifications

In the discussion of design and procurement specifications, the NRC staff provided information on previous audits performed of design certification applicants' specifications to support a regulatory finding under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 52.47, "Contents of applications; technical information," which requires in part that "information normally contained in certain procurement specifications and construction and installation specifications be completed and available for audit." KHNP described their current progress in developing specifications. Specifically, design specifications are complete for nuclear steam supply system (NSSS) components at a level of detail consistent with the staff's expectations. Piping system design specifications for other systems have been prepared to support the piping analyses. For these piping systems, detailed design information exists in a number of documents such as system design criteria and system functional descriptions. In addition, the applicant has prepared technical specifications that are similar to design specifications for some plant system components in the previous APR1400 project (e.g., SKN 3&4).

In a follow-up discussion, the NRC staff clarified that an acceptable audit scope would include samples from these categories of documents, with a "crosswalk" or process document available to show how procurement specifications would be prepared from detailed design documents.

To support the future audit, KHNP voiced its intent to provide a list of the design and technical specifications for all safety-related structures, systems, and components (SSCs) in the NSSS and other plant systems for the APR1400 design. The NRC staff will select a sample of the safety-related SSCs for audit of their specifications in accordance with 10 CFR 52.47. In addition, the NRC staff might conduct an audit of the specifications for a sample of nonsafety-related SSCs with high safety significance.

Functional Design, Qualification, and IST of Pumps, Valves, and Dynamic Restraints

KHNP provided a presentation that addressed some initial issues with DCD Tier 2, Section 3.9.6, "Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints," that were identified by the NRC staff during the acceptance review. Specifically, KHNP voiced its intent to revise the DCD as follows:

1. Add commitments to incorporate the guidance of NUREG-1482, "Guidelines for Inservice Testing at Nuclear Power Plants," Revision 2, Generic Letter 96-05, "Periodic Verification of Design-Basis capability of Safety-Related Power-Operated Valves," and the Joint Owners Group (JOG) Motor-Operated Valve (MOV) Periodic Verification Program.
2. Add implementation of ASME *Operation and Maintenance of Nuclear Power Plants* (OM Code) cases OMN-1 and OMN-13, as accepted in Regulatory Guide 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," Revision 1.
3. Specify functional qualification of safety-related active pumps, valves, and dynamic restraints in accordance with ASME QME-1-2007, as accepted in Regulatory Guide 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," Revision 3.
4. Include a COL item for the COL applicant to provide a full description of the IST program.

The NRC staff provided an overview discussion of previous design certification reviews of functional design, qualification, and IST programs for pumps, valves, and dynamic restraints. The NRC staff described the COL applicant's responsibility to either fully describe the IST program or include an ITAAC for the operational program, and the efficiencies that could be gained if a design certification applicant chooses to fully describe a program that the COL applicant can incorporate by reference. The NRC staff's slides (referenced above) provided multiple suggestions and proposed changes to the DCD to clarify information, correct inconsistencies and outdated information, and (if KHNP chooses to) complete the full description of the IST program. KHNP voiced its intent to consider these additional items and provide appropriate changes to the DCD.

Pipe Rupture Hazards Analysis

In this portion of the meeting, the NRC staff described potential non-conservatisms in the jet modeling in the American National Standards Institute (ANSI) / American Nuclear Society (ANS) Standard 58.2, "Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture," 1988 Edition, referenced by KHNP in the DCD. As an update to the SRP to provide more specificity on these issues is still underway, the NRC staff pointed KHNP to the public discussion of these issues in the draft Appendix A to Section 3.6.2 of the mPower Design-Specific Review Standard (DSRS), "Determination of Rupture Locations

and Dynamic Effects Associated with the Postulated Rupture of Piping," (available at ADAMS Accession No. ML12230A013). To support the discussion, the NRC staff also provided select printed pages from the following publicly available documents:

- ANSI/ANS 58.2, pages 52 and 53
- Wallis, G., "The ANSI/ANS Standard 58.2-1988: Two Phase Jet Model," September 14, 2004 (ADAMS Accession No. ML050830344), page 9

KHNP described proprietary aspects of their overall plan to address these issues, which involves computational fluid dynamics (CFD) and an analytical model based on open literature. The applicant also described the schedule for completing certain portions of the analyses in June 2015, followed by another interaction with the NRC, all analyses by the end of August 2015, and a final technical report submittal by the end of September 2015. KHNP also voiced its intent to provide summary information on the pipe rupture hazards analysis approach in the DCD, similar to what will be provided for the piping analysis, given that DAC are not expected to be used.

Overall, the NRC staff found that the methodology described by KHNP appears to be reasonable and conservative. However, the staff noted that the technical report should include detailed information to substantiate or justify the applicability of the analytical model based on open literature or available test data. In addition, the staff noted that the convergence studies (spatial and time resolution) need to be described in the report when a CFD method is used. The staff will review the details of the methodology and its results that will be submitted in the report in September 2015.

The NRC staff's slides (referenced above) described additional clarifications that should be included in the DCD description of pipe ruptures. To support the discussion of ITAAC, the NRC staff provided page 13 of the master list of standardized ITAAC provided by the NRC at a public meeting with industry representatives on April 1, 2015 (Accession No. ML15086A191). The NRC staff also provided an additional request for clarification not presented on the slides, observing that the discussion of "analyzed/unanalyzed" boundaries on page 3.6-14 of DCD Tier 2, Section 3.6.2 could be confusing and should match the classification breaks described in DCD Tier 2, Section 3.2. KHNP voiced its intent to consider these additional items and provide appropriate changes to the DCD.

Additional Mechanical Engineering Topics

On the final afternoon of the meeting, the NRC staff presented slides that listed certain clarifications needed and inconsistencies that should be corrected in other DCD sections reviewed by the Mechanical Engineering Branch.

DCD Tier 2, Sections 3.2.1, "Seismic classification," and 3.2.2, "System Quality Group Classification"

The NRC staff described multiple clarifications and inconsistencies related to these classification topics and the associated DCD Table 3.2-1. KHNP addressed some of these issues in the meeting (e.g., clarifying references on p. 3.2-4 that were in error and clarifying the codes of record for the APR1400) and voiced a general intention to address all of the issues identified by the staff through changes to the DCD.

DCD Tier 2, Section 3.9.1, "Special Topics for Mechanical Components"

The NRC staff described the scope of audits typically performed to address computer code verification and validation details described in SRP Section 3.9.1. KHNP indicated that the information needed was available for audit, so a future audit will be planned (see list below). In addition, the NRC staff identified a potential gap because no transient events were classified as Service Level C conditions. KHNP clarified that the same events have been addressed, but were generally recategorized in a conservative fashion. The applicant expressed its intent to update the DCD description to clarify and justify any differences from previous NRC guidance.

DCD Tier 2, Section 3.9.2, "Dynamic Testing and Analysis of Systems, Components, and Equipment"

The NRC staff described multiple locations in DCD Section 3.9.2 and the associated technical report, APR1400-Z-M-NR-14009, "Comprehensive Vibration Assessment Program for the Reactor Vessel Internals," where clarifications would support the staff's review. For several items, KHNP clarified the similarity of the APR1400 approach to the System 80+ certified design approach and suggested references in the DCD, as well as specific portions of the DCD and technical report, that should aid the staff's review. KHNP also provided information on the historical nature of the fatigue endurance limit listed in Table 2-5, "Predicted and Measured Stresses of the Valid Prototype," (proprietary) of the technical report; clarified the use of absolute sum to combine loads from pump pulsation, random turbulence, and vortex shedding; and described the assumption about pumps being in phase. For the pump phase item, KHNP voiced the intent to evaluate the DCD description and add appropriate justification for the assumption.

DCD Tier 2, Section 3.9.3, "ASME Code Class 1, 2 and 3 Components, Component Supports, and Class CS Core Support Structures"

The NRC staff identified, on their slides, several DCD statements that should be clarified or deleted. For example, COL item 3.9(2) (and references in the text) should be deleted based on the level of detail necessary at the application stage; instead, ITAAC for as-built component design reports address this topic. KHNP voiced its intent to revise the DCD to address each of these.

DCD Tier 2, Section 3.9.4, "Control Element Drive Mechanisms"

The NRC staff raised two issues for clarification described on the slides. For the first issue regarding deformation, KHNP described that this information was based on the System 80 scram test, and that more information would be available for audit in stress reports for the control element drive mechanism (CEDM), to be completed by June. The NRC staff may audit these reports in support of their review. For the second issue regarding material changes, KHNP clarified that the components changed are not moving parts and do not affect the life cycle of the CEDM.

DCD Tier 2, Section 3.9.5, "Reactor Pressure Vessel Internals"

The NRC staff described additional information that may be needed to support the review of dimensional change accommodation and retention of components in the reactor internals. KHNP clarified that multiple figures are available in the DCD, and additional information may be found in Table 3.9-16, "Nominal Dimensional Comparison of Reactor Internals," and DCD Tier 2, Sections 3.9.5, 4.5.2, and 4.5.2.6. KHNP also clarified that preload issues for fasteners have been considered in the selection of materials, as well as through the design of an insert pin and lock bar. Further information is available in the stress report and drawings for the reactor internals, to be completed by June. The NRC staff may audit these reports in support of their review.

DCD Tier 2, Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment"

The NRC staff observed that the discussion of fatigue cycles and amplitudes in DCD Tier 2, Section 3.10.1.3 is not consistent with SRP Section 3.10. KHNP described the relationship of this information to SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," as well as Annex D to IEEE Standard 344. The applicant voiced the intent to check this information and give a response that either justifies or revises the assumption. KHNP also confirmed that an erroneous reference was provided in DCD Tier 2, Section 3.10.2.2.d and voiced its intent to correct it in the DCD.

DCD Tier 2, Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment"

The NRC staff provided an overview discussion of NRC reviews of environmental qualification (EQ), both at the design and operational stage. The types of information outlined by the NRC in the first bullet of the first slide for this section should be included consistently in both DCD Tier 2, Section 3.11 (where some related but incomplete information is currently in 3.11, 3.11.2, 3.11.3.2, and 3.11.6) and in the associated technical report APR1400-E-X-NR-14001, "Equipment Qualification Program." KHNP voiced its intent to make these changes, as well as to address the issues raised with ITAAC. KHNP also clarified that the equipment tables in the two documents should be the same, and that the scope of these tables was safety-related equipment.

The NRC staff described the COL applicant's responsibility to either fully describe the EQ operational program or include an ITAAC for the operational program, and the efficiencies that could be gained if a design certification applicant chooses to fully describe a program that the COL applicant can incorporate by reference. The NRC staff's slides (referenced above) provided multiple suggestions and proposed changes to the DCD to clarify information, correct inconsistencies information, and (if KHNP chooses to) complete the full description of the EQ program. KHNP voiced its intent to consider these additional items and provide appropriate changes to the DCD.

Future Interactions

As a result of the meeting discussions, the following audits are planned tentatively, with formal audit plans to be issued closer to the audit date:

- June 2015: Design and procurement specifications (possibly with stress reports for certain components that will be completed by June).
- June 2015: Computer code verification and validation for selected codes and references listed in DCD Tier 2, Section 3.9.1.
- August 2015: Completed piping analyses, including Class 1 main and branch lines and portions of the main steam and feedwater piping, with the exception of EAF analyses; completed pipe rupture hazards analyses and completed analyses, with the exception of updated jet impingement loads.
- March 2016: Follow-up audit on piping analysis, including EAF analyses and additional segments of the main steam and feedwater piping; follow-up audit on pipe rupture hazard analyses, including updated jet impingement loads.

The NRC staff plans to have additional public meetings on topics reviewed by the Mechanical Engineering Branch. To follow the progress of the jet impingement modeling approach, two potential meetings or teleconferences may be conducted in approximately June and August 2015. Additional meetings or teleconferences may be scheduled during the Phase 1 review to cover other needed clarifications on mechanical engineering topics not addressed in the April 2015 meeting. Meeting notices will be issued for each interaction following normal NRC processes.

At the conclusion of the meeting, KHNP committed to consider all of the feedback from the meeting and propose the most effective approach for providing updated information to the NRC (e.g., a letter with DCD markups or a response to an NRC request for additional information). KHNP will engage with the NRC project managers to finalize the path forward on these issues.

Please direct any inquiries by phone to William Ward at 301-415-7038 or via e-mail to William.Ward@nrc.gov or Bruce Olson at 301-415-3731 or via e-mail to Bruce.Olson@nrc.gov.

Docket No.: 052-046

Enclosure:
1. APR1400 Design Certification Review
   Mechanical Engineering Topics Presentation
2. List of Attendees

cc w/enclosure: See next page

- June 2015: Design and procurement specifications (possibly with stress reports for certain components that will be completed by June)
- June 2015: Computer code verification and validation for selected codes and references listed in DCD Tier 2, Section 3.9.1
- August 2015: Completed piping analyses, including Class 1 main and branch lines and portions of the main steam and feedwater piping, with the exception of EAF analyses; completed pipe rupture hazards analyses and completed analyses, with the exception of updated jet impingement loads
- March 2016: Follow-up audit on piping analysis, including EAF analyses and additional segments of the main steam and feedwater piping; follow-up audit on pipe rupture hazard analyses, including updated jet impingement loads

The NRC staff plans additional public meetings on topics reviewed by the Mechanical Engineering Branch. To follow the progress of the jet impingement modeling approach, two potential meetings or teleconferences may be conducted in approximately June and August 2015. Additional meetings or teleconferences may be scheduled during the Phase 1 review to cover other needed clarifications on mechanical engineering topics not addressed in the April 2015 meeting. Meeting notices will be issued for each interaction following normal NRC processes.

At the conclusion of the meeting, KHNP committed to consider all of the feedback from the meeting and proposed the most effective approach for providing updated information to the NRC (e.g., a letter with DCD markups or a response to an NRC request for additional information). KHNP will engage with the NRC project managers to finalize the path forward on these issues.

Please direct any inquiries by phone to William Ward at 301-415-7038 or via e-mail to William.Ward@nrc.gov or Bruce Olson at 301-415-3731 or via e-mail to Bruce.Olson@nrc.gov.

Docket No.: 052-046

Enclosure:
1. APR1400 Design Certification Review
   Mechanical Engineering Topics Presentation
2. List of Attendees

cc w/enclosure: See next page

DISTRIBUTION:
See Next Page

ADAMS Accession No: Pkg.: ML15124A886 **NRC-001**

OFFICE	DNRL/LB2: PM	DNRL/LB2: PM	DNRL/LB2: LA	DNRL/LB2: PM
NAME	BOlson	WWard	CMurphy (MBrown for)	JCiocco
DATE	05/04/15	05/01/15	05/06/15	05/07/15

OFFICE	DNRL/LB2: PM (s)	DNRL/LB2: PM (s)
NAME	Bolson	WWard
DATE	05/12/15	05/14/15

OFFICIAL RECORD COPY

Memo to Samuel Lee from Bruce Olson and William Ward dated May 14, 2015

SUBJECT: SUMMARY OF THE APRIL 14 - 15, 2015, PUBLIC MEETING WITH KOREA HYDRO AND NUCLEAR POWER CO. LTD. TO DISCUSS TOPICS RELATED TO THE ADVANCED POWER REACTOR 1400 DESIGN

DISTRIBUTION:

PUBLIC	RidsAcrsAcnwMailCenter	RidsNroLAMBrown	BOlson, NRO
LB2 R/F	RidsOgcMailCenter	RidsOpaMailCenter	SLee, NRO
D101	RidsNroDnrlEPB2	RidsNroDnrl	JCiocco, NRO
TClark, NRO	JSteckel, NRO	FAkstulewicz, NRO	JTappert, NRO
WWard, NRO	MDelligatti, NRO	RCaldwell, NRO	YLi, NRO
JHuang, NRO	ATsirigotis, NRO	JStrnisha, NRO	TLe, NRO
TScarbrough, NRO	YWong, NRO	CWu, NRO	YLaw, NRO
NHansing, NRO			

KHNP Mailing List

3/2/2015

Harry (Hyun Seung) Chang
Senior Manager
KHNP Washington DC Center
8100 Boone Blvd, Suite 620
Vienna, VA 22182

Myung-Ki Kim
Project Manager
APR1400 Design Certification
Korea Hydro and Nuclear Power Co.
70-1312-gil, Yuseong-daero, Yuseong-gu,
Daejeon, 305-343, Korea

Jung-Ho Kim
Senior Manager
Technology Policy & Planning Dept.
KHNP Headquarters
512 Yeongdong-daero Gangnam-gu
Seoul, 135-791, Korea

Yun Ho Kim
Director
KHNP Washington DC Center
8100 Boone Blvd, Suite 620
Vienna, VA 22182

Email

kimmkcri@khnp.co.kr [Myung-Ki Kim]
leejaeyong@khnp.co.kr [Jae Yong Lee]
hansang.kim@khnp.co.kr [Hansang Kim]
dohwan.lee@khnp.co.kr [Do-Hwan Lee]
hs.chang@khnp.co.kr; hyunseung.chang@gmail.com [Harry (Hyun Seung) Chang]
junghokim@khnp.co.kr [Jung-Ho Kim]
yunho.kim@khnp.co.kr; yshh8226@gmail.com [Yun Ho Kim]
kang.joonseok@khnp.co.kr [Joon-Seok Kang]
limhs@kepco.co.kr [Hyun Seung Lim]
beraka@kepco.co.kr [Seong Key Cho]
puritys@kepco.co.kr [Byeong Soo Kwon]
joys@kepco.co.kr [Young Sun Cho]