14 VERIFICATION PROGRAMS

Chapter 14, "Verification Programs," of this safety evaluation report (SER) describes the U.S. Nuclear Regulatory Commission (NRC or Commission) staff's review of Chapter 14, "Verification Programs," of Revision 1 to the U.S. Advanced Power Reactor 1400 (APR1400) Design Control Document (DCD), submitted in March 2017. The information provided in Chapter 14 of the APR1400 DCD addresses major phases of the initial test program (ITP), including preoperational tests, initial fuel loading and initial criticality, low-power tests, and power ascension tests. This chapter also describes the bases, processes, and selection criteria used to develop the Tier 1 material, which are to be verified appropriately by inspections, tests, analyses, and acceptance criteria (ITAAC).

This chapter of the SER provides the NRC staff's review of the ITP and the ITAAC for the APR1400 as part of the NRC design certification (DC) review being conducted by the NRC staff under Title 10 of the *Code of Federal Regulations* (10 CFR), Part 52, "Licenses, Certifications and Approvals for Nuclear Power Plants." The NRC staff conducted this review in accordance with the Standard Review Plan (SRP), NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: Light Water Reactor (LWR) Edition," March 2007, Chapter 14.

14.1 Specific Information to be Addressed for the Initial Plant Test Program

Introduction

The APR1400 DCD, Section 14.1, "Specific Information to be Addressed for the Initial Plant Test Program," lists the relevant requirements of the applicable regulations and the 12 areas covered by the ITP. There was no combined license (COL) information required in regard to APR1400 DCD, Section 14.1.

Evaluation

The NRC staff reviewed conformance of the APR1400 DCD, Section 14.1 to Regulatory Guide (RG) 1.206, "Combined License Applications for Nuclear Power Plants," Sections C.I.14.1, "Specific Information to be Addressed for the Initial Plant Test Program," and C.I.14.2, "Initial Plant Test Program," and the introduction section of RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants." RG 1.206, Section C.I.14.1 describes six regulations that address the scope of the ITP. In addition, the introduction section of RG 1.68 references General Design Criteria (GDC) 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," which requires, in part, that structures, systems, and components (SSCs) important to safety shall be tested to quality standards commensurate with the importance of the safety functions to be performed. These seven regulations are referenced in Section 14.2.3 of this SER. Additionally, RG 1.206, Section C.I.14.2, identifies the 12 areas that should be covered by the ITP.

The NRC staff evaluated the APR1400 DCD, Section 14.1 and determined that DCD, Section 14.1 referenced the regulations identified in Section 14.2.3 of this SER and the 12 areas covered by the ITP listed in Section 14.2.2 of this SER, as described by RG 1.206 and RG 1.68, with one exception. Specifically, the NRC staff determined that the DC applicant did not include

10 CFR Part 50, Appendix A, GDC 1 as it relates to testing important-to-safety SSCs that are within the scope of the Quality Assurance Program (QAP) and the ITP. In RAI 278-8226, NRC Question 14.02-39 (Agency-Wide Documents Access and Management System (ADAMS) Accession No. ML15303A502), the NRC staff requested that the DC applicant add 10 CFR Part 50, Appendix A, GDC 1 as a regulatory basis for SSCs that should be tested within the scope of the QAP and ITP.

In the response to RAI 278-8226, Question 14.02-39 (ADAMS Accession No. ML16012A550), the DC applicant proposed to add a reference to 10 CFR Part 50, Appendix A, GDC 1 as it relates to important to safety SSCs in DCD, Sections 14.1 and 14.2. The NRC staff determined that the RAI response is acceptable because the proposed change to the DCD will include the seven regulations identified in RG 1.206 and RG 1.68; therefore RAI 278-8226, Question 14.02-39 is resolved. The NRC staff verified that the proposed changed has been incorporated in the APR1400 DCD, Revision 1.

Conclusion

The NRC staff concludes that the information provided in APR1400 DCD, Section 14.1 adequately describes the specific information to be addressed for the ITP, and is thus acceptable. All issues relating to this section of the initial test program have been resolved.

14.2 Initial Plant Test Program

14.2.1 Introduction

The APR1400 ITP is intended to verify that the as-built facility configuration and operation complies with the approved plant design and applicable regulations. The ITP consists of preoperational and initial startup testing. Major phases of testing include:

- Preoperational Tests – The preoperational tests are conducted following the completion of construction but before fuel loading.

- Initial Fuel Loading – Initial fuel loading starts after completion of the preoperational testing.

- Initial Criticality and Low-Power Tests – The initial criticality phase of the startup test program confirms that criticality is achieved in a safe and controlled manner. Following initial criticality, a series of low-power physics tests are performed to verify selected core design parameters.

- Power-Ascension Tests – A series of power ascension tests is conducted to bring the reactor to full power.

The scope of the ITP, as well as the general plans for accomplishing the test program, is described to demonstrate that due consideration has been given to matters that normally require advance planning.

The technical aspects of the ITP are described to show that: (1) the test program adequately verifies the functional requirements of plant SSCs; and (2) the sequence of testing is such that the safety of the plant does not depend on untested SSCs. In addition, the measures are

described to ensure that: (1) the ITP is accomplished with adequate numbers of qualified personnel; (2) adequate administrative controls will be established to govern the initial test program; (3) the test program is used, to the extent practicable, to train and familiarize the plant's operating and technical staff in the operation of the facility; and (4) the adequacy of plant operating and emergency procedures is verified, to the extent practicable, during the period of the ITP.

The NRC staff reviewed the DC applicant's ITP in accordance with the guidance in RG 1.206 Section C.I.14, dated June 2007; SRP Section 14.2, "Initial Plant Test Program – Design Certification and New License Applicants," dated March 2007; and RG 1.68 dated June 2013.

14.2.2 Summary of Application for DCD Section 14.2

The DC applicant provided specific information which addressed the ITP in 12 different subsections: (1) summary of test program and objectives; (2) organization and staffing; (3) test procedures; (4) conduct of test program; (5) review, evaluation, and approval of test results; (6) test records; (7) test program conformance with NRC Regulatory Guides (RG); (8) utilization of reactor operating and testing experience in developing the plant ITP; (9) trial use of plant operating and emergency procedures; (10) initial fuel loading and initial criticality; (11) ITP schedule and sequence; and (12) individual test descriptions.

14.2.3 Regulatory Basis for DCD Section 14.2

The relevant requirements of NRC regulations for the initial plant test program, and the associated acceptance criteria, are specified in SRP Section 14.2 and are summarized below. Interfaces with other SRP sections can also be found in SRP Section 14.2.

- 10 CFR 30.53(c) which requires that each licensee (defined as an entity licensed to receive and possess byproduct material in this context) perform, or permit the Commission to perform, tests of radiation detection and monitoring instruments.

  In nuclear power plants, radiation detection and monitoring instruments are used for ambient monitoring related to worker radiation protection, effluent monitoring, automatic initiation of features to mitigate accidental releases of radioactive materials, and automatic initiation of engineered safety features to minimize the consequences of design-basis accidents. Application of 10 CFR 30.53(c) to the ITP ensures that the capabilities to perform these functions are adequately verified initially and that deficiencies are identified and corrected. This provides increased assurance of reliable radiation detection/monitoring and instrument response to any detected adverse radiological conditions.

- 10 CFR 50.34(b)(6)(iii) which requires plans for preoperational testing and initial operations.

- 10 CFR 50.43(e) which has additional requirements for design certification applicants that propose nuclear reactor designs that differ significantly from light-water reactor designs that were licensed before 1997, or use simplified, inherent, passive, or other innovative means to accomplish their safety functions. These requirements include demonstrating the safety of the design through means such as testing, analysis, experience and data, as applicable.

- 10 CFR Part 50, Appendix A, GDC 1, “Quality Standards and Records,” which requires important-to-safety SSCs be tested under both the QAP and the ITP.

- Appendix B to 10 CFR Part 50, Criterion XI, “Test Control,” which requires test controls for safety related SSCs under the scope of the QAP and ITP.

- Appendix J to 10 CFR Part 50, which requires Type A, B and C preoperational leakage rate tests of the primary containment and related systems and components that penetrate the primary containment pressure boundary as specified in Section III.A, “Leakage Testing Requirements.”

  The primary reactor containment provides a barrier against the release of fission products after accidents. The extent of overall containment leakage at pressures associated with accident conditions affects the public dose and environmental damage consequences of accidents. Application of Appendix J to the ITP ensures that the containment performs as a leakage barrier as specified in the design and as assumed/credited in safety analyses that evaluate the public dose and environmental consequences of design basis accidents.

- 10 CFR 52.79(a)(28) which requires plans for preoperational testing and testing during initial operations. For COL applications under 10 CFR Part 52, the applicant must describe the ITP, in accordance with 10 CFR 52.79(a)(28). The requirements in 10 CFR 52.47 do not require a DC applicant to submit an ITP. However, DC applications should include proposed testing activities for the ITP to support the COL applications.

- 10 CFR Part 52, Subpart A, Subpart B, and Subpart C which requires inspections, tests, analyses, and acceptance criteria (ITAAC). Although the ITAAC review is conducted in Section 14.2, ITP tests are often used as the basis for ITAAC, so the relationship between the ITP and the ITAAC is addressed in this section of the SER where pertinent.

14.2.4 Technical Evaluation for DCD Subsections 14.2.1 through 14.2.12

14.2.4.1 DCD Subsection 14.2.1, Summary of Test Program and Objectives

Introduction

The APR1400 DCD, Subsection 14.2.1 describes the ITP that is performed during the initial startup of the APR1400 plant and identifies general prerequisites and specific objectives for each phase. The ITP commences with the completion of construction and installation and ends with the completion of power ascension testing. The ITP consists of preoperational tests and initial startup tests following in four phases:

Phase I: Preoperational Testing
Phase II: Fuel loading and post-core hot functional testing
Phase III: Initial criticality and low-power physics testing
Phase IV: Power ascension testing

The purpose of these tests is to demonstrate that the facility operates in accordance with its design during steady-state conditions and, to the extent practicable, during anticipated transients.

Evaluation

The NRC staff reviewed conformance of APR1400 DCD, Subsection 14.2.1 to the guidance in SRP Section 14.2.II.1, "Summary of Test Program and Objectives"; RG 1.206, Section C.I.14.2.1, "Summary of Test Program and Objectives"; and the general guidelines and applicable regulatory positions in RG 1.68. RG 1.206, Section C.I.14.2.1, states in part, that, "the applicant should describe major phases of the initial test program as well as the general prerequisites and specific objectives to be achieved for each phase."

The NRC staff confirmed that the DC applicant described the summary of the ITP and included a description of the objectives of each of the appropriate major phases of the test program in Subsection 14.2.1 of the APR1400 DCD.

RG 1.68, Appendix A, "Initial Test Program," identifies the major phases of the ITP which include: (1) Preoperational Testing, (2) Initial Fuel Loading and Pre-Criticality Testing, (3) Initial Criticality Testing, (4) Low-Power Testing, and (5) Power-Ascension Testing. RG 1.206, Section C.I.14.2.1 provides that the COL applicant should address major phases of the initial test program as well as the general prerequisites and specific objectives to be achieved for each phase. The NRC staff noted that the applicant's proposed test program provided the following phases and objectives:

- Phase I – Preoperational Testing

  Demonstrate that structures, systems, and components (SSCs) operate in accordance with design operating modes throughout the full design operating range. Preoperational testing provides reasonable assurance that systems and equipment perform in accordance with the safety analysis report.

- Phase II – Fuel Loading and Post-Core Hot Functional Testing

  Provide a systematic process for safely accomplishing and verifying the initial fuel loadings. Provide additional assurance that plant systems necessary for normal plant operation function as expected and to obtain performance data on core-related systems and components.

- Phase III – Initial Criticality and Low-Power Physics Testing

  Provide reasonable assurance that initial criticality is achieved in a safe and controlled manner. Substantiate that the Safety Analysis and Technical Specifications assumptions and limits have been met. Demonstrate that core characteristics are within the expected limits and provide data for benchmarking the design methodology used for predicting the core characteristics later in the life of the plant.

- Phase IV – Power Ascension Testing

  Demonstrate that the facility operates in accordance with its design during steady-state conditions and, to the extent practicable, during anticipated transients.

The NRC staff finds that the applicant has adequately identified and described the major phases of the ITP because (1) the DC applicant included the major phases identified in RG 1.68, and (2) the DC applicant adequately described the general prerequisites and specific objectives to be achieved for each phase, consistent with RG 1.206.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.1 adequately describes the activities related to the phases of the ITP: (1) preoperational testing; (2) fuel loading and post-core hot functional testing; (3) initial criticality and low power physics testing; and (4) power ascension testing, and is therefore acceptable. All issues relating to this section of the ITP have been resolved.

14.2.4.2 DCD Subsection 14.2.2, Organization and Staffing

Introduction

In the APR1400 DCD, Subsection 14.2.2, "Organization and Staffing," the DC applicant stated that the staff responsibilities, authorities and personnel qualifications for performing the APR1400 ITP are the responsibility of the COL applicant.

Evaluation

The NRC staff reviewed conformance of APR1400 DCD, Subsection 14.2.2 to the guidance in RG 1.206, Section C.I.14.2.2, "Organization and Staffing"; SRP Section 14.2.II, "Acceptance Criteria," Section 3.A, "Management Organizations," and Section 3.D, "Staff Responsibilities, Authorities and Qualifications"; and RG 1.68, Section C.6, "Participation of Plant Operating and Technical Staff." In APR1400 DCD, Subsection 14.2.2, the DC applicant stated that the site-specific organization, the participation of staff in the test program, and the training program are all the responsibility of the COL applicant. The NRC staff finds that because staffing will be determined by the COL applicant and is, thus, outside the scope of design certification, it is acceptable to defer responsibility for the site-specific organization to the COL applicant. The staff confirmed that the COL applicant's responsibility to develop the site-specific organization and staffing levels for implementation of the ITP is captured in COL item 14.2(1) in APR1400 DCD, Subsection 14.2.13.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.2 adequately describes the activities related to the organization and staffing for the ITP, and is thus acceptable. The NRC staff also concludes that because staffing will be determined by the COL applicant and is, thus, outside the scope of design certification, it is acceptable to defer responsibility for the site-specific organization to the COL applicant.

14.2.4.3 DCD Subsection 14.2.3, Test Procedures

Introduction

In APR1400 DCD, Subsection 14.2.3, "Test Procedures," the DC applicant provided guidelines for the development of test procedures, including format requirements, adherence to applicable RGs, and provisions for review and approval by responsible personnel. In general, testing during all phases of the ITP is conducted using detailed, step-by-step written procedures to control the conduct of each test. Such test procedures specify testing prerequisites, describe desired initial conditions, include appropriate methods to direct and control test performance (including the sequencing of testing), and specify acceptance criteria by which the test is to be evaluated, and provide for or specify the format by which data or observations are to be recorded.

Evaluation

The NRC staff reviewed the conformance of the APR1400 DCD, Subsection 14.2.3 with the guidance in RG 1.68, Section C.4, "Procedures," and SRP Section 14.2. The NRC staff notes that the DC applicant followed the guidance of the SRP and provided the controls to develop test procedures. The DC applicant provided for detailed procedure guidelines and procedures used to develop the test procedures, a minimum set of topic areas to be included in each procedure, and the reference materials to be used in the preparation of each test procedure.

The APR1400 DCD, Subsection 14.2.3 indicates that a COL applicant is responsible for providing site-specific controls for the review and approval of test procedures for preoperational and startup tests. Additionally, the DC applicant stated that the submittal by the COL applicant of applicable procedures and guidelines to the staff for review will be conducted as described in APR1400 DCD, Subsection 14.2.11, "Test Program Schedule." The APR1400 DCD, Subsection 14.2.3, states, in part, that "the plant operator provides reasonable assurance for preparation and designates the approval process for Phases I through IV test procedures…[T]est procedures are based on the requirements of system designers and applicable NRC Regulatory Guides (RGs)." The NRC staff finds that because site specific controls for the review and approval of test procedures will be determined by the COL applicant and is, thus, outside the scope of design certification, it is acceptable to defer responsibility for the control of site-specific ITP test procedures to the COL applicant. The DCD discussion is also acceptable because it references the need to account for system design and directs the COL applicant to use NRC guidance. The NRC staff confirmed that the COL applicant's responsibility for site-specific preoperational and startup test specifications and test procedures is captured in COL Items 14.2(2) and 14.2(3) in APR1400 DCD, Subsection 14.2.13.

However, the NRC staff identified that additional information was needed regarding the startup administrative manual (SAM). In RAI 91-7867, Question 14.02-08 (ADAMS Accession No. ML16182A597), the NRC staff requested that the DC applicant place the SAM on the docket.

In its June 30, 2016 revised response to RAI 91-7867, Question 14.02-08 (ADAMS Accession No. ML16182A597), the DC applicant submitted an initial copy of the SAM. The NRC staff reviewed the initial copy of the SAM and determined that it provided the framework for the COL applicants to develop their own SAM to conduct the ITP; however; the NRC staff determined

that it did not address all of the DC applicant's administrative control responsibilities in accordance with the guidance of SRP Section 14.2.

In follow up RAI 513-8663, Question 14.02-67 (ADAMS Accession No. ML16221A563), the NRC staff requested that the DC applicant address bullet items A through D identified in SRP Section 14.2.II.3, "Initial Test Program Administrative Procedures," related to the DC applicant's administrative control responsibilities for completing the SAM, including the administrative controls for the list of test abstracts in the APR1400 DCD, Section 14.2. The NRC staff also requested that the DC applicant add the list of test abstracts included in APR1400 DCD, Section 14.2 to the SAM. In the February 3, 2017 response to RAI 513-8663, Question 14.02-67 (ADAMS Accession No. ML17034A412), the DC applicant proposed to add to the SAM, the administrative control responsibilities referenced in SRP Section 14.2.II.3 for the DC applicant. In addition, the DC applicant proposed to reference the list of ITP test abstracts for the preoperational, post core hot functional, low power physics, and power accession test phases in the SAM. The NRC staff reviewed the proposed changes and determined that the DC applicant did not reference the Initial Fuel Load Test, Post Core Ex-Core Neutron Flux Monitoring System Test, and the Initial Criticality Test in the SAM.

In the June 4, 2017, revised response to RAI 513-8663, Question 14.02-67, (ADAMS Accession No. ML17155A000), the DC applicant proposed to update the SAM to include the Initial Fuel Load Test, the Post Core Ex-Core Neutron Flux Monitoring System Test, the Initial Criticality/Low Power Physics Test, and all other added tests and changes that have been incorporated into the APR1400 DCD, Revision 1, Section 14.2. The NRC staff determined that the proposed change provides that the SAM includes the test abstracts of SSCs that will be tested in the ITP per the guidance in RG 1.68, Appendix A, Section A-2, "Initial Fuel Loading and Pre-Critical Tests," and Section A-3; "Initial Criticality." Therefore, RAI 513-8663, Question 14.02-67, which was being tracked as an open item, and RAI 91-7867, Question 14.02-08 are resolved.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.3 adequately describes the guidelines for the development of test procedures for the ITP, and is thus acceptable. The NRC staff also concludes that because site-specific administrative procedures to be developed by the COL applicant will govern the development of test procedures, it is acceptable to defer responsibility for the site-specific preoperational and startup test procedures to the COL applicant. All issues relating to this section of the initial test program have been resolved.

14.2.4.4 DCD Subsection 14.2.4, Conduct of Test Program

Introduction

In the APR1400 DCD, Subsection 14.2.4, "Conduct of Test Program," the DC applicant stated that the COL applicant is responsible for planning and conducting the ITP. The DC applicant also provided the format of the administrative procedures that will be used to conduct the initial test program. This section describes the administrative controls that govern the conduct of the test program. This description includes the administrative controls used to ensure that necessary prerequisites are satisfied for each major phase and for individual tests. The administrative controls pertaining to adherence to approved test procedures during the conduct

of the test program, as well as the methods for effecting changes to approved test procedures, are described.

Evaluation

The NRC staff reviewed the conformance of APR1400 DCD, Subsection 14.2.4 to the guidance in RG 1.206, Section C.I.14.2.4, "Conduct of Test Program"; SRP Sections 14.2.II and 14.2.II.3; and RG 1.68, Position C.2, "Prerequisites for Testing." The NRC staff finds that the DC applicant followed the guidance of the SRP, RG 1.206, and RG 1.68 in that APR1400 DCD, Subsection 14.2.4 states that the COL applicant is responsible for the planning and the conduct of the initial test programs. Also, the DC applicant stated that the startup test group will conduct the initial test program in accordance with administrative procedures and requirements. In addition, the DC applicant included specific direction that the COL applicant's procedures will (1) define the format and content of startup test procedures, and (2) define the review and approval process for both initial procedures and subsequent revisions or changes, consistent with Section C.I.14.2.4 of RG 1.206. The NRC staff confirmed that the COL applicant's responsibility for site-specific preoperational and startup test specifications and test procedures is captured in COL items 14.2(2) and 14.2(3) in APR1400 DCD, Subsection 14.2.13.

Conclusion

The NRC staff determined that the APR1400 DCD, Subsection 14.2.4 describes the activities related to review, evaluation, and approval of test results for the initial test program, and is thus acceptable. The NRC staff also concludes that, because the conduct of the test program will be completed by the COL applicant, it is acceptable to defer responsibility for the development of detailed administrative procedures to the COL applicant. All issues relating to this section of the initial test program have been resolved.

14.2.4.5 DCD Subsection 14.2.5, Review, Evaluation, and Approval of Test Results

Introduction

In the APR1400 DCD, Subsection 14.2.5, "Review, Evaluation, and Approval of Test Results," the DC applicant stated that the COL applicant is responsible for the site-specific administrative procedures for review and approval of test results.

This section describes the specific controls to be established for the review, evaluation, and approval of test results for each major phase of the program by appropriate personnel and/or organizations. This description includes specific controls to be established to ensure notification of affected and responsible organizations or personnel when test acceptance criteria are not met, as well as the controls established for corrective actions and retests, as required.

Evaluation

The NRC staff reviewed conformance of the APR1400 DCD, Subsection 14.2.5 to the guidance in RG 1.206, Section C.I.14.2.5, "Review, Evaluation and Approval of Test Results"; SRP Sections 14.2.II, and 14.2.II.3, Subsection F, "Review, Evaluation and Approval of Test Results"; and RG 1.68, Section C.9, "Test Reports." The NRC staff finds that the DC applicant followed

the guidance of the SRP, RG 1.206, and RG 1.68 in that APR1400 DCD, Subsection 14.2.5 states that:

> *The COL applicant is to review and evaluate individual test results in a test report made available to NRC personnel after preoperational and startup tests are completed. The specific test acceptance criteria for determining success or failure of a test shall be included in the test report approval of the test results. The test report should also include test results associated with any license conditions in the plant specific Initial Test Program (COL 14.2(7)).*

The COL applicant's responsibility to review and evaluate individual test results is captured in COL item 14.2(7) in DCD, Subsection 14.2.13. The NRC staff finds that the APR1400 DCD, Subsection 14.2.5 included specific direction for the COL applicant to review, evaluate, and approve test records in accordance with RG 1.206, Section C.I.14.2.5.

Conclusion

The NRC staff concludes that the information provided in APR1400 DCD, Subsection 14.2.5 adequately describes the activities related to review, evaluation, and approval of test results for the initial test program, and is thus acceptable. The NRC staff finds that all issues relating to this section of the initial test program have been resolved.

Also, the NRC staff concludes that, because review and approval of the test results will be completed by the COL applicant, it is acceptable to defer responsibility for the development of detailed administrative procedures for the review and approval of test results to the COL applicant.

14.2.4.6 DCD Subsection 14.2.6, Test Records

Introduction

In APR1400 DCD, Subsection 14.2.6, "Test Records," the DC applicant provided a description of the controls that will be implemented to maintain initial test program records.

Evaluation

The NRC staff reviewed the conformance of APR1400 DCD, Subsection 14.2.6 to the guidance in RG 1.68, Section C.9. The APR1400 DCD, Subsection 14.2.6 states that the official copy of each test procedure and the information specifically called for in the test procedure shall be retained for the life for the plant by the COL applicant consistent with the guidance of RG 1.28. However, RG 1.28 only covers preoperational tests under the ITP, not startup tests.

In the review of APR1400 DCD, Subsection 14.2.6, the NRC staff determined that the information provided in APR1400 DCD, Subsection 14.2.6 was inadequate. In RAI 91-7867, Question 14.02-5 (ADAMS Accession No. ML15201A768), the NRC staff requested the DC applicant to revise APR1400 DCD, Subsection 14.2.6 to address retention of startup testing procedures and startup test results as part of the plant's historical records in accordance with RG 1.68.

In the June 30, 2016 response to RAI 91-7867, Question 14.02-5 (ADAMS Accession No. ML16182A597), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.6 to state that the preoperational and startup test procedures and test results are to be retained for the life of the plant by the COL applicant.

The NRC staff determined that this change to the APR1400 DCD, Subsection 14.2.6 meets RG 1.68, Section C.9 because it describes retention of startup test procedures and startup test report results; therefore, it is acceptable. Therefore, RAI 91-7867, Question 14.02-5 is resolved. The NRC staff verified the proposed change has been incorporated in the APR1400 DCD, Revision 1. In addition, the NRC staff confirmed that the COL applicant's responsibility for retaining preoperational and startup test procedures and results is captured in COL Items 14.2(2) and 14.2(3) in APR1400 DCD, Subsection 14.2.13.

Conclusion

The NRC staff concludes that the information provided in APR1400 DCD, Subsection 14.2.6 adequately describes protocols pertaining to the disposition of test procedures and test data following completion of the test program, and is thus acceptable. All issues relating to this section of the initial test program have been resolved.

14.2.4.7 DCD Subsection 14.2.7, Conformance of Test Programs with NRC Regulatory Guides

Introduction

In APR1400 DCD, Subsection 14.2.7, "Conformance of Test Programs with Regulatory Guides," the DC applicant references APR1400 DCD, Subsection 1.9.1 and Table 1.9-1, "APR1400 Conformance with NRC Regulatory Guides," which provide a list of specific RGs related to testing and testing programs. This section also references Table 14.2-7, "Conformance Matrix of RG 1.68 Appendix A versus Individual Test Descriptions," which cross-references the matrix of the applicable guidance in RG 1.68 Appendix A to the test descriptions listed in DCD, Subsection 14.2.12 to demonstrate compliance with RG 1.68.

Evaluation

The NRC staff reviewed conformance of APR1400 DCD, Subsection 14.2.7 to the guidance in SRP Section 14.2.II.2, "Test Program's Conformance with Regulatory Guides"; RG 1.20, "Comprehensive Vibration Assessment Programs for Internals during Preoperational and Initial Startup Testing," Regulatory Position C.1.4, "Non-Prototype Category I"; and the general guidelines and applicable regulatory positions in RG 1.68.

SRP Section 14.2 states, in part, that the DC or COL applicant should establish and describe an ITP that is consistent with the regulatory positions outlined in RG 1.68. SRP Section 14.2 also includes a list of RGs that provide more detailed information pertaining to the testing. RG 1.68, Appendix A, references a set of supplemental regulatory guides that provide guidance for particular tests during the preoperational and initial startup phases. The supplemental RGs contain additional information to help determine if performance of the tests in the proposed manner will likely accomplish the objectives of certain plant tests.

In the APR1400 DCD, Subsection 14.2.7, the DC applicant referenced Table 1.9-1, which lists RGs utilized for the development of the APR1400 ITP. In addition, Table 14.2-7 lists the system test descriptions that conform to RG 1.68, Appendix A. The NRC staff reviewed the aforementioned tables to ensure that the applicable RGs were included in the development of the ITP. For those instances in which the DC applicant determined that RGs were not applicable to the APR1400 design or where exceptions to RGs were proposed, the NRC staff reviewed the DC applicant's justification for the exception to ensure that the test program scope remained sufficient. The APR1400 DCD, Subsections 14.2.7.1.1 through 14.2.7.1.13 provide exceptions and/or clarifications between the proposed ITP, as described in 14.2.12, to the regulatory positions in RG 1.68. In most cases, the exceptions provide bases as to why the APR1400 will not be tested as described in RG 1.68 due to differences in the design.

The NRC staff reviewed the APR1400 DCD, Subsections 14.2.7.1.1 through 14.2.7.1.13 and concluded that the proposed exceptions and/or clarifications were acceptable because the principal design criteria established in Appendix A to 10 CFR Part 50 are met, except as described below. The NRC staff identified the following areas where additional information was needed.

The NRC staff determined that in Table 14.2-7, the DC applicant did not reference APR1400 DCD, Subsections 14.2.12.1.2, "Reactor Coolant System Test," and 14.2.12.1.37, "Safety Depressurization and Vent System Test." Therefore, testing of the reactor coolant gas vent system using vent valves for a number of major reactor coolant system (RCS) components (e.g., reactor vessel upper head vent valves, pressurizer vent valves, etc.) in the RCS was not referenced to the appropriate testing guidance in RG 1.68. In RAI 91-7867, Question 14.02-2 (ADAMS Accession No. ML15201A768), the NRC staff requested that the DC applicant add APR1400 DCD, Subsections 14.2.12.1.2 and 14.2.12.1.37 to row 1.a.2.h of Table 14.2-7. In addition, the NRC staff requested the DC applicant to verify if other APR1400 test abstract subsections are correctly referenced in Table 14.2-7 for conformance with RG 1.68, Appendix A.

In the December 9, 2015 response to RAI 91-7867, Question 14.02-2 (ADAMS Accession No. ML15343A502), the DC applicant proposed to revise Table 14.2-7 to add references to the APR1400 DCD, Subsections 14.2.12.1.2 and 14.2.12.1.37 and verified that no other test abstract subsections were missing. The NRC staff determined that this response adequately addressed the NRC staff's requested revisions to meet RG 1.68, Appendix A, related to the list of tests and is acceptable. Therefore, RAI 91-7867, Question 14.02-2 is resolved. The NRC staff verified that the proposed change has been incorporated in the APR1400 DCD, Revision 1.

In the APR1400 DCD, Subsection 14.2.7.1.13, "Reference Section C, Regulatory Position 4," which discussed exceptions to RG 1.68, Regulatory Position C.4, the DC applicant states:

> *This section requires inclusion of acceptance criteria that account for uncertainties. The test summaries in Subsections 14.2.12.2.1 and 14.2.12.1.46 are essential to the demonstration of conformance to the requirements for structures, components, and features important to safety.*

In its review, the NRC staff determined that the DC applicant should provide additional information on what uncertainties, if any, should be included in the test acceptance criteria

related to the APR1400 DCD, Subsections 14.2.12.1.46 and 14.2.12.2.1. The DC applicant also needed to describe any exceptions from the guidance in RG 1.68, Regulatory Position C.4 it is taking regarding these test abstracts. The NRC staff requested this information in RAI 91-7867, Question 14.02-6 (ADAMS Accession No. ML15201A768).

In the December 9, 2015, response to RAI 91-7867, Question 14.02-6 (ADAMS Accession No. ML15343A502), the DC applicant provided the following response**:**

> *Uncertainties include the design value that should be met to satisfy the safety analysis assumption and to maintain the safety related function(s). These values will be included in each specific test procedure acceptance criteria, such as the design flowrate of the pump, response time of the valve, actuation setpoint of the control system, etc. However, the exact value to be used in the procedure will be provided by the COL applicant. Test plans for 14.2.12.1.46, "Pre-Core Hot Functional Test Controlling Document," and 14.2.12.2.1, "Post-Core Hot Functional Test Controlling Document" are the controlling documents for all the pre-core and post-core evolutions and plans. Therefore, these two procedures do not include the design related uncertainties.*

The NRC staff determined that the DC applicant's response is acceptable because design related uncertainties are specific to each COL site and will be included in the COL's site specific test procedures and test plans. Therefore the design related uncertainties are not included in the APR1400 DCD, Section 14.2 test abstracts. Based on the above, RAI 91-7867, Question 14.2-6 is resolved.

In RAI 91-7867, Question 14.02-9 (ADAMS Accession No. ML15201A768) and RAI 187-8101, Question 14.02-10 (ADAMS Accession No. ML15292A501), the NRC staff requested the DC applicant to revise APR1400 DCD, Table 1.9-1 to include individual ITP tests to conform to the guidance in RG 1.20. For a non-prototype plant like the APR1400, the DC applicant should consider adding two tests which include the Internals Vibration Monitoring System Test in APR1400 DCD, Subsection 14.2.12.1.41 and the Nuclear Steam Supply System (NSSS) Integrity Monitoring System Test in APR1400 DCD, Subsection 14.2.12.4.18.

In the August 28, 2015, response to RAI 91-7867, Question 14.02-9 (ADAMS Accession No. ML15240A044) and in the May 19, 2016, response to RAI 187-8101, Question 14.02-10 (ADAMS Accession No. ML16142A015), the DC applicant stated that the comprehensive vibration assessment program (CVAP) is used to verify the structural integrity of the reactor internals for flow-induced vibration prior to commercial operation. Since an analysis program and an inspection program are being implemented for the APR1400 and the results are being assessed in those programs, implementation of a vibration measurement program is not necessary in accordance with RG 1.20. The DC applicant stated that the reactor internal vibration test is excluded from CVAP because the APR1400 is classified as a non-prototype category I plant in accordance with the guidance provided in RG 1.20. This is also stated in APR1400 DCD, Subsection 14.2.7.1.6.

The DC applicant also noted that the Nuclear Instrument Monitoring System (NIMS) (which includes the Internal Vibration Monitoring System (IVMS), Loose Parts Monitoring System (LPMS), and the Acoustic Leak Monitoring System (ALMS)) is used to verify the proper operation of vibration monitoring of these systems and that test results are used to establish alarm set-points and to evaluate the adequacy of system design parameters. Also, most of the

NIMS is non-safety-related (e.g., except for LPMS, which is designed to meet RG 1.33). The DC applicant also noted that none of the preoperational test and startup tests are needed for the DC applicant's commitments to vibration monitoring in RG 1.20. Therefore, since the system tests for IVMS, LPMS, and ALMS are not related to RG 1.20 testing, it is not necessary to include reference to APR1400 DCD, Subsections 14.2.12.1.41, 14.2.12.1.42, 14.2.12.1.43 or 14.2.12.4.18 in Table 1.9.1 for RG 1.20 applicability.

The NRC staff reviewed the DC applicant's response to RAI 91-7867, Question 14.02-9 and RAI 187-8101, Question 14.02-10. In accordance with the guidance of RG 1.20, the vibration measurement program can be omitted for non-prototype category I reactors if an inspection program is implemented. The DC applicant stated that it will satisfy the commitment for CVAP by implementing an inspection program that provides for inspection of the reactor internals as described in APR1400 DCD, Section 3.9. The NRC staff determined that although APR1400 DCD, Subsections 14.2.12.1.41, "Internals Vibration Monitoring System Test," 14.2.12.1.42 "Loose Parts Monitoring system," 14.2.12.1.43, "Acoustic Leak Monitoring System Test, and 14.2.12.4.18, "Baseline Nuclear Steam Supply System Integrity Test," include some IVMS test monitoring activities, these tests are not required meet the guidance in RG 1.20. Therefore, RAI 91-7867, Question 14.02-9 and RAI 187-8101, Question 14.02-10, which were being tracked as an open item, are resolved.

Conclusion

The NRC staff concludes that the information provided in APR1400 DCD, Subsection 14.2.7 adequately describes the conformance of KHNP's test programs with NRC regulatory guides, and is therefore acceptable.

14.2.4.8 DCD Subsection 14.2.8, Use of Reactor Operating and Test Experience in the Development of the Initial Test Program

Introduction

In the APR1400 DCD, Subsection 14.2.8, "Use of Reactor Operating and Testing Experience in the Development of Initial Test Program," the DC applicant discusses the COL applicant's ability to use relevant operating and testing experiences gained from previous successful startups. This section states that the COL applicant is to describe its program for reviewing available information on reactor operating and testing experiences and discusses how it used this information in developing the initial test program.

Evaluation

The NRC staff reviewed conformance of the APR1400 DCD, Subsection 14.2.8 to the guidance in SRP Section 14.2.II.3.G, "Utilization of Reactor Operating and Testing Experiences in Development of Test Program," and the general guidelines and applicable regulatory positions in RG 1.68 and RG 1.20.

In the APR1400 DCD, Subsection 14.2.8, the DC applicant noted that a COL applicant would have the benefit of experience acquired with the successful and safe startup of the reference plant, Shin-Kori Nuclear Unit 3 (SKN #3) APR1400 plant. The reactor operating and testing experience gained from the reference plant and other reactor types is factored into the design

and test system information for plant equipment and systems that are demonstrated during the preoperational and startup test programs.

Upon review of APR1400 DCD, Subsection 14.2.8, the NRC staff identified the following areas where additional information is needed. A description of the specific issues identified by the NRC staff is as follows:

In APR1400 DCD, Subsection 14.2.8.1, "First-of-a-kind Tests," Revision 0, the DC applicant stated, in part, that:

> *First-of-a-kind (FOAK) tests are defined as new, unique, or special tests for new design features in plants. The functional testing requirements necessary to verify FOAK test performance should be identified if these design features are used in the APR1400 in the United States. These tests are performed only for the first plant.*
>
> *The APR1400 is not a first-of-a-kind plant since it is preceded by Shin-Kori Units 3&4 (SKN3&4) in Korea, which are scheduled to begin commercial operation. Therefore, FOAK testing and operational data will be available prior to the APR1400 in the United States.*

The NRC staff determined that the first APR1400 plant built in the USA will not be a prototype plant with FOAK tests per the regulations in 10 CFR 50.2, "Prototype Plant," and 10 CFR 50.43(e). However, the NRC staff does not accept the DC applicant's position that the first APR1400 plant built in South Korea is a FOAK plant. As such, the DC applicant cannot take credit for prototype plant test that occurred at SKN #3 in South Korea.

In RAI 91-7867, Question 14.02-7 (ADAMS Accession No. ML15201A768), the NRC staff requested that the DC applicant revise the APR1400 DCD, Subsection 14.2.8.1 to be consistent with 10 CFR 50.2, 10 CFR 50.43(e), Revision 4 to RG 1.68, Section C.7, "Trial Testing of Plant Emergency, Operating and Surveillance Test Procedures," RG 1.68, Appendix A, Section A-6, "First-of-a-Kind (FOAK) Testing," and Section A-7, "Design Qualification Tests for Advanced Reactors."

In the June 30, 2016, response to RAI 91-7867, Question 14.02-07 (ADAMS Accession No. ML16182A597), the DC applicant proposed to revise the APR1400 DCD, Subsection 14.2.8.1 by deleting the references to SKN #3 being a prototype plant and to refer to Palo Verde Nuclear Generation Station (PVNGS) Unit 1, as the prototype plant of the APR1400 for the vibration monitoring system and the natural circulation test. The NRC staff has reviewed the proposed DCD revision and determined that it is acceptable because PVNGS Unit 1 and the APR1400 design both have the same number of fuel assemblies, enrichment and almost the exact same core thermal power (APR1400 thermal power = 3983 Mwt, PVNGS Unit 1 core thermal power = 3990 Mwt). In accordance with RG 1.20, the first APR1400 built in the USA will be a non-prototype Category I plant. The APR1400 does not have any FOAK tests. The NRC staff determined that the DC applicant's response and the proposed update to the APR1400 DCD, Subsection 14.2.8.1 meets the guidance in RG 1.20 and RG 1.68 for non-prototype plants and it is acceptable; therefore, RAI 91-7867, Question 14.02-07 is resolved. The NRC staff verified that the proposed changes have been incorporated in the APR1400 DCD, Revision 1.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.8 adequately describes the activities related to the review of relevant operating and testing experiences gained from previous successful startups, and is therefore acceptable.

14.2.4.9 DCD Subsection 14.2.9, Trial Use of Plant Operating and Emergency Procedures

Introduction

In the APR1400 DCD, Subsection 14.2.9, "Trial Use of Plant Operating and Emergency Procedures," the DC applicant described the COL applicant's responsibilities related to development of plant procedures, as well as a description of how, and to what extent, the plant operating, emergency, and surveillance procedures are tested during the initial test program.

Evaluation

The NRC staff reviewed conformance of APR1400 DCD, Subsection 14.2.9 to the guidance in SRP Section 14.2.II.3.H, "Trial Use of Plant Operating and Emergency Procedures," and RG 1.68, Section C.7. SRP Section 14.2 indicates that the DC or COL applicant should incorporate, to the extent practicable, plant operating, emergency, and surveillance procedures into the test program, or otherwise verify these procedures through use during the test program. The APR1400 DCD, Subsection 14.2.9 indicates that the COL applicant is to provide a schedule for the development of plant procedures, as well as a description of how, and to what extent, the plant operating, emergency, and surveillance procedures are use-tested during the initial test program.

Additionally SRP Section 14.2 indicates the DC or COL applicant should provide additional operator training and participation based on the performance and evaluation of the test results of certain initial tests, and that an acceptable program will satisfy the criteria described in Three Mile Island (TMI) Action Plan Item I.G.1 of NUREG-0660 and NUREG-0737. The NRC staff noted that APR1400 DCD, Subsection 14.2.9 states that the COL applicant is to identify the operator training to be conducted as part of the low-power testing program related to the resolution of TMI Action Plan Item I.G.1, as described in (1) NUREG-0660 – NRC Action Plans Developed as a Result of the TMI-2 Accident, Revision 1, August 1980 and (2) NUREG-0737 – Clarification of TMI Action Plan Requirements. The NRC staff confirmed that the COL applicant's responsibility for identifying the specific operator training to be conducted as part of the low-power testing program related to the resolution of TMI Action Plan Item I.G.1 is captured in COL Item 14.2(12) in APR1400 DCD Subsection 14.2.13.

The NRC staff finds that it is acceptable to defer the review of the trial use of operating and emergency procedures to the COL phase, because the development of operating and emergency procedures will depend upon detailed plant-specific design information. The NRC staff also finds that the information provided in the APR1400 DCD, Subsection 14.2.9 adequately describes that the schedule for the development of the plant operating and emergency procedures will allow sufficient time for trial use of these procedures during the initial test program as appropriate and to the extent possible, and is thus acceptable. The NRC staff confirmed that the COL applicant's responsibility for the trial use of plant operating and emergency procedures is captured in COL item 14.2(11) in APR1400 DCD, Subsection 14.2.13.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.9 adequately addresses the trial use of plant operating and emergency procedures. All issues relating to this section of the initial test program have been resolved.

14.2.4.10 DCD Subsection 14.2.10, Initial Fuel Loading and Initial Criticality

Introduction

In the APR1400 DCD, Subsection 14.2.10, "Initial Fuel Loading and Initial Criticality," the DC applicant stated that initial fuel loading and initial criticality will be performed in a controlled manner during the startup test program. The minimum initial conditions for the core and the criteria for the safe loading of fuel are specified. Criteria are also specified for a safe and controlled approach to criticality.

Evaluation

The NRC staff reviewed the conformance of the APR1400 DCD, Subsection 14.2.10 to the guidance in SRP Section 14.2.II.4.A, "Initial Fuel Loading/Initial Criticality/Low Power /Power Ascension Testing," and RG 1.68, Appendix A, Sections A-2, and A-3. As stated in the regulatory guidance, initial fuel loading and pre-critical tests should (1) ensure safe initial core loading, (2) ensure that provisions are in place to maintain shutdown margin, and (3) ensure that the facility is in a final state of readiness to achieve criticality and perform low-power testing.

In the APR1400 DCD, Subsection 14.2.10 the DC applicant provided five Subsections: 14.2.10.1, "Initial Fuel Loading"; 14.2.10.1.1, "Safe Loading Criteria"; 14.2.10.1.2, "Fuel Loading Procedure"; 14.2.10.2, "Initial Criticality"; and 14.2.10.2.1, "Safe Criticality Criteria," which addressed RG 1.68, Appendix A, Section A-2, and Section A-3.

Initial Fuel Loading

The DC applicant included provisions for initial fuel loading prerequisites. The NRC staff noted that these provisions included Technical Specifications compliance, use of approved plant procedures, proper verification of water level and chemistry, continuous area radiation monitoring and calibration and response of nuclear instrumentation. The NRC staff verified that the DC applicant identified those prerequisites necessary for safe initial fuel loading in accordance with RG 1.68 and SRP Section 14.2.

The NRC staff finds that the DC applicant provided an adequate description of the prerequisites for initial fuel load, and is thus acceptable.

Safe Loading Criteria

The DC applicant described the criteria that require fuel loading operations to stop, which include if (1) the neutron count rate from either temporary nuclear channel unexpectedly doubles during any single loading step, and (2) the neutron count rate on any individual nuclear channel increases by a factor of 5 during any single loading step excluding an anticipated change due to detector/source.

The NRC staff finds that the DC applicant provided an adequate description of the safety criteria for halting fuel loading operations, and is thus acceptable.

Fuel Loading Procedure

The DC applicant describes the applicable precautions and limitations, prerequisites, initial conditions, and the necessary procedural steps that will be included in the initial fuel loading procedure.

The NRC staff finds that the DC applicant provided an adequate description of the procedural steps for initial fuel load, and is thus acceptable.

Initial Criticality

In the APR1400 DCD, Subsection 14.2.10, the DC applicant described the controls to be used for controlled approach to criticality. These controls include the use of approved plant procedures, use of an orderly combination of control element assembly withdrawal and boron concentration reduction, and monitoring of the core response. The DC applicant included provisions for initial criticality perquisites.

The NRC staff finds that the DC applicant provided an adequate description of the controls to be implemented during the initial approach to criticality, and is thus acceptable.

Safe Criticality Criteria

The DC applicant provided the criteria for reasonable assurance of a safe approach to criticality. The NRC staff noted the criteria included that the Technical Specifications are met, a sustained start up rate not in excess of one decade per minute, and a minimum of one decade per minute overlap is observed between the startup and log safety channels of the ex-core nuclear instruments.

The NRC staff finds that the DC applicant provided an adequate description of the process to provide reasonable assurance of a safe approach to criticality, and is thus acceptable.

Conclusion

The NRC staff concludes that the information provided in APR1400 DCD, Subsection 14.2.10 adequately describes the minimum initial conditions for the core and the criteria for the safe loading of fuel and the criteria for providing a safe and controlled approach to criticality, and is thus acceptable. The NRC staff finds that all issues relating to this section of the ITP have been resolved.

14.2.4.11 DCD Subsection 14.2.11, Test Program Schedule

Introduction

In the APR1400 DCD, Subsection 14.2.11, the DC applicant stated that the scheduling of individual tests or test sequences will be established so that systems and components that are required to prevent or mitigate the consequences of postulated accidents are tested prior to fuel

loading. Tests that require a substantial core power level for proper performance will be performed at the lowest power level commensurate with obtaining acceptable test data. In addition, the DC applicant stated that the COL applicant is to specify the testing sequence to provide reasonable assurance that safety of the plant is not compromised during the test program and to provide reasonable assurance that the conduct of a specific test does not place the plant in a condition for which untested systems would be relied on for safety.

Evaluation

The NRC staff reviewed conformance of APR1400 DCD, Subsection 14.2.11 to the guidance in RG 1.206, Section C.I.14.2.11, "Test Program Schedule"; RG 1.68, Section C.5, "Schedule"; and SRP Section 14.2.II and Subsection 14.2.II.3.C, "Test Program Schedule and Sequence." RG 1.68 states that sufficient time should be scheduled to perform an orderly and comprehensive testing, providing for a minimum time of approximately 9 months for conducting the preoperational testing phase, and a minimum time of approximately 3 months for conducting the initial startup testing phase. In addition, SRP Section 14.2 states, in part, that the safety of the plant should not depend entirely on the performance of untested systems, components, or features.

In the APR1400 DCD, Subsection 14.2.11, the DC applicant states that it is the responsibility of the COL applicant to develop a test program that considers the following components:

- The COL applicant should allow at least 9 months for conducting preoperational testing.
- The COL applicant should allow at least 7 months for conducting startup testing, including fuel loading, low-power tests, and power-ascension tests.
- Approved test procedures should be in a form suitable for review by regulatory inspectors at least 60 days prior to their intended use or at least 60 days prior to fuel loading for fuel loading and startup test procedures.

The NRC staff finds that the APR1400 DCD, Subsection 14.2.11 included specific direction for the COL applicant to develop a test program that allocates sufficient time to perform orderly and comprehensive testing. The NRC staff confirmed that the COL applicant's responsibility for the test program schedule is captured in COL item 14.2(13) in APR1400 DCD, Subsection 14.2.13. In addition, the NRC staff finds that the APR1400 DCD, Subsection 14.2.11 is acceptable because it provides that the COL applicant will schedule tests so that systems and components that are required to prevent or mitigate the consequences of postulated accidents are tested prior to fuel loading. Additionally, the APR1400 DCD provides that the COL applicant's test schedule and sequence of testing is to ensure that tests that require a substantial core power level for proper performance will be performed at the lowest power level commensurate with obtaining acceptable test data.

Conclusion

The NRC staff concludes that the information provided in the APR1400 DCD, Subsection 14.2.11 adequately describes the test program schedule. All issues relating to this section of the ITP have been resolved.

14.2.4.12 DCD Subsection 14.2.12, Individual Test Descriptions

Introduction

The APR1400 DCD, Subsection 14.2.12 contains individual preoperational and startup test abstracts. Each abstract identifies test objectives, prerequisites for conducting testing, test methods, test data requirements, and acceptance criteria for successful completion of the tests. The minimum test requirements are generally based on system or component functional design requirements that were used in the safety analysis. Detailed preoperational and startup test procedures will be developed using these test abstracts.

Evaluation

The NRC staff reviewed conformance of the APR1400 DCD, Subsection 14.2.12, "Individual Test Descriptions," to the guidance in SRP Section 14.2.II.5, "Individual Test Descriptions/Abstracts," and the general guidelines and applicable regulatory positions in RG 1.68. RG 1.68, Appendix A addresses the specific tests required for each of the five phases of the initial test program, which are: (1) preoperational testing; (2) initial fuel loading and pre-criticality testing; (3) initial criticality testing; (4) low-power testing; and (5) power ascension testing.

In the APR1400 DCD, Subsection 14.2.12 the NRC staff identified 135 preoperational tests, 11 post core load hot functional tests, 6 low power tests, and 26 power ascension tests. For each of the test abstracts, the NRC staff reviewed the test objectives, test prerequisites, test methods, data requirements, and acceptance criteria to verify conformance with NRC regulatory guidance. From the start of the review in March 2015 until October 2015, the NRC staff reviewed these tests and identified the same generic issues with the format and descriptions for all 178 listed tests and a failure to follow the guidance of RG 1.68, Appendix A for SSCs that should be tested.

This resulted in NRC staff issuing a large number of RAI questions (90). Since the issues applied to all of Section 14.2, on October 8, 2015, the NRC staff held a conference call with the DC applicant and requested the DC applicant to revise all of APR1400 DCD, Section 14.2. The NRC staff suspended issuing any new RAIs and asked the DC applicant to delay responding to currently issued RAIs until the tests referenced in each RAI question were revised. During the call discussion, the DC applicant provided a sample revision which NRC staff agreed was much improved and followed the guidance of RG 1.68. The DC applicant provided the revised Section 14.2 on February 24, 2016 (ADAMS Accession No. ML16056A002). The revised Section 14.2 served as a new starting point, still as APR1400 DCD, Revision 0, for the review.

The revised DCD, Subsection 14.2.12 included 139 preoperational tests, 11 post-core hot functional tests, 6 low power physics tests and 26 power ascension tests, 182 tests total. The DC applicant also upgraded each test description with new objectives, prerequisites, test methods, data requirements and acceptance criteria.

In the March 10, 2017 submittal of APR1400 DCD, Section 14.2, Revision 1 (ADAMS Accession No. ML17096A392), the DC applicant revised DCD, Subsection 14.2.12 to include 153 preoperational tests and 10 post-core hot functional tests, while the number of power ascension and low power physics tests remained at 26 and 6, respectively. The NRC staff reviewed the new tests and the upgrades to each test description and determined that the proposed changes

to the APR1400 DCD, Subsection 14.2.12 meets the guidance in RG 1.68, Appendix A for the list of APR1400 tests that should be included in the ITP.

For those aspects of the APR1400 DCD, Subsection 14.2.12 for which no RAIs were necessary, the NRC staff determined the DC applicant provided an adequate test program to address those specific functions. The NRC staff also verified that the tests are appropriately sequenced so that plant safety is never entirely dependent on the performance of untested SSCs. The NRC staff also determined, using applicable guidance, that the test descriptions: (1) contained appropriate content for the descriptions of test objectives, test prerequisites, test methods, data requirements and acceptance criteria, and (2) were acceptable because they were consistent with the general guidelines and applicable regulatory positions contained in RG 1.68.

For some aspects of the APR1400 DCD, Subsection 14.2.12, the NRC staff determined that additional information was required to complete its review. The discussion below first addresses those RAIs that are not specific to an ITP phase. Then the discussion addresses RAIs specific to an ITP phase (pre-operational tests, post-core hot functional tests, low power physics tests, and power ascension tests).

Radiation Protection System

RG 1.68 provides guidance on initial tests that are acceptable to NRC staff as part of the ITP. RG 1.68, Appendix A provides guidance on the types of tests that should be included as part of the ITP. Various radiation-protection-related items that RG 1.68 states should be tested were not addressed in the ITP for the APR1400 design. These included the following:

1. Testing of laboratory equipment used to analyze or measure radiation levels and radioactivity concentrations (see RG 1.68, Appendix A, Section A-1.k item 3).

2. Testing for leakage control and detection for the chemical and volume control system (CVCS) and testing of the gaseous systems for leak detection or equivalent testing (see RG 1.68, Appendix A, Section A-1.l).

3. Testing of components to control the temperature of the steam generator blowdown system (SGBS), as discussed in APR1400 DCD, Subsection 10.4.8, to protect the steam generator blowdown resin beds, preventing a sudden loss of resin bed efficiency and the release of radioactivity above established limits and contamination of otherwise clean portions of plant systems (see RG 1.68, Appendix A, Section A-1.k and A-1.m).

In RAI 281-8232, Question 14.02-54 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant provide the above tests in the ITP or justify an alternative.

In the June 30, 2016, response to RAI 281-8232, Question 14.02-54 (ADAMS Accession No. ML16182A588), the DC applicant provided that the COL applicant is to develop the test program of laboratory equipment used to analyze or measure radiation levels and concentrations. Therefore, the list of COL items in APR1400 DCD, Subsection 14.2.13 will be revised to add a requirement that the COL applicant develop the appropriate test program for the subject equipment.

The NRC staff reviewed the proposed change and determined that the COL applicant's responsibility to develop the test program of personnel monitors, radiation survey

instruments, and laboratory equipment is captured in COL item 14.2(16) as requested in RAI 281-8232, Question 14.02-54. The NRC staff also verified that the proposed changes have been incorporated in the APR1400 DCD, Revision 1.

In addition, the DC applicant indicated that testing for leakage control and detection for the CVCS and gaseous rad-waste systems are not necessary, since the accident source term does not enter into these systems as a result of the accident due to containment isolation. The NRC staff determined that the DC applicant's response is acceptable because the CVCS and gaseous rad-waste systems can be isolated during an accident, if necessary. Additionally, the containment isolation valve is tested in DCD, Subsection 14.2.12.1.124; thus the NRC staff concluded that the DC applicant's explanation for not performing leak test detection of CVCS and gaseous rad-waste systems is consistent with the testing guidance in RG 1.68, Appendix A, Section A-5, "Power Ascension Tests," Test Item n, for radiation leakage testing, and Test Item z, related to independent laboratory testing.

The NRC staff determined that the DC applicant did not provide an adequate response to the third item requested RAI 281-8232, Question 14.02-54, because the response did not discuss the testing of isolation features of the SGBS based on resin bed temperature and radioactivity.

In RAI 277-8227, Question 14.02-38 (ADAMS Accession No. ML15303A462), the NRC staff requested additional information about the objectives of the test, test methods and acceptance criteria for the preoperational testing plan for the SGBS to evaluate the plan in accordance with RG 1.68 Appendix A, Section A-1.k, "Radiation Protection Systems," and Section A-1.m, "Radioactive Waste Handling and Storage Systems."

In the June 30, 2016, response to RAI 277-8227, Question 14.02-38 (ADAMS Accession No. ML16182A554), the DC applicant proposed expanding the APR1400 DCD, Subsection 14.2.12.1.66 with a new list of test objectives explicitly addressing valve operation, actuation signals, alarms, status lights, and flow path for secondary water processing. The DC applicant also proposed adding a list of acceptance criteria based on the specific design attributes described in APR1400 DCD, Subsection 10.4.8, "Steam Generator Blowdown System." In addition, the DC applicant proposed removing the resin regeneration requirement from the test plan since resin regeneration is not an SGBS function. Lastly, the DC applicant proposed to include testing of the SGBS valves used to control the temperature in the resin beds and the potential release of radioactivity.

The NRC staff determined that these changes to the APR1400 DCD, Subsection 14.2.12.1.66 are acceptable because the DC applicant updated the preoperational test objectives and acceptance criteria for the SGBS consistent with the guidance in RG 1.68, Appendix A, Section A-1.m related to testing steam generator blowdown. Specifically, APR1400 DCD, Subsection 14.2.12.1.66 was updated to include six new SGBS test objectives and test acceptance criteria, including lists of several components (e.g., valves, interlocks, alarms, status lights, ESFAS and DPS response signals, etc.) which are functionally tested. Additionally, the NRC staff determined that testing of the automatic isolation function due to high temperature will be performed consistent with the regulatory guidance in RG 1.68, Appendix A, Section A-1.k, which states that the temperature of the steam generator blowdown system should be monitored to protect resin beds from excessive temperature, which could damage them and result in an unacceptable radioactive release or contamination event. Based on the above, RAI 277-8227,

Question 14.02-38 and RAI 281-8232, Question 14.02-54, which were being tracked as an open item, are resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

In addition to this, the NRC staff identified a list of systems, components, and features for which the ITP should demonstrate that systems and components used to process, store, and release liquid, gaseous, and solid radioactive wastes are functionally operable and can achieve design flow rates. The NRC staff issued RAI 284-8234, Question 14.02-65 (ADAMS Accession No. ML15306A358) requesting this information.

In the June 17, 2016, response to RAI 284-8234, Question 14.02-65 (ADAMS Accession No. ML16169A374), the DC applicant proposed revisions to APR1400 DCD, Subsections 14.2.12.1.65, 14.2.12.1.66, 14.2.12.1.67, 14.2.12.1.99, 14.2.12.1.104, and 14.2.12.1.105 to address preoperational testing of off-gas monitors; radiation monitors; isolation features for the SGBS, including thermal protection of demineralizer resin beds; automatic isolation features for ventilations systems; ventilation system gaseous effluent radiation release limits; diversion of exhaust flows; gas, liquid and solid rad-waste systems; and waste process systems, including testing of mobile process equipment carrying radioactive fluids.

The NRC staff reviewed the DC applicant's response to RAI 284-8234, Question 14.02-65 and determined that the DC applicant provided the requested information, consistent with the guidance in RG 1.68, with one exception. Namely, the DCD applicant failed to address testing of (1) the isolation features for the SGBS based on the presence of radioactivity and (2) thermal protection of the demineralizer beds. The APR1400 DCD, Subsection 10.4.8 also mentions these two features. However, the testing of these two features was addressed in the DC applicant's June 30, 2016 response to RAI 277-8227, Question 14.02-38 (ADAMS Accession No. ML16182A554) in its discussion of the test objectives, methods, and acceptance criteria for the SGBS. Therefore, RAI 284-8234, Question 14.02-65 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

Reactor Coolant Pump Tests

The NRC staff determined that the APR1400 DCD, Subsection 14.2.12 did not include sufficient information regarding testing for the Reactor Coolant Pumps (RCPs). In RAI 279-8175, Question 14.02-42 (ADAMS Accession No. ML15303A547) the NRC staff requested that the DC applicant discuss testing performed for RCP components, including the pump, motor, and associated power sources. In addition the NRC staff requested the DC applicant to discuss the performance of Motor Current, Motor Power, Pump Motor Vibration, Motor Stator temperature, and Proper transfer from variable speed startup preoperational test for the RCPs.

In the June 15, 2016, response to RAI 279-8175, Question 14.02-42 (ADAMS Accession No. ML16167A540), the DC applicant stated that the revised Section 14.2 submitted on February 24, 2016 (ADAMS Accession No. ML16056A002) provided extensive updates to preoperational, post core hot functional and power ascension tests in APR1400 DCD, Subsections 14.2.12.1.1 and 14.2.12.1.2, 14.2.12.1.56, 14.2.12.1.136, 14.2.12.1.137, 14.2.12.2.2 and 14.2.12.4-18 for the RCP motors; the RCP Vibration Monitoring System; Pre-Core and Post Core NSSS Integrity Monitoring; and many other RCS components**.** The DC applicant also stated that the variable speed startup operation and the over-speed trip function of the RCP motor are not applicable to the APR1400 design. The NRC staff determined that the revisions to the aforementioned test

included adequate testing for the Motor Current, Motor Power, Pump Motor Vibration, and Motor Stator temperature, to verify acceptable RCP pump and motor performance; therefore, the DC applicant response is acceptable. Based on the above, RAI 279-8175, Question 14.02-42 is resolved.

Additionally, the NRC staff determined that the APR1400 DCD, Subsection 14.2.12 did not include sufficient information regarding the important-to-safety functions of the RCPs. In RAI 279-8175, Question 14.02-41 (ADAMS Accession No. ML15303A547), the NRC staff requested the DC applicant to provide additional information related to preoperational test methods in APR1400 DCD, Subsections 14.2.12.1.2 and/or 14.2.12.1.7 to address important-to-safety functions related to the RCPs.

In the July 12, 2016, response to RAI 279-8175, Question 14.02-41 (ADAMS Accession No. ML1619A348), the DC applicant summarized extensive revisions to APR1400 DCD, Subsections 14.2.12.1.2, 14.2.12.1.7, 14.2.12.1.43, 14.2.12.1.136, 14.2.12.1.137, and 14.2.12.2.2 and 14.2.12.4.18 related to testing RCP seal pressure and temperature; RCP seal injection performance, including RCP seal filters; RCP vapor seals; RCP seal differential pressure alarms; operational checks for CVCS auxiliary charging pumps and discharge check valves; the acoustic lead rate monitoring system; and pre-core and post core NSSS integrity monitoring, that were included in the revised Section 14.2 submitted on February 24, 2016 (ADAMS Accession No. ML16056A002).

The DC applicant also stated that the instrumentation calibration for RCP bearing metal temperature, oil flow and pressure, oil levels, cooling water flow and temperatures are included in prerequisites 2.2 and 2.3 for the RCS test (14.2.12.1.2). The acceptance criteria for performing the initial run of the RCPs (test method 3.4) with RCP bearing metal temperature detectors, oil flow and pressure, oil levels within design limits, and normal operating ranges are included in acceptance criteria 5.11 of the RCS Test (14.2.12.1.2).

The NRC staff determined that the DC applicant's response to RAI 279-8175, Question 14.02-41 was acceptable because it included an adequate description of the test to be implemented for the important-to-safety functions, noted in the paragraph above, in accordance with 10 CFR Part 50, Appendix A, GDC 1. The NRC staff also determined that the DC applicant appropriately updated APR1400 DCD Subsection 14.2.12 with vibration monitoring of the RCP seal shaft and frame as part of the tests described in Subsections 14.2.12.2.2 and 14.2.12.4.18. The NRC staff determined that the DC applicant's response and changes to these tests meet 10 CFR Part 50, Appendix A, GDC 1 and the guidance in RG 1.68 and is, therefore, acceptable. RAI 279-8175, Question 14.02-41 is resolved.

Piping System Tests

The NRC staff was not able to determine whether the DC applicant identified which specific systems are included in the ITP, and whether, as stated in SRP Section 3.9.2, "Dynamic Testing and Analysis of Systems, Structures, and Components," testing is conducted on all American Society of Mechanical Engineer (ASME) Class 1, 2, and 3 piping systems. In RAI 151-8078, Question 03.09.02-3 (ADAMS Accession No. ML15234A007), the NRC staff requested the DC applicant to (1) provide a listing of the high- and moderate-energy piping systems inside containment that are covered by the vibration, thermal expansion, and dynamic effects testing program, and (2) provide the list of snubbers on systems that are subjected to sufficient thermal

movements from cold to hot position. The NRC staff further requested the APR1400 DCD, Section 14.2 be revised to clarify the scope of the ITP.

In the October 7, 2016 response to RAI 151-8078, Question 03.09.02-3 (ADAMS Accession No. ML16281A442), the DC applicant stated that the listing of the high- and moderate-energy piping systems inside containment that are covered by the vibration, thermal expansion, and dynamic effects testing program will be at the detailed design phase after the piping physical layout is designed, and will be included in the test procedure, which the COL applicant is responsible for developing. Additionally, the DC applicant stated that the list of snubbers on systems that are subjected to sufficient thermal movements from cold to hot position will be provided at the detailed design phase after the piping analyses and supports design are completed and will also be included in the test procedure, which the COL applicant is responsible for developing. The DC applicant proposed to add a COL item to APR1400 DCD, Subsection 14.2.13 and Table 1.8-2 to address the COL applicant developing a test procedure to include a listing of high- and moderate-energy piping systems inside containment that are covered by the vibration, thermal expansion, and dynamic effects testing program as described in APR1400 DCD, Subsection 3.9.2.1. Additionally, the DC applicant proposed to revise Subsection 3.9.2.1 to indicate that the list of snubbers that are subjected to sufficient thermal movements from cold to hot position, will be provided as a part of the test procedure, which is the responsibility of the COL applicant.

The NRC staff finds that it is acceptable to defer the list of high- and moderate-energy piping systems and snubbers to the COL application phase, because the development of the piping physical layout, piping analyses and supports will depend upon detailed plant-specific design information. In addition, the NRC staff confirmed that the COL applicant's responsibility to develop the test procedure including a listing of the high- and moderate-energy piping systems is captured in COL item 14.2(4) in APR1400 DCD, Subsection 14.2.13. RAI 151-8078, Question 03.09.02-3, regarding APR1400 DCD Chapter 14.2 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1. Additional concerns regarding piping systems are address in the Chapter 3 SER, Subsection 3.9.2.

Additionally, in RAI 151-8078, Question 03.09.02-4, the NRC staff requested the DC applicant to provide a listing of the different flow modes to which the systems will be subjected during the vibration, thermal expansion, and dynamic effects testing program to confirm that the piping systems, restraints, components, and supports have been adequately designed to withstand flow-induced dynamic loadings under the steady-state and operational transient conditions anticipated during service.

In the March 24, 2016 response to RAI 151-8078, Question 03.09.02-4 (ADAMS Accession No. ML16084A989), the DC applicant stated that a listing of the different flow modes will be provided at the COL applicant's detailed design phase since the flow modes and their results on the piping systems are determined after the piping analyses are completed. The DC applicant proposed to add a COL item to Table 1.8-2 to address the COL applicant developing a test procedure to include a listing of the different flow modes to which the systems will be subjected during the vibration, thermal expansion, and dynamic effects testing program as described in APR1400 DCD, Subsection 3.9.2.1.

The NRC staff determined that because a listing of the different flow modes will be determined by the COL applicant and is, thus, outside the scope of design certification, it is acceptable to

defer to the COL applicant for the descriptions of vibration, thermal expansion, and dynamic effects testing as described in the guidance found in RG 1.20 and RG 1.68, Appendix A, Section A-1a, "Reactor Coolant System," and Section A-5, "Power Ascension Tests," Test Item o. The NRC staff confirmed that the COL applicant's responsibility to develop the test procedure including a listing of the different flow modes is captured in COL item 14.2(5) in APR1400 DCD, Subsection 14.2.13. Therefore, RAI 151-8078 Question 03.09.02-4 is resolved. The NRC staff verified that the proposed change has been incorporated into the APR1400 DCD, Revision 1.

Pressurizer Surge Line Tests

NRC Bulletin (BL) 88-11, "Pressurizer Surge Line Stratification Test," and SRP Section 3.12, "ASME Code Class 1, 2, and 3 Piping Systems, Piping Components and Their Associated Supports," discuss the potential for stresses induced by thermal stratification in the pressurizer (PZR) surge line (SL). In particular, BL 88-11 requested the establishment of a program that would monitor the PZR SL for the effects of thermal stratification beginning with hot functional testing (HFT). APR1400 DCD, Subsection 3.12.5.10 states the APR1400 conforms with BL 88-11, but the APR1400 DCD, did not include the description of a test program to implement monitoring of the PZR SL consistent with BL 88-11, SRP Sections 3.2 and 14.2 (as was included in other DC applications that have been reviewed and approved by the NRC.) Therefore, in RAI 70-8027, Question 03.12-3 (ADAMS Accession No. ML15196A596), the NRC staff requested the following from the DC applicant:

1. According to BL 88-11, thermal stratification occurs in the PZR SL during heat up, cool down and steady state operation of the plant. The NRC staff requested that the DC applicant discuss whether a monitoring or test program is planned to verify the design transients used in the structural design of the SL or how this verification will take place. The NRC staff asked the DC applicant to describe the test program for the PZR SL and its implementation consistent with BL 88-11 and SRP Section 3.2, that will demonstrate that stratification temperature measurements for the APR1400 PZR SL will be within deflection limits and result in no adverse consequences (such as contacting the pipe whip restraints), and discuss the effects of PZR SL stratification testing for which this test continues at least through the first cycle of plant operation (i.e., hot functional and power ascension testing portions of the ITP).

2. Given the PZR SL monitoring is the responsibility of the COL applicant, please discuss in future DCD revisions, the COL applicant responsibilities. Specifically, APR1400 DCD, Table 1.8.2 and Subsections 3.12.7 and 14.2.13 should be updated to identify COL items for PZR SL monitoring.

In the March 23, 2016, response to RAI 70-8027, Question 03.12-03 (ADAMS Accession No. ML16083A396**)**, the DC applicant proposed to add APR1400 DCD, Subsection 14.2.12.1.140, "Pre-Core Pressurizer Surge Line Stratification Test," which included acceptance criteria 5.1 which states:

Verification that surge line temperatures are within design limits

The NRC staff reviewed the test objectives, prerequisites, test methods, data required, and acceptance criteria in the proposed test abstract. The NRC staff determined that the DC

applicant's response and proposed update to the APR1400 DCD, Subsection 14.2.12.1.140 to monitor PZR surge line temperatures meets the testing guidance in NRC BL 88-11 and RG 1.68, Appendix A, Section A-1.j, "Instrumentation and Control Systems"; which requires the implementation of a program to confirm pressurizer surge line integrity. The NRC staff verified that the proposed change has been incorporated into the APR1400 DCD, Revision 1.

Additionally, the NRC staff reviewed the DC applicant's response to RAI 70-8027, Question 03-12-03, and determined that the DC applicant did not add anything to require a power ascension test. The NRC staff determined that the DC applicant should add more information to APR1400 DCD, Subsection 14.2.12.4.18, "NSSS Monitoring System Test," to address testing during the first cycle of plant operation (i.e., hot functional and power ascension testing portions of the ITP).

The DC applicant provided a supplemental response in the September 7, 2016, response to RAI 70-8027, Question 03.12-03 (ADAMS Accession No. ML16251A336). The DC applicant proposed to add APR1400 DCD, Subsection 14.2.12.4.27, "Fatigue Monitoring System Test," which includes monitoring the fatigue usages for the early identified locations, including the PZR SL, that will experience thermal stratification. The NRC staff determined that this response is acceptable because it satisfies the requirement for the implementation of a program to monitor the effects of thermal stratification on pressurizer surge line integrity in accordance with testing guidance in BL 88-11 and RG 1.68 and it addresses testing during the first cycle of plant operation. The NRC staff verified that the proposed change has been incorporated into the APR1400 DCD, Revision 1.

The DC applicant also stated that the COL applicant's responsibilities for implementing the PZR SL monitoring program is captured in a COL item in APR1400 DCD, Subsection 3.12.8. Therefore, RAI 70-8027, Question 03.12-03 regarding APR1400 DCD, Chapter 14.2 is resolved. Additional concerns regarding piping systems and piping supports are addressed in the Chapter 3 SER, Section 3.12.

Incorporation of Operating Experience

The NRC staff determined that certain information necessary for the NRC staff to make a finding in accordance with 10 CFR 52.47(a)(22), that operating experience insights have been incorporated into the design, had not been included in the APR1400 DCD, Subsection 14.2.12. In RAI 151-8078, Question 03.09.02-12 (ADAMS Accession No. ML15234A007), the NRC staff requested that the DC applicant justify not including a vibration assessment for the shutdown cooling and other emergency core cooling systems (ECCS) lines, given operating experience at the similar PVNGS plant where a flow-excited acoustic resonance was experienced in the shutdown cooling system, resulting in leaking and failure of an isolation valve.

In the October 23, 2015, response to RAI 151-8078, Question 03.09.02-12 (ADAMS Accession No. ML15296A568), the DC applicant stated that:

> *Vibration assessment for the shutdown cooling system lines is not required for the APR1400 based on the operating experience insights from the PVNGS plant and the OPR1000.*
>
> *Palo Verde Unit 1 experienced extensive outages or periods of low power operation during the first half of 2006 due to excessive vibration levels in the*

Unit 1 Train A Shutdown Cooling System (SCS) suction line. Arizona Public Service Company (APS) conducted extensive investigations to determine the source of the SCS suction line vibrations and to determine the reasons for the increased vibration levels. APS concluded that the vibration was flow induced and was caused by coupling between an excitation source, vortex shedding in the SCS suction line tee due to RCS flow over the SCS suction nozzle, and an acoustic resonator. After evaluating many options, APS resolved the problem by moving the SCS suction line isolation valve SI-V651 nearer to the RCS hot leg. The new location of the SCS suction line isolation valve SI-V651 is 11 feet from the RCS nozzle compared to the original location which was approximately 52.5 feet from the nozzle.

The SCS suction line designs of the OPR1000 and APR1400 are similar to the PVNGS plant SCS suction line re-design. Specifically, the SCS suction line diameters (16 inches) and hot leg diameters (42 inches) of the OPR1000 and APR1400 are the same as those of the PVNGS plant. The locations of the SCS suction line isolation valves SI-V651/V652 are 11 feet 4 inches from the RCS nozzle for the OPR1000 and 12 feet 8 inches from the RCS nozzle for the APR1400. All locations are similar to the new location of SI-V651 in the PVNGS plant. In addition, an excessive vibration in the SCS suction line has not been reported in any of the OPR1000 plants. Therefore, based on the design configuration and similar plant operating experience, the possibility of excessive vibration levels in the SCS suction line experienced in the PVNGS plant Unit 1 SCS Train A is very low for the APR1400 and inclusion in the vibration assessment program is not necessary.

The NRC staff determined the that the DC applicant included an appropriate basis for not including a vibration assessment in its response based on OPR1400 operating experience and based on similarities between the APR1400 design and the PVNGS re-design, which was intended to address the operating issues previously experienced at PVNGS. Therefore, the DC applicant's response related to operational experience for vibration assessment of the shutdown cooling system and ECCS in similar reactor designs meets 10 CFR 52.47(a)(22). Based on the above, RAI 151-8078, Question 03.09.02-12 is resolved.

Initial Fuel Loading/Inverse Count Ratio Tests

RG 1.68 provides guidance on initial fuel load and initial criticality tests in Appendix A, Section A-2 and Section A-3; and guidance on initial fuel load and initial criticality test procedures in Appendix C, "Preparation of Procedures," Section C-2, "Fuel Loading," and Section C-3, "Initial Criticality Procedures." However, the APR1400 DC application did not include any initial fuel load/initial criticality tests to conform to the guidance in RG 1.68, which specifies the following tests:

- Initial Fuel Loading, to establish prerequisites and conditions for initial fuel loading and procedures to ensure safe loading.

- Inverse Count Ratio or 1/M Plot Test for Fuel Loading, for verification of sub-criticality during fuel loading.

- Initial Criticality, to describe the procedure for achieving initial criticality in a controlled manner.

RAI 524-8697, Question 14.02-69 requested that the DC applicant revise the APR1400 DCD to include tests for initial fuel load/initial criticality.

In the December 19, 2016 response to RAI 524-8697, Question 14.02-69 (ADAMS Accession No. ML16354B585), the DC applicant proposed the addition of two new tests:

- DCD, Subsection 14.2.12.2.1, Initial Fuel Loading

- DCD, Subsection 14.2.12.3.1, Initial Criticality

The DC applicant stated that the inverse count ratio or 1/M plot test does not warrant a separate test since it is a continual process that is implemented during initial fuel load and initial criticality. Therefore, the inverse count ratio or 1/M plot test will be described as part of the initial fuel loading process and as part of the initial criticality process.

The DC applicant also proposed to update APR1400, DCD Tables 14.2-2 and 14.2-3 to incorporate the new tests and titles added to the ITP and update Table 14.2-7 to incorporate initial fuel loading and initial criticality tests.

The NRC staff reviewed the proposed updates to the APR1400 DCD, Section 14.2 related to initial fuel loading and initial criticality tests and determined that the proposed changes provide assurance that the facility is in a final state of readiness to achieve initial criticality. Additionally, the proposed changes provide that (1) design, analytical models, and assumptions used in the safety analyses for the facility are confirmed and (2) operability of plant systems and design features that could not be completely tested during the preoperational test phase are confirmed in accordance with the guidance found in RG 1.68, Appendix A, Subsections A-2, and A-3; therefore, **RAI 524-8697, Question 14.02-69, which was being tracked as an open item, is resolved. These updates to APR1400 DCD, Section 14.2 are being tracked as Confirmatory Item 14.2.12-6.**

Emergency Response Data System

The NRC staff determined that the APR1400 DCD, Section 14.2 did not include sufficient detail regarding testing of the emergency response data system (ERDS). In RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML15306A018), the NRC staff requested the following:

1. Update APR1400 DCD, Chapters 11 and 12 to specify which radiation monitors are responsible for transmitting the ERDS parameters required in 10 CFR Part 50, Appendix E.

2. Include a test in the applicable initial test program to ensure that each of these radiation monitors are accurately transmitting data to the ERDS and the ERDS is accurately providing the correct data.

3. 10 CFR Part 50, Appendix E, Section VI.2.a.(i), identifies that reactor coolant radioactivity monitors should be included as monitors that send a signal via ERDS. It

was unclear which monitors identified are meeting this function. The NRC staff asked the DC applicant to indicate which monitors are being relied on to perform this function and describe how the monitors provide reactor coolant radioactivity levels. As an alternative, the DC applicant was requested to add a new monitor(s) and describe how reactor coolant radioactivity levels are measured.

In the July 6, 2016 response to RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML16188A428), the DC applicant stated that Subsections 11.5.2.2.e, "Containment air monitors (RE-039A and 040B)," and 11.5.2.2.g, "Condenser vacuum pump vent effluent monitor (RE-063)," were revised to state that the monitors transmit the radiation signals to the ERDS as proposed in the response to RAI 131-8087 Question 11.05-1 via KHNP letter MKD/NW-16-0480L, dated May 11, 2016 (ADAMS Accession No. ML16132A380). In addition the DC applicant proposed to revise Subsection 11.5.2.2.5.m, "Main steam line area and N-16 radiation monitors (RE-217, 218, 219, and 220)," to state that these monitors transmit the radiation signals to the ERDS. The NRC staff verified that the proposed changes to DCD, Subsections 11.5.2.2.5.e, 11.5.2.2.5.g, and 11.5.2.2.5.m have been incorporated into the APR1400 DCD, Revision 1.

The NRC staff determined that 10 CFR Part 50, Appendix E, Section VI.2.a.(i), indicates that containment radiation level is one of the parameters required to be monitored by the ERDS. Therefore, the containment upper operating area monitors (RE-233A and RE-234B) should be included as monitors that transmit signals to the ERDS because the purpose of RE-233A and RE-234B is to identify containment high range radiation levels during accident conditions, as required by 10 CFR 50.34. Additionally, 10 CFR Part 50, Appendix E, Section VI.2.a.(i), indicates that reactor coolant radioactivity monitors should be included as monitors that send a signal via ERDS. It was unclear which of the monitors identified are meeting this function. The NRC staff asked the DC applicant to indicate which monitor is being relied on to perform this function and describe how it is being relied on to provide reactor coolant radioactivity levels.

In the December 9, 2016 revised response to RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML16344A487), the DC applicant proposed to revise Subsections 11.5.2.3.5.h, "CVCS letdown monitor and CVCS gas stripper effluent monitor (RE-204 and 265)," to indicate that the reactor coolant radioactivity monitor located in the letdown line of CVCS (RE-204) transmits a radiation signal to the ERDS. The DC applicant also proposed to revise Subsection 12.3.4.1.5.a, "Safety-related area monitors (RE-231A, 232B, 241A, 242B, 233A, and 234B)," to indicate that the containment upper operating area monitors (RE-233A, RE-234B) transmit radiation signals to the ERDS.

The NRC staff determined that the DC applicant's response was not acceptable. 10 CFR Part 50, Appendix E, Section VI, specifies that numerous radiation monitoring system parameters should be transmitted to the ERDS (and therefore to the NRC). These are reactor coolant, containment, condenser air removal, effluent radiation, and process radiation monitor levels. However, many of the process and effluent radiation monitors discussed in APR1400 DCD, Section 11.5 were not listed in the RAI response as sending a signal to ERDS. The staff determined that the RAI response and the APR1400 DCD should be updated to include these monitors as monitors that transmit data via ERDS or the RAI response should be updated to provide justification for why it is acceptable for these process and effluent monitors to not transmit data to ERDS.

In the August 11, 2017 revised response to RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML7223B357), the DC applicant proposed to update APR1400 DCD, Chapters 11 and 12 to specify that all radiation process and effluent monitors (gaseous and liquid), the containment air monitor, the main control room (MCR) air intake monitors, gaseous radwaste system exhaust monitor, main steam line monitors, and containment upper operating area monitors (RE-233A and RE-234B), transmit radiation signals to the licensing entity via the ERDS. The NRC staff determined that the DC applicant's response provided that the radiation monitoring system parameters, as required per 10 CFR Part 50, Appendix E, Section VI, will be transmitted to the ERDS.

Additionally, in the July 6, 2016 response to RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML16188A428), the DC applicant stated that the signals from the RMS monitors stated above are sent to the gaseous process effluent radiation monitoring and sampling system (PERMSS). The gaseous PERMSS communicates with the information processing system (IPS) to transmit these parameters to ERDS. The IPS receives these parameters via unidirectional communication and transmits these parameters to the ERDS. The communication test between the gaseous PERMSS and the IPS is performed at the manufacturer's facility during the factory acceptance testing (FAT). The communication test between the IPS and the ERDS is performed at the site during the initial test period. Since the manufacturer for the gaseous PERMSS has not been determined for APR1400, the DC applicant states that the test method for the communication between the gaseous PERMSS and IPS cannot be determined at this time. Therefore, the communication test between the gaseous PERMSS and the ERDS will be performed by the COL applicant. The DC applicant proposed to add a COL Item to ensure that the COL applicant will perform the appropriate interface testing of the PERMSS with ERDS.

It was unclear to the NRC staff how tests between the radiation monitors and the plant information processing system will be done at the manufacturer's facility and why this testing does not need to be performed at the reactor site. The NRC staff requested the DC applicant to provide a justification or revise the RAI response, as appropriate.

In the August 11, 2017 revised response to RAI 281-8232, Question 14.02-49 (ADAMS Accession No. ML7223B357), the DC applicant revised the response to specify that since the manufacturers for the RMS have not been determined; the communication test between the radiation monitoring systems (both the PERMSS and ARMS), the information processing system, and the ERDS will be performed by the COL applicant, instead of at the manufacturers facility as the previous revision of the response indicated.

The NRC staff determined that it is acceptable to defer the responsibility for testing the communication between radiation monitors and the plant information processing system to the COL applicant, as the manufacturer for the APR1400 RMS has not yet been determined. The COL applicant's responsibility to perform the appropriate interface testing of the PERMSS and ARMS monitors with ERDS is captured in the proposed COL item 14.2(14). Based on the above, **RAI 281-8232, Question 14.02-49, which was being tracked as an open item, is resolved and the proposed changes to the APR1400 DCD are tracked as Confirmatory Item 14.2.12-7.**

Natural Circulation Test (First-of-a-Kind Test)

In APR1400 DCD, Subsection 14.2.12.4.22, "Natural Circulation Test (First-of-a-Kind Test)," Revision 0, the DC applicant described the test methodology that would be used for the Natural Circulation FOAK test. The NRC staff requested additional information regarding this FOAK test in RAI 384-8100, Question 05.04.07-3 (ADAMS Accession No. ML16032A106) and RAI 528-8709, Question 14.02-70 (ADAMS Accession No. ML16319A333), with the latter RAI question being tracked as an open item. In the March 17, 2016, response to RAI 384-8100, Question 05.04.07-03 (ADAMS Accession No. ML16077A291) and in the February 3, 2017 response to RAI 528-8709, Question 14.2-70 (ADAMS Accession No. ML17034A399), the applicant provided acceptable responses to the staff's RAIs.

Subsequently, however, the applicant submitted APR1400 DCD, Section 14.2, Revision 1 dated March 2017 (ADAMS Accession No. ML17096A392), which deleted APR1400 DCD, Subsection 14.2.12.4.22, because testing to verify the design heat removal, boron mixing plant cool down/depressurization, and stable natural circulation conditions are maintained was already performed at PVGNS Unit 1, which is the prototype plant for the APR1400 design. RG 1.68 Appendix A, Section A-4, "Low Power Tests," Test Item t, provides that comparison of the plant's reactor coolant system hydraulic data to a reference prototype plant of similar design and configuration is an acceptable means for verification of natural circulation. The DC applicant collected operating experience data from PVGNS Unit 1. Therefore the NRC staff finds the DC applicant's justification for not performing this test on the first APR1400 plant built in the USA is acceptable.

Control Rod Drive System

The NRC staff determined that the DC applicant needed to provide sufficient acceptance criteria to ensure adequacy of the test results, in relation to the Control Rod Drive System (CRDS), for the tests described in the APR1400 DCD, Subsections 14.2.12.1.27, "Digital Rod Control System," 14.2.12.1.36, "Control Element Drive Mechanism Cooling System Test," 14.2.12.1.54, "Pre-Core Control Element Drive Mechanism Performance Test," and 14.2.12.2.4, "Post-Core Control Element Drive Performance Test." The NRC staff requested this information in RAI 136-8081, Question 04.06-02 (ADAMS Accession No. ML15227A013).

Additionally, RAI 136-8081, Question 04.06-02 asked questions related to DCD, Subsection 14.2.12.2.4 regarding measurement of RCS temperature and pressure, examination of insertion and withdrawal times of the control element assemblies (CEA), and measurement of control element drive assembly (CEDM) coil resistance.

In the September 14, 2015 response (ADAMS Accession No. ML15257308), the DC applicant proposed updates to the APR1400 DCD Subsections noted in RAI 136-8081, Question 04.06-02, with more clear and complete acceptance criteria. The proposed revisions to the APR1400 DCD include: (1) deleting reference to APR1400 DCD, Subsections 4.6.1 and 4.6.2 from APR1400 DCD, Subsection 14.2.12.1.27 as these subsections do not apply to the preoperational test described in APR1400 DCD, Subsection 14.2.12.1.27; (2) adding alarm set points and the interlock design of the CEDM cooling subsystem to APR1400 DCD, Subsection 9.4.6.2.1.3 and adding indication and alarm of the CEDM cooling subsystem to APR1400 DCD, Subsection 9.4.6.5.1; (3) adding CEDM coil temperature acceptance limit to APR1400 DCD, Subsection 14.2.12.1.54; and (4) adding CEA withdrawal speed and CEDM coil resistance to

the data requirements and clarified the acceptance criteria in APR1400 DCD, Subsection 14.2.12.2.4 to state that CEA withdrawal speed meets APR1400 DCD, Subsection 4.3.1.7. The NRC staff reviewed the DC applicant's response and proposed revision to the APR1400 DCD and determined that the changes to the APR1400 DCD satisfy the requirements of GDC 18 and the guidance found in RG 1.68, Appendix A, Section A-1.b, "Reactivity Control Systems," Section A-2, and Section A-3 because the changes incorporate sufficient acceptance criteria to ensure that the functional design requirements covered by these tests will be verified before startup. RAI 136-8081, Question 04.06-02 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.4.12.1 Preoperational Tests

The following is a list of "Phase I: Preoperational Testing" abstracts described in APR1400 DCD, Subsections 14.2.12.1.1 through 14.2.12.1.153:

14.2.12.1.1 Reactor coolant pump motor initial operation test
14.2.12.1.2 Reactor coolant system test
14.2.12.1.3 Pressurizer pilot-operated safety relief valve test
14.2.12.1.5 Chemical and volume control system letdown subsystem test
14.2.12.1.6 Volume control tank subsystem test
14.2.12.1.7 Chemical and volume control system charging subsystem test
14.2.12.1.8 Chemical addition subsystem test
14.2.12.1.9 Reactor drain tank subsystem test
14.2.12.1.10 Equipment drain tank subsystem test
14.2.12.1.11 Boric acid batching tank subsystem test
14.2.12.1.12 Concentrated boric acid subsystem test
14.2.12.1.13 Reactor makeup subsystem test
14.2.12.1.14 Holdup subsystem test
14.2.12.1.15 Boric acid concentrator subsystem test
14.2.12.1.16 Gas stripper subsystem test
14.2.12.1.17 Boronometer subsystem test
14.2.12.1.18 Process radiation monitor subsystem test
14.2.12.1.19 Gas stripper effluent radiation monitor subsystem test
14.2.12.1.20 Shutdown cooling system test
14.2.12.1.21 Safety injection system test
14.2.12.1.22 Safety injection tank subsystem test
14.2.12.1.23 Engineered safety features – component control system test
14.2.12.1.24 Plant protection system test
14.2.12.1.25 Ex-core neutron flux monitoring system test
14.2.12.1.26 Fixed in-core nuclear signal channel test
14.2.12.1.27 Digital rod control system test
14.1.12.1.28 Reactor regulating system test
14.2.12.1.29 Steam bypass control system test
14.2.12.1.30 Feedwater control system test
14.2.12.1.31 Core operating limit supervisory system test
14.2.12.1.32 Reactor power cutback system test
14.2.12.1.33 Fuel storage and handling system test
14.2.12.1.34 Auxiliary feedwater system test
14.2.12.1.35 Reactor coolant system hydrostatic test
14.2.12.1.36 Control element drive mechanism cooling system test

14.2.12.1.37 Reactor coolant gas vent system test
14.2.12.1.38 Containment spray system test
14.2.12.1.39 Integrated engineered safety features / loss of power test
14.2.12.1.40 In-containment water storage system test
14.2.12.1.41 Internals vibration monitoring system test
14.2.12.1.42 Loose parts monitoring system test
14.2.12.1.43 Acoustic leak monitoring system test
14.2.12.1.44 Information processing system and qualified information and alarm system test
14.2.12.1.45 Turbine generator building open cooling water system test
14.2.12.1.46 Pre-core hot functional test controlling document
14.2.12.1.47 Pre-core instrument correlation
14.2.12.1.48 Remote shutdown console test
14.2.12.1.49 Diverse protection system test
14.2.12.1.50 Pre-core test data record
14.2.12.1.51 Pre-core reactor coolant system expansion measurements
14.2.12.1.52 Pre-core reactor coolant and secondary water chemistry data
14.2.12.1.53 Pre-core pressurizer performance test
14.2.12.1.54 Pre-core control element drive mechanism performance test
14.2.12.1.55 Pre-core reactor coolant system flow measurements
14.2.12.1.56 Pre-core reactor coolant system heat loss measurement
14.2.12.1.57 Pre-core reactor coolant system leak rate measurement
14.2.12.1.58 Pre-core chemical volume control system integrated test
14.2.12.1.59 Pre-core safety injection check valve test
14.2.12.1.60 Pre-core boration / dilution measurements
14.2.12.1.61 Downcomer feedwater system water hammer test
14.2.12.1.62 Main turbine systems test
14.2.12.1.63 Main steam safety valve test
14.2.12.1.64 Main steam isolation valves and MSIVBVs test
14.2.12.1.65 Main steam system test
14.2.12.1.66 Steam generator blowdown system test
14.2.12.1.67 Main condenser and condenser vacuum systems test
14.2.12.1.68 Feedwater system test
14.2.12.1.69 Condensate system test
14.2.12.1.70 Turbine steam seal system test
14.2.12.1.71 Circulating water system test
14.2.12.1.72 Steam generator hydrostatic test
14.2.12.1.73 Heater drains system test
14.2.12.1.74 Chilled water system test
14.2.12.1.75 Essential service water system test
14.2.12.1.76 Component cooling water system test
14.2.12.1.77 Spent fuel pool cooling and cleanup system test
14.2.12.1.78 Turbine generator building closed cooling water system test
14.2.12.1.79 Condensate storage system test
14.2.12.1.80 Normal lighting system test
14.2.12.1.81 Emergency lighting system test
14.2.12.1.82 Compressed air system test
14.2.12.1.83 Process sampling system test
14.2.12.1.84 Heat tracing system test
14.2.12.1.85 Fire protection system test

14.2.12.1.86 Emergency diesel generator mechanical system test
14.2.12.1.87 Emergency diesel generator electrical system test
14.2.12.1.88 Emergency diesel engine fuel oil system test
14.2.12.1.89 Alternate AC source system test (mechanical)
14.2.12.1.90 Alternate AC source system test (electrical)
14.2.12.1.91 Containment polar crane test
14.2.12.1.92 Fuel handling area cranes test
14.2.12.1.93 Reactor containment building HVAC system test
14.2.12.1.94 Reactor containment purge HVAC system test
14.2.12.1.95 Control room area HVAC system test
14.2.12.1.96 Turbine generator building HVAC system test
14.2.12.1.97 Emergency diesel generator area HVAC system test
14.2.12.1.98 Fuel handling HVAC system test
14.2.12.1.99 Compound building HVAC system test
14.2.12.1.100 Balance of control room HVAC system test
14.2.12.1.101 Hydrogen mitigation system test
14.2.12.1.102 Containment hydrogen recombiner system test
14.2.12.1.103 Liquid waste management system test
14.2.12.1.104 Solid waste management system test
14.2.12.1.105 Gaseous waste management system test
14.2.12.1.106 Process and effluent radiological monitoring system test
14.2.12.1.107 Area radiation monitoring system test
14.2.12.1.108 4,160V Class 1E auxiliary power system test
14.2.12.1.109 480V Class 1E auxiliary power system test
14.2.12.1.110 Unit main power system test
14.2.12.1.111 13,800V non-Class 1E auxiliary power system test
14.2.12.1.112 4,160V non-Class 1E auxiliary power system test
14.2.12.1.113 480V non-Class 1E auxiliary power system test
14.2.12.1.114 Non-Class 1E dc power systems test
14.2.12.1.115 Class 1E dc power systems test
14.2.12.1.116 Offsite power system test
14.2.12.1.117 Balance-of-plant piping thermal expansion measurement test
14.2.12.1.118 Balance-of-plant piping vibration measurement test
14.2.12.1.119 Containment integrated leak rate test and structural integrity test
14.2.12.1.120 Fuel transfer tube functional test and leak test
14.2.12.1.121 Equipment hatch functional test and leak test
14.2.12.1.122 Containment personnel airlock functional test and leak test
14.2.12.1.123 Containment electrical penetration assemblies test
14.2.12.1.124 Containment isolation valves leakage rate test
14.2.12.1.125 Loss of instrument air test
14.2.12.1.126 Mid-loop operations verification test
14.2.12.1.127 Seismic monitoring instrumentation test
14.2.12.1.128 Auxiliary steam system test
14.2.12.1.129 Containment isolation valves test
14.2.12.1.130 Post-accident monitoring instrumentation test
14.2.12.1.131 Electrical and I&C equipment areas HVAC system test
14.2.12.1.132 Auxiliary building controlled area HVAC system test
14.2.12.1.133 Auxiliary building clean area HVAC system test
14.2.12.1.134 Leakage detection system test
14.2.12.1.135 Leakage control and detection of system outside of containment

14.2.12.1.136 RCP vibration monitoring system
14.2.12.1.137 NSSS integrity monitoring system (pre-core)
14.2.12.1.138 Core protection calculator system test
14.2.12.1.139 Diverse indication system test
14.2.12.1.140 Pre-core pressurizer surge line stratification test
14.2.12.1.141 Local of vital equipment
14.2.12.1.142 Access to vital equipment
14.2.12.1.143 Equipment to permit observation of abnormal presence or activity of persons or vehicles
14.2.12.1.144 Vehicles barrier system to protect against the design basis threat vehicle bombs
14.2.12.1.145 Vital areas with active intrusion detection systems
14.2.12.1.146 Security alarm annunciation and video assessment information
14.2.12.1.147 Location and equipment of the central and secondary alarm stations
14.2.12.1.148 Secondary security power supply system
14.2.12.1.149 Intrusion detection and assessment systems
14.2.12.1.150 Equipment and emergency exits
14.2.12.1.151 Security communication systems
14.2.12.1.152 Bullet-resisting barriers
14.2.12.1.153 Security alarm devices and transmission lines

In comparing the APR1400 preoperational tests to the preoperational testing recommended in RG 1.68, Appendix A, Section 1, the NRC staff identified several areas where additional information was required to complete its review, as discussed below.

14.2.12.1.3 Pressurizer Pilot-Operated Safety Relief Valve Test

In RAI 233-8244, Question 05.02.02-5 (ADAMS Accession No. ML15296A004), the NRC staff noted that GDC 30 requires the RCS pressure boundary be designed, fabricated, erected and tested to the highest quality standards practical. Application of GDC 30 provides assurance that the RCS pressure boundary will have an extremely low probability of failure due to manufacturing or design defects. The NRC staff requested the DC applicant define the complete pre-service or preoperational test to be performed on the pressurizer pilot operated safety relief valves (POSRVs) and update APR1400 DCD, Section 14.2 accordingly.

In the June 30, 2016, response to RAI 233-8244, Question 05.02.02-5 (ADAMS Accession No. ML16182A585), the DC applicant proposed to update APR1400 DCD, Subsection 14.2.12.1.3, "Pressurizer Pilot-Operated Safety Relief Valve Test," with the following additional test method and data requirement items:

TEST METHOD
…
3.3 Determine opening dead times, stroke times and closing times
…

DATA REQUIRED
…
4.3 Opening dead times, stroke times and closing times
4.4 Lead detection temperatures

The NRC staff determined that the DC applicant's proposed changes provide for adequate testing of the POSRVs' function to ensure integrity of the pressure boundary in accordance with the guidance in RG 1.68. Based on the above, RAI 233-8244, Question 05.02.02-5 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.7 Chemical and Volume Control System Charging Subsystem Test

The NRC staff identified that a number of non-safety related risk significant SSCs that are important-to-safety, including the Auxiliary Charging Pump (ACP) and the ACP Discharge Check Valve, were not included in the ITP tests. In RAI 278-8226, Question 14.02-40 (ADAMS Accession No. ML15303A502), the NRC staff requested the DC applicant to provide test methods and acceptance criteria for all non-safety-related risk significant SSCs that are also considered important to safety and identify these in APR1400 DCD, Table 17.4-1 and include them within the scope of the ITP in APR1400 DCD, Section 14.2.

In the June 30, 2016, response to RAI 278-8226, Question 14.02-40 (ADAMS Accession No. ML16182A545), the DC applicant identified that ACP and ACP discharge check valve are to be tested as part of the ITP and proposed changes to APR1400 DCD, Subsection 14.2.12.1.7, "Chemical and Volume Control System Charging Subsystem Test," to include the test objectives, method, and acceptance criteria for the preoperational tests performed to verify proper operation of the ACP and the flow path to the RCP seals through the ACP discharge check valve.

The NRC staff determined that the proposed revisions to APR1400 DCD, Subsection 14.2.12.1.7 to include tests for the ACP and ACP discharge valve provide that the important-to-safety components in the CVCS are tested as required by 10 CFR Part 50, Appendix A GDC 1 and in accordance with the guidance in RG 1.68, Section B, "Discussion." Based on the above, RAI 278-8226, Question 14.02-40 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.18 Process Radiation Monitor Subsystem Test

In RAI 285-8202, NRC Question 14.02-66 (ADAMS Accession No. ML15306A468), the NRC staff requested an explanation for an inconsistency in the acceptance criteria of APR1400 DCD, Subsection 14.2.12.1.18, "Process Radiation Monitor Subsystem Test." The acceptance criteria references APR1400 DCD, Subsection 9.3.4.5.6, which directs the reader to the Boronometer topic instead of 9.3.4.5.5.2, "Process Radiation Monitor."

In the May 19, 2016, response to RAI 285-8202, Question 14.02-66 (ADAMS Accession No. ML16142A012), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.18, Acceptance Criteria 5.1, to reference the correct APR1400 DCD, Subsection 9.3.4.5.5.2. The NRC staff determined the proposed change identifies the correct APR1400 DCD, Subsection and is acceptable; therefore, RAI 285-8282, Question 14.02-66 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.20 Shutdown Cooling System Test; 14.2.12.1.21 Safety Injection System Test

In APR1400 DCD, Chapter 1, Table 1.9.1 and APR1400 DCD, Subsection 14.2.7.3, the DC applicant commits to regulatory guidance in RG 1.79, "Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors."

The NRC staff determined that since the DC applicant committed to RG 1.79, more information should be added to APR1400 DCD, Subsections 14.2.12.1.20 and 14.2.12.1.21. Specifically, the prerequisite sections should be updated to state that "vent valves should be closed before starting these ECCS pumps" since RG 1.79, "Prerequisite Section C," states that "vent valves should be closed before starting ECCS pumps." The NRC staff also determined that additional information was needed on non-condensable gas intrusion into the ECCS. In RAI 91-7867, Question 14.02-03 (ADAMS Accession No. ML15201A768) the NRC staff asked for an engineering evaluation for non-condensable gas intrusion into ECCS and prerequisite test checks to verify vent valves are closed before starting the ECCS pumps consistent with the prerequisite section of RG 1.79.

In the August 26, 2016, response to RAI 91-7867, Question 14.02-03 (ADAMS Accession No. ML16239A430), the DC applicant provided a detailed summary on how gas accumulation would be managed in the ECCS. The DC applicant's response included a list of potential pathways for gas intrusion in the APR1400 safety injection system (SIS) and shutdown cooling system (SCS), which make up the ECCS, and SIS and SCS design features to prevent or control gas accumulation to acceptable levels in order to maintain system operability. Thus, the NRC staff finds that the DC applicant has adequately addressed the NRC staff's concerns regarding non-condensable gas intrusion into the ECCS.

The DC applicant also proposed to update the prerequisite section in APR1400 DCD, Subsections 14.2.12.1.20 and 14.2.12.21 to include verification that the SCS and SIS are vented and the vent valves are closed before starting the SIP or SCS. The pre-operational test procedure for the ECCS will describe the criteria for determining the amount of gas that would be considered acceptable rather than including this information in the ITP. The NRC staff determined that this response meets the guidance in RG 1.79, Regulatory Position C and is acceptable; therefore, **RAI 91-7867, Question 14.02-03 is resolved and this change to the APR1400 DCD is being tracked as Confirmatory Item 14.2.12.1-4**.

14.2.12.1.23 Engineered Safety Features – Component Control System Test

The APR1400 DCD, Subsection 14.2.12.1.23 provides a preoperational test for the Engineered Safety Feature – Component Control System (ESF-CCS). In RAI 198-8208, Question 14.02-20 (ADAMS Accession No. ML15245A5456), the NRC staff requested additional information regarding the objectives, prerequisites, test methods, and acceptance criteria to determine whether this test meets the requirements of Criterion XI of Appendix B to 10 CFR Part 50.

In the August 17, 2016, response to RAI 198-8208, Question 14.02-20 (ADAMS Accession No. ML16230A479), the DC applicant proposed to revise test plans for ESF-CCS to include: the basis for conducting the ESF-CCS test, test objectives for the ESF-CCS, component operation within the ESF-CCS, inter-cabinet interfaces with digital instrumentation and control (I&C) that need to be met, enhanced prerequisites for ESF-CCS components, enhanced test method steps, more detailed tests for ESF-CCS divisions, more detail on ESF actuation signals

generated by the Plant Protection System (PPS), more detail on loss of offsite power and emergency diesel generator (EDG) sensor inputs to the ESF-CCS, use of the Diverse Protection System (DPS) to generate diverse actuations signals, manual controls for ESF plant components, ESF-CCS transfer controls from the MCR to the Remote Shutdown Room (RSR), and enhanced electrical independence tests for each ESF-CCS division. Additionally the DC applicant proposed to upgrade the acceptance criteria for each ESF-CCS division to align with the corresponding test objective and test method. This was done so that the test acceptance criteria confirm that no unexpected interactions with other safety divisions occur.

Based on the DC applicant's proposed changes, the NRC staff determined that the initial tests for the ESF-CCS are adequate to verify the as-built and as-installed equipment meet the functional requirements for the ESF-CCS in conformance with the requirements of Criterion XI of Appendix B to 10 CFR Part 50 and with RG 1.68, Appendix A, Section A-1, "Engineered Safety Features." As such, RAI 198-8208, Question 14.02-20 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.24 Plant Protection System Test; 14.2.12.1.138 Core Protection Calculator System Test

The APR1400 DCD, Subsection 14.2.12.1.24, provides the initial test for the PPS. In RAI 198-8208, Question 14.02-21 (ADAMS Accession No. ML15254A546), the NRC staff determined that additional information is required regarding the objectives, prerequisites, test methods, and acceptance criteria to determine whether this test meets the requirements of Criterion XI of Appendix B to 10 CFR Part 50.

In the June 22, 2016 response to RAI 198-8208, Question 14.02-21 (ADAMS Accession No. ML16174A465) the DC applicant stated that information requested in RAI 198-8208, Question 14.02-21 was included in the revised APR1400 DCD, Section 14.2 submitted on February 24, 2016 (ADAMS Accession No. ML16056A002). The DC applicant's response also provided additional clarification on the objectives, prerequisites, test methods, and acceptance criteria that were revised in the APR1400 DCD, Section 14.2 submitted in February 2016. The NRC staff reviewed the DC applicant's response and determined that clarification on the following items was needed: (1) the DC applicant's deletion of verification of the interlock functions and demonstration of redundancy, electrical independence, coincidence, and fail safe on loss of power, (2) which test would verify the operation of the Core Protection Calculator System (CPCS), (3) why it would not be practical to complete the response time verification from sensor input to actuated equipment in a single test, (4) verification of the as-installed PPS system, (5) use of the term "should be" in acceptance criteria as opposed to the term "is." The NRC staff found that except for the requested clarifications, the response was acceptable because the proposed changes provided that testing required to demonstrate that PPS SSCs will perform satisfactorily in service in accordance with Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

The DC applicant provided a revised response to RAI 198-8208, Question 14.02-21 on September 26, 2016 (ADAMS Accession No. ML16270A372). In reviewing the DC applicant's revised response, the NRC staff noted that the DC applicant proposed to: (1) revise the test objectives in APR1400 DCD, Subsection 14.2.12.1.24 to include testing of the interlock functions, redundancy, and electrical independence within the PPS and (2) revise the term "should be" to "is" or "are" to provide a more definitive requirement for the as-installed system to

meet the acceptance criteria. With the exception of the two issues identified below, the NRC staff determined that the proposed changes satisfied the requirements of Criterion XI of Appendix B to 10 CFR Part 50 because the changes provide that testing is performed to demonstrate that PPS SSCs will perform satisfactorily. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1. The two issues identified by the NRC staff are:

1) For the CPCS test in 14.2.12.1.138, where are redundancy and independence of the as-installed CPCS verified?

2) Item (3)(j) of the RAI response does not address the NRC staff's questions from the previous supplemental response request. Specifically, why can't the design accommodate a single test to verify response time for each reactor trip (RT) and ESF function? Why is overlap testing required? Per IEEE Std 338-1987, "the response time test should include as much of each safety system, from sensor input to actuated equipment, as is practicable in a single test. Where it is not practical to simultaneously test the entire set of equipment from sensor to actuated equipment in one test, verification of system response time shall be accomplished by measuring the response times of discrete portions of the system and showing that the sum of all the response times is within limits of the overall system requirement." For the response time testing, does the RT trip path include the CPCS?

In the December 19, 2016 response to RAI 198-8208, Question 14.02-21 (ADAMS Accession No. ML16354B588), the DC applicant stated that it doesn't want to do response time testing in a single test because it would be more efficient and beneficial for maintenance purposes to have a modular testing methodology rather than one single test methodology for measuring the system response time.

The NRC staff determined that the DC applicant's response to perform modular testing is an acceptable method to meet Criterion XI of Appendix B to 10 CFR Part 50 and RG 1.68, Appendix A, Section A-1.j because if there are response time delays beyond the expected response time, the DC applicant can determine which portion of the system resulted in the additional delays.

The DC applicant also proposed to revise APR1400 DCD, Subsection 14.2.12.1.138 to provide the details relating to the CPCS redundancy and independence testing which meet the guidance of RG 1.68 for the CPCS system. Therefore, the NRC staff determined that all the issues regarding **RAI 198-8208, Question 14.02-21, which was being tracked as an open item, are resolved and the proposed changes are tracked as Confirmatory Item 14.2.12.1-6.**

14.2.12.1.25 Ex-Core Neutron Flux Monitoring System

The APR1400 DCD, Subsection 14.2.12.1.25 provides the preoperational test for the Ex-Core Neutron Flux Monitoring System (ENFMS). The NRC staff determined that additional information is required to determine whether this test meets the requirements of Criterion XI of Appendix B to 10 CFR Part 50. Therefore, in RAI 198-8208, Question 14.02-22 (ADAMS Accession No. ML15254A546), the NRC staff requested that the DC applicant provide clarification for the objectives, prerequisites, and how electrical independence is verified.

In the November 29, 2016 response to RAI 198-8208, Question 14.02-22 (ADAMS Accession No. ML16334A537), the DC applicant stated that APR1400 DCD, Subsection 14.2.12.1.25 will be updated with the following additions: The DC applicant will (1) add Subsection 7.2.1.1.c to the Acceptance Criteria to verify the functional performance of all channels of the ENFMS and add the completion of the ENFMS FAT as a prerequisite in the test plan, and (2) add an objective, test method and acceptance criteria to verify electrical independence between the safety and non-safety related channels of the ENFMS.

The NRC staff determined the DC applicant's response is acceptable because it provides the appropriate test objectives, prerequisites and electrical independence test requirements needed for adequate testing of the ENFMS. The proposed changes satisfy Criterion XI of Appendix B to 10 CFR Part 50 and are in accordance with the guidance found in RG 1.68, Appendix A, Section A-1.j. Therefore, RAI 198-8208, Question 14.02-22 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.26 Fixed In-Core Nuclear Signal Channel Test

The APR1400 DCD, Subsection 14.2.12.1.26 describes the initial test for the fixed in-core nuclear instrumentation system. The NRC staff requested additional information to determine whether this test meets the requirements of Criterion XI of Appendix B to 10 CFR Part 50. Therefore, in NRC Question 14.02-23 in RAI 198-8208 (ADAMS Accession No. ML15254A546), the NRC staff requested that the DC applicant clarify the objectives of the test by providing verification of the proper operation of both the in-core instrumentation and core exit thermocouple (CET) and to add a test prerequisite specifying verification of the location of each in-core detector or justify why it is not needed.

In the June 30, 2016 response to RAI 198-8208, Question 14.02-23 (ADAMS Accession No. ML16182A569), the DC applicant stated:

> *As the title of FSAR Tier 2, Section 14.2.12.1.26 implies, item 1.2 is to verify the proper amplifier operation inside FIDAS cabinet itself, but does not include the verification of CET (Core Exit Thermocouple) itself, which are addressed in the post-core and power ascension test stages. Instead, as specified in items 1.3 and 1.4 of amended Section 14.2.12.2.26 that was submitted to the staff (ref. KHNP submittal MKD/NW-16-0156L dated February 24,2016; ML16056A003), only the cable continuity and insulation resistance of the interface cables related with CET and in-core detectors is to be verified. In addition, the coverage of verification is clearly specified in item 1.1 and 1.2 of amended Section 14.2.12.2.26.*

Additionally, the DC applicant stated the following:

> *Each in-core instrumentation (ICI) assembly is assembled such that five in-core detectors are located by equal distance from ICI bullet nose with the allowance of +/- 1 inch, which is ensured by the quality control program required by the procurement specification and administered by the vendor at the time of manufacturing. Verifying that the detectors are positioned correctly within the ICI bullet nose assembly is not an attribute that would be performed by the licensee after receipt of the equipment. Unlike in-core detector testing and core*

performance testing where it is important to assure that the ICI bullet nose is in the proper location within the fuel assembly, the Fixed In-Core Nuclear Signal Channel Test is performed by injecting test signals to ensure proper circuit processing. Based on this justification, it is not necessary to add a prerequisite to specify that the proper location of each in-core detector is to be verified in 14.2.12.1.26.

The NRC staff reviewed the DC applicant's response and determined that it was not clear what the "fixed in-core nuclear signal channel instrumentation" is since this terminology is not used in Chapter 7. DCD Subsection 7.7.1.1.g states, "The signals from the fixed in-core neutron flux detector assemblies are processed by the fixed in-core detector amplifier system (FIDAS) and are sent to the IPS for monitoring and display. The IPS performs the background, beta decay delay, and Rhodium depletion compensation using in-core nuclear instrumentation signal processing programs." The NRC staff asked the DC applicant to modify the APR1400 DCD such that both sections of the APR1400 DCD are consistent. Additionally, the NRC staff reviewed APR1400 DCD, Subsection 14.2.12.4.16, "In-Core Detector Test," and determined that the justification for not verifying the proper location of each in-core detectors as a prerequisite was not clear. The NRC staff asked the DC applicant to clarify which test within the ITP would verify the detectors are positioned correctly within the ICI bullet nose assembly.

In the DC applicant's March 23, 2017 revised response to RAI 198-8208, Question 14.02-23 (ADAMS Accession No. ML17082A453), the DC applicant stated that the terminology "Fixed in-core nuclear signal channel instrumentation" in APR1400 DCD, Subsection 14.2.12.1.26, Prerequisite 2.2 would be revised to "Fixed in-core nuclear instrumentation signal channel" to be consistent with the terminology in APR1400 DCD, Subsection 7.7.1.1.g. Additionally, the DC applicant also clarified why verifying the proper location of each in-core detector is not a prerequisite for APR1400 DCD, Subsection 14.2.12.1.26. Specifically, the applicant stated that if a mis-positioning of a detector exists, it can be found during the "In-core Detector Test," which is described in APR1400 DCD, Subsection 14.2.12.4.16. The applicant stated that after the in-core detectors are installed, there is no credible means to check the mis-positioning of the detector before the Power Ascension Test (PAT) stage. During the PAT, mis-positioning of the detector can be found by the "In-core Detector Test" using the neutron flux signals from the in-core detectors. The tests using the power distribution from in-core detector signals (e.g., the Steady State Core Performance Test in APR1400 DCD, Subsection 14.2.12.4.10) have a prerequisite for operation of the in-core instrumentation system.

Based on the clarification provided and the identification of other initial tests to verify that in-core detectors are aligned, the NRC staff finds that the verification of proper location of each in-core detector does not need to be a prerequisite for APR1400 DCD, Subsection 14.2.12.1.26. The NRC staff determined that the DC applicant's response related to correct location of the in-core detector meets the guidance in RG 1.68, Appendix A, Section A-1.c, "Reactor Protective System and Engineered Safety Feature Actuation System," and Appendix C, "Preparation of Procedures"; therefore, **RAI 198-8208, Question 14.02-23, which was being tracked as an open item, is resolved and this issue is being tracked as Confirmatory Item 14.2.12.1-8**.

14.2.12.1.28 Reactor Regulating System Test

The APR1400 DCD, Subsection 14.2.12.1.28 describes the preoperational test for the Reactor Regulation System (RRS). In RAI 198-8208, Question 14.02-24 (ADAMS Accession No. ML15245A546), the NRC staff requested additional information regarding the prerequisites for

the RRS test. Specifically, the NRC staff asked for clarification as to why the RRS test included software installation prerequisites that were not included for all systems that include software.

In the October 18, 2016, response to RAI 198-8208 Question 14.02-24 (ADAMS Accession No. ML16292A856), the DC applicant summarized the following changes to APR1400 DCD, Section 14.2:

> *For the software installation of the Plant Protection System (PPS), the Engineered Safety Features-Component Control System (ESF-CCS), the Fixed In-core Detector Amplification System (FIDAS) and the Reactor Power Cutback System (RPCS), DCD Sections 14.2.12.1.23, 14.2.12.1.24, 14.2.12.1.26 and 14.2.12.1.32 will be revised.*
>
> *In addition, DCD Section 14.2.12.1 will be revised to add the software installation prerequisite for the following sy[s]tem tests: Boronometer Subsystem (14.2.12.1.17), Process Radiation Monitor Subsystem (14.2.12.1.18), Gas Stripper Effluent Radiation Monitor Subsystem (14.2.12.1.19), Remote Shutdown Console (14.2.12.1.48), Diverse Protection System (DPS) (14.2.12.1.49), Process and Primary Sampling System (14.2.12.1.83), Hydrogen Mitigation System (14.2.12.1.101), Process and Effluent Radiological Monitoring System (14.2.12.1.106), Area Radiation Monitoring System (14.2.1.12.1.107), Seismic Monitoring Instrumentation System (14.2.12.1.127), Core Protection Calculator System (CPCS) (14.2.12.1.138), and the Diverse Indication System (DIS) (14.2.12.1.139).*

The NRC staff determined that the DC applicant's proposal to include software installation as prerequisites for all the systems that contain software meets 10 CFR 52.47(a)(2) for installation of I&C systems and the guidance in RG 1.68, Regulatory Guidance Position C.2, "Prerequisites for Testing," Appendix A, Section A-1.j because the changes ensure that the appropriate prerequisites are met. Therefore, RAI 198-8208, Question 14.2-24 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.29 Steam Bypass Control System Test

The APR1400 DCD, Subsection 14.2.12.1.29, "Steam Bypass Control System Test," describes the initial test for the Steam Bypass Control System (SBCS). APR1400 DCD, Subsection 7.7.1.1.d describes the three signals generated for the two different modes of operation for the SBCS control of the turbine bypass valve, including the modulation mode, the quick opening mode, and a valve permissive signal mode. The NRC staff reviewed the test methods specified in Item 3.0 of this test and could not determine where all the different modes of operation for the turbine bypass valves are tested. In RAI 198-8208, Question 14.02-25 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant modify this test to include testing of the SBCS for all the modes described in APR1400 DCD, Subsection 7.7.1.1.d.

In the June 22, 2016, revised response to RAI 198-8208, Question 14.02-25 (ADAMS Accession No. ML16174A465), the DC applicant updated the test methods in APR1400 DCD, Subsection 14.2.12.1.29 to verify that the SBCS ITP tests the two different modes (the modulation mode and the quick opening mode) and the three types of control signals, i.e. the modulation signal, the quick opening signal, and the valve permissive signal. The NRC staff

determined the DC applicant's response meets 10 CFR Part 50, Appendix A, GDC 1 and RG 1.68, Appendix A, Section A-1.j and is acceptable because the changes verify the as-installed SBCS components. Therefore, RAI 198-8208, Question 14.02-25 is resolved. The NRC verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.30 Feedwater Control System Test

The APR1400 DCD, Subsection 14.2.12.1.30 provides the preoperational test for the Feedwater Control System (FWCS). In RAI 198-8028, Question 14.02-26 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant to modify this test to include testing for the FWCS during all conditions described in APR1400 DCD, Subsection 7.7.1.1.c.

In the January 4, 2017 response to RAI 198-8208, Question 14.02-26 (ADAMS Accession No. ML17004A031), the DC applicant proposed changes to the objectives and acceptance criteria in APR1400 DCD, Subsection 14.2.12.1.30, "Feedwater and Auxiliary Feedwater Systems Test" to address the NRC staff's concerns. The DC applicant also explained how the testing of the FWCS across all plant conditions is covered by several tests, identified the test associated with each plant condition, and proposed a change to APR1400 DCD, Subsection 14.2.12.4.3,"Control Systems Checkout Test" to clearly describe that a test is performed to verify the flow percentage.

The NRC staff determined that the DC applicant's response and proposed revisions to the APR1400 DCD provide objectives and acceptance criteria that meet 10 CFR Part 50, Appendix A, GDC 1 and the guidance in RG 1.68, Appendix A, Section A-1.j because the proposed revisions demonstrate the operation of the FWCS controls over the design operating range. Therefore, RAI 198-8208, Question 14.02-26 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.32 Reactor Power Cutback System Test

The APR1400 DCD, Subsection 14.2.12.1.32 describes the preoperational test for the Reactor Power Cutback System (RPCS). In RAI 198-8208, Question 14.02-27 (ADAMS Accession No. ML15254A546), the NRC staff determined that these RPCS functions should be verified in this test and should be identified as test objectives. The corresponding test method and acceptance criteria should support demonstrating how these functions are verified in the ITP. The NRC staff requested that the DC applicant modify APR1400 DCD, Subsection 14.2.12.1.32 to include this information.

In the November 8, 2016, response to RAI 198-8028, Question 14.02-27 (ADAMS Accession No. ML16313A591), the DC applicant added objectives and prerequisites to APR1400 DCD, Subsection 14.2.12.1.32, "Reactor Power Cutback System Test," and updated the prerequisites in APR1400 DCD, Subsection 14.2.12.4.6, "Unit Load Rejection Test," to include assurance that the RPCS functions properly.

The NRC staff determined that these updates to the APR1400 DCD, Subsections 14.2.12.1.32 and 14.2.12.4.6 are acceptable because the revised test methods provide adequate assurance that the RPCS functions properly, RPCS functions are captured in the test objectives and the test prerequisites define what must be accomplished before the tests are to be conducted.

Therefore, the NRC staff finds that the proposed revisions meet 10 CFR Part 50, Appendix A, GDC 1 and the guidance in RG 1.68 Appendix A, Section A-1.j. Based on the above, RAI 198-8208, Question 14.02-27 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.33 Fuel Storage and Handling System Test

The APR1400 DCD, Subsection 14.2.12.1.33 provides the preoperational tests for the fuel handling and storage systems. In RAI 181-8011, Question 09.01.04-4 (ADAMS Accession No. ML15244B159), the NRC staff asked the DC applicant to justify why the APR1400 DCD did not include a static load test at 125 percent rated load and a dynamic load test at 100 percent rated load for the refueling equipment in accordance with RG 1.68 Section A-1.n.

In the January 6, 2016, response to RAI 181-8011, Question 09.01.04-4 (ADAMS Accession No. ML16006A568), the DC applicant proposed adding the requested testing as Step 3.9.4 in APR1400 DCD, Subsection 14.2.12.1.33, "Fuel Handling and Storage System Test." The NRC staff determined that by adding the rated load tests to the APR1400 DCD, the DC applicant's response meets the guidance in RG 1.68, Appendix A, Section A.-1.n, "Fuel Storage and Handling Systems," and is acceptable. RAI 181-8011, Question 09.01.04-4 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.34 Auxiliary Feedwater System Test

The APR1400 DCD, Subsection 14.2.12.1.34 provides the initial test descriptions for the Auxiliary Feedwater System (AFWS). In RAI 198-8208, Question 14.02-28 (ADAMS Accession No. ML15254A546), the NRC staff requested that the DC applicant identify the test method item that verifies the AFWS response to manual controls, or alternatively that the DC applicant modify APR1400 DCD Subsection 14.2.12.1.34, "Auxiliary Feedwater System," to include this information.

In the June 30, 2016, response to RAI 198-8208, Question 14.02-28 (ADAMS Accession No. ML16182A548), the DC applicant proposed to upgrade DCD, Subsection 14.2.12.1.34 with a revised test plan that included several changes to verify the AFWS response to several different manual, simulated and automatic controls.

Based on the proposed changes to APR1400 DCD, Subsection 14.2.12.1.34 to include manual controls for the AFWS, the NRC staff determined that the issues identified in RAI 8208, Question 14.02-28 are resolved. As such, the NRC staff finds the AFWS test described in the APR1400 DCD, Subsection 14.2.12.1.34 meets guidance in RG 1.68 Appendix A-1.d and is acceptable because the changes verify the as-installed AFWS component. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.37 Reactor Coolant Gas Vent System Test

The APR1400 DCD, Subsection 14.2.12.1.37 provides the initial test descriptions for the Safety Depressurization and Reactor Coolant Gas Vent System (RCGVS). The NRC staff determined that the acceptance criteria was incomplete and also referenced incorrect DCD design sections. In RAI 175-8034, Question 05.04.12-9 (ADAMS Accession No. ML15295A499), the NRC staff

requested that the DC applicant correct the erroneous references to the acceptance criteria for the RCGVS.

In the May 4, 2016, response to RAI 175-8034, Question 05.04.12-9 (ADAMS Accession No. ML16125A479), the DC applicant clarified that the APR1400 DCD, Subsection 14.2.12.1.37 describes RCGVS testing, whereas the APR1400 DCD, Subsection 14.2.12.1.3 describes testing of the safety depressurization of the POSRVs. The DC applicant revised the title of APR1400 DCD, Subsection 14.2.12.1.37 to "Reactor Coolant Gas Vent System Test," and removed references to the POSRVs in the revised Section 14.2 submitted on February 24, 2016 (ADAMS Accession No. ML16056A002). The DC applicant also revised the APR1400 DCD, Subsection 14.2.12.1.37 to remove incorrect references to other parts of the APR1400 DCD and include acceptance criteria that clearly relate to the test objectives and methods. The NRC staff determined that the revisions to the preoperational test procedures and their acceptance criteria are adequate to verify RCGVS operation; therefore, the NRC staff determined that the response is acceptable. Based on the above, RAI 175-8034, Question 05.04.12-9 is resolved.

14.2.12.1.38 Containment Spray System Test

The APR1400 DCD, Subsection 14.2.12.1.38 provides the initial test descriptions for the Containment Spray System (CSS). The Section 5.0, Acceptance Criteria states:

> *1.1 The containment spray system and containment spray pumps perform as described in Subsection 6.2.2.2.*

The NRC staff determined that the test method as written was too vague to meet 10 CFR Part 50, Appendix A, GDC 40 for the Containment Heat Removal System. Therefore, in RAI 19-7899, Question 14.02-01 (ADAMS Accession No. ML15152A518), the NRC staff requested that the test method be revised such that the test acceptance criteria in APR1400 DCD, Subsection 14.2.12.1.38 have items in the test methods that: (1) verify spray flow under minimum net positive suction head conditions, and (2) verify that static head as measured from the pumps ensures the design assumptions made in APR1400 DCD, Subsection 6.2.2.2 remain valid.

In the July 2, 2015 response to RAI 19-7899, Question 14.02-1 (ADAMS Accession No. ML15183A077), the DC applicant made additions to the test methods in APR1400 DCD, Subsection 14.2.12.1.38. The NRC staff determined that the proposed revisions are acceptable because the added test items (1) clarify the CSS system head requirements (i.e. characteristics such as frictional loss terms) and test acceptance criteria for the entire system, and (2) include the static head of the as-built pumps in the test method to meet the test assumptions for the analyses in Chapter 6 of the APR1400 DCD. Therefore, the NRC staff concludes that the DC applicant meets the containment spray testing guidance in RG 1.68, Appendix A, Section A-1.i, "Integrity of Systems Outside of Containment that Contain Radioactive Material for BWRs and PWRs." Based on the above, RAI 19-7899, Question 14.02-1 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.39 Integrated Engineered Safety Features / Loss of Power Test

The APR1400 DCD, Subsection 14.2.12.1.39 provides the initial test descriptions for the integrated Engineering Safety Features (ESF)/loss of power test. In RAI 198-8208, Question 14.02-29 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant

demonstrate how the ESF-CCS functions that mitigate loss of power to Class 1E buses are verified. In addition, the NRC staff requested that the DC applicant demonstrate which test method verifies the test objective of demonstrating electrical redundancy, independence, and load group assignment.

In the August 17, 2016 response to RAI 198-8208, Question 14.02-29 (ADAMS Accession No. ML16230A478), the DC applicant proposed changes to the test methods and acceptance criteria in APR1400 DCD, Subsection 14.2.12.1.39 to verify ESF-CCS functions, electrical redundancy, independence and load group assignment, and EDG full load capability.

Based on the DC applicant's proposed changes, the NRC staff determined the integrated ESF/loss of power test is adequate to verify the as-built and as-installed equipment to meet RG 1.68, Appendix A, Section A-1.j, and the requirements of Criterion XI of Appendix B to 10 CFR Part 50. As such, the NRC staff determined that the issues identified in RAI 198-8208, Question 14.02-29 are resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.41 Internals Vibration Monitoring Systems Test

The APR1400 DCD, Subsection 14.2.12.1.41 provides the initial test descriptions for the Internals Vibration Monitoring System (IVMS). In RAI 198-8208, Question 14.02-30 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant justify why operation of the ENFMS is not a prerequisite for the IVMS Test.

In the October 18, 2016 response to RAI 198-8208, Question 14.02-30 (ADAMS Accession No. ML16292A856), the DC applicant included the following:

> *Neutron flux signals from ENFMS are not needed to check the IVMS function for preoperational testing; rather, simulated neutron flux signals are used in accordance with Section 14.2.1.1 which states that simulated signals or inputs are used to demonstrate the full range of the systems that are used during normal operation.*
>
> and
>
> *The acceptance criterion 5.2 in KHNP submittal MKD/NW-16-0156L for test plan 14.2.12.1.41 states that all 12 channels of ex-core signals are received at the IVMS system as described in the related design specification… In performing the test, the 12 channels of the ex-core simulated signals are generated from signal generators and transmitted by injecting into the Fiber Optic Transmitter (FOT) of the ENFMS and not directly into the IVMS.*

The NRC staff determined that the DC applicant response provides adequate justification for why operation of ENFMS is not a prerequisite for the IVMS test and meets the testing guidance for nuclear instrumentation in RG 1.68, Appendix A, Section A-1.j, "Instrumentation and Control"; therefore, it is acceptable. RAI 198-8208, Question 14.02-30 is resolved.

14.2.12.1.48 Remote Shutdown Console Test

The APR1400 DCD, Subsection 14.2.12.1.48 describes the remote shutdown console test which verifies the capability to shut down the reactor from the remote shutdown console. In RAI 198-8208, Question 14.02-37 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant to demonstrate how the manual controls in the MCR are verified in the ITP to meet the requirements of Criterion XI of Appendix B to 10 CFR Part 50.

In the June 22, 2016 response to RAI 198-8208, Question 14.02-37 (ADAMS Accession No. ML16174A465), the DC applicant stated that verifying the manual controls to control safety-related equipment required to shut down the reactor are described in each test description in the APR1400 DCD, Subsection 14.2.12. APR1400 DCD, Subsection 14.2.1 will be revised to include the description that testing of manual controls for the capability to shut down the reactor will be performed from the MCR for safety-related equipment.

The NRC staff determined that it was not clear where manual controls to control safety-related equipment are verified in this section. For example, it was not clear which test verifies the operation of the diverse manual ESF actuation (DMA). Further, there was no integrated test of the MCR manual controls (similar to the APR1400 DCD Section 14.2.12.48, Objective 1.2, "To determine transfer of control occurs and that the plant can be cooled down from the remote shutdown console") to verify that the plant can be cooled down.

In Revision 1 of the APR1400 DCD, Tier 2, Section 14.2.12.1.23, the applicant added Objective 1.8, "To verify the interface of the diverse manual ESF actuation (DMA) switches, for each ESF component with a DMA interface, including correct ESF component response." Based on this addition, the NRC staff finds that this test is sufficient to meet the guidance of RG 1.68 for verifying the operation of the DMA switches.
After further discussions with the applicant, the NRC staff determined that although the DC applicant will not perform an integrated test of the MCR manual controls, the controls for each system and component are tested from MCR individually as specified in APR1400 DCD, Tier 2, Section 14.2.12. In addition, the integrated system design (i.e., hardware, software, procedure and personnel elements) is evaluated in accordance with NUREG-0711, Human Factors Verification and Validation, to verify that the integrated system design supports the safe operation of the plant. NUREG-0711, Section 11.4.3.3 specifies that the simulators which represents the as-built HSI can be used as a testbed for the evaluation of the integrated system design. Thus the NRC staff determined that the DC applicant's proposal meets the requirements of Criterion XI of Appendix B to 10 CFR Part 50. Based on the above, **RAI 198-8208, Question 14.02-37, which was being tracked as an open item, is resolved and the proposed change to the APR1400 DCD is being tracked as Confirmatory Item 14.2.12.1-19.**

14.2.12.1.49 Diverse Protection System Test

In RAI 198-8208, Question 14.02-31 (ADAMS Accession No. ML15245A546), the NRC staff requested the DC applicant justify why all the automatic functions performed by the Diverse Protection System (DPS) were not verified in the DPS test described in APR1400 DCD, Subsection 14.2.12.1.49. The objective of this test is to verify the proper operation of the DPS. However, the test methods for this test only verified the operation of the reactor trip switchgear system (RTSS) trip circuit breaker and operation of the alternate auxiliary feedwater actuation signals using simulated input signals. It was not clear to the NRC staff whether the simulated signals will be injected into the DPS. The NRC staff requested the DC applicant to

clarify this in the test methods description of this subsection. In addition, APR1400 DCD, Section 7.8 and the referenced technical reports identified additional automatic safety actuation signals performed by the DPS. The NRC staff requested the DC applicant to justify why these functions are not verified in this preoperational test.

In the June 20, 2016 response to RAI 198-8208, Question 14.02-31 (ADAMS Accession No. ML16173A245), the DC applicant summarized the major DPS automatic actuation signal functions from DCD, Subsection 7.8.1.1, such as the generation of reactor trip signal, turbine trip signal, auxiliary feedwater actuation signal (AFAS), and safety injection actuation signal (SIAS), that would be added to APR1400 DCD, Subsection 14.2.12.1.49. The DC applicant also determined that additional clarifications pertaining to the DPS signals, in particular the turbine trip signal, and other editorial changes should be made to enhance the ITP.

The NRC staff determined that the proposed revisions to the APR1400 DCD, Subsection 14.2.12.1.49 are acceptable to verify the operation of the DPS. However, it was unclear to the NRC staff whether the operation of the diverse indication system (DIS) and diverse manual switches (DMA) were included in this test. The NRC staff requested that the DC applicant submit a supplemental response to clarify if these two items are included in this test or whether other tests covers the operation of these items.

In the October 7, 2016 revised response to RAI 198-8208, Question 14.02-31 (ADAMS Accession No. ML1628A223), the DC applicant clarified that the ITP for the DMA switches is addressed in APR1400 DCD, Subsection 14.2.12.1.23 (as shown in the proposed markups in the response to RAI 198-8208, Question 14.02-20 (ADAMS Accession No. ML16230A478)). The DC applicant also clarified that the ITP for the DIS is addressed in APR1400 DCD, Subsection 14.2.12.1.139 as shown in the revised APR1400 DCD, Section 14.2 submitted on February 24, 2016 (ADAMS Accession No. ML16056A002). Based on the above clarification and the review of the DIS and DPS ITPs included in the revised APR1400 DCD, Section 14.2, which address all of the functions of the DPS; the NRC staff finds that the response meets the guidance in RG 1.68, Appendix A, Section A-1.j and is acceptable. Therefore, RAI 198-8208, Question 14.02-31 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.53 Pre-Core Pressurizer Performance Test

In RAI 198-8208, Question 14.02-32 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant demonstrate how the operation of the low-level interlock is verified in the pre-core pressurizer performance test described in APR1400 DCD, Subsection 14.2.12.1.53.

In the June 20, 2016, response to RAI 198-8208, Question 14.02-32 (ADAMS Accession No. ML16173A245), the DC applicant stated that:

> *All interlocks related to the pressurizer pressure and level are verified by decreasing and increasing the pressurizer pressure and level through the pre-core pressurizer performance test as specified in 14.2.12.1.53. Specifically, the pressurizer low-level interlock signal, which is the pressurizer low level heater cutoff signal, turns all pressurizer heaters off. Once pressurizer level drops below the pressurizer low level heater cutoff setpoint (as specified in test method*

3.6), verification of the interlock is made by operator actions in attempts to turn all heaters on manually with the pressurizer low-level interlock signal activated. If all the heaters are not able to be turned on at these conditions, the pressurizer low-level interlock signal is considered valid. Additionally, DCD Tier 2 14.2.12.1.53, test method 3.6 will be revised to clarify the specified level for the verification.

The NRC staff determined that the proposed changes to the APR1400 DCD, Subsection 14.2.12.1.53 clearly indicate that the pressurizer level should be set below the low-level interlock set point for this test, which allows for the verification of the operation of the low-level interlock. As such, the NRC staff determined that the pre-core pressurizer performance test described in the APR1400 DCD, Section 14.2.12.1.53 meets 10 CFR Part 50, Appendix A, GDC 1; Criterion XI of Appendix B to 10 CFR Part 50; and RG 1.68, Appendix A, Section A-1.a and Section A-1,j. Therefore, RAI 198-8208, Question 14.02-32 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.54 Pre-Core Control Element Drive Mechanism Performance Test

In RAI 198-8208, Question 14.02-33 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant demonstrate how the test objective to verify proper operation and sequencing of the CEDM is accomplished in the pre-core CEDM performance test described in APR1400 DCD, Subsection 14.2.12.1.54.

In the June 20, 2016, response to RAI 198-8208, Question 14.02-33 (ADAMS Accession No. ML16173A245), the DC applicant stated that:

During the pre-core Control Element Drive Mechanism (CEDM) performance test in Tier 2, Section 14.2.12.1.54, the functions of the digital rod control system (DRCS) and the CEDM without CEA extension shaft are tested to verify that the CEDM operates in the proper power sequence with four CEDM coils for CEA insertion and withdrawal. In every insertion/withdrawal step operation, the sequence of the CEDM coil power for each CEDM is monitored by the power regulator of the DRCS power cabinets. The test includes a check to ensure that the DRCS trouble alarm is actuated if abnormal CEDM power is sensed or CEDM motion is stopped. The recorded CEDM coil trace is also used to verify that the coil traces for withdrawal and insertion motion occur in the proper sequence. Verification of the proper sequencing will be added to the Acceptance Criteria in the ITP for 14.2.12.1.54.

For the proper operation of the regulating control groups, the out-of-sequence alarm is provided by the NSSS application program of the IPS. The out-of-sequence alarm, which is different than the above mentioned DRCS trouble alarm, is tested in Tier 2, Section 14.2.12.2.4 with the manual individual operation of each individual CEA when the other CEAs are positioned at the bottom of the core. For clarification, the out-of-sequence alarm test will be added to Tier 2, Section 14.2.12.2.4.

The NRC staff evaluated the proposed revisions to APR1400 DCD, Subsection 14.2.12.1.54 to add proper sequencing of the CEDM as an acceptance criterion and clarify that the direct current voltage across the shunt indicates the CEDM coil power trace and the proposed

changes to APR1400 DCD, Subsection 14.2.12.2.4 to add an out-of-sequence alarm test. The NRC staff determined that the above proposed revisions provide for verification of proper operation and sequencing of the CEDM. As such, the NRC staff determined that the pre-core CEDM performance test described in DCD, Subsection 14.2.12.1.54 is acceptable to verify the as-installed CEDM meets 10 CFR 50, Appendix A, GDC 1 and the guidance in RG 1.68; Appendix A, Section A-1.b; therefore, RAI 198-8208, Question 14.02-33 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.80 Normal Lighting System Test

To establish compliance with 10 CFR Part 50, Appendix A, GDC 17, the NRC staff issued RAI 280-8220, Question 14.02-44 (ADAMS Accession No. ML15306A016), which requested the DC applicant to discuss: (1) how the normal lighting system test verifies that required electrical power supplies and control circuits are available or provide adequate justification that it is not needed and (2) confirm that when testing normal lighting systems, other lighting systems will be de-energized in the rooms.

In the July 16, 2016 response to RAI 280-8220, Question 14.02-44 (ADAMS Accession No. ML16198A009), the DC applicant noted that for the normal lighting system test, the power sources for the lighting distribution panels are energized and the circuit breakers for the panels are closed. This testing configuration verifies that required electrical power supplies and control circuits are available. According to the DC applicant, the normal lighting system is not important to safety and the requirements of GDC 17 and GDC 18 do not apply to this system. The emergency alternating current (ac) lighting system (EDG backed) is always turned on and combines with lighting supplied by non-safety power to provide adequate illumination levels that support operation and maintenance activities during normal plant operation. Therefore, when testing the normal lighting, only the emergency dc lighting fixtures are not turned on. The DC applicant stated that APR1400 DCD, Subsection 14.2.12.1.80 will be revised to incorporate these clarifications.

The NRC staff reviewed the DC applicant's response to RAI 8220, Question 14.02-44 and the proposed updates to APR1400 DCD, Subsection 14.2.12.1.80. The NRC staff determined that the normal lighting test, as described in the paragraph above, meets the guidance for testing normal lighting in RG 1.68, Appendix A, Section A-1.g, "Electrical Systems," because the proposed change verifies that required electrical power supplies and control circuits are available. The NRC staff agrees that the normal lighting system is not important to safety and therefore is not required to meet the requirements of GDC 17 and GDC 18. As such, the NRC staff determined that the DC applicant's response is acceptable and therefore, RAI 280-8220, Question 14.02-44 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.81 Emergency Lighting System Test

To establish compliance with 10 CFR Part 50, Appendix A, GDC 17 and GDC 18, the NRC staff issued RAI 280-8220, Question 14.02-45 (ADAMS Accession No. ML15306A016), which requested that the DC applicant confirm the ability of the emergency lighting system by simulating a loss of the normal lighting and observing that the emergency system automatically activates. The NRC staff also requested that the DC applicant discuss how this test verifies that

required electrical power supplies and control circuits are available or provide adequate justification that it is not needed.

In the July 16, 2016 response to RAI 280-8220, Question 14.02-45 (ADAMS Accession No. ML16198A009), the DC applicant stated, in part that:

> *The ability of emergency dc lighting system is verified by simulating a loss of the normal lighting and observing that the emergency dc lighting system automatically activates. The emergency ac lighting system is always turned on and combines with the normal lighting system to provide[] adequate illumination levels during normal plant operation. Therefore, a loss of the normal lighting system causing an automatic activation is not simulated in the emergency ac lighting system test. For the emergency lighting system test, the power sources for the lighting distribution panels are energized and the circuit breakers for the panels are closed as stated in DCD Tier 2, Subsection 14.2.12.1.81, Emergency Lighting System Test, 2.0 prerequisites. This test configuration verifies that required electrical power supplies and control circuits are available. DCD Tier 2, Subsection 14.2.12.1.81 will be revised to incorporate the clarification above.*

The NRC staff determined that DC applicant response to RAI 280-8220, Question 14.02-45 for testing the emergency lighting system, as described in the paragraph above, is adequate because the proposed change verifies that required electrical power supplies and control circuits are available. The NRC staff also determined that the proposed revisions to APR1400 DCD, Subsection 14.2.12.1.81 meet the testing guidance for emergency lighting in RG 1.68, Appendix A, Section A-1.g and is acceptable. As such, RAI 280-8220, Question 14.02-45 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.84 Heat Tracing System Test

In RAI 57-7965, Question 08.03.01-4 (ADAMS Accession No. ML15189A490), the NRC staff requested the DC applicant to identify any safety-related mechanical systems protected by Class 1E sources that require heat tracing and freeze protection to maintain process temperatures. The NRC staff requested that if there are any mechanical systems protected by Class 1E sources that need to be heat traced, the DC applicant should justify why non-Class 1E power is used for the heat tracing circuits. The NRC staff also requested that the DC applicant describe equipment associated with the heat tracing/freeze protection system. Finally, APR1400 DCD, Subsection 14.2.12.1.84, “Heat Tracing System Test,” does not mention verification of redundancy and electrical independence as acceptance criteria for the heat tracing system test. Therefore, the NRC staff requested the DC applicant to describe how the redundancy and electrical independence will be verified for Class 1E equipment/systems during the initial testing phase.

In the August 19, 2015, response to RAI 57-7965, Question 08.03.01-4 (ADAMS Accession No. ML15231A804), the DC applicant stated:

> *The heat tracing (HT) system mentioned in DCD Tier 2, Subsection 8.3.1.1.7 does not provide heat tracing or freeze protection for any safety- related piping or equipment. Accordingly, Class 1E power is not provided.*

Apart from the heat tracing system mentioned above, there are sample lines for containment air monitors in the process and effluent radiological monitoring system (PERMS; refer to DCD Tier 2, Subsection 11.5.2.2), which are equipped with local heat tracing to which Class 1E power is supplied.

The local heat tracing provided as part of PERMS and the heat tracing test for the sample lines will be performed along with other supporting systems of PERMS. Redundancy and electrical independence of the local heat tracing for PERMS will be verified by reviewing the PERMS detailed design before the initial testing phase for PERMS.

In order to clearly identify the local heat tracing test required for PERMS, KHNP will revise DCD Tier 2, Subsection 14.2.12.1.106.

The NRC staff determined that the DC applicant's response to RAI 57-7965, Question 08.02.01-4 and the proposed revision to the APR1400 DCD, Subsection 14.2.12.1.106 meets the testing guidance for heat tracing in RG 1.68, Appendix A, Section A-1.o, "Auxiliary and Miscellaneous Systems," in that the proposed testing demonstrates operability and verifies redundancy and electrical independence of the associated systems. Therefore, RAI 57-7965, Question 08.03.01-4 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.85 Fire Protection System Test

As part of RAI 140-8139, Question 09.05.01-33 (ADAMS Accession No. ML15295A464), the NRC staff requested the DC applicant to revise APR1400 DCD, Subsection 14.2.12.1.85 to state that the initial fire protection system testing will be in accordance the criteria in the codes and standards referenced in DCD, Subsection 9.5.1.

In the September 4, 2015, response to RAI 140-8139, Question 09.05.01-33 (ADAMS Accession No. ML15247A253), the DC applicant stated:

Tier 2, Subsection 14.2.12.1.85 will be revised to move the seven items listed under Tier 2, Subsection 14.2.12.1.85, "Fire Protection System Test," Item 3.0, "TEST METHOD," to Item 1.0, "OBJECTIVES" and under Item 3.0, "TEST METHOD," … the following statement will be added: "Demonstrate that the initial fire protection system testing is in accordance with the criteria in the codes and standards referenced in DCD Tier 2, Subsection 9.5.1, 'Fire Protection Program.'"

The NRC staff determined that this RAI response and the proposed update to APR1400 DCD Section 14.2.12.1.1.85 adequately meets the testing guidance for fire protection in RG 1.68, Appendix A, Section A-1.o because it provides a requirement to verify that the initial fire protection system testing is in accordance with the criteria in the codes and standards referenced in APR1400 DCD, Subsection 9.5.1. Based on the above, RAI 140-8139, Question 09.05.01-33 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.86 Emergency Diesel Generator Mechanical System Test

In RAI 191-8210, Question 14.02-12 (ADAMS Accession No. ML15245A786), the NRC staff requested the DC applicant to upgrade the APR1400 DCD, Subsection 14.2.12.1.86 to describe how the test verifies EDG and auxiliary system alarms, interlocks, and control functions and describe how the test demonstrates EDG responses consistent with GDC 17 and GDC 18.

In the June 28, 2016 response to RAI 191-8210, Question 14.02-12 (ADAMS Accession No. ML16180A269), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.86 in its entirety to:

A) To verify that EDG diesel generator system alarms, interlocks, and control functions perform as designed, Items 1.1, 1.2, 3.2, 3.3, 4.1, 4.3, 4.5, 5.2, 5.3, 5.4, and 5.5 will be provided, as shown in the attachment to this response.

B) To verify how the mechanical and electrical trips, as listed in Subsection 8.3.1.1.3.3, "Tripping Devices" are demonstrated, Items 1.2, 3.3, 4.3, 4.5, and 5.4 will be provided, as shown in the attachment to this response.

C) For performing this test, "Prerequisites" Items 2.2 and 2.3 must be completed to verify that EDG instrumentation operates over the design range, as shown in the attachment to this response.

D) To verify that alarms and interlocks perform as designed, Items 1.2, 3.3, 4.3, 4.5, 5.4, and 5.5 will be provided, as shown in the attachment to this response.

To verify that the EDG alarm occurs as designed, a simulated signal for each alarm is used during the testing.

To verify that interlocks occur as designed, a simulated trip signal is used during the testing. To test the operation of the interlock upon a normal trip signal, the following procedure is performed.

a) simulate the normal trip signal,

b) start the EDG,

c) verify that the EDG does not start.

To test the operation of the interlock upon an emergency start signal, the following procedure is performed.

a) simulate the emergency trip signal,

b) attempt to stop the EDG when the EDG is operating, then verify that the EDG does not stop,

c) simulate the normal trip signal, then verify that the EDG does not stop.

Detailed procedures will be described in the detailed design phase.

E) EDG instrumentation calibration is a prerequisites condition for testing of the EDG. Therefore, it is included as prerequisite condition Item 2.3.

F) Prerequisite condition item 2.3 ensures that EDG instrumentation response meets the accident analysis assumptions, such as time response, accuracy, and control stability.

G) To demonstrate an acceptable level of reliability of the EDG starting, reliability tests are performed by ensuring 25 consecutive tests without failures in accordance with IEEE 387, "Standard for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations." The ability of the EDG to reliably start is verified through items 1.2, 3.3, 4.2, and 5.6 as shown in the attachment.

The NRC staff reviewed the proposed revision to APR1400 DCD, Subsection 14.2.12.1.86 and determined that the proposed revision is acceptable because it: (1) provides an adequate level of detail to ensure that the test verifies EDG and auxiliary system alarms, interlocks, and control functions and (2) describes acceptable EDG responses consistent with GDC 17 and GDC 18 by verifying that onsite power systems provide sufficient capacity and capability. RAI 191-8210, Question 14.02-12 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

In addition, in RAI 515-8681, Question 14.02-68 (ADAMS Accession No. ML16226A022), the NRC staff requested the DC applicant confirm that 25 consecutive tests without failures is 25 start and load tests, in accordance with IEEE Std. 387-1995 and confirm that the load tests are in accordance with IEEE Std. 387-1995, Section 7.2.1.3, "Rated Load Test."

In the October 7, 2016 response to RAI 515-8681, Question 14.02-68 (ADAMS Accession No. ML16281A240), the DC applicant updated DCD, Subsection 14.2.12.1.86, to replace "valid tests" with "valid start and load-run tests." The DC applicant also indicated that the rated load test in accordance with IEEE Std. 387-1995, Section 7.2.1.3 will be performed during site acceptance testing and is not applicable to this preoperational test.

The NRC staff determined that the proposed revisions to APR1400 DCD, Subsection 14.2.12.1.86 meets the guidance in Section 7.3, "Pre-operational testing," of IEEE Std. 387-1995 by requiring a minimum of 25 valid start and load tests without failure on each installed EDG. Additionally, the NRC staff determined that since IEEE Std. 387-1995 does not require rated load tests for preoperational testing, it is acceptable for the rated load tests to be performed during site acceptance testing. Therefore, RAI 515-8681, Question 14.02-68 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.87 Emergency Diesel Generator Electrical System Test

APR1400 DCD, Subsection 14.2.12.1.87, "Emergency Diesel Generator Electrical System Test," states that the test demonstrates the following: (1) the ability of each EDG to carry the continuous rated load, (2) the ability of each EDG to attain and stabilize frequency and voltage

within the rated limits and time, and (3) each EDG starts automatically on ESFAS signal and/or 4.16 kV bus loss of voltage and the EDG rated voltage and frequency has been attained.

IEEE Std. 387-1995, Section 7.5 and Table 3, "Site Testing," prescribe the load tests that are to be performed during pre-operational testing which include (1) largest load rejection, (2) design load rejection and (3) endurance and load tests. RG 1.9, which endorses IEEE Std. 387-1995, provides guidance for slow-start, load-run, and fast-start pre-operational tests that should be performed in addition to those in IEEE Std. 387-1995. The NRC staff determined that the DC applicant adequately addressed the IEEE Std. 387-1995 load test requirements and the additional preoperational test guidance set forth in RG 1.9. The NRC staffs further evaluation of conformance to RG 1.9 is in Section 8.3.1 of the SER.

In RAI 191-8210, Question 14.02-13 (ADAMS Accession No. ML15245A786), the NRC staff requested the DC applicant revise DCD, Subsection 14.2.12.1.87, "EDG Electrical System Test," to add the following two items:

a. Discuss whether this test verifies that EDG alarms, interlocks, and control functions are as designed and if so, how.

b. Adequate ventilation is necessary for the operation of EDGs. Discuss how adequate ventilation is verified before performing tests of the EDG.

In the June 28, 2016 response to RAI 191-8210, Question 14.02-13 (ADAMS Accession No. ML16180A269), the DC applicant stated that the testing of EDG alarms, interlocks, and control functions is performed in accordance with APR1400 DCD, Subsection 14.2.12.1.86. The testing described in APR1400 DCD, Subsection 14.2.12.1.87 is performed when the EDG mechanical system test in APR1400 DCD, Subsection 14.2.12.1.86 is completed. The DC applicant also revised APR1400 DCD, Subsection 14.2.12.1.87 in its entirety to address how the test verifies the EDG electrical system. To address the NRC staff's question with regard to adequate ventilation for the EDG during operation, the DC applicant stated that the testing of the EDG area HVAC is provided in APR1400 DCD, Subsection 14.2.12.1.97, "Emergency Diesel Generator Area HVAC System Test."

The NRC staff determined that the DC applicant's response and the proposed revision to the APR1400 DCD, Subsection 14.2.12.1.87 is acceptable because it provides adequate testing requirements for the EDG electrical system and meets the testing guidance in RG 1.68, Appendix A, Section A-1.g. The DC applicant also adequately clarified how other tests address verification of EDG alarms, interlocks, and control functions and adequate EDG ventilation. Based on the above, RAI 191-8210, Question 14.02-13 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.88 Emergency Diesel Generator Auxiliary Systems Test

In RAI 191-8210, Question 14.02-14 (ADAMS Accession No. ML15245A786), the NRC staff requested the DC applicant to address why the EDG intake air and exhaust gas systems' ability to support full load capacity is not included in APR1400 DCD, Subsection 14.2.12.1.88 and to discuss how APR1400 DCD, Subsection 14.2.12.1.88 verifies that the starting air system is capable of achieving a single EDG start when the receiver is at the minimum receiver design pressure.

In the July 8, 2016 response to RAI 191-8210, Question 14.02-14 (ADAMS Accession No. ML16190A355), the DC applicant stated that all of the EDG auxiliary systems are included in DCD, Subsection 14.2.12.1.86, "EDG Mechanical System Test," except for the emergency fuel oil system. To prevent redundancy in testing, the DC applicant added testing of all support systems, including air intake and exhaust, to APR1400 DCD, Subsection 14.2.12.1.86 (see RAI 191-8210, Question 14.02-12 (ADAMS Accession No. ML16180A629)). The DC applicant also revised APR1400 DCD, Subsection 14.2.12.1.88 in its entirety to only contain the test guidance for the emergency diesel fuel oil system. In response to the NRC staff question on the starting air system, the DC applicant stated that APR1400 DCD, Subsection 14.2.12.1.86 will demonstrate that each air receiver is capable of providing five cranking cycles without being recharged, and thus capable of achieving EDG successful starts. According to the DC applicant, no further change to APR1400 DCD, Subsection 14.2.12.1.88 is necessary.

The NRC staff reviewed the proposed revisions to APR1400 DCD, Subsections 14.2.12.1.86 and 14.2.12.1.88 and determined that this response demonstrates that: (1) the EDG intake air and exhaust gas systems' ability to support full load capacity is tested in APR1400 DCD, Subsection 14.2.12.1.86; (2) the EDG fuel oil system is tested in APR1400 DCD, Subsection 14.2.12.1.88; and (3) and APR1400 DCD, Subsection 14.2.12.1.86 verifies that the starting air system is capable of achieving a single EDG start when the receiver is at the minimum receiver design pressure. Based on the above, the NRC staff determined that the DC applicant's proposed revisions are acceptable and meet the testing guidance for EDG sub-systems in RG 1.68, Appendix A, Subsection A-1.g, Item 3. Therefore, RAI 191-8210, Question 14.02-14 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.89 Alternate AC Source System Test; 14.2.12.1.90 Alternate AC Source Support Systems Test

The NRC staff determined that the APR1400 DCD, Subsections 14.2.12.1.89 and 14.2.12.1.90 did not provide sufficient detail to demonstrate that the alternate ac (AAC) gas turbine generator (GTG) can obtain rated voltage and frequency within 2 minutes after the receipt of a starting signal. In RAI 191-8210, Question 14.02-11 (ADAMS Accession No. ML15245A786), the NRC staff requested the DC applicant discuss the specific mechanical and electrical trips, indications, alarms, and number of starts required. Furthermore, the DC applicant was asked to discuss:

a) how adequate ventilation is assessed,

b) how the continuous rating is verified,

c) how the time requirements are verified for reaching required voltage and frequency,

d) how these tests verify that upon a simulated station blackout (SBO) that the GTG starts from standby to energize the buses,

e) how these tests demonstrate the capability to reject a loss of the largest single load, and

f) how these tests demonstrate the ability to synchronize the GTG with offsite power while loaded upon a simulated restoration of offsite power.

In the October 5, 2016 response to RAI 191-8210, Question 14.02-11, (ADAMS Accession No. ML16279A508), the DC applicant proposed to revise in its entirety APR1400 DCD, Subsections 14.2.12.1.89 and 14.2.12.1.90 to include: (1) assessment of adequate ventilation; (2) verification of continuous rating; (3) verification of time requirements for reaching required voltage and frequency; (4) verification that upon a simulated SBO that the GTG starts from standby to energize the buses; (5) demonstration of the capability to reject a loss of the largest single load; (6) demonstration of the ability to synchronize the GTG with offsite power while loaded upon a simulated restoration of offsite power; (7) demonstration of the adequacy and operation of the fuel systems; (8) demonstration of the operation of the lube oil and cooling systems; and (9) demonstration of the operation of the exhaust/intake system.

The NRC staff determined that the DC applicant's response to RAI 191-8210, Question 14.02-11 and the proposed revisions to APR1400 DCD, Subsections 14.2.12.1.89 and 14.2.12.1.90 related to testing the AAC GTG is acceptable because it addresses the specific concerns raised in the RAI and provides sufficient detail to demonstrate that the AAC GTG can obtain rated voltage and frequency within 2 minutes after the receipt of a starting signal. Based on the above, the NRC staff determined that the proposed revisions to the APR1400 DCD, Subsections meet 10 CFR Part 50, Appendix A, GDC 17 and 18, and the guidance in RG 1.68, Appendix A, Section A-1.g, Item 3. Therefore, RAI 191-8210, Question 14.02-11 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

In RAI 529-8711, Question 14.02-71 (ADAMS Accession No. ML16319A337), the NRC staff requested the DC applicant discuss how the APR1400 DCD, Subsection 14.2.12.1.89 demonstrates that the AAC GTG and its supporting systems can be started, controlled, and monitored from the RSR to cope with an SBO.

In the January 6, 2017 response to RAI 529-8711, Question 14.02-71 (ADAMS Accession No. ML17006A395), the DC applicant proposed to add tests for the AAC GTG and the AAC GTG support systems to APR1400 DCD, Subsection 14.2.12.1.89 and 14.2.12.1.90. The NRC staff determined that this response meets 10 CFR 50, Appendix A, GDC 17 and 18, and RG 1.68, Appendix A, Section A-1.g, Item 3, "Emergency or Standby AC Power Supplies," because the proposed change provides that testing will be completed to demonstrate that the AAC GTG and supporting systems can be controlled and monitored from the RSR. Based on the above, **RAI 529-8711, Question 14.02-71 which was being tracked as an open item, is resolved and this change to APR1400 DCD, Section 14.2 is being tracked as Confirmatory Item 14.2.12.1-33.**

14.2.12.1.99 Compound Building HVAC System Test; 14.2.12.1.132 Auxiliary Building Controlled Area HVAC System Test

In RAI 281-8232, Question 14.02-47 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant to update APR1400 DCD, Subsections 14.2.12.1.99, "Compound Building HVAC [Heating, Ventilation and Air Conditioning] System Test," and 14.2.12.1.132, "Auxiliary Building Controlled Area HVAC System Test," to provide for testing to verify the airflow rate acceptance criteria provided in APR1400 DCD, Table 12.2-26. The HVAC system airflow rates provided in this table are airflow rates relied upon to provide reasonable assurance that airborne concentrations remain below derived airborne concentration (DAC) limits.

In the June 15, 2015 response to RAI 281-8232, Question 14.02-47 (ADAMS Accession No. ML16167A537), the DC applicant proposed to add acceptance criteria to APR1400 DCD, Subsections 14.2.12.1.99 and 14.2.12.1.132, to ensure that the ITP provides for testing of the Compound Building HVAC system and the Auxiliary Building controlled area HVAC system to maintain exhaust airflow rates from the radiologically controlled rooms at a minimum to the HVAC flows in APR1400 DCD, Table 12.2-26.

The NRC staff determined that the DC applicant's response to RAI 281-8232, Question 14.02-47 and the proposed revision to APR1400 DCD, Subsections 14.2.12.1.99 and 14.2.12.1.132 meets the testing guidance in RG 1.68, Appendix A, Section A-1.m because the proposed acceptance criteria verify minimum exhaust airflow rates from these radiologically controlled rooms in accordance with APR1400 DCD, Table12.2-26 and therefore, is acceptable. Based on the above, RAI 281-8232, Question 14.02-47 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.103 Liquid Waste Management System Test; 14.2.12.1.105 Gaseous Waste Management System Test

In RAI 283-8229, Question 14.02-62 (ADAMS Accession No. ML15306A269), the NRC staff requested the DC applicant to address why APR1400 DCD, Subsections 14.2.12.1.103 and 14.2.12.1.105 did not identify specific test methods or acceptance criteria for SSCs that are non-safety related but risk significant. The NRC staff also requested the following information:

1. Provide a description of what key SSCs would be identified by the Expert Panel for index numbers 184 and 375.

2. Provide a description of the testing method to verify the operation of the Gaseous Radwaste System - Containment Isolation Valve in Subsection 14.2.12.1.105 or wherever applicable.

3. Provide a description of the testing method to verify the operation of 'key SSCs' in the Gaseous Waste Management System in 14.2.12.1.105 or wherever applicable.

4. Provide a description of the testing method to verify the operation of 'key SSCs' in the Liquid Waste Management System in Subsection 14.2.12.1.103 or wherever applicable.

5. Please address these items and provide a markup for the proposed DCD changes.

In the October 26, 2016, response to RAI 283-8229, Question 14.02-62 (ADAMS Accession No. ML16300A432*),* the DC applicant provided the following:

1. The Expert Panel considered PRA importance and deterministic method to identify the Key SSCs. The gaseous waste management system (GWMS - 184) and the liquid waste management system (LWMS - 375) were identified by deterministic consideration. These systems are those that are designed to maintain radwaste materials contained within the system boundary to prevent spreading of radwaste materials outside of the defined

boundary. As shown in Table 17.4-1, the specific SSCs identified by the Expert Panel for GWMS and LWMS included only the containment isolation valves (Level 2) because GWMS and LWMS are not credited in the PRA model except for the containment isolation valves.

2~4. As a result of the upgrade effort described in the original response (ref. KHNP submittal MKD/NW-16-0156L "Submittal of Revised DCD Section 14.2 Initial Plant Test Program" dated February 24, 2016; ML16056A003), the contents of Section 14.2.12.1.103 and 14.2.12.1.105 of DCD Tier 2 has been generally enhanced. The preoperational test for liquid and gaseous waste management system has also included the description for testing of the key system control, alarms and indications in accordance with RG 1.68 as required by sub-questions 2 through 4 of this RAI. The revised Sections 14.2.12.1.103 and 14.2.12.1.105 including previous markups are provided in the Attachment for clarity.

Since the test for the containment isolation valve operation of gaseous radwaste system will be performed in accordance with Section 14.2.12.1.129, Section 14.2.12.1.105 will be revised as indicated in Attachment to this response. Section 14.2.12.1.129 was previously revised to address the CIV, (also submitted by MKD/NW-16-0156L), and is provided in the Attachment for information.

The NRC staff determined that the DC applicant's response and the proposed revisions to APR1400 DCD, Subsections 14.2.12.1.103 and 14.2.12.1.105 are acceptable because they (1) adequately identify the non-safety but risk significant SSCs in the gaseous waste management system (GWMS) and liquid waste management system (LWMS) for the reasons stated by the DC applicant, and (2) provide sufficient test methods and acceptance criteria for SSCs that are non-safety but risk significant. Based on the above, the NRC staff determined that the proposed revisions are acceptable and meet the LWMS and GWMS testing guidance in RG 1.68, Section A-1.m. As such, RAI 283-8229, Question 14.02-62 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

Additionally, the NRC staff determined that the test method and acceptance criteria in APR1400 DCD, Subsection 14.2.12.1.103 for the LWMS was not fully described. In RAI 194-8172, Question 14.02-17 (ADAMS Accession No. ML15246A077), the NRC staff requested the DC applicant to provide verification of manual and automatic response to normal control, alarms, and indication in the acceptance criteria of APR1400 DCD, Subsection 14.2.12.1.103.

In the September 24, 2016 response to RAI 194-8172, Question 14.02-17 (ADAMS Accession No. ML16268A001), the DC applicant stated, in part, that:

The LWMS test objectives have been expanded from one general objective to four, more detailed objectives and eight new acceptance criteria have been incorporated. Among various items included in the revised test plan is verification of manual and automatic system controls on key system alarms including high-level alarms associated with liquid tanks and other alarms such as radiation monitor and dual isolation valves, and includes those associated with the Detergent Waste Tank.

If a release from the Detergent Waste Tank exceeds the predetermined setpoint, an alarm is initiated, the discharge valve closes automatically, and the operator manually turns off the detergent waste pump and diverts the flow to the chemical waste tank. Though Section 14.2.12.1.103 does not specifically reference the Detergent Waste Tank liquid effluent release, it is part of the Liquid Waste Management System and is included in the test plan. The test plan is written to test all of the components in the system, including the associated Detergent Waste Tank components. Objectives 1.1, 1.2, and 1.3, Test Methods 3.1, 3.3, 3.5, and 3.6, and Acceptance Criteria 5.2, 5.5, 5.6 and 5.7 were written in general terms and also encompasses the process to adequately test the Detergent Waste Tank portion of the system.

The NRC staff reviewed the DC applicant response and proposed revisions to APR1400 DCD, Subsection 14.2.12.1.103 and determined that it meets the guidance for testing the LWMS in RG 1.68, Appendix A, Section A.1.m because the changes provide an acceptable test method and acceptance criteria for the LWMS, including the Detergent Waste Tank. Therefore, RAI 194-8172, Question 14.02-17 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

The NRC staff concluded that the test method provided in APR1400 DCD, Subsection 14.2.12.1.103 for testing the features of the LWMS did not test the system as a whole as it did not functionally test the radiation detector. In RAI 283-8229, Question 14.02-63 (ADAMS Accession No. ML15306A269), the NRC staff requested the DC applicant to address the use of a radiation source in testing the system features, control alarms, indicating instrumentation, and status lights are functional for the LWMS.

In the October 5, 2016, response to RAI 283-8229, Question 14.02-63 (ADAMS Accession No. ML16279A542), the DC applicant provided the following:

Since the LWMS discharge radiation monitor is considered as a part of the Process and Effluent Radiological Monitoring System (PERMS), the test for the radiation monitor, including the functionality of the detector, alarms, status lights, etc., will be performed in accordance with Section 14.2.12.1.106. The DCD Section 14.2.12.1.103 pertains to the verification that the LWMS discharge valve closes and pump operation stops upon receipt of a high radiation signal from the radiation monitors. One of the changes proposed in the referenced upgrade of 14.2.12.1.103 was to include a reference to Section 14.2.12.1.106 in the ITP related to the test method of the radiation monitor.

A radiation check source cannot be used to verify the monitor alarm setpoint and radiation level indication. Verification of the alarm setpoint and radiation level indication will normally be accomplished periodically using an appropriate calibration source. A simulated radiation signal will be used to replicate the radiation level required to test the BOP ESFAS signals and RMS alarm functionality. Since the LWMS radiation monitors are tested with a radiation check source as part of an ITAAC, they do not need to be re-tested with a radiation check source as part of the ITP. DCD Tier 2, Subsection 14.2.12.1.106 will be revised to consistently refer to a simulated signal that is to be used for the testing of the radiation monitors.

The NRC staff originally determined that LWMS radiation monitors should be tested with a radiation check source under both the ITAAC and the ITP preoperational test; therefore, this test would be performed and counted once under both the ITAAC and the ITP preoperational test. However, after further discussion with the DC applicant, the NRC staff determined that it was acceptable to use a simulated source during preoperational testing as long as the LWMS radiation monitors are tested with a radiation check source prior to fuel load. The NRC staff determined that since the LWMS radiation monitors are tested with a radiation check source as part of an ITAAC, RAI 283-8229, Question 14.02-63, which was being tracked as an open item, is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.104 Solid Waste Management System Test

In RAI 193-8181, Question 14.02-16, the NRC staff requested the DC applicant to revise APR1400 DCD, Subsection 14.2.12.1.104 acceptance criteria to include verification of manual and automatic response to normal control, alarms, and indications for the solid waste management system (SWMS).

In the June 16, 2016 response to RAI 193-8181, Question 14.02-16 (ADAMS Accession No. ML16168A467), the DC applicant proposed revisions to APR1400 DCD, Subsection 14.2.12.1.104 to add a cross reference to DCD Table 11.4-6 where the following indications from the Rad-Waste Storage Room were added to the test:

1. *Tank level, tank pressure, and demineralized water inlet flow rate of the Low-Activity Spent Resin Bed.*
2. *Tank level of the Spent Resin Long-Term Storage Tank.*
3. *High alarms for tank level of the Low-Activity Spent Resin Tank and Spent Resin Long-Term Storage Tank.*

The NRC staff determined that the proposed revision to APR1400 DCD, Subsection 14.2.12.1.104 is acceptable because it provides acceptance criteria for the verification of manual and automatic response to normal control, alarms and indications for the SWMS. Based on the above, the NRC staff determined that the proposed DCD revision meets RG 1.68, Appendix A, Section A-1.m. RAI 193-8181, Question 14.02-16 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.105 Gaseous Waste Management System Test

The NRC staff concluded that the test method provided in APR1400 DCD, Subsection 14.2.12.1.105 for testing the features of the GWMS did not test the system as a whole as it did not functionally test the radiation detector. In RAI 283-8229, Question 14.02-64 (ADAMS Accession No. ML15306A269), the NRC staff requested the DC applicant to address the use of a radiation source in testing the system features, controls alarms, indicating instrumentation, and status lights for the GWMS to verify that they are functional.

In the October 5, 2016, response to RAI 283-8229, Question 14.02-64 (ADAMS Accession No. ML16279A542), the DC applicant stated:

Since the GRS [Gaseous Radiation System] discharge radiation monitor is considered a part of the Process and Effluent Radiological Monitoring System (PERMS), the test for the radiation monitor, including the functionality of the detector, alarms, status lights, etc., will be performed in accordance with Section 14.2.12.1.106. DCD Section 14.2.12.1.105 pertains to the verification that the GRS discharge valve closes upon receipt of a high radiation signal from the radiation monitors. One of the changes proposed in the referenced upgrade of 14.2.12.1.105 was to include a reference to Section 14.2.12.1.106 in the ITP related to the test method of the radiation monitor.

A radiation check source cannot be used to verify the monitor alarm setpoint and radiation level indication. Verification of the alarm setpoint and radiation level indication will normally be accomplished periodically using an appropriate calibration source. A simulated radiation signal will be used to replicate the radiation level required to test the BOP ESFAS signals and RMS alarm functionality. Since the GRS radiation monitors are tested with a radiation check source as part of an ITAAC, they do not need to be re-tested with a radiation check source as part of the ITP.

The NRC staff originally determined that GRS radiation monitors should be tested with a radiation check source under both the ITAAC and the ITP preoperational test; therefore, this test would be performed and counted once under both the ITAAC and the ITP preoperational test. However, after further discussion with the DC applicant, the NRC staff determined that it was acceptable to use a simulated source during preoperational testing as long as the GRS radiation monitors are tested with a radiation check source prior to fuel load. The NRC staff determined that since the GRS radiation monitors are tested with a radiation check source as part of an ITAAC, RAI 283-8229, Question 14.02-64, which was being tracked as an open item, is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

In RAI 192-8180, Question 14.02-15, the NRC staff requested the DC applicant revise the APR1400 DCD, Subsection 14.2.12.1.105 to include verification of manual and automatic response to normal control, alarms, and indications.

In the April 7, 2016 response to RAI 192-8180, Question 14.02-15 (ADAMS Accession No. ML160098A297), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.105 to include: (1) verification of automatic valve operation upon the receipt of a high-high oxygen concentration signal and a high radiation signal, and (2) an additional test objective to correspond with the upgraded test method and acceptance criteria provided in the February 24, 2016 revision of APR1400 DCD, Section 14.2 (ADAMS Accession No. ML16056A002). Additionally the DC applicant's response stated that the verification for radiation and oxygen concentration alarm actuation, including associated monitoring, is conducted with the Process and Effluent Radiological Monitoring System, as described in Subsection 14.2.12.1.106, and the Process and Primary Sampling System, as described in Subsection 14.2.12.1.83, respectively. However, the NRC staff determined that the April 7, 2016 response to RAI 192-8180, Question 14.02-15 (ADAMS Accession No. ML16098A297), did not include information regarding the test methodologies, prerequisites and acceptance criteria for the various components that are a part of the GWMS.

In the June 16, 2017 revised response RAI 192-8180, Question 14.02-15 (ADAMS Accession No. ML17167A249), the DC applicant proposed to revise the test method for the GWMS to: (1) verify the operation of the GWMS equipment as described in APR1400 DCD, Section 11.3 (2) verify automatic valve operation upon the receipt of a low flow signal from the Gaseous Radwaste System (GRS) discharge line; (3) verify automatic valve operation upon the receipt of low-low ACU (Air Cleaning Unit) exhaust flow signal; and (4) verify automatic drain valve operation upon the receipt of low and high GRS header drain tank level. In addition, the DC applicant proposed to revise the associated acceptance criteria to reflect the aforementioned revisions to the test method.

The NRC staff determined that the proposed revisions provide for verification of manual and automatic response to normal control, alarms, and indications as it relates to monitoring and complying with the effluent concentration limits specified in Appendix I of 10 CFR Part 50. Based on the above, **RAI 192-8180, Question 14.02-15, which was being tracked as an open item, is resolved. The proposed changes to the APR1400 DCD are being tracked as Confirmatory Item 14.2.12.1-39.**

14.2.12.1.106 Process and Effluent Radiological Monitoring System Test; 14.2.12.1.107 Area Radiation Monitoring System Test

The APR1400 DCD, Subsections 14.2.12.1.106 and 14.2.12.1.107 indicate that simulated signals will be used to test control actions and alarms, instead of using a calibration source. In RAI 281-8232, Question 14.02-50 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant to:

1. Revise the ITP in order to test the functionality of the radiation monitor computer system in order to ensure that radiation levels, alarms, and control actions are properly being communicated between the radiation monitors, the monitor computer system, the main control room, and any applicable system actuation with a radiation calibration source, or justify why the use of simulated signals is acceptable.

2. Update APR1400 DCD, Subsections 14.2.12.1.106 and 14.2.12.1.107, to test the control functions or alarms associated with high radiation levels with a radiation calibration source, or justify why the use of simulated signals is acceptable.

In the June 15, 2016 response to RAI 281-8232, Question 14.02-50 (ADAMS Accession No. ML16167A537), the DC applicant stated, in part that:

> *1. The advantage of using a simulated test signal is the ability to adjust the signal level to check various actuation setpoints such as alarm setpoints and interlock setpoints. This adjustability is not readily available with a radioactive check source, which generally provides just a fixed level and for this reason, section 14.2.12.1.106 and 107 describe tests using a simulated test signal. The functionality check of the system using the simulated test signal is more suitable for the intended test. In conjunction with the use of a simulated signal for verification of the setpoint for the alarm and radiation level, the calibration source is used to verify the calibration/drift of the detector sensor during the periodic surveillance functional test period of the radiation monitor.*

2. *In accordance with the discussion provided in (1) above, the use of a simulated test signal is suitable for the intended test.*

The NRC staff's review of the DC applicant's response to RAI 281-8232, Question 14.02-50, concluded that all radiation monitors should be tested with a radiation check source. The NRC staff determined that the above response is not acceptable and the DC applicant should consider revising its response to use a radiation check source to verify that radiation monitors are functional under the ITP to meet the testing guidance in RG 1.68, Appendix A, Section A-1.k.

In the July 31, 2017 to response RAI 281-8232, Question 14.02-50 (ADAMS Accession No. ML17212B046) the DC applicant specified that as part of the ITAAC, each channel of the PERMSS and ARMS will be tested with a radiation check source to ensure the radiation detectors adequately respond to radiation. Additionally, the DC applicant stated that the radiation monitors will also be calibrated periodically during operation as part of the radiation protection program.

The NRC staff originally determined that each channel of the PERMSS and ARMS should be tested with a radiation check source under both the ITAAC and the ITP preoperational test; therefore, this test would be performed and counted once under both the ITAAC and the ITP preoperational test. However, after further discussion with the DC applicant, the NRC staff determined that it was acceptable to use a simulated source during preoperational testing as long as each channel of the PERMSS and ARMS are tested with a radiation check source prior to fuel load. The NRC staff determined that since each channel of the PERMSS and ARMS are tested with a radiation check source as part of an ITAAC, the DC applicant's response is acceptable and RAI 281-8232, Question 14.02-50, which was being tracked as an open item, is resolved.

In RAI 195-8182, Question 14.02-18 (ADAMS Accession No. ML152534A346), the NRC staff requested the DC applicant to revise APR1400 DCD, Subsection 14.2.12.1.106 to include verification of manual and automatic response to normal control, alarms, and indications for the PERMSS.

In the March 29, 2016 response to RAI 195-8182, Question 14.02-18, the DC applicant proposed to expand the description in the acceptance criteria for the PERMSS to address the system's monitoring and signal generation when the radiation level detected exceeds the preset levels in accordance with the system design criteria and description in APR1400 DCD, Section 11.5. The NRC staff determined that the proposed response provides that verification of radiation monitor and isolation valves to monitor and control effluent discharge to the environment are addressed as required by 10 CFR Part 50, Appendix I. Therefore, RAI 195-8182, Question 14.02-18, which was being tracked as an open item, is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

In RAI 281-8232, Question 14.02-46 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant include preoperational testing of the area radiation monitors or provide justification why it is unnecessary.

In the June 30, 2016 response to RAI 281-8232, Question 14.02-46 (ADAMS Accession No. ML16182A588), the DC applicant indicated that the airborne radiation monitors are part of the

process and effluent radiological monitors (airborne monitors) that are tested in APR1400 DCD, Subsection 14.2.12.1.106. The DC applicant revised the title of test in APR1400 DCD, Subsection 14.2.12.1.107 in Table 14.2-1, to delete the airborne monitors and specify testing of the area radiation monitoring system.

The NRC staff determined that the DC applicant's response to RAI 281-8232, Question 14.02-46 and the proposed revision to Table 14.2-1 clarifies that testing of the area radiation monitors will be performed in accordance with the guidance in RG 1.68, Appendix A, Section A-1.m, to demonstrate operability of these radiation monitoring systems and therefore, is acceptable. Based on the above, RAI 281-8232, Question 14.02-46 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.108 4,160 V Class 1E Auxiliary Power System Test

The APR1400 DCD, Subsection 14.2.1.12.1.108 stated that the preoperational test will verify the 4,160 V and 480 V safety-related systems load shed as designed on undervoltage. In RAI 282-8238, Question 14.02-59 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant discuss whether this included degraded voltage conditions and loss-of voltage conditions to meet Appendix A to 10 CFR Part 50, GDC 17 and GDC 18 for the 4.16 kV and 480 V safety-related systems. Specifically, GDC 17 requires onsite and offsite power systems to provide sufficient capacity and capability to permit functioning of SSCs that are important to safety, and GDC 18 requires the testing of electric power systems that are important to safety.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-59 (ADAMS Accession No. ML16230A116), the DC applicant proposed to clarify the test methods and acceptance criteria and to keep consistency with APR1400 DCD, Chapter 8, "Electric Power," as well as the other subsections of Chapter 14. Specifically, APR1400 DCD, Subsection 14.2.12.1.108 was revised to incorporate in Test Method 3.4, a clarification that load shedding of the 4.16 kV safety loads occurs on undervoltage conditions (i.e., loss of voltage and degraded voltage condition) of the switchgear. APR1400 DCD, Subsections 14.2.12.1.109 (480 V Class 1E) and 14.2.12.1.113 (480 V non-Class 1E) and Tables 14.2-1 and 14.2-7 were also revised to reflect this testing. The NRC staff reviewed the DC applicant's response and determined that the proposed update to add electrical system test methods and acceptance criteria to APR1400 DCD, Subsections 14.2.1.1.108, 14.2.12.1.109 (480 V Class 1E) and 14.2.12.1.113 (480 V non-Class 1E), as well as the proposed update to Tables 14.2-1 and 14.2-7 are acceptable because they clarify that loss of voltage and degraded voltage conditions are included in the tests. Therefore, the NRC staff concludes that the revised description of the electrical system testing meets 10 CFR Part 50, Appendix A, GDC 17 and GDC 18, and the testing guidance in RG 1.68, Appendix A, Section A-1g. Based on the above, RAI 282-8238, Question 14.02-59 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.110 Unit Main Power System Test

The APR1400 DCD, Subsection 14.2.1.12.1.110 discusses the Unit Main Power System Test. Test Method 3.6 states, "verify the operation of interlocks, alarms, and protective relays." In RAI 282-8238, Question 14.02-57 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant discuss how this test verifies that the backup relay protection scheme works for simulated single failures by verifying operation of the primary and backup

relay systems in order to meet the regulatory requirements of GDC 17 for onsite and offsite power systems to provide sufficient capacity and capability to permit functioning of SSCs that are important to safety and GDC 18 for the testing of electric power systems that are important to safety.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-57 (ADAMS Accession No. ML16230A116), the DC applicant stated that after a more detailed review of the ITP for the electrical items, the DC applicant developed a general revision of APR1400 DCD, Subsections 14.2.12.1.108 through 14.2.12.1.116 to clarify the test methods and acceptance criteria and to keep consistency with APR1400 DCD, Chapter 8 as well as the other subsections of Chapter 14. The DC applicant also stated:

> *Protection of the major components (e.g., main generator, main transformer, and unit auxiliary transformers) of the unit main power system is provided by three multifunction protective systems (MPSs). When a protective function in one MPS detects a fault, the MPS provides a signal (e.g., trip and/or alarm) for operation of a lockout relay and associated protective equipment. The MPSs of major components are provided with a two-out-of-three (2oo3) coincidence logic in order to preclude spurious operation of protective equipment due to any erroneous operation of any single MPS and to provide reasonable assurance of secure operation of the protective equipment under a fault condition. Upon receipt of at least two individual signals out of three MPSs, the lockout relay is energized and trips the associated protective device(s).*
>
> *In the preoperational tests phase, operation of the protection scheme is checked and verified by circuit operational tests, which ensure the relay protection scheme works in the event of a single failure.*

The proposed revision to APR1400 DCD, Subsection 14.2.12.1.110 was included in the February 24, 2016 submittal of the revised APR1400 DCD, Section 14.2 (ADAMS Accession No. ML16056A002) and was revised a second time to provide further clarification.

The NRC staff reviewed the DC applicant's response and proposed revisions to APR1400 DCD, Subsection 14.2.12.1.110 and determined that the more detailed test methods and acceptance criteria for the Unit Main Power System Test meets the regulatory requirements for electrical systems in GDC 17 and GDC 18, and the testing guidance in RG 1.68, Appendix A, Section A-1.g. Specifically, the proposed testing verifies that the backup relay protection scheme works for simulated single failures by verifying operation of the primary and backup relay systems in order to meet the regulatory requirements of GDC 17 for onsite and offsite power systems to provide sufficient capacity and capability to permit functioning of SSCs that are important to safety and GDC 18 for the testing of electric power systems that are important to safety. Therefore, RAI 282-8238, Question 14.02-57 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.111 13,800 V Normal Auxiliary Power System Test

The APR1400 DCD, Subsection 14.2.1.12.1.111, "13,800 V Normal Auxiliary Power System Test," discusses the 13,800 V normal auxiliary power system test. In RAI 282-8238, Question 14.02-58 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant to

discuss how this test verifies the alignment of the 13.8 kV buses to the alternate offsite supply, upon a loss of normal offsite power supply in order to meet the regulatory requirements of GDC 17 for onsite and offsite power systems to provide sufficient capacity and capability to permit functioning of SSCs that are important to safety and GDC 18 for the testing of electric power systems that are important to safety.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-58 (ADAMS Accession No. ML16230A116), the DC applicant stated that a general revision of APR1400 DCD, Subsections 14.2.12.1.108 (4.16 kV Class 1E), 14.2.12.1.111 (13.8 kV non-Class 1E), and 14.2.12.1.112 (4.16 kV non-Class 1E) to incorporate changes that will comprise the test methods and acceptance criteria for the automatic bus transfer tests was included in the February 24, 2016 submittal of the revised APR1400 DCD, Section 14.2 (ADAMS Accession No. ML16056A002). The DC applicant clarified that detailed procedures for the bus transfer tests for the 4.16 kV and 13.8 kV auxiliary power systems will be developed and provided by the COL applicant.

The NRC staff reviewed the DC applicant's response and determined that the response is acceptable because the proposed changes adequately incorporate testing for automatic bus transfers in accordance with the regulatory requirements for electrical systems in Appendix A to 10 CFR Part 50, GDC 17 and GDC 18, and the test guidance in RG 1.68, Appendix A, Subsection A.1.g, "Electrical System," for APR1400 DCD, Subsections 14.2.12.1.108, 14.2.12.1.111 and 14.2.12.1.112. The NRC staff confirmed that the COL applicant's responsibility to prepare the site-specific test procedures to be used for the conduct of the startup testing is captured in COL item 14.2(2) in APR1400 DCD, Subsection 14.2.13. Therefore, RAI 282-8238, Question 14.02-58 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.114 Non-Class 1E DC Power Systems Test

The APR1400 DCD, Subsection 14.2.12.1.114, discusses the non-Class 1E DC Power Systems Test. Test Methods 3.1, 3.2 and 3.3 for the batteries and battery chargers of the 125 Vdc, 250 Vdc, and alternate AC 125 Vdc power systems, respectively, each state that the battery discharge and charging tests will be performed. In RAI 282-8238, Question 14.02-55 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant to discuss the tests for the battery chargers to verify that the battery charger DC output meets design criteria and regulatory requirements in Appendix A to 10 CFR Part 50, GDC 17 for onsite and offsite power.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-55 (ADAMS Accession No. ML16230A116), the DC applicant proposed a revision of APR1400 DCD, Subsection 14.2.12.1.114, which included adding test objectives to verify the proper performance of the battery chargers in the float equalization mode, verify proper operation of the battery chargers with its output voltage regulation and ripple design value, and verify that the standby battery chargers can supply the proper voltage to the non-Class 1E DC control center. Additionally, the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.114 to include an additional test method to verify the battery charger capacity and that the battery charger output meets design requirements. Lastly, the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.114 to include acceptance criteria for the aforementioned added test objectives.

The NRC staff reviewed the DC applicant's response and the proposed revisions to APR1400 DCD, Subsection 14.2.12.1.114 and determined that the more descriptive test methods and acceptance criteria adequately verify that the battery charger DC output meets design criteria, and therefore meets the regulatory requirements for electrical systems in Appendix A to 10 CFR Part 50, GDC 17 and the test guidance for electrical systems in RG 1.68 Appendix A, Section A.1.g. Therefore, RAI 282-8238, Question 14.02-55 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.115 Class 1E DC Power System Test

In RAI 282-8238, Question 14.02-56 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant to provide the following clarifications regarding the APR1400 DCD, Subsection 14.2.12.1.115, "Class 1E DC Power Systems Test": (1) clarify whether this test demonstrates that the Class 1E DC power systems are capable of performing as designed in the required operating modes; (2) discuss the test for the battery chargers to verify that the battery charger DC output meets design criteria; (3) discuss how the electrical independence and redundancy of power supplies for safety-related functions are checked for the Class 1E DC power system; and (4) discuss how this test determines that the voltage that would be available at the Class 1E inverters would exceed the design minimum if the batteries were discharged to the minimum voltage limit.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-56 (ADAMS Accession No. ML16230A116), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.115 to reflect that the capacity and capability of Class 1E DC system in the required operating modes is demonstrated by the test. The discharge test stated in Test Method 3.1.1 is for the batteries and the charging test stated in Test Method 3.1.2 is for the battery chargers. Related items to verify that the battery charger DC output meets design criteria are included in the following Parts of the test: Objectives 1.3, 1.8, and 1.9; Test Methods 3.1.2 and 3.5; Data Required 4.2; and Acceptance Criteria 5.2, 5.4, 5.5, and 5.6. The electrical independence and redundancy of power supplies for safety related functions are tested and verified as stated in Test Objective 1.10, Test Method 3.7, and Acceptance Criteria 5.18. The minimum voltages of the battery bank and individual cells are checked and verified in accordance with Test Method 3.2 and Data Required 4.1. The minimum available voltage at the Class 1E inverters is tested and verified as stated in Test Objectives 1.5 and 1.6; Test Methods 3.3 and 3.4; Data Required 4.3; and Acceptance Criteria 5.16.

The NRC staff reviewed the DC applicant's response and determined that the update to the APR1400 DCD, Subsection 14.2.12.1.115 objectives, test methods and acceptance criteria meets the regulatory requirements for electrical systems in Appendix A to 10 CFR Part 50, GDC 17 and testing guidance in RG 1.68, Appendix A, Section A-1.g. Specifically, the revised test description addresses the NRC staff's concerns by adequately describing (1) how the test demonstrates proper functioning of the Class 1E DC system, (2) how the test verifies that the battery charger DC output meets design criteria, (3) verification of electrical independence and redundancy of power supplies for safety related functions, and (4) verification that the voltage that would be available at the Class 1E inverters would exceed the design minimum if the batteries were discharged to the minimum voltage limit. Therefore, RAI 282-8238, Question 14.02-56 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.116 Offsite Power System Test

The APR1400 DCD, Subsection 14.2.1.12.1.116, "Offsite Power System," discusses the offsite power system test. In RAI 282-8238, Question 14.02-60 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant to confirm that this test includes demonstrating the operation of protective relaying, alarms, and control devices of the main, unit auxiliary and standby auxiliary transformers.

In the August 16, 2016 response to RAI 282-8238, Question 14.02-60 (ADAMS Accession No. ML16200A116), the DC applicant proposed a general revision of APR1400 DCD, Subsection 14.2.12.1.116 to clarify the test methods and acceptance criteria and to keep consistency with APR1400 DCD, Chapter 8 as well as the other subsections of Chapter 14. The proposed revision to the offsite power system test includes demonstrating the operation of protective relaying and alarms of the main, unit auxiliary, and standby auxiliary transformers (Main Transformers, Unit Auxiliary Transformers, and Standby Auxiliary Transformers); collectively called power transformers. Additionally, the proposed revision to APR1400 DCD, Subsection 14.2.12.1.116 added a new Test Method 3.5 to clearly indicate that the test will demonstrate the operation of protective relaying, alarms, and associated control devices of the power transformers.

The NRC staff reviewed and determined that the DC applicant's response and proposed update to APR1400, DCD Section 14.2.12.1.116 test methods and acceptance criteria are acceptable because they clearly include testing of the SSCs identified in the NRC staff's RAI. Therefore, the NRC staff concludes that the revised test description meets the regulations for electrical systems in Appendix A to 10 CFR Part 50, GDC 17 and electrical system testing requirements in GDC 18, and the testing guidance for electrical systems in RG 1.68 Appendix A, Section A-1.g. Based on the above, RAI 8238, Question 14.02-60 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1

14.2.12.1.117 Balance-of-Plant Piping Thermal Expansion Measurement Test

In RAI 151-8078, Question 03.09.02-7 (ADAMS Accession No. ML15234A407), the NRC staff requested the DC applicant to provide a description of the thermal motion monitoring program for verification of snubber movement, adequate clearances and gaps, the acceptance criteria, and the method regarding how motion will be measured.

In the March 24, 2016 response to RAI 151-8078, Question 03.09.02-7 (ADAMS Accession No. ML16084A989), the DC applicant proposed to revise APR1400 DCD, Subsection 3.9.2.1.3 to state that the thermal motion monitoring program will include verification of snubber movement, adequate clearances and gaps, the acceptance criteria, and how the motion is to be measured. The thermal motion monitoring program would be included as part of the test procedure completed by the COL applicant. The DC applicant also proposed to revise the APR1400 DCD, Section 14.2.12.1.117 acceptance criteria to add the correct reference to APR1400 DCD, Subsection 3.9.2 for ITP testing commitments related to the ASME OM Code. In addition, the DC applicant proposed to add a COL item to APR1400 DCD, Subsection 14.2.13 and Table 1.8.2 to address the thermal motion monitoring program as described in APR1400 DCD, Subsection 3.9.2.1.3.

The NRC staff determined that the DC applicant's response meets RG 1.68, Appendix A, Section A-1, "Preoperational Testing," and is acceptable because COL item 14.2(6) in

APR1400 DCD, Subsection 14.2.13 describes the COL applicant's responsibility to develop the test procedure, including a description of the thermal motion monitoring program for verification of snubber movement, adequate clearances and gaps, the acceptance criteria, and the method regarding how motion will be measured. Additionally, the proposed change provides that the DCD will identify the necessary topics the COL applicant's procedure must address. The NRC staff also agrees with the DC applicant's correction to reference APR1400 DCD, Subsection 3.9.2. Therefore, RAI 151-8078, Question 13.09.02-7 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.118 Balance-of-Plant Piping Vibration Measurement Test

In RAI 151-8078, Question 03.09.02-6 (ADAMS Accession No. ML15234A007), the NRC staff requested the DC applicant to provide appropriate ITP test descriptions for each of the transient vibration conditions in accordance with provisions of RG 1.68 and ASME Operation and Maintenance(OM)-3 such that the APR1400 would meet 10 CFR Part 50, Appendix A, GDCs 14 and 15. As pertinent here, GDCs 14 and 15 require that the reactor coolant pressure boundary does not fail and can withstand normal operation, including anticipated operational occurrences.

In the March 24, 2016 response to RAI 151-8078, Question 03.09.02-6 (ADAMS Accession No. ML16084A989), the DC applicant provided the following information:

> *ITP 14.2.12.1.118, "Balance-of-Plant Piping Vibration Measurement Test" includes testing of the systems to withstand flow induced dynamic loadings under the steady state and operational transient conditions and references DCD Section 3.9. The associated test procedures will include the detailed test specifications in accordance with the general requirements of RG 1.68 and the specific vibration testing requirements of ASME OM Part 3. To ensure that the requirements of RG 1.68 and ASME OM are included, DCD Tier 2, Subsection 3.9.2.1 will be updated to specify that these specific provisions are addressed as part of the test program.*

The NRC staff determined that the DC applicant's response is acceptable because it describes testing for each of the transient vibration conditions and references the acceptable testing methodologies in RG 1.68 and the ASME OM Code. Given this, the proposed DCD change meets 10 CFR Part 50, Appendix A, GDC 14, GDC 15, and RG 1.68, Appendix A, Section A-1. Therefore, RAI 151-8078, Question 03.09.02-6 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.128 Auxiliary Steam System Test

In RAI 281-8232, Question 14.02-48 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant to:

1. Update APR1400 DCD, Subsection 14.212.1.128, Auxiliary Steam System Test, to include a test to ensure that the radiation monitor performs its function of automatically redirecting the condensate to the LWMS.

2. Specify which radiation monitor performs this function and update APR1400 DCD, Chapters 11 and 12 to ensure it is clear which monitor performs this function.

In the August 17, 2016 response to RAI 281-8232, Question 14.02-48 (ADAMS Accession No. ML16230A490), the DC applicant proposed to revise APR1400 DCD, Subsection 14.2.12.1.128 to include testing of radiation monitor PR-RE/RT-103, associated with the Auxiliary Steam System, to verify automatic redirection of the condensate to the LWMS. The DC applicant also proposed to include acceptance criteria 5.3 in APR1400 DCD, Subsection 14.2.12.1.128. This acceptance criteria ensures that the monitor functions as described in APR1400 DCD, Subsection 10.4.10. APR1400 DCD, Subsection 10.4.10, indicates that the monitor actuates an alarm in the MCR and automatically diverts potential radioactive material in the condensate to the LWMS. In addition, the DC applicant addressed which radiation monitors perform the function to automatically redirect the condensate to the liquid radwaste management system. The NRC staff determined the proposed changes ensure that the radiation monitor automatically redirects the auxiliary steam system condensate to the LWMS, and therefore meets the guidance in RG 1.68, Section A-1.k for testing the function of the radiation monitor. Therefore, RAI 281-8232, Question 14.02-48 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.1.134 Leakage Detection System Test

The APR1400 DCD, Subsection 14.2.12.1.134, "Leakage Detection System Test," demonstrates the operation of the various leakage detection systems. It will test the sump level switches and flow monitors, airborne radioactivity monitor, and/or atmosphere humidity monitors using simulated signals. Subsection 5.0/5.1, "Acceptance Criteria," of this test states that "the leakage detection system operates as described in APR1400 DCD, Subsection 5.2.6.1."

However, the NRC staff could not find the referenced APR1400 DCD, Subsection 5.2.6.1. It was not clear that this preoperational test includes the verification of the capability of RCS leakage detection instrumentations.

As part of RAI 80-8040, Question 05.02.05-2 (ADAMS Accession No. ML15295A317), the NRC staff requested the DC applicant revise information (supposedly in APR1400 DCD, Subsection 5.2.6.1) but incorrectly referenced in APR1400 DCD, Subsection 14.2.2.12.1.134 and demonstrate that the proposed ITP has adequately addressed the tests identified in RG 1.68, Appendix A.

In the February 24, 2016, update to APR1400 DCD, Subsection 14.2.12.1.134, "Leakage Detection System Test," (ADAMS Accession No. ML16056A002) the DC applicant changed acceptance criteria 5.1 to:

5.1 The leakage detection system operates as designed and described in Subsection 5.2.5.2.2

This is a cross reference to APR1400 DCD, Subsection 5.2.5.2.2, "Primary Indicators of Reactor Coolant Unidentified Leakage." The NRC staff determined that this change to APR1400 DCD, Subsection 14.2.12.1.134 acceptance criteria satisfies requirements to test that leakage detection sensitivity and capability meets TS leakage guidance in RG 1.245 in accordance with

guidance in RG 1.68, Appendix A, Section A.1.k Item 5. Therefore, RAI 80-8040, Question 05.02.05-2 is resolved.

14.2.12.1.141 Local of equipment; 14.2.12.1.142 Access to vital equipment; 14.2.12.1.143 Equipment to permit observation of abnormal presence or activity of persons or vehicles; 14.2.12.1.144 Vehicles barrier system to protect against the design basis threat vehicle bombs; 14.2.12.1.145 Vital areas with active intrusion detection systems; 14.2.12.1.146 Security alarm annunciation and video assessment information; 14.2.12.1.147 Location and equipment of the central and secondary alarm stations; 14.2.12.1.148 Secondary security power supply system; 14.2.12.1.149 Intrusion detection and assessment systems; 14.2.12.1.150 Equipment and emergency exits; 14.2.12.1.151 Security communication systems; 14.2.12.1.152 Bullet-resisting barriers; 14.2.12.1.153 Security alarm devices and transmission lines

The DC applicant developed 13 physical security preoperational test abstracts in APR1400 DCD, Subsections 14.2.12.1.141 through 14.2.12.1.153 that are included under the ITP and are associated with ITAAC. Having preoperational tests in the ITP overlap with the ITAAC is acceptable per the guidance in RG 1.68, Revision 4. For the evaluation of the physical security ITAAC and the associated preoperational test abstracts, see FSER Section 14.3.12.

14.2.4.12.2 Post-Core Hot Functional Tests

The following is a list of “Phase II: Fuel Loading and Post-Core Hot Functional Testing” abstracts described in APR1400 DCD, Subsections 14.2.12.2.1 through 14.2.12.2.10:

14.2.12.2.1 *Post-core hot functional test controlling document*
14.2.12.2.2 *NSSS integrity monitoring system (post-core)*
14.2.12.2.3 *Reactor coolant system flow measurements*
14.2.12.2.4 *Post-core control element drive mechanism performance*
14.2.12.2.5 *Post-core reactor coolant and secondary water chemistry data*
14.2.12.2.6 *Post-core pressurizer spray valve and control adjustments*
14.2.12.2.7 *Post-core reactor coolant system leak rate measurement*
14.2.12.2.8 *Post-core in-core instrumentation test*
14.2.12.2.9 *Post-core instrument correlation*
14.2.12.2.10 *Post-core acoustic leak monitor system test*

The NRC staff reviewed and evaluated the 10 post core hot functional test objectives, test prerequisites, test methods, test data requirements and test acceptance criteria included in APR1400 DCD, Subsection 14.2.12.2. In comparing the APR1400 hot functional tests to the testing recommended in RG 1.68, Appendix A, Section 2, “Initial Fuel Loading and Precritical Tests,” the NRC staff determined that a number of post core hot functions tests reviewed in APR1400 DCD, Subsection 14.2.12.2 did not contain acceptable test objectives, test prerequisites, test methods, test data requirements and test acceptance criteria to demonstrate that these hot functional tests can verify that the tested SSCs can perform their intended safety-related, defense-in-depth and normal operation functions; therefore, parts of APR1400 DCD, Subsection 14.2.12.2 were not acceptable. The NRC staff identified areas where additional information was required to complete its review. Descriptions of the specific issues are as follows:

14.2.12.2.9 Post-Core Instrument Correlation

The APR1400 DCD, Subsection 14.2.12.2.9, provides the post-core instrument correlation test. In RAI 198-8208, Question 14.02-34 (ADAMS Accession No. ML15245A546), the NRC staff requested the DC applicant to demonstrate how the test objective of the Post-Core Instrument Correlation (PCIC) Test stated in APR1400 DCD, Subsection 14.2.12.2.9 can be accomplished with the test methods described in this subsection. The test objective is "[t]o demonstrate proper operation of the plant protection system (PPS), core protection calculators (CPCs), information processing system (IPS), and qualified indication and alarm system (QIAS)." However, the test methods only required the PPS, CPCs, IPS and QIAS readouts and the main control room instrument readings to be obtained. It did not appear that these test methods would demonstrate the proper operation of the PPS, CPCs, IPS, and QIAS. In addition, the acceptance criteria for this test stated, "The IPS, QIAS, PPS, and CPCs perform as described in Sections 7.2 and 7.7 of the APR1400 DCD." APR1400 DCD, Sections 7.2 and 7.7 contained a significant amount of design descriptions for these systems. It was unclear what specific design criteria needed to be met for these systems with this test. As part of RAI 198-8208, Question 14.02-34, the NRC staff requested the DC applicant identify the specific acceptance criteria that need to be met with this test.

In the November 1, 2016 response to RAI 198-8208, Question 14.02-34 (ADAMS Accession No. ML16306A436), the DC applicant stated:

> *The purpose of the Post-Core instrument Correlation is to verify that the as-installed instrumentation is functional for specific I&C systems. Therefore, the objectives in Subsection 14.2.12.2.9 will be modified to align with the purpose of this test.*

The NRC staff determined that the DC applicant's proposed revision to APR1400 DCD, Subsection 14.2.12.2.9 related to PCIC test objectives adequately describes the functional tests to be performed to demonstrate that the PCIC will perform satisfactorily in service, in accordance with the guidance in RG 1.68, Appendix A, Section A-1.j, and, thus, it is acceptable. Therefore, RAI 198-8208, Question 14.02-34 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.2.11 Post-Core Ex-Core Neutron Flux Monitoring System Test

The APR1400 DCD, Subsection 14.2.12.2.11, "Post-Core Ex-Core Neutron Monitoring System Test," described the post-core ENFMS test. The acceptance criteria for this test stated that the "[ENFMS] performs as described in Subsection 7.7.1.1.h." APR1400 DCD, Subsection 7.7.1.1.h only described the operation of the non-safety channels of the ENFMS. As such, it was not clear to the NRC staff whether this test is only applicable to the non-safety channels or whether it is also supposed to test the safety channels. In RAI 198-8208, Question 14.02-35 (ADAMS Accession No. ML15254A546), the NRC staff requested that the DC applicant clarify the scope of this test (i.e. whether it is for both safety and non-safety channels of the ENFMS, or just the non-safety channels). In addition, if this test was only applicable to the non-safety channel of the ENFMS, the NRC staff requested that the DC applicant identify where the safety channels of the ENFMS are tested in the post core ITP.

In the June 20, 2016, response to RAI 198-8208, Question 14.02-35 (ADAMS Accession No. ML16173A245), the DC applicant stated that:

> *According to the RG 1.68, the proper functional performance tests of the ENFMS and the proper performance tests of the audio and visual indications for both safety and non-safety channels of ENFMS are conducted in the pre-operational testing described in 14.2.12.1.25.*
>
> *During the initial fuel loading, neutron count rate is continuously monitored by displaying, recording, and audible information by two temporary source-range channels or at least one temporary channel and one permanent channel (startup channel of the ENFMS) as described in 14.2.10.1 so that all changes in the multiplication factor are observed. Before this step, the startup channels of the ENFMS are calibrated. For consistency, Section 14.2.10.1 will be revised to add this calibration.*
>
> *The proper functional performance tests of the ENFMS and the proper performance tests of the audio and visual indications for both safety and non-safety channels of ENFMS are not required during post-core HFT in RG 1.68. Therefore, Section 14.2.12.2.11 in the APR1400 FSAR Tier 2 will be deleted.*
>
> *As the Section 14.2.12.2.11 is deleted, the Table 14.2-7 in the APR1400 FSAR Tier 2 will be revised. For 2.g of RG 1.68, App. A, Subsection # and Individual Test will be revised to "14.2.10.1 Initial Fuel Loading". For 4.c of RG 1.68, App. A, Subsection # and Individual Test will be revised to "14.2.10.2.1 Safe Criticality Criteria" because a minimum of 1 decade of overlap is observed between the startup and log safety channels of the ex-core nuclear instruments as described in g of the Section 14.2.10.2.1. For 4.d of RG 1.68, App. A, Subsection # and Individual Test will be revised to "14.2.12.1.24 Plant Protection System Test" because the operation of associated protective functions and alarms for plant protection is tested as described in the Section 14.2.12.1.24.*

The NRC staff determined that this response is not acceptable since deleting APR1400 DCD, Subsection 14.2.12.2.11 would not verify initial fuel loading/initial criticality testing of ENFMS neutron monitors when first loading fuel. The ENFMS preoperational test only covers simulated neutron signals and not actual neutron signals because there is no fuel in the reactor. Therefore, the NRC requested that the DC applicant update or move this test to the applicable portions of the APR1400 DCD, Subsection 14.2.12 where ENFMS neutron monitor testing should be performed, or justify why the test is not needed. Additionally, the NRC staff requested that the DC applicant should consider testing both in-core and ex-core neutron detectors, the CPC and any other digital I&C systems needed to support initial fuel load/initial criticality testing.

In the July 20, 2017 revised response to RAI 198-8208, Question 14.02-35 (ADAMS Accession No. ML17201Q511), the DC applicant stated that, "The startup channels are used during initial fuel loading. The startup channels and safety log power channels are used during initial criticality. Both the safety linear power and control channels are used during power operation. Power distribution is needed from 20 percent power. The safety linear power channels are used to generate core power distribution. The non-safety in-core detectors are also used to generate the core power distribution." The DC applicant provided a table of how operability verification of

the ex-core and in-core detector systems with actual neutron sources or by plant startup conditions after the systems' pre-operational tests will be conducted as, described in Subsection 14.2.12.1.25 and Subsection 14.2.12.1.26 of the APR1400 DCD. The DC applicant also referenced the response to RAI 524-8697, Question 14.02-69 in which a new test to incorporate the ex-core tests of safety linear power channel and control channel was proposed. The NRC staff found the that the new test proposed in the response to RAI 524-8697, Question 14.02-69 provides for adequate testing of the ex-core neutron monitoring system within the power ascension tests, and conforms to RG 1.68. As such, the NRC staff determined that deleting APR1400 DCD, Subsection 14.2.12.2.11 is acceptable. Based on the above, **RAI 198-8208, Question 14.02-35, which was being tracked as an open item, is resolved. The proposed changes are being tracked as Confirmatory Item 14.2.12.2-2.**

14.2.4.12.3 DCD Subsection 14.2.12.3, Low Power Physics Tests

The following is a list of "Phase III: Initial Criticality and Low-Power Physics Testing" abstracts described in APR1400 DCD, Subsections 14.2.12.3.1 through 14.2.12.3.6:

14.2.12.3.1 *Low-power biological shield survey test*
14.2.12.3.2 *Isothermal temperature coefficient test*
14.2.12.3.3 *Shutdown and regulating control element assembly group worth test*
14.2.12.3.4 *Differential boron worth test*
14.2.12.3.5 *Critical boron concentration test*
14.2.12.3.6 *Control element assembly symmetry*

In comparing the APR1400 initial criticality and low power physics tests to the testing recommended in RG 1.68, Appendix A, Section 3 and Section 4, the NRC staff identified areas where additional information was required to complete its review. A description of the specific issue is as follows:

14.2.12.3.1 Low-Power Biological Shield Survey Test

In APR1400 DCD, Subsections 14.2.12.3.1, "Low-power biological shield survey test," and 14.2.12.4.9, "Biological shield survey test," the acceptance criteria indicated that the biological shield performs as described in APR1400 DCD, Subsection 12.3.2.2; however, APR1400 DCD, Subsection 12.3.2.2 provided no information on how the biological shield is expected to perform. Therefore, in RAI 281-8232, Question 14.02-51 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant clarify what is meant by this statement, update APR1400 DCD, Subsection 12.3.2.2 to provide information on the shielding criteria for the biological shield, or update APR1400 DCD, Subsections 14.2.12.3.1 and 14.2.12.4.9 to reference an accurate section.

In the August 9, 2016, response to RAI 281-8232, Question 14.02-51 (ADAMS Accession No. ML16222A939), the DC applicant stated, in part, that:

> *As a result of related comments that resulted from review of KHNP's response to RAI 281-8232 Question 14.02-52, changes to DCD Tier 2 Subsection 14.2.12.3.1, "Low-Power Biological Shield Survey Test" and Subsection 14.2.12.4.9 "Biological Shield Survey Test" are being proposed. Subsection 14.2.12.3.1 is being revised to "Baseline Biological Shield (Primary Shield) Radiation Measurements Test" to describe the radiation survey to be performed*

around the primary shield structure areas prior to initial power operation to establish radiation baseline levels for comparison of buildup resulting from normal power operation (Please refer to Attachment 1 of this response). Subsection 14.2.12.4.9 is being revised to "Biological Shield (Primary Shield) Radiation Measurements Test" and addresses radiation measurements at 5% or less, 50%, and 100% power levels to ensure that the radiation dose is acceptable and as designed (Please refer to Attachment 2 of this response). The Biological Shield (Primary Shield) Radiation Measurements Test includes, which may include [sic] areas adjacent to the reactor, steam generators, reactor coolant pumps, and the pressurizer (RCS components), high and very high radiation areas inside the Auxiliary Building and the Compound Building. These designated areas are identified in DCD Subsections 14.2.12.3.1 and 14.2.12.4.9 for clarity. The reference to DCD Tier 2 Subsection 12.3.2.2 has been removed, since the acceptance criteria for "Baseline Radiation Measurements Test" and the "Radiation Measurements Test" are provided in Sub-item 5 "Acceptance Criteria" of Subsections 14.2.12.3.1 and 14.2.12.4.9, respectively in DCD Tier 2 Chapter 14.

The term 'primary shield' refers to the heavily reinforced concrete structure that houses the reactor vessel, provides the primary radiation shielding, and provides protection for the reactor vessel from internal missiles (DCD Tier 2 Subsection 3.8.3.1.5). The term, 'secondary shield' refers to the reinforced concrete structure surrounding the steam generators, the reactor coolant pumps, and the pressurizer (DCD Tier 2 Subsection 3.8.3.1.6). The term, 'biological shield' is a general term used for the provision of shielding against radiation around the primary and the secondary shielding structures. Since the baseline and the regular radiation measurement tests not only include areas of the RCS components, but also include high and very high radiation areas adjacent to these components, DCD Subsections 14.2.12.3.1 and 14.2.12.4.9 are revised accordingly.

The NRC staff reviewed the proposed acceptance criteria for the "Baseline Radiation Measurements Test," and the "Radiation Measurements Test," provided in APR1400 DCD, Subsections 14.2.12.3.1 and 14.2.12.4.9 and determined that the acceptance criteria adequately addressed the performance of the biological shield and is consistent with the guidance in RG 1.68, Appendix A, Section A-1.k to demonstrate the proper operation of the components used to monitor or measure radiation levels, provide for personnel protection, or control or limit the release of radioactivity. Based on the above, RAI 281-8232, Question 14.02- 51 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.4.12.4 DCD Subsection 14.2.12.4, Power Ascension Tests

The following is a list of "Phase IV: Power Ascension Testing" abstracts described in APR1400 DCD, Subsections 14.2.12.4.1 through 14.2.12.4-26:

14.2.12.4.1 *Variable Tavg (isothermal temperature coefficient and power coefficient) test*
14.2.12.4.2 *Unit load transient test*
14.2.12.4.3 *Control systems checkout test*
14.2.12.4.4 *Reactor coolant and secondary chemistry and radiochemistry test*

14.2.12.4.5 *Turbine trip test*
14.2.12.4.6 *Unit load rejection test*
14.2.12.4.7 *Shutdown from outside the main control room test*
14.2.12.4.8 *Loss of offsite power test*
14.2.12.4.9 *Biological shield survey test*
14.2.12.4.10 *Steady-state core performance test*
14.2.12.4.11 *Intercomparison of plant protection system, core protection calculator, information processing system, and qualified information and alarm system inputs*
14.2.12.4.12 *Verification of core protection calculator power distribution related constants test*
14.2.12.4.13 *Feedwater and auxiliary feedwater system test*
14.2.12.4.14 *Core protection calculator verification*
14.2.12.4.15 *Main steam atmospheric dump and turbine bypass valve capacity test*
14.2.12.4.16 *In-core detector test*
14.2.12.4.17 *Core operating limit supervisory system verification*
14.2.12.4.18 *NSSS integrity monitoring system*
14.2.12.4.19 *Loss of one main feedwater pump*
14.2.12.4.20 *Penetration temperature survey test*
14.2.12.4.21 *HVAC capability test*
14.2.12.4.22 *Liquid waste management system test*
14.2.12.4.23 *Gaseous waste management system test*
14.2.12.4.24 *Pseudo-ejected CEA test*
14.2.12.4.25 *Pseudo-dropped CEA test*
14.2.12.4.26 *Fatigue monitoring system test*

In comparing the APR1400 power ascension tests to the testing recommended in RG 1.68, Appendix A, Section 5, "Power-Ascension Tests," the NRC staff identified a number of power ascension tests in APR1400 DCD, Subsection 14.2.12.4 that did not contain acceptable test prerequisites, test methods, test data requirements and test acceptance criteria to adequately demonstrate that APR1400 power ascension tests can perform their intended safety-related, defense-in-depth and normal operation functions; therefore, parts of APR1400 DCD, Subsection 14.2.12.4 were not acceptable. The NRC staff identified several areas where additional information was required to complete its review. Descriptions of the specific issues are as follows:

14.2.12.4.7 Shutdown from Outside the Main Control Room Te*st*

In RAI 198-8208, Question 14.02-36 (ADAMS Accession No. ML15254A546), the NRC staff requested the DC applicant demonstrate how the test objective for safely cooling down the plant from hot standby to cold shutdown conditions from outside the MCR is met with the test methods described in APR1400 DCD, Subsection 14.2.12.4.7,"Shutdown from Outside the Main Control Room."

In the June 22, 2016, response to RAI 198-8208, Question 14.02-36, (ADAMS Accession No. ML16174A465), the DC applicant stated, in part that:

> *As described in the attached markup and DCD Tier 2 section 14.2.12.1.48, the capability to cool down the plant to the cold shutdown condition from the remote shutdown room is demonstrated during pre-core hot functional testing.*

Therefore, during power ascension tests, the objective of the shutdown from outside the main control room test is to demonstrate the plant can be placed in the hot shutdown condition and maintained for at least 30 minutes from outside the control room. According to NRC Regulatory Guide 1.68.2 Revision 2, licenses do not need to demonstrate cold shutdown capability immediately following the test to achieve and maintain a safe hot shutdown from outside the control room. KHNP submitted a revised DCD Tier 2 section 14.2.12.4.7 as a result of the upgrade effort described in the original response (ref. KHNP submittal MKD/NW-16-0156L dated February 24, 2016; ML16056A003). As a result of subsequent review, the ITP for Shutdown for Outside the Main Control Room Test will be further enhanced as indicated on the attached markup to make additional clarifications to the test objectives, test method and acceptance criteria to meet NRC Regulatory Guide 1.68.2 Revision 2.

The NRC staff determined that the proposed update to APR1400 DCD Subsection 14.2.12.4.7 to clarify test objectives, test methods and acceptance criteria to place the plant in a safe hot shutdown condition for at least 30 minutes from the RSR ensures the design capability for prompt hot shutdown of the reactor in accordance with the requirements of GDC 19 for equipment outside the control room to safely shut down the reactor and bring it to hot shutdown condition and the guidance in RG 1.68.2 to demonstrate this capability and is thus acceptable. Therefore, RAI 198-8208, Question 14.02-36 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

14.2.12.4.8 Loss of Offsite Power Test

The APR1400 DCD, Subsection 14.2.12.4.8 discusses the Loss-of-Offsite-Power Test. In RAI 282-8238, Question 14.02-61 (ADAMS Accession No. ML15306A232), the NRC staff requested the DC applicant to discuss how this test demonstrates that upon a loss of offsite power, there is an automatic transfer from offsite power to the onsite emergency diesel generators.

In the August 16, 2016, response to RAI 282-8238, Question 14.02-61 (ADAMS Accession No. ML16230A116), the applicant stated:

The initial test program to demonstrate an automatic transfer from offsite power to the onsite emergency diesel generators (EDGs) upon a loss of offsite power (LOOP) is addressed by the preoperational test described in DCD Tier 2 Subsection 14.2.12.1.87. The preoperational test stated in Part 3.3 of Subsection 14.2.12.1.87, which was provided in the revised response to the RAI 191-8210, Question 14.2-13 (reference KHNP submittal: MKD/NW-16-0684L dated June 28, 2016; ML16180A271), evaluates the ability of EDG start and closing of associated circuit breakers on an undervoltage condition of the 4.16 kV Class 1E bus, which is meant to simulate a LOOP.

The NRC staff reviewed the changes proposed in the DC applicant's June 28, 2016, response to RAI 191-8210, Question 14.02-13 (ADAMS Accession No. ML16180A269). The NRC staff determined that the proposed change is acceptable because it satisfies the testing requirements to demonstrate proper operation of transfer schemes for the EDG electrical system in accordance with the regulations in 10 CFR Part 50, Appendix A, GDC 17 and GDC 18, and the

testing guidance for electrical systems in RG 1.68, Appendix A, Section A-1.g. The NRC staff also agrees that it is appropriate to perform this testing in the preoperational phase rather than the power ascension phase. Therefore, RAI 282-8238, Question 14.02-61 is resolved.

14.2.12.4.9 Biological Shield Survey Test

In RAI 281-8232, Question 14.02-53 (ADAMS Accession No. ML15306A018), the NRC staff requested the DC applicant to update the objective for the biological shield survey test in the APR1400 DCD, as appropriate, to specify that the test will assist in determining allowable occupancy times for areas outside the biological shield.

In the April 19, 2016, response to RAI 281-8232, Question 14.02-53 (ADAMS Accession No. ML16110A460), the DC applicant updated APR1400 DCD, Subsection 14.2.12.4.9, Test Objective 1.2, to state:

> *To assist in determination of allowable occupancy times for these areas outside the biological shield during power operation.*

The NRC staff determined that the proposed change to APR1400 DCD, Subsection 14.2.12.4.9 is acceptable because it satisfies the requirements for conducting neutron and gamma radiation surveys to establish the adequacy of the airborne activity monitoring system in accordance with the testing guidance in RG 1.68, Appendix A, Section A.5, "Power Ascension Tests," Test Item bb, for radiation shields which also references RG 1.69, "Concrete Radiation Shields and Generic Shield Testing for Nuclear Power Plants." Therefore, RAI 281-8232, Question 14.02-53 is resolved. The NRC staff verified that the proposed changes have been incorporated into the APR1400 DCD, Revision 1.

Conclusions

Pending the incorporation of the information in the confirmatory items discussed above into the DCD, the NRC staff concludes that the DC applicant adequately describes the system testing requirements for the individual preoperational, post-core hot functional, low-power physics, and power accession tests, and is thus acceptable. All issues relating to this section of the ITP have been resolved.

14.2.5 DCD Subsection 14.2.13, Combined License Information Items

Introduction

In APR1400 DCD, Subsection 14.2.13, "COL Information Items," the DC applicant lists the COL information items relative to the implementation of the ITP, for which responsibility will be deferred to the COL applicant.

Evaluation

The NRC staff reviewed the list of COL responsibilities related to the ITP in APR1400 DCD, Subsection 14.2.13, Combined Licensee Information, for consistency with RG 1.206, Section C.I.14, "Verification Programs," and RG 1.68, Section A, "Introduction." In RAI 91-7867, Question 14.02-4 (ADAMS Accession No. ML15201A768) the NRC staff identified corrections below (identified in italics) related to COL applicant responsibilities that the DC applicant should

add to APR1400 DCD, Subsection 14.2.13 for consistency with the guidance in RG 1.68 and SRP Section14.2:

COL 14.2(1) The COL applicant is to develop the site-specific organization and staffing levels appropriate for its facility *to implement the initial test program. The COL applicant's plant operating and plant technical staff should participate, to the extent practical, in developing and conducting the ITP and evaluating the test results*.

COL 14.2(2) The COL applicant is to prepare the site specific *preoperational and startup* test *specifications and test* procedures that is to be used for the conduct of the plant *Initial Test Program*. *The preoperational and startup test procedures should have controls in place to ensure that test procedures include appropriate prerequisites, objectives, safety precautions, initial test conditions, methods to direct and control test performance and test acceptance criteria by which the test is evaluated. Testing performed at other than design operating conditions for systems is to be reconciled either through the test acceptance criteria or post-test data analysis*. These procedures are to be submitted at least 60 days prior to their intended use to the NRC staff for review as described in Subsection 14.2.11.

COL 14.2(3) The COL applicant is to prepare a startup administrative manual *(SAM) which contains administrative controls that govern the conduct of each major phase of the ITP. This description should include the administrative controls used to ensure that necessary prerequisites are satisfied for each major phase and for individual tests. The COL applicant should also describe the methods to be followed in initiating plant modifications or maintenance tasks that are deemed to be necessary to conduct the ITP. This description should include methods used to ensure retesting following such modifications or maintenance. In addition, the description should discuss the involvement of design organizations with the COL applicant in reviewing and approving proposed plant modifications. The COL applicant should also describe in the SAM adherence to approved test procedures during the conduct of the ITP as well as the methods for effecting changes to approved test procedures*.

COL 14.2(4) The COL applicant is to perform a review and evaluation of individual test results *in a test report made available to NRC personnel after preoperational and startup tests are completed. The specific test acceptance criteria for determining success or failure of a test shall be included in the test report approval of the test results. The test report should also include test results associated with any license conditions in the plant specific ITP*.

COL 14.2.(6) The COL applicant is to develop a *sequence and* schedule for the development of the plant operating and emergency procedures should allow sufficient time for trial use of the procedure during the Initial Test Program. The *sequence and* schedule for plant startup is to be developed by the COL applicant to allow sufficient time to systematically perform the required testing in each phase.

COL 14.2(7) *The COL applicant is responsible for establishing hold points at selected milestones throughout the power ascension test phase to ensure that designated personnel or groups evaluate and approve relevant test results before proceeding to the next power-ascension test phase. At a minimum, the COL applicant should establish hold points at approximately 25-percent, 50-percent, and 75-percent power-level test conditions for pressurized-water reactors*.

COL 14.2(13) *The COL applicant is responsible for retaining preoperational and startup test procedures and test results as part of the plant's historical records in accordance with 10 CFR 50.36, "Technical Specification," 10 CFR 50.71, "Maintenance of Records, Making of Reports," 10 CFR 50, Appendix B, Criterion XVII, "Test Records," and RG 1.28, "Quality Assurance Program Criteria (Design and Construction.)*"

The NRC staff also requested the DC applicant to make number sequence changes to COL 14.2(*8*) through COL 14.2(*12*) but no text changes were needed.

The DC applicant was also asked to revise APR1400 DCD, Subsections 14.2.2, "Organization and Staffing," 14.2.3, "Test Procedures," and 14.2.6, "Test Records," to note these changes in COL applicant responsibilities for implementing the ITP in APR1400 DCD, Subsection 14.2.13, "COL Information Items."

In the March 10, 2017 submittal of APR1400 DCD, Section 14.2, Revision 1 (ADAMS Accession No. ML17096A392), the DC applicant substantially revised the list of COL information items to incorporate other areas of COL responsibility that were identified by the applicant and in response to RAIs from the NRC staff. The NRC staff verified that the aforementioned recommended changes were incorporated into Revision 1 of the APR1400 DCD. The NRC staff determined that by adopting the proposed text, and making the appropriate modifications to APR1400 DCD, Subsections 14.2 and 14.2.13, the response meets RG 1.206, Section C.I.14, SRP Section 14.2, and RG 1.68 and is acceptable. Therefore, RAI 91-7867, Question 14.02-04 is resolved. The COL information items for Section 14.2 of the APR1400 DCD are stated in the following table.

Item No.	Description
14.2(1)	The COL applicant is to develop the site-specific organization and staffing level appropriate for its facility to implement the initial test program. The COL's plant operating and plant technical staff should participate, to the extent practical, in developing and conducting the Initial Test Program and evaluating the test results.
14.2(2)	The COL applicant is to prepare the site-specific preoperational and startup test specifications and test procedures and/or guidelines that is to be used for the conduct of the plant Initial Test Program. The preoperational and startup test procedures should have controls in place to ensure that test procedures include appropriate prerequisites, objectives, safety precautions, initial test conditions, methods to direct and control test performance and test acceptance criteria by which the test is evaluated. Testing performed at other than design operating conditions for systems is to be reconciled either through the test acceptance criteria or post-test data analysis. These procedures are to be submitted at least 60 days prior to their intended use to the NRC staff for review as described in Subsection 14.2.11.
14.2(3)	The COL applicant is to prepare a startup administrative manual (SAM) which contains administrative controls that govern the conduct of each major phase of the ITP. This description should include the administrative controls used to ensure that necessary prerequisites are satisfied for each major phase and for individual tests. The COL applicant should also describe the methods to be followed in initiating plant modifications or maintenance tasks that are deemed to be necessary to conduct the ITP. This description should include methods used to ensure retesting following such modifications or maintenance. In addition, the description should discuss the involvement of design organizations with the COL applicant in reviewing and approving proposed plant modifications. The COL applicant should also describe in the SAM adherence to approved test procedures during the conduct of the ITP as well as the methods for effecting changes to approved test procedures.
14.2(4)	The COL applicant is to develop the test procedure including a listing of the high- and moderate-energy piping systems inside containment that are covered by the vibration, thermal expansion, and dynamic effects testing program.
14.2(5)	The COL applicant is to develop the test procedure including a listing of the different flow modes to which the systems will be subjected during the vibration, thermal expansion, and dynamic effects testing program to confirm that the piping systems, restraints, components, and supports have been adequately designed to withstand flow-induced dynamic loadings under the steady-state and operational transient conditions anticipated during service.
14.2(6)	The COL applicant is to develop the test procedure including a description of the thermal motion monitoring program for verification of snubber movement, adequate clearances and gaps, the acceptance criteria, and the method regarding how motion will be measured.

Item No.	Description
14.2(7)	The COL applicant is to perform review and evaluation of individual test results in a test report made available to NRC personnel after preoperational and startup tests are completed. The specific test acceptance criteria for determining success or failure of a test shall be included in the test report approval of the test results. The test report should also include test results associated with any license conditions in the plant specific Initial Test Program.
14.2(8)	The COL applicant is responsible for establishing hold points at selected milestones throughout the power ascension test phase to ensure that designated personnel or groups evaluate and approve relevant test results before proceeding to the next power ascension test phase. At a minimum, the COL applicant should establish hold points at approximately 25- percent, 50- percent, and 75-percent power-level test conditions for pressurized-water reactors.
14.2(9)	The COL applicant is responsible for retaining preoperational and startup test procedures and test results as part of the plant's historical records in accordance with 10 CFR 50.36, "Technical Specification," 10 CFR 50.71, "Maintenance of Records, Making of Reports," 10 CFR 50, Appendix B, Criterion XVII, "Test Records," and RG 1.28, "Quality Assurance Program Criteria (Design and Construction)." The preoperational and startup testing procedures and test results are to be retained for the life of the plant be the COL applicant.
14.2(10)	The COL applicant is to describe its program for reviewing available information on reactor operating and testing experiences and discusses how it used this information in developing the initial test program. The description is to include the sources and types of information reviewed, the conclusions or findings, and the effect of the review on the initial test program.
14.2(11)	The COL applicant is to provide a schedule for the development of plant procedures, as well as a description of how, and to what extent, the plant operating, emergency, and surveillance procedures are use-tested during the initial test program.
14.2(12)	The COL applicant that references the APR1400 design certification is to identify the specific operator training to be conducted as part of the low-power testing program related to the resolution of TMI Action Plan Item I.G.1, as described in (1) NUREG-0660 – NRC Action Plans Developed as a Result of the TMI-2 Accident, Revision 1, August 1980 and (2) NUREG-0737 – Clarification of TMI Action Plan Requirements.

Item No.	Description
14.2(13)	The COL applicant is to develop a sequence and schedule for the development of the plant operating and emergency procedures should allow sufficient time for trial use of these procedures during the Initial Test Program. The sequence and schedule for plant startup is to be developed by the COL applicant to allow sufficient time to systematically perform the required testing in each phase.
14.2(14)	The COL applicant is to perform the appropriate interface testing of the gaseous PERMSS monitors with ERDS.
14.2(15)	The COL applicant is to prepare the preoperational test of cooling tower and associated auxiliaries, and raw water and service water cooling systems.
14.2(16)	The COL applicant is to develop the test program of personnel monitors, radiation survey instruments, and laboratory equipment used to analyze or measure radiation levels and radioactivity concentrations.
14.2(17)	The COL applicant is to prepare the site-specific preoperational and startup test specification and test procedure and/or guideline for plant and offsite communication system.
14.2(18)	The COL applicant is to prepare the pre-operational test of ultimate heat sink pump house.
14.2(19)	The COL applicant is to prepare the testing and verification of ultimate heat sink cooling chains.

Conclusion

The NRC staff finds that list of COL information items adequately describes the actions necessary for the COL applicant or holder to implement the ITP in accordance with the guidance included in RG 1.206, Section C.I.14, SRP Section 14.2, and RG 1.68, and is therefore acceptable. All issues relating to this section of the ITP have been resolved.

14.2.6 Conclusions

As discussed above, the NRC staff completed its review of APR1400 DCD, Chapter 14.1 and 14.2, and concluded that, pending the incorporation of the information in the confirmatory items discussed above into the DCD, the DC applicant has fully addressed the information related to the ITP. The NRC staff used the requirements of 10 CFR 30.53(c); 10 CFR 50.34(b)-(6)(iii); 10 CFR 50.43(e); 10 CFR Part 50, Appendix A, GDC 1; Appendix B to 10 CFR Part 50, Criterion XI; Appendix J to 10 CFR Part 50; 10 CFR 52.79(a)(28); 10 CFR Part 52, Subpart A, Subpart B, and Subpart C; and the guidance in SRP Section 14.2 as the bases for evaluating the acceptability of the KHNP's ITP.