November 10, 2014

Dr. Myung Ki Kim
Korea Hydro and Nuclear Power Co. Ltd.
Central Research Institute
70-1312-GIL Yuseong-Daero, Yuseong-Gu
Daejeon, 305-343, Korea

SUBJECT: NUCLEAR REGULATORY COMMISSION INSPECTION OF KOREA HYDRO AND NUCLEAR POWER CO. LTD. REPORT NO. 99901453/2014-201 AND NOTICE OF VIOLATION

Dear Dr. Myung Ki Kim:

On September 22, 2014 through September 26, 2014, the U.S. Nuclear Regulatory Commission (NRC) conducted an inspection at the Korea Hydro and Nuclear Power (KHNP) Central Research Institute facilities in Daejeon, Republic of Korea. The purpose of this limited scope inspection was to assess KHNP's compliance with the provisions of selected portions of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and 10 CFR Part 21, "Reporting of Defects and Noncompliance." This inspection specifically evaluated KHNP's implementation of their quality assurance (QA) processes and procedures for testing activities performed in support of the KHNP design certification application. The enclosed report presents the results of this inspection. This NRC inspection report does not constitute NRC endorsement of your overall quality assurance QA or 10 CFR Part 21 programs.

Based on the results of this inspection, the NRC determined that four Severity Level IV violations of NRC requirements occurred. The NRC evaluated these violations in accordance with the agency's Enforcement Policy, which is available on the NRC's Web site at http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html.

These violations are cited in the enclosed Notice of Violation (Notice) and circumstances surrounding them are described in detail in the subject inspection report. The violations are being cited in the Notice because the NRC inspection team identified examples in which KHNP failed to adequately implement KHNP's design control, test control (2 violations) and corrective action in accordance with Appendix B to 10 CFR Part 50.

You are required to respond to this letter and should follow the instructions specified in the enclosed Notice when preparing your response. If you have additional information that you believe the NRC should consider, you may provide it in your response to the Notice. The NRC review of your response to the Notice will also determine whether further enforcement action is necessary to ensure compliance with regulatory requirements.

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," of NRC's "Rules of Practice," a copy of this letter, its enclosures, and your response 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, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy, proprietary, or Safeguards Information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request that such material be withheld from public disclosure, you must specifically identify the portions of your response that you seek to have withheld and provide, in detail, the bases for your claim (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."

Sincerely,

/RA Aaron Armstrong Acting for/
Kerri A. Kavanagh, Chief
Quality Assurance Vendor Inspection Branch
Division of Construction Inspection
and Operational Programs
Office of New Reactors

Project No.: 0782

Enclosures:
1. Notice of Violation
2. Inspection Report No. 99901453/2014-201
   and Attachment

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," of NRC's "Rules of Practice," a copy of this letter, its enclosures, and your response 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, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy, proprietary, or Safeguards Information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request that such material be withheld from public disclosure, you must specifically identify the portions of your response that you seek to have withheld and provide, in detail, the bases for your claim (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."

Sincerely,

Kerri A. Kavanagh, Chief
Quality Assurance Vendor Inspection Branch
Division of Construction Inspection
and Operational Programs
Office of New Reactors

Project No.: 0782

Enclosures:
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2. Inspection Report No. 99901453/2014-201
   and Attachment

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NOTICE OF VIOLATION

Korea Hydro and Nuclear Power Co. LTD.
Central Research Institute
70-1312-GIL Yuseong-Daero, Yuseong-Gu
Daejeon, 305-343, Korea

Project No.: 0782
Report No. 99901453/2014-201

During a U.S. Nuclear Regulatory Commission (NRC) inspection of Korea Hydro and Nuclear Power Co. Ltd., (KHNP) conducted at the KHNP Central Research Institute facilities in Daejeon, Republic of Korea, on September 22, 2014, through September 26, 2014, violations of NRC requirements were identified. In accordance with the NRC Enforcement Policy, the violations are listed below:

A. Criterion III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," states in part that, "the design control measures shall provide for verifying or checking the adequacy of design, such as by the performance of design reviews, by the use of alternate or simplified calculational methods, or by the performance of a suitable testing program. (…) Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, it shall include suitable qualifications testing of a prototype unit under the most adverse design conditions."

   "Design changes, including field changes, shall be subject to design control measures commensurate with those applied to the original design and be approved by the organization that performed the original design unless the applicant designates another responsible organization."

   Drawing #: K00-A1-001-SO1-M00, "Test Facility of In-vessel Test-Detailed Recirculation Flow Path RC-101," Revision 0, dated July 30, 2012 specifies the size of the flow channel around the fuel assembly.

   KHNP APR1400-K-A-I(RA)-P, "Test Plan for IDE of the APR1400," Revision 3, dated July 2014, Section 2.3, "Test Column," states, in part, "the bottom region is shaped as a cone to avoid settling and loss of debris during the test."

   <u>Contrary to the above</u>, as of September 26, 2014, KHNP failed to verify the adequacy of the design by the performance of a suitable testing program and to adequately control design changes. Specifically:

   a. KHNP did not verify that the test loop assembly met the design requirements for the size of the flow channel around the fuel assembly. The flow channel gap measurements taken by KHNP during the tests exceeded the design specifications stated in K00-A1-001-SO1-M00.

   b. KHNP did not verify that the lower plenum of the test loop assembly met the design requirements of a cone shape to prevent settling as required by KHNP APR1400-K-A-I(RA)-P. The lower plenum of the test loop

assembly did have a slight inclination angle. However, the inclination angle was inadequate resulting in significant debris settling.

c. KHNP failed to perform documented evaluations of design changes for changes to test loop assemblies to reduce impinging of bubbles in the system and debris settling.

This issue has been identified as Violation 99901453/2014-201-01.

This is a Severity Level IV violation (Section 6.5.d of the NRC Enforcement Policy).

B. Criterion XI, "Test Control" of Appendix B to 10 CFR Part 50 states, that, "A test program shall be established to assure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed in accordance with written test procedures which incorporate the requirements and acceptance limits contained in applicable design documents. (…) Test procedures shall include provisions for assuring that all prerequisites for the given test have been met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions."

DC-DG-11-02, "Test Procedure for the APR 1400 In-vessel Downstream Effects," describes the test parameters and steps to perform the in-vessel downstream effects tests.

Contrary to the above, as of September 26, 2014, KHNP failed to perform the test program in accordance with written test procedures and failed to assure that a prerequisite for the tests have been met. Specifically:

1. KHNP failed to use an approved procedure to perform testing. KHNP used a preliminary revision of the test procedure during a test and the later approved revision 4 included test parameters that differed from the preliminary revision used at the beginning of the test.

2. KHNP failed to follow the test procedure. KHNP failed to complete a quality control (QC) hold step and continued the test without stopping. KHNP also failed to appropriately document the measurements of the gap size as required by the test procedure.

3. KHNP failed to assure that a prerequisite for QC hold points acceptance criteria was achievable for cold leg break tests. The cold leg break test's QC hold point acceptance criteria required verification that the differential pressure (dP) change after 30 minutes of the debris addition was less than or equal (≤) 2%. However, the uncertainty for the dP change in the cold leg break tests exceeded the 2% dP change stated as the acceptance criteria.

This issue has been identified as Violation 99901453/2014-201-02.

This is a Severity Level IV violation (Section 6.5.d of the NRC Enforcement Policy).

C. Criterion XI, “Test Control” of Appendix B to 10 CFR Part 50 states, that, “Test procedures shall include provisions for assuring that all prerequisites for the given test have been met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions.”

   Contrary to the above, as of September 26, 2014, KHNP failed to assure that adequate test instrumentation was available and used during the tests. Specifically, KHNP used an electromagnetic flow meter outside its calibration range to measure and control flow during eight cold leg break tests. The flow rate used for the cold leg break tests were between 9.2 lpm (liters/minute) and 16.6 lpm, which was below the flow meter calibrated range of 34.17 lpm to 251.67 lpm.

   This issue has been identified as Violation 99901453/2014-201-03.

   This is a Severity Level IV violation (Section 6.5.d of the NRC Enforcement Policy

D. Criterion XVI, “Corrective Action,” of Appendix B to 10 CFR Part 50 states that measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected.

   The NRC conducted a regulatory audit on November 11-13, 2013 of Korea Hydro and Nuclear Power Co. Ltd. (KHNP), Advanced Power Reactor 1400 (APR1400) In-Vessel Downstream Effects (IDE) performance tests at KHNP Central Research Institute facility in Daejeon, South Korea. During the audit, NRC identified nine observations considered to be conditions adverse to quality.

   Contrary to the above, as of September 26, 2014, KHNP failed to promptly identify and correct conditions adverse to quality identified during the NRC audit in November 2013 and the NRC inspection in September 2014. Specifically,

   1. KHNP failed to identify in their corrective action program four of the nine conditions adverse to quality identified during the NRC audit in November 2013 and failed to correct three of these conditions.

   2. KHNP entered into their corrective action program the other five conditions adverse to quality identified during the NRC audit in November 2013 and completed their corrective actions. However, two of these five conditions adverse to quality were not adequately corrected.

   3. During this inspection, KHNP failed to identify, evaluate and document test abnormalities during the testing as conditions adverse to quality.

   This issue has been identified as Violation 99901453/2014-201-04.

   This is a Severity Level IV violation (Section 6.5.d of the NRC Enforcement Policy).

In accordance with the provisions of 10 CFR 2.201, “Notice of Violation,” KHNP is hereby required to submit a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with a copy to the

Chief, Quality Assurance Vendor Inspection Branch, Division of Construction Inspection and Operational Programs, Office of New Reactors, within 30 days of the date of the letter transmitting this Notice of Violation. This reply should be clearly marked as a "Reply to a Notice of Violation" and should include for each violation (1) the reason for the violation, or, if contested, the basis for disputing the violation or severity level; (2) the corrective steps that have been taken and the results achieved; (3) the corrective steps that will be taken to avoid further violations, and (4) the date when full compliance will be achieved. Your response may reference or include previous docketed correspondence, if the correspondence adequately addresses the required response. Where good cause is shown, consideration will be given to extending the response time.

If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

Because your response will be made available electronically for public inspection in the NRC Public Document Room or from the NRC Agencywide Documents Access and Management System, accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html, to the extent possible, it should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."

Dated at Rockville, MD, this 10th day of November 2014.

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

Project No.:	0782
Report No.:	99901453/2014-201
Applicant:	Korea Hydro and Nuclear Power Co 70-1312-GIL Yuseong-Daero, Yuseong-Gu Daejeon, 305-343, Korea
Applicant Contact:	Dr. Myung Ki Kim, Project Manager, KHNP APR1400 Licensing
Nuclear Industry Activity:	KEPCO and KHNP submitted a letter informing NRC of the proposed plan for re-submittal of application for the APR1400 Standard Design Certification with a target date of December 2014.
Inspection Dates:	September 22-26, 2014

Inspectors:	Aixa Belen-Ojeda	NRO/DCIP/MVIB	Team Leader
	Thomas Kendzia	NRO/DCIP/QVIB	
	Shanlai Lu	NRO/DSRA/SRSB	
	Diego Saenz	NRO/DSRA/SRSB	

Approved by: Kerri A. Kavanagh, Chief
Quality Assurance Vendor Inspection Branch
Division of Construction Inspection
and Operational Programs
Office of New Reactors

EXECUTIVE SUMMARY

Korea Hydro and Nuclear Power Co
Project No 0782

The U.S. Nuclear Regulatory Commission (NRC) conducted an inspection to verify that Korea Hydro and Nuclear Power Co, (hereafter referred to as KHNP), had implemented an adequate quality assurance (QA) program in support of downstream in-vessel effects testing activities that complies with the requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." In addition, the NRC inspection also verified that KHNP implemented a program under 10 CFR Part 21, "Reporting of Defects and Noncompliance," that met the NRC's regulatory requirements. The NRC inspection team conducted the inspection at the KHNP Central Research Institute (CRI) facilities in Daejeon, Republic of Korea, from September 22-26, 2014.

This technically focused inspection evaluated the implementation of KHNP's QA policies and procedures implemented to support the design, fabrication, assembly, and testing of the downstream in-vessel effects testing activities as described in NRC Inspection Manual Chapter 2508, "Construction Inspection Program: Design Certification." Korea Electric Power Corp (KEPCO) and KHNP submitted a letter informing NRC of the proposed plan for re-submittal of application for the APR1400 Standard Design Certification with a target date of December 2014 and its intent to begin the pre-application review process. As part of this effort, KHNP CRI conducted a test program to obtain test data to verify that the system components downstream of the sump strainer are designed to allow adequate cooling given the coolant characteristics after passing through the sump strainer to satisfy the requirements of Criterion 38, "Containment Heat Removal", of Appendix A, "General Design Criteria," to 10 CFR Part 50 and 10 CFR Part 50.46(b)(5) regarding the long-term spray system and Emergency Core Cooling System.

The NRC inspection team verified the following testing-related activities:

- test plan, procedures and configuration management
- test results and data collection
- translation of design specification into test requirements
- documentation and evaluation of test anomalies
- test personnel qualifications

The NRC inspection team observed the following testing-related activities:

- test bundle assembly demonstration
- debris preparation and chemical preparation
- establishment of the test loop initial conditions
- debris additions
- measurement of the test results

The NRC inspection team also reviewed corrective actions from the NRC audit of KHNP related to the downstream in-vessel effects testing performed in November 2013.

In addition to verifying and observing these activities, the NRC inspection team verified that measuring and test equipment (M&TE) were properly identified, marked, calibrated, and used within the calibrated range.

The NRC based its inspection on the following:

- Appendix B to 10 CFR Part 50
- 10 CFR Part 21, "Reporting of Defects and Noncompliance"

During this inspection, the NRC inspection team followed Inspection Procedure (IP) 35034, "Design Certification Testing Inspection," dated January 27, 2012; IP 35017, "Quality Assurance Implementation Inspection," dated July 29, 2008; and IP 36100, "Inspection of 10 CFR Part 21 Programs for Reporting Defects and Nonconformance," dated February 13, 2012.

The information below summarizes the results of this inspection..

10 CFR Part 21

The NRC inspection team concluded that the implementation of KHNP's 10 CFR Part 21 program is consistent with the regulatory requirements. Based on its review, the NRC inspection team determined that KHNP is adequately implementing its policies and procedures associated with 10 CFR Part 21 in support of KHNP's downstream in-vessel effects testing activities. No findings of significance were identified.

Training and Qualification

The NRC inspection team concluded that the implementation of KHNP's training and qualification program is consistent with the regulatory requirements of Criterion II, "Quality Assurance Program," of Appendix B to 10 CFR Part 50. Based on its review, the NRC inspection team determined that KHNP is adequately implementing its policies and procedures in support of downstream in-vessel effects testing activities. No findings of significance were identified.

Control of Purchased Equipment, Materials, and Services

The NRC inspection team concluded that the implementation of KHNP's oversight of contracted activities is consistent with the regulatory requirements of Criterion VII, "Control of Purchased Equipment, Material and Services," of Appendix B to 10 CFR Part 50. Based on its review, the NRC inspection team determined that KHNP is adequately implementing its policies and procedures in support of downstream in-vessel effects testing activities. No findings of significance were identified.

Test Control

The NRC inspection team identified one violation with multiple examples of KHNP's failure to implement the requirements of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50. Violation 99901453/2014-201-01 involved KHNP's failure to: 1) verify the adequacy of the design by the performance of a suitable testing program; and 2) adequately control design changes to the test loop for the downstream effects testing activities. Also, the NRC inspection team identified two violations with multiple examples of KHNP's failure to implement the requirements of Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50. Violation

99901453/2014-201-02 involved KHNP's failure to: 1) perform the test program in accordance with written test procedures; and 2) assure that a prerequisite for the tests have been met. Violation 99901453/2014-201-03 is discussed in the Control of Measuring and Test Equipment section.

Control of Measuring and Test Equipment

The NRC inspection team determined that the implementation of KHNP's program for M&TE was consistent with the regulatory requirements of Criterion XII, "Control of Measuring and Test Equipment," of Appendix B to 10 CFR Part 50. The NRC inspection team identified Violation 99901453/2014-201-03 of Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50 for the failure of KHNP to ensure that instrumentation required to accurately perform the testing was used within its calibrated range.

Nonconformance

The NRC inspection team concluded that the implementation of KHNP's program for nonconformance is consistent with the regulatory requirements of Criterion XV "Nonconforming Material, Parts, or Components," of Appendix B to 10 CFR Part 50. Based on its review, the NRC inspection team determined that KHNP is adequately implementing its policies and procedures in support of downstream in-vessel effects testing activities. No findings of significance were identified.

Corrective Actions

The NRC inspection team identified one violation with multiple examples of KHNP's failure to implement the requirements of Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. Violation 99901453/2014-201-04 involved KHNP's failure to ensure that conditions adverse to quality were promptly identified and corrected.

REPORT DETAILS

1. 10 CFR Part 21 Program

a. Inspection Scope

The NRC inspection team reviewed KHNP's quality assurance manual (QAM), policies and implementing procedures that govern the evaluation program to determine compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 21, "Reporting of Defects and Noncompliance." Specifically, the NRC inspection team reviewed KHNP's Quality Assurance program Description (QAPD), QAM and Control of 10CFR21 Procedure (QA-15-03-DC) which describes the authorities and responsibilities for evaluating and reporting defects and noncompliance.

The inspectors also reviewed KHNP's procedures that govern corrective actions and the control and correction of nonconforming items to verify an adequate link to the 10 CFR Part 21 process. The NRC inspection team reviewed a sample of corrective action reports and nonconformance reports to verify that KHNP was adequately screening issues for 10 CFR Part 21. The NRC inspection team interviewed selected KHNP's personnel involved with the identification and processing of corrective actions, nonconformances, or Part 21 screening or evaluations to ensure their understanding of 10 CFR Part 21 and the reporting requirements.

b. Observations and Findings

No findings of significance were identified.

c. Conclusions

The NRC inspection team concluded that the implementation of KHNP's 10 CFR Part 21 program is consistent with the regulatory requirements. Based on its review, the NRC inspection team determined that KHNP was adequately implementing its policies and procedures in support of downstream in-vessel effects testing activities. No findings of significance were identified.

2. Training and Qualification of Personnel

a. Inspection Scope

The NRC inspection team reviewed KHNP's procedures to verify that KHNP was implementing training activities in a manner consistent with regulatory requirements and industry standards. The NRC inspection team reviewed the training and qualification process for KHNP's test personnel to verify conformance with the requirements in Criterion II, "Quality Assurance Program," of Appendix B to 10 CFR Part 50. In addition, the NRC inspection team discussed the personnel training and qualification process with KHNP's management, interviewed test personnel, and observed them during the performance of testing.

b. Observations and Findings

No findings of significance were identified.

c. Conclusions

The NRC inspection team concluded that the implementation of KHNP's training and qualification program was consistent with the regulatory requirements of Criterion II of Appendix B to 10 CFR Part 50. No findings of significance were identified

3. Oversight of Contracted Activities

a. Inspection Scope

The NRC inspection team reviewed the implementation of KHNP QA programs for control of purchased material, equipment, and services in support of downstream in-vessel effects testing activities. Specifically, the NRC inspection team reviewed the policies and implementing procedures to verify compliance with the regulatory requirements of Criterion VII, "Control of Purchased Material, Equipment, and Services," of Appendix B to 10 CFR Part 50. In addition, the NRC inspection team discussed these programs with management and technical staff of KHNP.

In addition, the NRC inspection team reviewed purchase orders (PO) related to KHNP APR1400 design certification application. The NRC inspection team verified that the purchase orders invoked the applicable requirements of 10 CFR Part 52, Appendix B to 10 CFR 50, ASME Section III, NQA-1-2008 and the 2009 Addenda, and imposed 10 CFR Part 21.

b. Observations and Findings

The NRC inspection team observed the PO documents from KHNP to Future & Challenge Technology, LTD for the construction of the test facility and noted that the test facility was purchased as commercial-grade. The NRC inspection team verified that KHNP was controlling the data under their quality assurance program.

No findings of significance were identified.

c. Conclusions

The NRC inspection team concluded that KHNP invoked appropriate procurement requirements, and maintained adequate oversight of contracted activities. The NRC inspection team also concluded that the implementation of KHNP's control of purchased material, equipment, and services program was consistent with the regulatory requirements of Criterion VII of Appendix B to 10 CFR Part 50. No findings of significance were identified.

4. Test Control

a. Inspection Scope

The NRC inspection team reviewed the implementation of KHNP's QA program for test control in support of downstream in-vessel effects testing activities. Specifically, the NRC inspection team reviewed: (1) the test plan, procedures and configuration management; (2) test results and

data collection; (3) the test apparatus and measurement equipment; (4) the translation of design specifications into test requirements; and, (5) the documentation and evaluation of test anomalies.

The NRC inspection team discussed the test control program with the KHNP management and technical staff, and observed testing activities being performed. The NRC inspection team focused on the policies and procedures governing the implementation of test control to verify compliance with the regulatory requirements of Criterion XI, 'Test Control," of Appendix B to 10 CFR Part 50. The NRC inspection team evaluated the planning, preparation, and execution of the tests to ensure that they were consistent with Generic Safety Issue (GSI) - 191, "Assessment of Debris Accumulation on Pressurized Water Reactor Sump Performance," requirements, and that they provided reliable and repeatable data.

b. Observations and Findings

The NRC inspection team observed KHNP test personnel measuring the dimension of the flow channel. KHNP test personnel measured the gap between the flow channel interior wall and the mock-up fuel assembly bottom nozzle and recorded the dimensions in the test procedure. The NRC inspection team identified that KHNP test personnel were entering the gap measurements in the wrong section in the test procedure. KHNP failed to perform the test program in accordance with written test procedures. The test personnel did not follow the test procedures during documentation of the measurements of the gap size. This has been identified as an example of Violation 99901453/2014-201-02 for Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50.

In addition, the NRC inspection team reviewed the measurements and Drawing #: K00-A1-001-SO1-M00 which specifies the size of the flow channel around the fuel assembly. The NRC inspection team determined that the right and left nominal gaps size exceeded the nominal gap size required by the design specifications in Drawing #: K00-A1-001-SO1-M00. The size of the flow channel has a significant impact on the total pressure drop across the debris bed. If the gap size between the flow channel inner surface and the mock-up fuel assembly is larger than the nominal value, the pressure drop across the debris bed could be smaller than what it should be in the operating nuclear power plant. KHNP failed to verify that the test loop assembly met the design requirements for the size of the flow channel around the fuel assembly. This has been identified as an example of Violation 99901453/2014-201-01 for Criterion III, "Design Control," of Appendix B to 10 CFR Part 50.

The NRC inspection team observed debris preparation, chemical preparation, establishment of the test loop initial conditions, debris additions, and measurement of the test results of one cold leg break test and one hot leg break test. During the NRC audit in November 2013 of the in-vessel downstream effects testing, the NRC audit team observed debris settling during the tests and questioned the impact of the debris settling in the calculations. KHNP changed the test loop to add a octahedron to the lower plenum to increase turbulence with the intent to decrease debris settling. However, the NRC inspection team observed significant debris settling at the bottom of the test loop during the cold leg break test. The debris settling became more significant after the addition of the chemical precipitates. The NRC inspection team reviewed KHNP APR1400-K-A-I(RA)-P, Section 2.3, "Test Column," which states that, "the bottom region is shaped as a cone to avoid settling and loss of debris during the test." Although the test loop included a slight inclination in the lower plenum (bottom region), the NRC inspection team did not consider it cone shaped, and it did not limit debris settling. KHNP failed to verify that the lower plenum of the test loop assembly met the design requirements of a cone shape to prevent

settling as required by KHNP APR1400-K-A-I(RA)-P. This has been identified as an example of Violation 99901453/2014-201-01 for Criterion III, “Design Control,” of Appendix B to 10 CFR Part 50.

During the November 2013 NRC audit, the NRC audit team identified debris settling and bubbles impinging in the system as findings. As a result of efforts to address these issues, KHNP made changes to the testing apparatus. These changes included: 1) replacing two perforated plexiglass plates with an octahedron at the lower plenum of the test loop, 2) filling the guide tube channels with silicone, 3) changing sections of the piping connected to the top of the flow channel to remove a flange, and 4) filling several flanges with silicone. The NRC inspection team noted that KHNP failed to perform documented evaluations of design changes for changes to test loop assemblies to reduce impinging of bubbles and debris settling in the system. This has been identified as an example of Violation 99901453/2014-201-01 for Criterion III, “Design Control,” of Appendix B to 10 CFR 50.

The NRC inspection team reviewed DC-DG-11-02, “Test Procedure for the APR1400 In-vessel Downstream Effects,” Revision 3 and Revision 4. During the NRC inspection team’s review of KHNP’s procedure change process, KHNP staff discussed the differences between the test procedure Revision 3 and Revision 4. The NRC inspection team noted that the copy of the procedure being used in the field during the testing was a preliminary version of the test procedure Revision 4. In addition, the NRC inspection team noted that the later approved Revision 4 included test parameters that differed from the preliminary revision used at the beginning of the test. Step 6.2 from the preliminary procedure being used in the field was different from the later approved Revision 4 procedure. KHNP failed to perform the test program in accordance with written test procedures by using an unapproved procedure. This has been identified as an example of Violation 99901453/2014-201-02 for Criterion XI, “Test Control,” of Appendix B to 10 CFR Part 50.

During observation of the hot leg break condition test (APR1400-22), the NRC inspection team reviewed Attachment 7.1 to the test procedure with KHNP QA and test personnel. The NRC inspection team noted that a quality control (QC) hold point that verified the delta pressure stability had not been performed and the testing had continued. The QC hold point was to verify that the pressure drop through the assembly had stabilized before proceeding with the test and it is a requirement of the test plan and the test procedure. The NRC inspection team discussed the missed QC hold point with the test director who concurred that the hold point had been missed. KHNP failed to perform the test program in accordance with written test procedures by not following the test procedure which required completing a QC hold point before continuing with the test. This has been identified as an example of Violation 99901453/2014-201-02 for Criterion XI, “Test Control,” of Appendix B to 10 CFR Part 50. KHNP wrote CAP 00792202 to address this issue.

The NRC inspection team also discussed the acceptance criteria for the QA hold point with the KHNP Quality Inspector overseeing the test. The cold leg break test’s QC hold point acceptance criteria required verification that the differential pressure (dP) change after 30 minutes of the debris addition was less than or equal (≤) 2%. However, the uncertainty for the dP change in the cold leg break tests exceeded the 2% dP change stated as the acceptance criteria in the procedure. KHNP failed to assure that a prerequisite for the tests had been met. Specifically, KHNP failed to assure that a prerequisite for QC hold points acceptance criteria was achievable for cold leg break tests. This has been identified as an example of Violation 99901453/2014-201-02 for Criterion XI, “Test Control,” of Appendix B to 10 CFR Part 50. KHNP wrote CAP 00792215 to address this issue.

c. Conclusions

The NRC inspection team identified one violation with multiple examples of KHNP's failure to implement the requirements of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50. Violation 99901453/2014-201-01 involved KHNP's failure to: 1) verify the adequacy of the design by the performance of a suitable testing program and 2) adequately control design changes to the test loop for the downstream effects testing activities. Also, the NRC inspection team identified two violations with multiple examples of KHNP's failure to implement the requirements of Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50. Violation 99901453/2014-201-02 involved KHNP's failure to: 1) perform the test program in accordance with written test procedures and 2) assure that a prerequisite for the tests had been met. Violation 99901453/2014-201-03 is discussed in the Control of Measuring and Test Equipment section.

5. Control of Measuring and Test Equipment

a. Inspection Scope

The NRC inspection team reviewed KHNP's QAM, policies and procedures for control of measuring and test equipment (M&TE) to verify compliance with Criterion XII, "Control of Measuring and Test Equipment," of Appendix B to 10 CFR Part 50. Specifically, the NRC inspection team reviewed KHNP's QAM and M&TE procedure (DC-DG-12-01) which describes the requirements for control and calibration of test equipment. The NRC inspection team inspected the M&TE associated with the downstream in-vessel effects testing being performed and reviewed the associated documentation of M&TE calibration to verify that the M&TE was calibrated to a nationally recognized standard, the calibration was current, and that the instrumentation range, accuracy and uncertainty was adequate for the testing performed.

b. Observations and Findings

The NRC inspection team observed the APR1400-22 cold leg break test being performed on September 22-24, 2014, with a flow rate of 9.2 lpm (liters/minute). The NRC inspection team reviewed the electromagnetic flow meter calibration documentation and identified that the calibrated flow rate range was 34.17 lpm to 251.67 lpm. The documentation also showed that the accuracy of the flow transmitter decreased at lower flow rates. The NRC inspection team discussed this with KHNP personnel. KHNP confirmed that they did not have any documentation that the flow meter had been calibrated for flow rates below 34.17 lpm, or would be accurate at the low flow rate used in the test. The NRC inspection team reviewed the test loop setup and noted that the flow transmitter output was used to control the pump speed and thus control the flow rate without independent indication of flow rate. With this setup, the NRC inspection team noted that flow data consistency (steady flow rate) did not mean the actual flow rate was steady. The NRC inspection team reviewed other test cases documented on Table 3, "Schedule of in-vessel downstream effect tests," of APR1400-K-A-I(RA)-13001, "Test Plan for In-vessel Downstream Effect (IDE) of the APR1400," and determined that for already performed tests, APR1400-61, 71, 81, 91, 93, 95, & 97, the flow rates established in those tests was also below the calibrated range of the flow transmitter. The NRC inspection team identified this issue as Violation 99901453/2014-201-03 for the failure of KHNP to ensure that instrumentation required to accurately perform the testing was used within its calibrated range. KHNP initiated CR 00791887 to address this issue.

c. Conclusions

The NRC inspection team determined that the implementation of KHNP's program for M&TE was consistent with the regulatory requirements of Criterion XII, "Control of Measuring and Test Equipment," of Appendix B to 10 CFR Part 50. The NRC inspection team identified Violation 99901453/2014-201-03 of Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50 for the failure of KHNP to ensure that instrumentation required to accurately perform the testing was used within its calibrated range.

6. Nonconformances

a. Inspection Scope

The NRC inspection team reviewed KHNP's QAM, policies, implementing procedures, and records that governed the control of nonconforming materials, parts, and components to verify compliance with Criterion XV, "Nonconforming Materials, Parts, or Components," of Appendix B to 10 CFR Part 50. Specifically, the NRC inspection team reviewed KHNP's QAM, and procedure QA-15-01-DC to verify that the procedure addressed the regulatory requirements for identification, documentation, segregation, disposition (including accepted as is, reject, repair or rework), and notification as appropriate. The NRC inspection team interviewed KHNP's personnel who administered the nonconformance process and verified that they were trained on the regulatory requirements and KHNP's processes and implementation for nonconforming items.

b. Observations and Findings

KHNP had no nonconforming items for the APR1400 project, but used the same process for Korean nuclear activities at this location. The NRC inspection team reviewed the list of nonconforming items for 2013 and 2014, and selected four samples to review to ensure that the process was being followed and the dispositions were appropriate.

No findings of significance were identified

c. Conclusions

The NRC inspection team concluded that the implementation of KHNP's program for nonconformance is consistent with the regulatory requirements of Criterion XV "Nonconforming Material, Parts, or Components," of Appendix B to 10 CFR Part 50. Based on its review, the NRC inspection team determined that KHNP is adequately implementing its policies and procedures in support of downstream in-vessel effects testing activities. No findings of significance were identified.

7. Corrective Action

a. Inspection Scope

The NRC inspection team reviewed KHNP's QAM, policies, implementing procedures, and records that govern corrective actions to verify compliance with Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. Specifically, the NRC inspection team reviewed

KHNP's procedures QA-16-01-DC "Control of CAR (Corrective Action Request)," and DC-DG-06, "Corrective Action Program."

KHNP has two corrective action processes, the CAR process which is used for Quality Assurance items (audits, quality surveillance and quality trend analysis), and the CR process which is used for all other conditions adverse to quality and corrective action for problems. The NRC inspection team reviewed the logs for CARs and CRs from 2013 and 2014 and selected CARS and CRs to review in detail to ensure that the processes were being followed and the dispositions were appropriate. The NRC inspection team interviewed KHNP personnel involved with the identification and processing of corrective actions, to assess their understanding of the KHNP processes and regulatory requirements.

b. Observations and Findings

NRC staff conducted a regulatory audit of KHNP's APR1400 downstream invessel effects testing at KHNP's facilities in Daejeon, Republic of Korea on November 11 - 13, 2013. During the audit, NRC identified nine audit findings considered to be conditions adverse to quality and they were presented to KHNP during the exit meeting and in the audit report.

The NRC inspection team noted that KHNP opened five condition reports in response to the November 2013 NRC audit. The NRC inspection team identified that KHNP did not enter the following issues into the corrective action program: 1) apparent spurious readings in dP5 during a test, 2) potential non-conservatism in the recirculation start time assumptions, 3) impact of debris settling on test, and 4) not promptly entering conditions adverse to quality into the KHNP corrective action program. The NRC inspection team determined that the issues of potential non-conservatism in the recirculation start time assumptions, impact of debris settling on test, and not promptly entering conditions adverse to quality into KHNP corrective action program also were not adequately corrected. KHNP failed to identify in their corrective action program four of the nine conditions adverse to quality identified during the NRC audit in November 2013 and failed to correct three of these conditions. This has been identified as the first example of Violation 99901453/2014-201-04 for Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. KHNP wrote CAP 00792202 to address this issue.

The NRC inspection team verified that the audit issues of bubbles impinging on the bottom nozzle and adequacy of procedure usage during the tests were entered into the corrective action program and the corrective actions were considered completed by KHNP. During the review of the corrective actions, the NRC inspection team determined that these conditions were not adequately corrected since the NRC inspection team observed these conditions reoccurring in the tests observed during the NRC inspection. The NRC inspection team identified this issue as the second example of Violation 99901453/2014-201-04 for KHNP's failure to ensure that conditions adverse to quality are adequately corrected. KHNP initiated CRs 00791901, 00791903, 00791904, 00791906, 00792198, 00792199, 00782200, and 00792202 to address the previous NRC audit issues that had not been corrected, and to address the violation.

After the NRC audit in November 2013, KHNP performed modifications to the test apparatus to eliminate debris settling and bubbles impinging on the bottom nozzle. However, the NRC inspection team observed debris settling during the APR1400-22 cold leg break test, and bubbles impinging on the bottom nozzle in the APR1400-72 hot leg break test and APR1400-22 test performed during the week of the inspection. KHNP personnel observed the build-up of debris due to settling and bubbles impinging on the bottom nozzle during testing, but did not

identify them as a nonconformance, condition adverse to quality, or test anomaly. The NRC inspection team discussed the issues above with KHNP testing personnel and noted that KHNP personnel did not initially consider the build-up of debris or bubbles impinging on the bottom nozzle as a nonconformance, condition adverse to quality, or test anomaly. The NRC inspection team determined that KHNP does not have a test anomaly process to document and evaluate test anomalies in the CR program. In addition, the NRC inspection team determined that the APR1400-22 cold leg break test, where the debris settling occurred, was similar to other low flow tests that had been performed since the NRC audit in November 2013. The NRC inspection team determined that the APR1400-72 hot leg break test and APR1400-22 cold leg break test, (where bubbles impinging on the bottom nozzle occurred), were similar to other tests that had been performed since the NRC audit in November 2013. Consequently, the NRC would expect that debris settling and bubbles impinging on the bottom nozzle occurred in other tests already performed. The NRC inspection team reviewed the nonconformance and corrective action logs from 2013 and 2014 and found no test anomalies, debris settling issues or bubbles impinging the bottom nozzle issues. The NRC inspection team identified this issue as the third example of Violation 99901453/2014-201-04 for the failure of KHNP to ensure that conditions adverse to quality are promptly identified and corrected. KHNP initiated CR 00792201 to address not documenting testing anomalies.

c. Conclusions

The NRC inspection team identified one violation with multiple examples of KHNP's failure to implement the requirements of Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. Violation 99901453/2014-201-04 involved KHNP's failure to ensure that conditions adverse to quality were promptly identified and corrected.

Entrance and Exit Meetings

On September 22, 2014, the NRC inspection team presented the inspection scope during an entrance meeting with KHNP personnel. September 26, 2014, the NRC inspection team presented the inspection results during an exit meeting with KHNP personnel.

1. PERSONS CONTACTED

Name	Company	Entrance Meeting	Exit Meeting	Interviewed
Myung Ki Kim	KHNP CRI	X	X	
Jae Yong Lee	KHNP CRI	X	X	X
Hansang Kim	KHNP CRI	X	X	X
Jeong-Kwan Suh	KHNP	X	X	X
Jae-Soo Lim	KHNP	X	X	X
Haeng-Jim Kim	KHNP	X	X	X
Joon Seok Kang	KHNP	X	X	X
Hye Young Shin	KHNP CRI	X	X	X
Edward Baker	Talisman	X	X	
Stanley Ritterbusch	WES	X	X	
JaeYong Song	WES	X	X	
Thomas Kendzia	NRC	X	X	
Aixa Belen-Ojeda	NRC	X	X	
Shanlai Lu	NRC	X	X	
Diego Saenz	NRC	X	X	
Edward Roach*	NRC		X	

* participated in the exit meeting by conference call

2. INSPECTION PROCEDURES USED

Inspection Procedure 35034, “Design Certification Testing Inspection,” dated January 27, 2010

Inspection Procedure 35017, “Quality Assurance Implementation Inspection,” dated July 29, 2008

Inspection Procedure 36100, “Inspection of 10 CFR Part 21 Programs for Reporting Defects and Nonconformance,” dated February 13, 2012

3. LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Item Number	Status	Type	Description
99901453/2014-201-01	Opened	NOV	Criterion III
99901453/2014-201-02	Opened	NOV	Criterion XI
99901453/2014-201-03	Opened	NOV	Criterion XI
99901453/2014-201-04	Opened	NOV	Criterion XVI

4. DOCUMENTS REVIEWED

Quallity Manuals and Plans

APR 1400-K-Q-TR-NP, “KHNP Quality Assurance Program Description (QAPD) for the APR1400 Design Certification, Revision 3, dated October, 2013

APR1400 DC-QAM, “Quality Assurance Manual for APR1400 DC Project,” Revision 2, dated November 2013

QA-02-01-DC, “Control of QAM and QAPD”, Revision 2, May, 2014

Purchase Orders

QA-04-01-DC, “Preparation and Control of the QA Requirements in the Procurement Documents,” Revision 2, dated June 2014

QA-07-02-DC, “Evaluation of the Prospective Supplier,” Revision 2, dated June 2014

KHNP L12-S012-000, Commercial Contract between KHNP and Future and Challenge for the construction of the test mockup, dated February 4, 2014

KHNP L14-S038-000, Contract between KHNP and KEPCO E&C, “Service Support for NRC DC Design Supplemental and Permission and Approval in the design of APR1400 NSSS, dated April 26, 2014

KHNP L14-S035-000, Contract between KHNP and Korea Nuclear Fuel, “Service Project for Permission and Approval of APR1400 Nuclear Fuel, dated August 14, 2014

Contract between KHNP and Doosan Heavy Industry, “Service Project for Permission and Approval of APR1400 Major Equipment Design, dated April 28, 2014

Training and Qualifications

DC-DG-02-03, “Test Personnel Qualification” Revision 3, August 2014

QA-02-03-DC, “Indoctrination and Training QA Personnel”, Revision 2, May, 2014

QA-02-05-DC, “Qualification for Inspectors”, Revision 2, May, 2014

10 CFR Part 21, Corrective Action, Nonconformance Programs

QA-07-03-DC, “Control of SDDR”, Revision 0, May, 2014

QA-15-01-DC, “Control of NCR”, Revision 2, June, 2014

QA-15-02-DC, “Trend Analysis for NCR”, Revision 2, June, 2014

QA-15-03-DC, “Control of 10CFR21 Reporting”, Revision 2, June, 2014

QA-16-01-DC, “Control of CAR”, Revision 2, June, 2014

QA-16-02-DC, “Trend Analysis of CAR”, Revision 2, June, 2014

QA-16-03-DC, “Control of SAQ”, Revision 2, June, 2014

QA-16-04-DC, “Control of WSO”, Revision 2, June, 2014

DC-DG-06, “Corrective Action Program”, Revision 0, August, 2012

Corrective Action Requests

List of all APR1400 project Corrective Action Requests (CARs) from 2013 & 2014
CARs, 000004, 000005, 000008, 000009, 000010, 000011, 000013, and 000014

Corrective Action Program – Condition Reports

List of all APR1400 project Condition Reports (CRs) from 2013 & 2014
CRs, 00623990, 00623977, 00701489, 0071499, 00701543, and 00701547

Non-Conformance Reports

List of all nuclear Non-Conformance Reports (NCRs) from 2013 & 2014
PumpValve-NCR-2013-01, PumpValve-NCR2013-02, 4100-QN202-CGID-03, 4100-QN202-EQ-04

New Corrective Action Program – Condition Reports Generated

CRs, 00792225, 00792222, 00792218, 00792215, 00792211, 00792209, 00792208, 00792207, 00792206, 00792205, 00792204, 00792203, 00792202, 00792201, 00792200, 00792199, 00792198, 00791906, 00791904, 00791903, 00791901, 00791887

Test Control Documents

APR1400-K-A-EC-14004, “Presentation for the IDE Test (GSI-191)” Response to NRC Audit: KHNP IDE Tests

APR1400-K-A-I(RA)-13001, “Test Plan for In-vessel Downstream Effect (IDE) of the APR1400,” Revision 3, July, 2014.

DC-DG-11-02, “Test Procedure for the APR1400 In-vessel Downstream Effects,” Revision 3, August 2014

DC-DG-11-02, “Test Procedure for the APR1400 In-vessel Downstream Effects,” Revision 4, September 2014

DC-DG-11-01, “Test Control,” Revision 0, November 2013

APR1400-E-N-NR-14001-P, “APR1400 Design Features to Address GSI-191,” Revision A, August 2014

WCAP-16530-NP-A, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191,” Revision 0, March 2008

APR1400-K-A-I(RA)-13001-P, “Test Plan for the IDE of the APR1400,” Revision 3, July 2014

DC-DG-03-01, “Design Change Control”, Revision 2, August, 2014

QA-10-01-DC, “Inspection for Manufacturing”, Revision 2, June, 2014

QA-10-02-DC, “Inspection for Transferred Items”, Revision 0, June, 2014

QA-10-03-DC, “Inspection for Receiving”, Revision 2, June, 2014

QA-10-04-DC, “Inspection for Maintenance”, Revision 0, June, 2014

QA-10-05-DC, “Inspection for Test”, Revision 0, June, 2014

Measuring and Test Equipment

DC-DG-12-01, “Control of Measuring an Test Equipment”, Revision 0, November 2013

Differential Pressure Transmitter (DP) 01, serial number 91M439885, calibrated February 26, 2014

DP 02, serial number 91M726931, calibrated March 21, 2014

DP 03, serial number 91M726930, calibrated March 21, 2014

DP 04, serial number 91M439880, calibrated February 26, 2014

DP 05, serial number 91M439879, calibrated February 26, 2014

Thermocouple (TC) 01, serial number KM12-7689-003, calibrated October 7, 2013

TC 02, serial number KM12-7689-004, calibrated October 7, 2013

TC 03, serial number KM12-7689-001, calibrated October 7, 2013

Ultrasonic Test Equipment USN60, serial number 41-045-13-0028, calibrated February 14, 2014

Electromagnetic Flowmeter FM-01, serial number 116203297, calibrated February 18, 2014