

14.0 VERIFICATION PROGRAMS

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14.0 VERIFICATION PROGRAMS

14.1 Introduction

This chapter of the safety evaluation report (SER or this report) provides the staff's review of the initial test program (ITP) and the inspections, tests, analyses, and acceptance criteria (ITAAC) of the GE-Hitachi Nuclear Energy (GEH) economic simplified boiling-water reactor (ESBWR) as part of the design certification review being conducted by the U.S. Nuclear Regulatory Commission (NRC) under Title 10 of the Code of Federal Regulations (10 CFR), Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The staff is conducting this review in accordance with NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," March 2007, (SRP), Chapter 14.

14.2 Initial Plant Test Program for Final Safety Analysis Reports

14.2.1 Regulatory Criteria

According to 10 CFR 52.47(a), the information for the design certification must include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the NRC. In accordance with the requirements in 10 CFR 50.34(b)(6)(iii) and 10 CFR 52.79(a)(28), an applicant for an operating license or combined license (COL) shall provide information concerning plans for pre-operational testing and initial operations.

Section 14.2 of Regulatory Guide (RG) 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 3, requires that applicants describe the technical aspects of the ITP in sufficient detail to show that the test program will adequately verify the functional requirements of plant structures, systems, and components (SSCs). The test program should also provide administrative controls to conduct the test program, describe the organizations involved in testing and staffing activities, describe measures to ensure compliance with test program RGs, provide for the use of operating and testing experience, and provide for the trial use of the plant operating and emergency procedures.

RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants," Revision 2, describes the general scope and depth of the ITPs that are acceptable to the staff for light-water-cooled nuclear power plants. As stated in the RG, the ITP should provide assurance through testing that the facility has been adequately designed and provide validation, to the extent practical, of the analytical models and assumptions used to predict plant responses to anticipated transients and postulated accidents.

SRP Section 14.2, issued March 2007, provides guidance and acceptance criteria to the staff for the review of a proposed design certification or COL Applicant's ITP. Since the COL Applicants referencing the ESBWR design certification are committed to SRP Section 14.2, the staff used this guidance document as part of its regulatory criteria for review and acceptance of the design certification applicant's list of COL information items. The COL Applicants are also committed to the ITP guidance in RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," C.I.IV, "Verification Programs," Section C.I.14.2, "Initial Plant Test Program," for COL information items.

In accordance with SRP Section 14.2, the applicant's ITP should address programmatic aspects including consideration of organization and staffing; administrative controls governing the ITP; preparation, review, and technical content of test procedures; conduct of the ITP; sequencing of testing steps; review, evaluation, and approval of test results; use of reactor operating and testing experiences; and verification by trial use, to the extent practical, of the adequacy of the facility's operating and emergency procedures.

The staff reviewed the applicant's ITP to determine whether it meets the relevant guidance in RG 1.68 and SRP Section 14.2, as they relate to demonstrating the performance capabilities of SSCs and design features that will be used during normal and abnormal operations.

14.2.2 Summary of Technical Information

The applicant provided the technical information associated with the ITP in design control document (DCD) Tier 2, Revision 9, Section 14.2. This information applies to the pre-operational testing phase as well as to the initial startup testing phase.

DCD Tier 2, Revision 9, Section 14.2.1, presents a general description of the ITP that includes: (1) construction test objectives, (2) pre-operational test objectives, (3) startup test objectives, and (4) organization and staffing. Pre-operational testing is normally conducted before fuel load, whereas initial startup testing begins with the initial fuel load and extends to commercial operation. DCD Tier 2, Revision 9, Section 14.2.1.4, presents the responsibilities of the organizational groups that will participate during the various testing phases of the ITP. The applicant states that as the principal designer of the ESBWR plant, it will be on site to direct the work of the constructor and to offer consultation and overall technical direction.

DCD Tier 2, Revision 9, Section 14.2.2 lists the ITP requirements for the startup administrative manual (SAM) test procedures; administrative requirements for conducting the test program; organizational methods used to review, evaluate, and approve test results; and retention periods for test records. DCD Tier 2, Revision 9, Section 14.2.3 lists the RGs used by the applicant for the development of the ITP.

In DCD Tier 2, Revision 9, Section 14.2.4, the applicant states that the ESBWR plant design has the benefit of the operating and testing experience acquired from the construction of previous boiling-water reactor (BWR) plant designs that are still in operation. In addition, the applicant states that it will use the additional operating and testing experience obtained from NRC licensee event reports, Institute of Nuclear Power Operations (INPO) correspondence, and other industry sources in the development of the ITP.

In DCD Tier 2, Revision 9, Section 14.2.5, the applicant states that it will use the plant operating and emergency procedures, to the extent practicable, during the implementation of the ITP. This approach will facilitate the familiarization of the plant's operating and technical staff with facility operating and emergency procedures and will verify, by trial use, the adequacy of such procedures.

In DCD Tier 2, Revision 9, Section 14.2.6, the applicant provides general guidance, including checks and verification requirements that will be applied during initial fuel loading and initial criticality. These activities include prefuel load, initial fuel loading, precriticality testing, and initial criticality.

In DCD Tier 2, Revision 9, Section 14.2.7, the applicant provides the proposed timetable for completing the ITP, including the schedule for completing the pre-operational test phase before fuel load and the startup and power ascension test phases. The Licensee will provide the test program schedule and the sequence for conducting each phase of the ITP, as stated in DCD Tier 2, Revision 9, Section 14.2.7. The applicant includes in its ITP the general guidance for the generation, review, and approval of procedures, as well as the actual testing and analysis of the results.

In DCD Tier 2, Revision 9, Section 14.2.8, the applicant describes the individual test descriptions for the SSCs and the design features anticipated for the ESBWR standard design. For each test, the section presents a general test purpose, prerequisites, general test method, and acceptance criteria.

14.2.3 Staff Evaluation

The staff reviewed the ESBWR ITP in accordance with the review guidance contained in RG 1.68 and SRP Section 14.2. In DCD Tier 2, Section 14.2, the applicant described the ESBWR ITP, which consists of pre-operational and initial startup tests. Pre-operational tests, which are performed after the construction and installation of plant equipment but before initial fuel loading, demonstrate the capability of the plant systems to meet relevant performance requirements. Startup tests, which begin with initial fuel loading, demonstrate the capability of the integrated plant to meet performance requirements. For each phase of the ITP, a design certification applicant needs to define organizational responsibilities, provide administrative controls for the development of the test program, and provide test abstracts, which include the objectives of each test, as well as a summary of prerequisites, test methods, and specific acceptance criteria. These test abstracts should address the criteria outlined in RG 1.68 and SRP Section 14.2. In addition, the applicant needs to describe how it considered the use of reactor operating and testing experience, the trial use of plant operating and emergency procedures, and conformance with applicable RGs. Conformance of a proposed test program to the above guidelines provides reasonable assurance that the facility can be operated in accordance with its design criteria and in a manner that will not endanger the health and safety of the public.

The staff noted that the applicant provided guidance in the areas of organization and staffing, conformance with RGs, test procedure control, utilization of reactor operating and testing experience, use of plant operating and emergency procedures, and test program scheduling and sequencing. In addition, the applicant provided individual test descriptions, test performance requirements, and acceptance criteria for each pre-operational and startup test. The following sections discuss these areas in detail.

14.2.3.1 Initial Test Program Objectives

The staff reviewed the pre-operational and initial startup testing objectives, as described in DCD Tier 2, Revision 9, Section 14.2. The staff noted that the applicant's proposed test program provided controls to: (1) ensure that construction was complete and acceptable, (2) demonstrate the capability of SSCs to meet performance requirements, (3) demonstrate, where practical, that the plant is capable of withstanding anticipated transients and postulated accidents, and (4) evaluate and demonstrate, to the extent possible, knowledge of the operating group about the plant and plant operating procedures, thus providing reasonable assurance that the plant can be brought safely to its rated power and can be safely operated during sustained power operations.

In the pre-operational testing phase description, the staff noted that the applicant provided controls to ensure that: (1) the design specifications and test acceptance criteria are met, (2) baseline test and operating data are obtained for future reference, (3) plant systems operate together on an integrated basis to the extent possible, and (4) plant operating staff obtains practical experience in the operation and maintenance of plant equipment and systems. In addition, the applicant stated that it will assist the COL Applicant with the development, implementation, and evaluation of normal, abnormal, and emergency operating procedures to the extent possible; establishment and evaluation of surveillance testing procedures; and demonstration that plant systems are operational in order to continue to fuel loading and initial startup testing.

In the initial startup testing phase description, the staff noted that the applicant provided controls to ensure: (1) a safe core loading, (2) a safe and orderly approach to initial criticality, and (3) the plant's ability to meet test acceptance criteria during low-power and power ascension testing based on sufficient testing.

In request for additional information (RAI) 14.2-81, the staff asked for information about the construction test objectives in DCD Tier 2, Section 14.2.1.1. Specifically, a staff review of DCD Section 14.2.1 indicated that the objectives of construction tests did not consider the possibility of field engineering changes to SSCs, and the section did not identify how such changes would be documented and reflected in the conduct of field tests and test acceptance criteria. Accordingly, the staff asked that the applicant update the DCD to include a description of the process that it will use to address how field engineering design changes to SSCs will be documented and reflected in the conduct of initial tests to ensure that the as-built plant will be built and operated in accordance with the design certification and in compliance with NRC regulations.

In response, the applicant stated the following:

The process of controlling and resolving problems encountered during plant testing phases is to be controlled by the quality process described in the Quality Assurance Program Document (QAPD) established by the COL Applicant and maintained by the Licensee. Problems uncovered in testing will be tied to the QAPD through a link in the SAM and will be added to the list of the items this manual will provide.

In accordance with this response, the applicant changed DCD Tier 2, Revision 3, by adding a seventh bullet to the content requirements of the SAM. Specifically, the applicant added the following bullet to DCD Tier 2, Revision 4, Section 14.2.2.1:

- Identifies the quality process to be used to control the resolution of test failures, deficiencies and oversights discovered in the ITP. This program will address the control of any plant modifications required to resolve these deficiencies.

DCD Tier 2, Revision 4, Section 14.2.2.1, also stated, in part, that “[a] SAM is developed and made available to the NRC 60 days prior to the scheduled start of the Preoperational Test Program.” The applicant also added the following COL information item related to the SAM in DCD Tier 2, Revision 4, Section 14.2.10:

14.2-1-H Per Subsection 14.2.2.1, the COL holder will make available 60 days prior to the scheduled start of the pre-operational test program, the SAM.

In accordance with SRP Section 14.2 and RG 1.206, the COL Applicant is required to provide the administrative controls governing the ITP. The staff determined that the administrative controls governing the ITP should be included in the SAM and the COL Applicant should provide the SAM during the COL application review phase. The staff noted that ESBWR DCD Sections 14.2.2.1 and 14.2.10 were not consistent with SRP Section 14.2 and RG 1.206, in that the DCD requires the Licensee to provide this information. The staff requested in RAI 14.2-81 S01, that the applicant revise ESBWR DCD Sections 14.2.2.1 and 14.2-10 and COL Information Item 14.2-1-H to be consistent with the requirement that the COL Applicant provide the SAM to the NRC for review and approval.

In response, the applicant stated they did not agree with the requested change. However, the applicant did agree to add a new COL information item requiring the COL Applicant to provide a description of how the ITP administration will be developed. The applicant stated that this includes discussions and description of the process, organizational controls, and requirements that are to be included in the SAM. The applicant also stated in its response that it will change the wording of the SAM from "Startup Administration Manual" to "Startup Administrative Manual" to be consistent with the guidance provided in SRP Section 14.2.

The applicant submitted DCD Tier 2, Revision 5, Section 14.2.10, to add COL Information Item 14.2-1-A, "Description—Initial Test Program Administration," and COL Information Item 14.2-5-A, "Site Specific Tests," provided below:

A description of the initial test program administration is developed and made available to the NRC by the COL Applicant (Subsection 14.2.2.1).

The COL Applicant will define any required site specific pre-operational and startup testing (Subsection 14.2.9).

In DCD Tier 2, Revision 5, Section 14.2.10, the applicant also revised the COL information item for the SAM to state that the a SAM is developed and made available by the Licensee to the NRC 60 days prior to the scheduled start of the pre-operational test program. This was designated as COL Information Item 14.2-2-H. Based on GEH's response and the changes provided in DCD Revisions 5, RAI 14.2-81S01 was resolved. However, in DCD Tier 2, Revision 6, the applicant revised the COL information item for the SAM to state that the COL Applicant will provide a milestone for completing the SAM and for making it available for NRC inspection and it was designated as COL Information Item 14.2-2-A. The staff determined that the revised COL Information Items 14.2-1-A and 14.2-2-A are acceptable because the staff will have the opportunity to review the description of the ITP administration, and the proposed milestone for completing the SAM as part of the COL application review to verify conformance with RG 1.68.

The applicant also revised four COL information items, as noted in Section 14.2.4 of this report. The staff finds that the changes provided in DCD Tier 2, Revision 5, are acceptable. Therefore, the changes resolve RAI 14.2-81 S01.

In RAI 14.2-82, the staff requested additional information regarding the pre-operational test objectives in DCD Tier 2, Section 14.2.1.2. Specifically, a review of DCD Tier 2, Revision 3, Section 14.2.1 determined that the objectives of the pre-operational test program did not consider operational programs and procedures as prerequisites for fuel loading and did not

identify when such programs need to be approved and in place. In the context of controlling and monitoring radioactive effluents, the programs include the radiological effluent technical specifications (TS) or standard radiological effluent controls (SREC), offsite dose calculation manual (ODCM), process control program (PCP), and radiological environmental monitoring program (REMP). Accordingly, the staff requested that the applicant update the DCD to identify these program documents and state when such documents must be approved and operationally ready for the conduct of pre-operational tests for all associated systems, as prerequisites before fuel loading.

In response to RAI 11.5-47, the applicant revised DCD Tier 2 to require the COL Applicant to fully describe the SREC, ODCM, and REMP listed in DCD Tier 2, Section 11.5.7, and the PCP in DCD Tier 2, Section 11.4.6. Furthermore, the COL information item in DCD Section 13.4.1, Revision 3, requires implementation milestones for all operational programs to be made available to the NRC for inspection before fuel load. In addition, COL Information Item 11.5.7.2 states that the COL Applicant will develop an ODCM that will include programs for monitoring and controlling the release of radioactive material into the environment.

The applicant stated in its response to RAI 14.2-82 that it was globally changing the COL holder items to COL Applicant items in DCD Tier 2, Revision 4. The applicant also updated DCD Tier 2, Sections 11.5.4.5, 11.5.4.6, 11.5.4.7, 11.5.4.8, and various paragraphs of Section 11.5.7 to show "COL Applicant." The applicant does not plan to revise DCD Section 14.2.1 to address COL Applicant issues, since DCD Sections 14.2.2 and 14.2.10 already discuss COL information. On this basis, the staff determined that RAI 14.2-82 is resolved.

On the basis of the above review, the staff finds that the applicant provided a set of objectives for the ITP that are consistent with the regulatory positions contained in RG 1.68 and SRP Section 14.2.

14.2.3.2 Initial Test Program's Conformance with Regulatory Guides

The staff reviewed the methodology used by the applicant to verify that the ITP meets the guidance in the RGs. SRP Section 14.2 states, in part, that the applicant should establish and describe an ITP that is consistent with the regulatory positions outlined in RG 1.68. SRP Section 14.2 also lists supplemental RGs that provide more detailed information pertaining to the testing. Appendix A to RG 1.68 references a set of supplemental RGs that provide additional guidance for particular tests during the pre-operational and initial startup phases. The supplemental RGs contain additional information to help determine if performance of the tests in the proposed manner will accomplish the objectives of certain plant tests.

In DCD Tier 2, Section 14.2.3, the applicant listed the RGs used in the development of the ESBWR ITP. In addition, DCD Tier 2, Section 1.9, Table 1.9-21 lists the RGs applicable to the ESBWR design. The staff reviewed the tables mentioned above to ensure that the applicable RGs were included in the development of the ITP. For those instances where the applicant determined that RGs were not applicable to the ESBWR design, or where the applicant proposed an exception to the RGs, the staff reviewed the applicant's justification for the exception to ensure that the scope of the test program remains sufficient.

The staff reviewed the list of RGs that the applicant had determined are not applicable to the ESBWR design and the exceptions to regulatory positions in these RGs. The list includes the following:

- RG 1.37, “Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants,” Revision 1
- RG 1.52, “Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants” Revision 3
- RG 1.79, “Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors,” Revision 1
- RG 1.95, “Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release,” Revision 1
- RG 1.108, “Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants,” Revision 1
- RG 1.116, “Quality Assurance Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems,” Revision 0-R

The staff determined that RGs 1.52 and 1.108 do not apply to the ESBWR design certification because the ESBWR design does not include Class 1E diesel generators (DGs) or safety-related atmospheric cleanup systems. RG 1.79 applies only to pressurized-water reactors, and therefore does not apply to the ESBWR design. The NRC withdrew RG 1.95, and it is therefore, not applicable to a design certification review. Thus, the staff concludes that with the exceptions to the regulatory positions in RG 1.37 and RG 1.116, the other RGs do not apply to the ESBWR design certification.

The staff also reviewed and evaluated proposed exceptions in RG 1.37 and RG 1.116 to verify that the applicant had adequately justified the alternate regulatory positions for testing. The applicant stated that Table 2-1 of NEDO-11209-04a, “GE Nuclear Energy Quality Assurance Program Description”, Revision 8, includes alternate positions to the requirements described in RGs 1.37 and 1.116 that the NRC had previously approved. The staff reviewed the alternate positions for testing described in the approved GEH Quality Assurance Program Description (QAPD) and determined that these exceptions meet the guidance in RG 1.68. Therefore, they remain acceptable for the ESBWR design certification application.

The staff issued RAI 14.2-37 to seek clarification of the applicability of the supplemental RGs in SRP Section 14.2.II (RG 1.56, “Maintenance of Water Purity in Boiling Water Reactors [for Comment],” Revision 1; RG 1.128, “Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” Revision 2; and RG 1.136, “Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments,” Revision 3). It appeared that DCD Tier 2, Section 14.2.3, did not include these RGs. In response, the applicant stated that DCD Tier 2 did list RG 1.56 but inadvertently omitted RG 1.128, which would be included in the next revision to Section 14.2.3. The staff confirmed that DCD Tier 2, Revision 3, did list both RG 1.56 and RG 1.128. In addition, the staff no longer recommends RG 1.136 in SRP Section 14.2.II, Revision 3, as a supplemental RG for the ITP. Because RG 1.68 provides more detailed guidelines for the initial tests, the staff determined that DCD Tier 2, Section 14.2.3 does not need to list RG 1.136. The applicant’s response is therefore acceptable, and RAI 14.2-37 is resolved.

On the basis of the above review, the staff finds that the ESBWR ITP adequately conforms to the general scope and depth of test programs, as described in RG 1.68, and also conforms to the test program regulatory positions stated in SRP Section 14.2. In addition, the staff finds that the applicant has adequately justified the noted exceptions.

14.2.3.3 Organizational and Staffing Responsibilities

The staff reviewed organizational and staffing responsibilities associated with the conduct of the ITP. SRP Section 14.2 and RG 1.68 state that “the applicant should provide and define the responsibilities of the organizational units that will carry out the ITP. These responsibilities include designated functions of each organizational unit and general steps to be followed in conducting these activities.”

The applicant proposed in DCD Tier 2, Section 14.2.1.4, a startup coordinating group (SCG) composed of representatives of the plant owner/operator, GEH, and others, for the conduct of the ITP. This group will be responsible for planning, executing, and documenting pre-operational and initial startup testing activities. In addition, the applicant stated that it will coordinate, in conjunction with the Licensee, overall technical direction to the station staff including shift personnel, in testing and operational activities in accordance with a SAM. The staff noted that the Licensee will define the responsibilities, authorities, and qualifications for normal plant staff that will be consistent with the ESBWR design, as described in DCD Tier 2, Section 13.2.

In RAI 14.2-16, the staff asked the applicant to include a COL information item to provide complete, detailed information regarding the applicant’s responsibilities, authorities, and personnel qualifications for conducting the ITP in accordance with RG 1.68. This is to ensure that the plant owner/operator provided the necessary information to be reviewed by the staff at the time of the COL application.

In response, the applicant revised DCD Tier 2, Section 14.2.9 and added a COL information item. The COL information item will have the Licensee describe: (1) the responsibilities of the organization that will carry out the test program, (2) methods and plans for providing the necessary manpower, (3) the staff responsibilities, authorities, and personnel qualifications for conducting the ITP, and (4) how the SAM is used to govern the administrative controls for conducting the ITP. The staff reviewed the applicant’s response to this RAI and DCD Tier 2, Revision 3, Section 14.2.9, and determined that the revised text appropriately included three of the four provisions noted above. Therefore RAI 14.2-16 is resolved. However, as discussed in Section 14.2.3.1 of this report, the COL information item was changed and now requires the COL Applicant to provide a milestone for completing the SAM and making it available for NRC inspection. In DCD Revision 6, this has been relabeled COL Information Item 14.2-2-A.

On the basis of the above review, the staff finds that organizational and staffing responsibilities associated with the conduct of the ITP submitted by the applicant provide adequate guidance and meet the regulatory positions in RG 1.68 and SRP Section 14.2.

14.2.3.4 Initial Test Program Test Procedures

The staff reviewed the methodology submitted by the applicant that will be used to develop, review, and approve individual test procedures to ensure that the relevant requirements of RG 1.68 and SRP Section 14.2 are met. SRP Section 14.2 and RG 1.68 specify that test procedures should control: (1) the sequencing of testing steps, (2) the preparation, review, and

approval of test procedures, (3) the use of temporary equipment, and (4) test acceptance criteria. RG 1.68 also states that the ITP should be conducted using test procedures developed and reviewed by personnel with appropriate technical backgrounds and experience. Additionally, RG 1.68 states that the principal design organizations should participate in establishing test performance requirements and test acceptance criteria.

In DCD Tier 2, Section 14.2.2 the staff noted that the applicant provided general guidance for the development and review of test specifications and procedures. The applicant stated that the startup group will conduct the ITP in accordance with a SAM. This manual, to be made available by the Licensee, will: (1) define the format of pre-operational and startup test procedures, (2) delineate the qualifications and responsibilities of the different positions within the startup group, (3) define the review and approval process for both initial procedures and subsequent revisions or changes, and (4) specify the process for the review and approval of test results and for the resolution of failures. The staff also noted that the SAM will include measures to provide approved test procedures to NRC inspection personnel approximately 60 days before the scheduled performance of the pre-operational tests and will include measures to provide approved procedures for power ascension tests to NRC inspection personnel 60 days before the scheduled fuel loading date.

In RAI 14.2-17, the staff asked the applicant to include a COL information item to provide complete, detailed information regarding the development, review, and approval of test procedures in accordance with RG 1.68.

In response, the applicant revised DCD Tier 2, Revision 5, Section 14.2.9 and added a COL Information Item 14.2-2-H for the Licensee to provide a SAM that delineates the development, review, and approval of test procedures per Appendix C to RG 1.68 (see RAI 14.2-81). In addition, the applicant stated in DCD Tier 2, Revision 5, Section 14.2.10, in COL Information Item 14.2-3-H, that the Licensee will make the approved test procedures available to the staff approximately 60 days before their intended use. The staff reviewed the applicant's response to this RAI and DCD Tier 2, Revision 3, Section 14.2.9, and determined that the revised text appropriately includes these provisions. Therefore, RAI 14.2-17 is resolved.

However, as discussed in Section 14.2.3.3 of this report, the applicant revised the COL information item for the SAM in Revision 6 to the DCD. In DCD Tier 2, Revision 6, this has been relabeled from COL Information Item 14.2-3-H to COL Information Item 14.2-2-A. The applicant also revised COL Information Item 14.2-3-H for test procedures to state that the COL Applicant will provide milestones for making available to the NRC approved test procedures satisfying the requirements for the ITP. This has been relabeled from COL Information Item 14.2-3-H to COL Information Item 14.2-3-A.

The staff finds that the general test specification and test procedure guidelines specified in DCD Tier 2, Revision 9, Section 14.2.2, are acceptable for the design certification because the guidelines are consistent with RG 1.68 and SRP Section 14.2. However, development of test specifications and test procedures will require detailed plant-specific design information and review and approval by the Licensee. Because plant-specific design information will be needed, the staff concludes that it is acceptable to defer responsibility for the development of detailed pre-operational and startup test specifications and test procedures to the Licensee.

14.2.3.5 Utilization of Reactor Operating and Testing Experience in the Development of the Initial Test Program

The staff reviewed the methodology submitted by the applicant to include reactor operating and testing experience in the development of the ITP. SRP Section 14.2 and RG 1.68 state that the applicant should describe how it used the operating and testing experiences of other facilities in the development of the ITP.

In DCD Tier 2, Section 14.2.4, the staff noted that the applicant considered the use of operational and testing experience gained from previous BWR plant designs, as well as operating and testing experience obtained from NRC licensee event reports, INPO correspondence, and other industry sources. The applicant stated that it has factored these experiences into the design and test specifications for the ITP. In DCD Tier 2, Section 14.2.2, the staff noted that the COL Applicant will be responsible for providing test specifications and test procedures for pre-operational and startup tests for review by the NRC and for the preparation of the SAM, which will contain the processes and standards that govern the activities associated with the plant ITP.

In RAI 14.2-18, the staff asked the applicant to include a COL information item to provide complete, detailed information regarding the utilization of reactor operating and testing experience, in accordance with RG 1.68.

In response, the applicant revised DCD Tier 2, Section 14.2.9, and added a COL information item requesting the Licensee to make a SAM available to the staff 60 days before use which delineates the utilization of previous reactor operating and testing experience in the development of the test procedures, in accordance with RG 1.68. The staff reviewed the applicant's response to this RAI and DCD Tier 2, Revision 3, Section 14.2.9, and determined that the revised text appropriately includes these provisions and is acceptable. Therefore, RAI 14.2-18 is resolved. DCD Tier 2, Revision 3, Section 14.2.9 was then moved to DCD Tier 2, Revision 9, Section 14.2.4. In DCD Revision 9, this is identified as COL Information Item 14.2-2-A.

The staff finds that the applicant has provided adequate ITP administrative controls, except as noted above, for the utilization of reactor operating and testing experience as described in RG 1.68 and SRP Section 14.2. However, development of ITP test procedures will require detailed plant-specific design information and review and approval by the Licensee, and thus, the staff concludes that it is acceptable to defer the review of the utilization of operating and testing experience to the Licensee.

14.2.3.6 Trial Use of Plant Operating and Emergency Procedures

The staff reviewed the methodology submitted by the applicant to verify plant operating and emergency procedures during the conduct of the ITP. SRP Section 14.2 states that the applicant should incorporate plant operating, emergency, and surveillance procedures into the test program, or otherwise verify these procedures through use, to the extent practicable, during the ITP.

In DCD Tier 2, Section 14.2.5, the staff noted that the applicant also included provisions to ensure that the plant's normal, surveillance, abnormal, and emergency operating procedures will be used, to the extent practical, throughout the pre-operational and initial startup tests. Additionally, the COL Applicant will be responsible for the SAM. In DCD Tier 2, Section 14.2.2,

the staff noted that the Licensee will be responsible for developing test specifications and test procedures for pre-operational and startup tests.

In RAI 14.2-19, the staff asked the applicant to include a COL information item to provide complete, detailed information regarding the trial use of operating and emergency procedures in accordance with RG 1.68. In response, the applicant revised DCD Tier 2, Section 14.2.9 and added a COL information item (In DCD Revision 6, this is identified as COL Information Item 14.2-2-A), for the Licensee, which states that the Licensee will make available a SAM to the staff, 60 days before use. The SAM will require the development of plant operating and emergency procedures before fuel loading and their application during the test program, consistent with Section C.7 of RG 1.68. The staff reviewed the applicant's response to this RAI and DCD Tier 2, Revision 3, Section 14.2.9, and finds that the revised text appropriately includes these provisions and is acceptable. This resolves RAI 14.2-19.

On the basis of the above review, the staff finds that it is acceptable to defer the trial use of operating and emergency procedures to the Licensee because the development of the ITP test procedures will require detailed plant-specific design information and review and approval by the Licensee.

14.2.3.7 Initial Test Program Schedule and Sequence

The staff reviewed the methodology submitted by the applicant that will be used to develop the ITP schedule and sequence. RG 1.68 states that sufficient time should be scheduled to perform orderly and comprehensive testing, to provide for a minimum time of about nine months for conducting the pre-operational testing phase, and to provide a minimum time of about three months for conducting the initial startup testing phase.

The staff noted that in DCD Tier 2, Section 14.2.7, the applicant provided measures for conducting each major phase of the ITP relative to the initial fuel load date. The Licensee will provide a schedule showing the timetable for the generation, review, and approval of procedures, as well as the actual testing and analysis of the results. The applicant also stated that approved test procedures will be available to the staff no later than 60 days before their intended use.

The staff reviewed the controls that will be implemented during the pre-operational and initial startup testing phases. The applicant provided general controls to ensure that during the pre-operational testing phase, testing is performed as systems and equipment availability allows, considering the interdependence of the systems. Additionally, the applicant stated that during the startup testing phase, test sequencing will depend on specified power conditions and intersystem prerequisites.

In RAI 14.2-20, the staff asked the applicant to include a COL information item to provide complete, detailed information regarding the development of the test program schedule and sequence in accordance with RG 1.68.

In response, the applicant revised DCD Tier 2, Section 14.2.9 and added a COL information item (eventually labeled COL Information Item 14.2-3-A) for the Licensee, which states that the Licensee will make available a SAM to the staff 60 days before use, which defines the requirements for the test program schedule that is consistent with Section C.5 of RG 1.68 and that the test sequence is consistent with Appendix A to RG 1.68. The staff reviewed the applicant's response to this RAI and DCD Tier 2, Revision 3, Section 14.2.9, and determined

that the revised text appropriately includes these provisions and is acceptable. Therefore, RAI 14.2-20 is resolved.

In DCD Revision 6, the applicant revised the COL information item for the testing schedule to state that the COL Applicant will provide a milestone for completing the detailed testing schedule and will make it available to the NRC. This has been relabeled COL Information Item 14.2-3-A in Revision 6 of the DCD.

On the basis of the above review, the staff finds that the guidance provided by the applicant is consistent with the criteria contained in RG 1.68 and SRP Section 14.2. Since the Licensee is designated as responsible for the test program schedule, the staff finds that it is acceptable to defer the detailed test program schedule and sequence to the Licensee. The COL Applicant will provide a milestone for completing the detailed testing schedule and making it available to the NRC (Subsection 14.2.7) (COL Information Item 14.2-4-A).

14.2.3.8 *First-of-a-Kind Tests*

SRP Section 14.2 and RG 1.68 state, in part, that “if new, unique, or first-of-a-kind (FOAK) principal design features will be used in the facility, the in-plant functional testing requirements necessary to verify their performance need to be identified at an early date to permit these test requirements to be appropriately accounted for in the final design.”

In RAI 14.2-95, the staff noted that in DCD Section 14.2.8.1 and Section 14.2.8.2, the applicant did not identify any pre-operational, startup, and power ascension tests that are FOAK tests in the ESBWR design. The staff requested additional information on pre-operational, startup, and power ascension tests that are FOAK tests in the ESBWR design.

In response, the applicant agreed that the ESBWR does have FOAK testing associated with the new design. The applicant identified the following FOAK tests:

- Reactor precritical heatup with reactor water cleanup/shutdown cooling (RWCU/SDC)
- Isolation condenser system (ICS) heatup and steady-state operations
- Power maneuvering in the feedwater temperature operating domain
- Load following

The applicant also added a new description of the power ascension test in DCD Tier 2, Section 14.2.8.2.35, and included this new information in DCD Tier 2, Table 14.2-1. The applicant also identified augmented FOAK tests in DCD Tier 2, Sections 14.2.8.2.7 and 14.2.8.2.11. The applicant added these FOAK tests in DCD Tier 2, Revision 5; therefore, this part of RAI 14.2-95 is resolved.

The staff found that some pre-operational test abstracts on new passive design systems in the ESBWR design, such as the gravity-driven cooling system (GDCS) and the passive containment cooling system (PCCS) are also FOAK tests. RAI 14.2-95 S01 requested the applicant to identify these test abstracts as FOAK tests in the ESBWR design.

In response, the applicant added the following information in DCD Tier 2, Revision 5, Section 14.2.8.1.64:

The PCCS is a unique ESBWR design for passive containment cooling in post accident conditions. The system consists of multiple loops or trains for

redundancy. The system will not have any special, one unit only, testing in Subsection 14.2.8.2.35 and will not have any preoperational startup testing in Subsection 14.2.8.2. All plants will perform a preoperational test in accordance to this section.

The applicant also added the following information in DCD Tier 2, Revision 5, Section 14.2.8.1.65:

The GDCS is a unique ESBWR passive cooling system to provide gravity driven flow into the vessel for emergency core cooling in LOCA conditions. This system will not have any special, one unit only, testing in Subsection 14.2.8.2.35 and will not have any operational startup testing in Subsection 14.2.8.2. All plants will perform a preoperational test in accordance to this section.

The staff finds that the applicant adequately addressed these pre-operational tests as unique FOAK tests for the ESBWR design; therefore, RAI 14.2-95 S01 is resolved.

In RAI 14.2-101, the staff requested the applicant to revise the DCD to classify the following FOAK tests in Section 14.2 as Tier 2*:

- 14.2.8.2.35.1 Reactor Pre Critical Heatup with RWCU/SDC
- 14.2.8.2.35.2 ICS Heatup and Steady State Operation
- 14.2.8.2.35.3 Power Maneuvering In the FW Temperature Operating Domain
- 14.2.8.2.35.4 Load Maneuvering Capability
- 14.2.8.2.35.5 Defense-in-Depth Stability Solution Evaluation Test

In DCD Tier 2, Revision 6, Section 14.2.8.2.35 the DCD applicant bracketed and italicized all of the test abstracts in Section 14.2.8.2.35 to designate them as Tier 2*. Prior NRC approval is required to change Tier 2* information. The staff finds this change acceptable and considers this RAI resolved. See Section 14.2.3.11 of this report for additional details.

14.2.3.9 Initial Fuel Loading and Initial Criticality

The staff reviewed the measures provided by the applicant that will be used during initial fuel loading and initial criticality. RG 1.68 and SRP Section 14.2 provide general guidance on the conduct of the ITP after the completion of pre-operational testing. As stated in the regulatory guidance, initial fuel loading and precritical tests ensure that: (1) initial core loading is safe, (2) provisions are in place to maintain a shutdown margin, and (3) the facility is in a final state of readiness to achieve criticality and to perform low-power testing.

In DCD Tier 2, Section 14.2.6, the applicant included provisions for pre-fuel load checks, initial fuel loading, precriticality, and initial criticality in accordance with RG 1.68 and SRP Section 14.2. The staff noted that these provisions included TS compliance, proper verification of water level and chemistry, calibration and response of nuclear instrumentation, shutdown margin verifications at predetermined intervals, and control rod functionality tests. These controls are consistent with the regulatory positions in RG 1.68.

In RAI 14.2-36, the staff requested that the applicant list all tests in the table of contents. In response, the applicant agreed to revise the table of contents to list the pre-operational test procedures in Section 1.2.8.1 and the general description of startup tests in Section 14.2.8.2. Therefore, RAI 14.2-36 is resolved.

On the basis of the above review, the staff concludes that the ITP adequately addresses the initial fuel loading and initial criticality testing and meets the associated guidance in RG 1.68 and SRP Section 14.2. The initial startup testing description in Section 14.2.3.11 of this report offers more detail.

14.2.3.10 Preoperational Test Descriptions

In DCD Tier 2, Section 14.2.8.1, the applicant provided 65 test abstracts for the pre-operational testing phase. For each of the pre-operational test abstracts, the staff reviewed the test description, purpose, prerequisites, general test acceptance criteria, and test methods to verify conformance with NRC regulatory guidance. The following is a list of the pre-operational test abstracts described in DCD Tier 2, Revision 9, Section 14.2.8.1:

- 14.2.8.1.1 Nuclear Boiler System (NBS) Preoperational Test
- 14.2.8.1.2 Feedwater Control System (FWCS) Preoperational Test
- 14.2.8.1.3 Standby Liquid Control System (SLCS) Preoperational Test
- 14.2.8.1.4 Control Rod Drive (CRD) System Preoperational Test
- 14.2.8.1.5 Rod Control and Information System Preoperational Test
- 14.2.8.1.6 Safety System Logic and Control Preoperational Test
- 14.2.8.1.7 Distributed Control and Information System (DCIS) Preoperational Test
- 14.2.8.1.8 Leak Detection and Isolation System (LD&IS) Preoperational Test
- 14.2.8.1.9 Reactor Protection System (RPS) Preoperational Test
- 14.2.8.1.10 Neutron Monitoring System (NMS) Preoperational Test
- 14.2.8.1.11 Plant Automation System (PAS) Preoperational Test
- 14.2.8.1.12 Remote Shutdown System Preoperational Test
- 14.2.8.1.13 RWCU Cooling System Preoperational Test
- 14.2.8.1.14 Fuel and Auxiliary Pools Cooling System (FAPCS) Preoperational Test
- 14.2.8.1.15 Process Sampling System Preoperational Test
- 14.2.8.1.16 Process Radiation Monitoring System Preoperational Test
- 14.2.8.1.17 Area Radiation Monitoring (ARM) System Preoperational Test
- 14.2.8.1.18 Containment Monitoring System (CMS) Preoperational Test
- 14.2.8.1.19 Instrument Air (IA) and Service Air (SA) Systems Preoperational Tests
- 14.2.8.1.20 High-Pressure Nitrogen Supply System Preoperational Test
- 14.2.8.1.21 Reactor Component Cooling Water System Preoperational Test
- 14.2.8.1.22 Makeup Water System Preoperational Test
- 14.2.8.1.23 Hot Water System Preoperational Test
- 14.2.8.1.24 Chilled Water System Preoperational Test
- 14.2.8.1.25 Heating, Ventilation, and Air Conditioning (HVAC) Systems Preoperational Test
- 14.2.8.1.26 Containment Inerting System Preoperational Test
- 14.2.8.1.27 Containment Isolation Valve Leakage Rate Tests
- 14.2.8.1.28 Containment Penetration Leakage Rate Tests
- 14.2.8.1.29 Containment Airlock Leakage Rate Tests
- 14.2.8.1.30 Containment Integrated Leakage Rate Test
- 14.2.8.1.31 Containment Structural Integrity Test
- 14.2.8.1.32 Pressure Suppression Containment Bypass Leakage Tests
- 14.2.8.1.33 Containment Isolation Valve Functional and Closure Timing Tests
- 14.2.8.1.34 Wetwell-to-Drywell Vacuum Breaker System Preoperational Test
- 14.2.8.1.35 DC Power Supply System Preoperational Test
- 14.2.8.1.36 AC Power Distribution System Preoperational Test
- 14.2.8.1.37 Standby Diesel Generator & AC Power System Preoperational Test

14.2.8.1.38	Plant Communications System Preoperational Test
14.2.8.1.39	Fire Protection System Preoperational Test
14.2.8.1.40	Radioactive Liquid Drainage and Transfer Systems Preoperational Tests
14.2.8.1.41	Fuel-Handling and Reactor Servicing Equipment Preoperational Test
14.2.8.1.42	Expansion, Vibration, and Dynamic Effects Preoperational Test
14.2.8.1.44	Condensate and Feedwater Systems (CFS) Preoperational Test
14.2.8.1.45	Condensate Cleanup System Preoperational Test
14.2.8.1.46	Reactor Water Chemistry Control Systems Preoperational Test
14.2.8.1.47	Condenser Air Removal System Preoperational Test
14.2.8.1.48	Off-gas System Preoperational Test
14.2.8.1.49	Condensate Storage and Transfer System Preoperational Test
14.2.8.1.50	Circulating Water System (CIRC) Preoperational Test
14.2.8.1.51	Plant Service Water System (PSWS) Preoperational Test
14.2.8.1.52	Turbine Component Cooling Water System Preoperational Test
14.2.8.1.53	Main Turbine Control System (MTCS) Preoperational Test
14.2.8.1.54	Main Turbine Bypass System Preoperational Test
14.2.8.1.55	Steam Bypass and Pressure Control System Preoperational Test
14.2.8.1.56	Heater, Drain, and Vent System Preoperational Test
14.2.8.1.57	Extraction Steam System Preoperational Test
14.2.8.1.58	Moisture Separator Reheater System Preoperational Test
14.2.8.1.59	Main Turbine and Auxiliaries Preoperational Test
14.2.8.1.60	Main Generator and Auxiliary Systems Preoperational Test
14.2.8.1.61	Seismic Monitoring System Preoperational Test
14.2.8.1.62	Liquid and Solid Radwaste Systems Preoperational Tests
14.2.8.1.63	ICS Preoperational Test
14.2.8.1.64	PCCS Preoperational Test
14.2.8.1.65	GDCS Preoperational Test

In comparing the ESBWR pre-operational test program to the pre-operational testing recommended in Section 1 of Appendix A to RG 1.68, the staff identified several areas where it required additional information to complete its review. The following sections discuss the specific issues.

14.2.3.10.1 Fire Protection System Preoperational Test

In RAI 14.2-4, the staff requested additional information about the fire protection system. The staff noted that fire protection systems are to be designed, fabricated, and installed in accordance with the applicable National Fire Protection Association (NFPA) standards, including requirements for the testing and inspection of installed systems and equipment. The staff noted that DCD Tier 2, Section 14.2.8.1.39 did not reflect these requirements. The staff also noted that the section did not include acceptance criteria. The high-level acceptance criteria appropriate to a DCD should be included. Additionally, the staff noted that the pre-operational tests and inspections should also include the following to verify the proper functioning of fire protection features:

- Verification of the integrity of fire barriers (such as penetration seals, fire doors, etc.).
- Verification of the correct location of fire protection equipment including sprinkler heads, spray nozzles, detectors, hose stations, and portable extinguishers.

In response, the applicant stated it would expand DCD Tier 2, Section 14.2.8.1.39 to include references to DCD Tier 2, Section 9.5.1.1 and Table 9.5-1, which include applicable NFPA standards and criteria. The applicant further expanded Section 14.2.8.1.39 to include verification of the proper installation of fire protection system components, including fire barriers, penetration seals, and fire doors, per the design basis in DCD Tier 2, Section 9.5.1.1. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.39, and finds the revised text responsive to the staff's concerns and is acceptable. Accordingly, the staff concludes that the fire protection system test description follows the guidance in RG 1.68, so it is acceptable. Therefore, RAI 14.2-4 is resolved.

14.2.3.10.2 Feedwater Control System Preoperational Test

In RAI 14.2-5, the staff requested additional information regarding the FWCS pre-operational test description in DCD Tier 2, Section 14.2.8.1.2. Section 1.J of Appendix A to RG 1.68 recommends the testing of instrumentation and control (I&C) systems that: (1) control normal operation of the facility, (2) provide information and alarms in the control room to monitor the operation and status of the facility, (3) establish that the facility is operating within design and license limits, (4) permit or support the operation of engineered safety features (ESFs), and (5) monitor and record important parameters during and following postulated accidents. In addition, Section 1.J of Appendix A to RG 1.68 includes provisions to verify the redundancy and electrical independence of this I&C system. However, the staff noted that the pre-operational test description of the FWCS did not specifically include testing the fault-tolerant digital controllers (FTDCs), nor did it include verification of electrical independence and redundancy of the FWCS.

In response, the applicant stated that the FTDCs will be tested as part of the FWCS factory acceptance tests (FAT) or pre-operational tests. The applicant also stated that DCD Tier 2, Section 7.7.3.4, details the testing of the FTDCs. The applicant explained that the redundancy and electrical independence of the FWCS will be verified by pre-operational tests, as described in DCD Tier 2, Sections 7.7.3.4 and 7.7.3.5. In addition, the applicant provided the following specification in Section 14.2.8.1.2 to demonstrate the testing of the FTDCs for redundancy and electrical independence of the FWCS. The specification states, "Proper operation of instrumentation and controls in the required combinations of logic and instrument channel trips, including verification of setpoints."

The staff determined that the response did not address the concern that the FTDCs and FWCS electrical independence and redundancy would be included within the scope of pre-operational testing. In its response to RAI 14.2-5 S01, the applicant further addressed the staff's concerns. The applicant's revised response clarified that as a prerequisite to verifying the operation of the FWCS, the FAT of the features and requirements of the FTDCs—as described in Sections 7.7.3.4 and 7.7.3.5—will be successfully completed. The staff reviewed the applicant's response to RAI 14.2-5 and the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.2. Based on these reviews, the staff finds the revised text is consistent with RG 1.68 and is acceptable. Accordingly, the staff concludes that the FWCS test description follows the guidance in RG 1.68 and is thus acceptable. Therefore, RAI 14.2-5 is resolved.

14.2.3.10.3 Standby Liquid Control System Preoperational Test

In RAI 14.2-6, the staff requested additional information regarding the SLCS pre-operational test description in DCD Tier 2, Section 14.2.8.1.3. Section 1.B of Appendix A to RG 1.68 recommends verifying the redundancy and electrical independence of the SLCS. Specifically, the staff noted that there was not a pre-operational test describing the verification of electrical

independence and redundancy for the SLCS Class 1E electrical system. Also, the staff noted the lack of information pertaining to testing of a heater installed in the mixing drum.

In response to RAI 14.2-6, the applicant stated that redundancy and electrical independence, as it applies to the ESBWR design, are associated with the squib valves, critical instrumentation, and initiating logic channels and will be verified through inspection, analysis, and/or pre-operational tests detailed in DCD Tier 2, Section 7.4.1.3.3. The applicant also stated that DCD Tier 2, Section 14.2.8.1.3 covers testing to support the above statement, as it calls for "Proper operation of instrumentation and equipment in the required combinations of logic and instrument channel trip." With respect to the testing of the mixing drum heater, the applicant stated that DCD Tier 2, Section 9.3.5.2 provides a detailed system description of the heating requirements for the SLCS. Specifically, the DCD states that electrical heating of the accumulator tank and the injection line is not necessary. The applicant also noted that the SLCS heaters, air spargers, and heat tracing used in previous BWR designs to control and maintain solution temperature have been eliminated.

The staff reviewed the applicant's response to this RAI. The staff determined that the operability testing of heaters, spargers, and heat tracing required in RG 1.68 is not applicable to the ESBWR because these components do not exist in the ESBWR design. Also, the staff determined that verification of redundancy and electrical independence, as described in DCD Tier 2, Section 7.4.1.3.3, meets the intent of RG 1.68 and is therefore adequate.

In the applicant's response to RAIs 14.2-6 S01 and 9.3-21 S01, the staff found that the applicant added the regulatory treatment of nonsafety system power supplies and plant investment protection A and B buses, which supply power to two redundant electrical heaters used to ensure that the common-mode failure for heating the SLCS accumulator rooms does not occur. In addition, the SLCS accumulator room temperature is monitored and alarmed when low.

Since the electrical heaters and the temperature alarms are needed to ensure the operability of the SLCS when the temperature falls below 15.6 degrees Celsius (C) (60 degrees Fahrenheit [F]), the staff requested additional information in DCD Tier 2, Section 14.2.8.1.3 to ensure that the heaters and temperature alarms in both SLCS accumulator rooms are tested to ensure that the SLCS remains operable in cold weather. This is RAI 14.2-6 S01.

In response, the applicant agreed to add test requirements to confirm the existence and functionality of the electrical room heaters for the SLCS accumulator rooms. However, the additional testing of the temperature alarms is deemed unnecessary, because this testing is covered by the third bullet in DCD Tier 2, Section 14.2.8.1.3. The staff finds that because the pre-operational test and the startup test in Section 14.2.8.2.34 for the SLCS follow the guidance in SRP Section 14.2 and RG 1.68, they are therefore acceptable. The applicant added the testing of electrical heaters in DCD Tier 2, Revision 5, Section 14.2.8.1.3; this resolves RAI 14.2-6.

14.2.3.10.4 Control Rod Drive System Preoperational Test

In RAI 14.2-7, the staff requested additional information regarding the description of the pre-operational test for the CRD system in DCD Tier 2, Section 14.2.8.1.4. Section 1.B of Appendix A to RG 1.68 recommends testing to verify the correct failure mode on a loss of power for the CRD system. In reviewing the description of the pre-operational test for the CRD system, the staff noted that DCD Tier 2, Section 14.2.8.1.4 did not include information pertaining to this test.

In its response to RAI 14.2-7, the applicant stated that Section 2.2.2 and Table 2.2.2-1 of the ESBWR DCD Tier 1 describe the verification of the correct failure mode for the CRD system. The correct failure mode will be verified in the normal course of the scram test in which a loss of power to the scram solenoid pilot valves in the hydraulic control units (HCUs) causes the scram. The applicant also stated that Section 14.2.8.1.4 enforces the described test in the specification "Proper operation of HCUs and associated valves."

The staff stated in RAI 14.2-7 S01 that the RAI response did not fully address its concern, because the bulleted item did not provide assurance that the CRD test included testing to verify the correct failure mode upon a loss of power. In addition, the staff determined that the test abstract in DCD Tier 2 did not adequately describe the required testing in accordance with RG 1.68. In response, the applicant included a sentence clarifying that as a prerequisite to verifying the operation of the CRD system, the following will be successfully completed: (1) factory quality control tests, (2) functional tests, and (3) operational tests as described in DCD Tier 2, Section 4.6.3.

The staff reviewed the applicant's response and the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.4. Based on these reviews, the staff finds the revised text is consistent with RG 1.68 and is acceptable. Therefore, the staff determined that verification of the correct failure mode upon a loss of power, as described in DCD Tier 1, Section 2.2.2, meets the intent of RG 1.68. In addition, the staff determined that the DCD revision clarifies the CRD system testing. Therefore, RAI 14.2-7 is resolved.

In RAI 14.2-39, the staff noted that the test description of the CRD system did not clearly state that the CRD high-pressure makeup mode of operation will be tested. This mode of operation will be initiated by a low reactor water Level 2 signal and the start of a standby pump, followed by the automatic opening of the injection valves. The staff questioned the applicant about this mode of operation and whether both CRD pumps will be tested.

In response, the applicant stated that the high-pressure makeup mode of operation will be tested, as indicated in the fifth item in DCD Tier 2, Section 14.2.8.1.4.. The item reads, "Proper operation of CRD makeup to reactor pressure vessel (RPV) on reactor low level signal." The applicant also stated that testing this mode includes the simultaneous operation of both CRD pumps to deliver the required high-pressure makeup flow rate to the reactor.

The staff reviewed the applicant's response. On the basis that the CRD system pre-operational test includes the testing of the CRD high-pressure makeup mode of operation, the staff finds that the CRD test description satisfies RG 1.68 requirements and is thus acceptable. Therefore, RAI 14.2-39 is resolved.

14.2.3.10.5 Safety System Logic Control System Preoperational Test

In RAI 14.2-8, the staff requested additional information regarding the safety system logic control (SSLC) system pre-operational test description in DCD Tier 2, Section 14.2.8.1.6. The staff noted that Section 1.C of Appendix A to RG 1.68 recommends testing the response time of each of the protection channels, including the sensors. However, the staff determined that the SSLC pre-operational test description did not clearly explain testing of the channel response time or sensor calibration and testing for the SSLC system channels and sensors.

In response, the applicant stated that the response time and calibration/testing of each of the safety-related channels (including sensors) would be performed as part of the testing of the

system with which they were associated. The applicant further stated that the ESF comprises the GDCS, the automatic depressurization system (ADS), the PCCS, the ICS, the SLCS, and the LD&IS. To that end, ESF channel response times for the ICS, GDCS, and ADS will be tested in accordance with DCD Tier 2, Sections 14.2.8.1.63, 14.2.8.1.65, and 14.2.8.1.1. For clarity, the applicant added to these sections the specification that the tests check for the “[a]cceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.”

The applicant stated that ESF channel response times for the LD&IS will be tested in accordance with DCD Tier 2, Section 14.2.8.1.8. For clarity, the applicant added to Section 14.2.8.1.8 the specification that the tests check for the “[a]cceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.”

The applicant also stated that ESF channel response times for the SLCS will be tested in accordance with DCD Tier 2, Section 14.2.8.1.3. To clarify that channel response times will be tested, the applicant added to Section 14.2.8.1.3 the specification “[a]cceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.”

The applicant stated that the PCCS channel response time test was not applicable because the PCCS does not rely on instrumentation to function. In addition, the applicant provided the requirement for channel response time testing for the RPS in DCD Tier 2, Section 14.2.8.1.9. The applicant’s response clarifies the pre-operational testing requirements for response time testing of RPS/ESF systems and is acceptable. For the calibration of sensors, the applicant stated that the RPS pre-operational test description addresses such testing.

Also, the applicant added a new item in the LD&IS pre-operational test description to address the calibration of sensors. The applicant noted that for the ICS, GDCS, and SLCS, the item “proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip,” which is cited in DCD Tier 2, Sections 14.2.8.1.63, 14.2.8.1.65, and 14.2.8.1.3, covers the calibration of sensors. The staff determined that this portion of the applicant’s response was not responsive to the staff’s concern, because the phrase cited above did not specify the calibration of sensors.

In response to RAI 14.2-8 S01, the applicant noted that it had added the phrase “[p]roper calibration of instrumentation” to DCD Tier 2, Sections 14.2.8.1.3, 14.2.8.1.63, and 14.2.8.1.65. The staff reviewed the test abstracts in DCD Tier 2, Revision 3, Sections 14.2.8.1.1, 14.2.8.1.3, 14.2.8.1.8, 14.2.8.1.9, 14.2.8.1.63, and 14.2.8.1.65 and determined that the revised text provides reasonable assurance that the response time testing and sensor calibration will be accomplished in these tests. Therefore, the change is acceptable. Accordingly, the staff concludes that the SSLC system test description follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-8 is resolved.

In RAI 14.2-68, the staff requested additional information regarding the SSLC pre-operational test description in DCD Tier 2, Section 14.2.8.1.6. The staff requested that the applicant describe the testing of the following design features:

- Bypass interlocks and resulting indication
- “Fail-safe” logic test for the RPS de-energization to trip
- A “fail-as-is” logic test for the ESF energization to trip

The applicant provided the following response to RAI 14.2-68:

The features suggested in the RAI are part of each individual safety-related system, which are covered by SSLC and they are being verified as a part of those systems. Reactor Protection System logic testing is described in 14.2.8.1.9. Additionally, the following tests will be added to DCD Tier 2, Subsection 14.2.8.1.6:

- Verify proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip;
- Verify bypass logic and bypass indications;

The ITAAC that will demonstrate conformance with “Operating Bypasses” and “Maintenance Bypasses” ([Institute of Electrical and Electronic Engineers Standard] IEEE-603-1991, Safety System Criteria 6.6 and 7.4, and 6.7 and 7.5) have been added to DCD Tier 1, in Subsection 2.2.15, Tables 2.2.15-1, and 2.2.15-2.

The preoperational test descriptions provided are considered appropriate to describe functional testing of logic that may be either fail-safe or fail-as-is. Subsection 14.2.8 discusses the level of detail for the descriptions of each preoperational test and the planned availability of the actual test procedures prior to their intended use.

The applicant added the two bullets noted above in DCD Tier 2, Revision 5, Section 14.2.8.1.6. Therefore, RAI 14.2-68 is resolved.

In RAI 14.2-70, the staff requested additional information regarding DCD Tier 2, Section 14.2.8.1.6. Specifically, the staff asked the applicant to include functional checks of the digital trip logic module (DTLM) and the safety system output logic unit (OLU) as described by the appropriate design specification.

The applicant provided the following response:

The terms DTLM and OLU are typically used in the NUMAC platform and may not be applicable to the SSLC. Without identifying specific components within an instrument channel and division of logic, guidance will be updated in DCD, Tier 2, Subsection 14.2.8.1.6, to test the instrumentation and controls in the appropriate design combinations of logic and instrument channel trip. Terms such as digital trip modules/DTLM (i.e., signal comparator modules), voting logic units and OLU, etc., are not called out specifically because their use and designation may vary, depending on the logic platform. This level of detail is addressed in the actual test procedures. The factory acceptance test(s) and preoperational tests (inclusive of the tests of individual systems) will thoroughly test that the logic (whether) individual chassis or integrated logic (in a common controller), input and output signals, operator interface and links to Non-Safety-Related Distributed Control and Information System (N-DCIS) are functioning correctly. Subsection 14.2.8 discusses the level of detail for the descriptions of each preoperational test and the planned availability of the actual test procedures prior to their intended use.

On the basis of the above review, the applicant plans to add the following items to DCD Tier 2, Section 14.2.8.1.6, as noted in the applicant's response to RAI 14.2-68:

- Verify proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip.
- Verify bypass logic and bypass indications.

The staff found the applicant's response to be unacceptable, since DCD Tier 2, Section 14.2.8.1.6 should identify the major functions. The identification of this information in the test abstract is necessary to demonstrate that the RPS will perform its intended safety functions.

In a follow-up response to RAI 14.2-70, the applicant stated that it does not plan to add design details, since this is a generic test plan with general test methods described in DCD Tier 2, Section 14.2.8.1.6. As discussed in the response, terms such as digital trip modules/DTLMs, voting logic units, and OLUs are not called out because their use and designation may vary depending on the logic platform. The actual test procedure addresses this level of detail. As previously indicated in the response to RAI 14.2-70, GEH updated DCD Tier 2, Section 14.2.8.1.6 to specify that the test will do the following:

- Verify proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip.

The NRC will have access to the detailed pre-operational tests as part of the design implementation process. Therefore, whether the applicant uses modules or controllers, the associated function is tested. On the basis of the response above and COL Information Item 14.2.3-A, the NRC inspectors will inspect the Licensee's pre-operational test procedures 60 days before their intended use.

However, in RAI 14.2-70 S01, the staff stated that regardless of whether the Licensee uses modules or controllers in the SSLC, the applicant should describe the SSLC major functions that will be tested in DCD Tier 2, Section 14.2.8.1.6. Regardless of the logic platform, the applicant should describe the SSLC sensor calibration and testing. In accordance with RG 1.68 and SRP Section 14.2, the applicant should include testing of the channel response time or sensor calibration and testing for the SSLC system channels and sensors in the SSLC pre-operational test description. RAI 14.2-70 S01 was being tracked as an open item in the SER with open items.

In response, the applicant stated the following:

The Safety System Logic and Control Engineered Safety Feature (SSLC/ESF) must satisfy Inspections, Tests, Analyses and Acceptance Criteria (ITAAC) and software management planned testing as part of implementation and installation. This means that testing that might otherwise be considered SSLC/ESF preoperational testing is already completed during the implementation and installation phases of the SSLC/ESF construction. Therefore, the only SSLC/ESF preoperational activities remaining involve the clearing of any SSLC/ESF system diagnostic alarms and any other site-specific testing determined to be necessary. Other systems' preoperational testing require a

functional SSLC/ESF and upon their completion further indicate a fully functional SSLC/ESF.

Detail sufficient to conclude that adequate SSLC/ESF testing has been performed prior to preoperational and startup testing is, therefore, part of the SSLC/ESF ITAAC and software management planned testing documentation. The "General Test Methods and Acceptance Criteria" does not cover details of the SAT because they are part of the Software Quality Assurance Program (SQAP) documentation. The NRC will have access to the detailed test/acceptance records as part of the design implementation process. Subsection 14.2.8.1.6 will be revised to include this detail.

DCD, Tier 2, Subsection 7.2.1.4.2 is an example of the specific types of SSLC/ESF tests performed during operation that verify proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trips, including channel response time or sensor calibration and testing. These types of tests are performed prior to operation in the preoperational test phase also.

The applicant added the following information to DCD Tier 2, Section 14.2.8.1.6:

The objective of this test is to verify proper operation of the Safety System Logic and Control Engineered Safety Feature (SSLC/ESF) and the safety-related distributed control and information system (Q-DCIS) and N-DCIS plant DCIS indicated in Subsection 14.2.8.1.7. Proper functioning of the DCIS includes those functions utilized for the preoperational testing and the aggregate plant systems.

The applicant also added the following information to DCD Tier 2, Section 14.2.8.1.6:

Because the SSLC/ESF must be functional for utilization in the preoperational testing of other systems, SSLC/ESF testing is completed during the implementation and installation phases of construction. The SSLC/ESF implementation and installation testing includes adhering to the commitments of the software development process (see Subsection 14.3.3.2). The commitments of the software plans include such testing as FAT and SAT. That which is not tested during the FAT, that which could change in transit, or that which is otherwise determined to need testing at the site is tested during the SAT.

The applicant added the information noted above to DCD Tier 2, Revision 6, Section 14.2.8.1.6. Therefore, RAI 14.2-70 S01 is resolved.

14.2.3.10.6 Distributed Control and Information System (DCIS) Preoperational Test

The staff noticed that in DCD Tier 2, Section 14.2.8.1.7, the description of the pre-operational testing for the DCIS is incomplete in that it does not provide sufficient detail to conclude that adequate system testing will be performed.

In RAI 14.2-99, the staff indicated that in DCD Tier 2, Section 14.2.8.1.7, the DCD should clarify that construction tests that include the DCIS FAT and the ITAAC commitment tests have been successfully completed.

The staff further indicated in RAI 14.2-99 that DCD Tier 2, Section 14.2.8.1.7 should describe the following elements in the “General Test Methods and Acceptance Criteria” after the DCIS installation: (1) Conduct of the site acceptance test (SAT) shall include both Q-DCIS and N-DCIS, and (2) The SAT shall test all DCIS functions and capabilities specified in the Technical Design Specification (major elements identified in the life-cycle phase summary baseline review record) of the DCIS. The following items should be considered during the DCIS pre-operational tests:

- (1) Video display unit (VDU) performance
- (2) Database capacity
- (3) All spare requirements
- (4) Cyber security aspects
- (5) Redundancy features of controllers
- (6) Power supplies
- (7) Data communications and interface requirements, etc
- (8) The system loop test shall be conducted for each Input/Output (I/O) by connecting all field devices to the DCIS I/O terminals.
- (9) The system control logic and man-machine interface design features shall be tested

In its response, the applicant stated the following:

Chapter 14 of the ESBWR DCD covers preoperational and startup testing. Preoperational testing follows completion of construction (and construction-related) inspections, tests, and acceptance and takes place before fuel is loaded. Startup testing takes place during and after fuel loading. Detail sufficient to conclude that adequate DCIS testing has been performed prior to preoperational and startup testing is, therefore, not included in Chapter 14.

Construction and preoperational testing concepts for the DCIS differ from other systems in that the DCIS must be functional before many other preoperational tests can begin. The DCIS must therefore be installed and shown to be working acceptably during construction, the implementation, and installation phases.

The DCIS must satisfy ITAAC and software management planned testing as part of implementation and installation. This means that testing that might otherwise be considered DCIS preoperational testing is already completed during the implementation and installation phases (of the DCIS construction). Therefore, the only DCIS preoperational tests remaining involve the clearing of any DCIS system diagnostic alarms and any other site-specific testing determined to be necessary. Other systems' preoperational testing turnover packages require a functional DCIS and upon their completion, further indicate a fully functional DCIS.

Detail sufficient to conclude that adequate DCIS testing has been performed prior to preoperational and startup testing is, therefore, part of the ITAAC and software management planned testing documentation. The NRC will have access to the detailed test/acceptance records as part of the design implementation process.

The "General Test Methods and Acceptance Criteria" does not cover details of the SAT because they are part of the SQAP documentation.

The DCIS system control logic and man-machine interface design features are tested as part of the other systems' testing and testing committed to in the software plans. Details on software plan tests will be in test plans developed through implementation of the Software Management Program and SQAP and include, but are not limited to, the following.

- VDU performance,
- Database capacity,
- All spare requirements,
- Cyber security aspects,
- Redundancy features of controllers,
- Power supplies,
- Data communications and interface requirements, etc.

The system loop testing is satisfied for each I/O through the testing of each system that makes up the DCIS.

Based on the response above, the applicant committed to making the following revision to DCD Tier 2, Section 14.2.8.1.7:

Purpose

The object of this testing is to verify proper functioning of both the safety-related (Q-DCIS) and non- safety-related (N-DCIS) plant DCIS. Proper functioning of the DCIS includes those functions utilized for the preoperational testing of the aggregate plant systems.

Prerequisites

Since the DCIS must be functional for utilization in the preoperational testing of other systems, DCIS testing is completed during the implementation and installation of phases of construction. The DCIS implementation and installation testing includes adhering to the commitments of the software plans (see Subsection 14.3.3.2). The commitments of the software plans include such testing as FAT, that which could change in transit, or that which is otherwise determined to need testing at the site is tested during the Site Acceptance Test.

DCIS construction tests have been successfully completed and the SCG has both reviewed test procedures and approved the initiation of testing. The required AC and DC electrical power sources shall be operational and the appropriate interfacing systems shall be available as required to support the specified testing.

General Test Methods and Acceptance Criteria

The testing of the following:

- Verify that all DCIS diagnostic alarms have been resolved, cleared, and documented as such or have been documented for later resolution during individual/specific systems preoperational testing.

The applicant added the above information to DCD Tier 2, Revision 6, Section 14.2.8.1.7. Therefore, RAI 14.2-99 is resolved.

14.2.3.10.7 Leak Detection and Isolation System Preoperational Test

In RAI 14.2-9, the staff requested additional information regarding the LD&IS pre-operational test description in DCD Tier 2, Section 14.2.8.1.8. Section 1.J of Appendix A to RG 1.68 recommends testing I&C systems that permit or support the operation of ESFs. In reviewing the LD&IS pre-operational test description, the staff determined that the test description did not address testing for the following manual control functions:

- Actuation of each main steam isolation valve (MSIV) test switch
- MSIV isolation switches
- MSIV logic reset
- RWCU/SDC isolation switch
- Containment isolation manual switch
- Containment isolation logic reset
- Reactor building HVAC isolation

In its response to RAI 14.2-9, the applicant stated that the test description in Section 14.2.8.1.8 included the pre-operational tests of all test switches, manual switches, isolation switches, and logic resets for the LD&IS. This testing is covered in the specification “Proper operation of instrumentation and controls in all combinations of logic and instrument channel trip.” The staff reviewed the applicant’s response to this RAI. On the basis that the LD&IS will be tested in conjunction with the manual control functions detailed above, as part of the overall containment isolation and main steamline isolation initiation logic, the staff finds that the LD&IS test description satisfies RG 1.68 and is adequate. Therefore, RAI 14.2-9 is resolved.

In RAI 14.2-73, the staff requested additional information on DCD Tier 2, Section 14.2.8.1.8, regarding information necessary to identify the interfacing functions and systems that must be available. These include the following:

- Drywell pressure signals, or simulated, from the RPS
- The reactor mode switch signals from the RPS
- The interlock from the RPS bypassing the MSIV isolation when not in the “RUN” mode

In its response to RAI 14.2-73, applicant stated the following:

ESBWR DCD, Tier 2, Revision 3, Subsection 14.2.8.1.8, 5th bullet requires the LD&IS Preoperational Test to demonstrate “Proper interface with related systems in regard to the input and output of leak detection indications and isolation initiation commands.” These indications include: the Drywell pressure signals, or simulated signals from the RPS; and the reactor mode switch signals from the RPS. Also, the 6 bullet of Subsection 14.2.8.1.8 “Proper operation of bypass switches and related logic” includes the interlock from the RPS bypassing the MSIV when not in “RUN” mode. The LD&IS interfacing diagram is provided in Figure 7.3-3.

However, the applicant does not plan to add information to DCD Tier 2, Section 14.2.8.1.8. In a supplemental RAI, the staff requested that the applicant describe under the LD&IS pre-operational test methods and acceptance criteria, the LD&IS component functions that can be tested during this test phase and the acceptance criteria that must be met to demonstrate that the LD&IS meets its design basis. In addition, the staff requested that the applicant revise DCD Tier 2, Section 14.2.8.1.8 to include the testing of I&C systems for the LD&IS, in accordance with RG 1.68 Appendix A, Item J, "Instrumentation & Control Systems," Items (1) through (25).

In a follow-up response to RAI 14.2-73, the applicant stated the following:

The operation of the LD&IS functional logic is demonstrated during a series of overlapping preoperational tests. As indicated in the GEH response to RAI 14.2-73, DCD, Subsection 14.2.8.1.8 (5 and 6 bullets) performs the applicable preoperational tests requested by the NRC RAI. LD&IS controls, interlocks and bypasses are also verified through LD&IS ITAAC No. 4, DCD, Tier 1, Table 2.2.12.5. The LD&IS and RPS controls, interlocks and bypasses are described in DCD, Tier 1, Table 2.2.12-4 and 2.2.7-3, respectively.

On the basis of the above response and COL Information Item 14.2.2-A, NRC inspectors will inspect the Licensee LD&IS and RPS pre-operational test procedures 60 days before their intended use.

However, in RAI 14.2-73 S01, the staff asked the applicant to describe the major functions in DCD Preoperational Test Section 14.2.8.1.8, including LD&IS controls, interlocks, and bypasses that are verified in the LD&IS ITAAC. These include the major LD&IS and RPS control, interlock, and bypass functions described in Tables 2.2.7-3, 2.2.12-4, and 2.2.12-5. RAI 14.2-73 S01 was being tracked as an open item in the SER with open items.

To address RAI 14.2-73 S01, the applicant added the following information to DCD Tier 2, Section 14.2.8.1.8:

The objective of this test is to verify proper response and operation of the LD&IS logic, the safety-related (Q-DCIS) and non-safety-related (N-DCIS) plant DCIS, indicated in Subsection 14.2.8.1.7. Proper functioning of the DCIS includes those functions utilized for the preoperational testing of the aggregate plant systems.

The applicant also added the following information to the "Prerequisites" section:

Since the RPS and SSLC/ESF must be functional for utilization in the preoperational testing of other systems, LD&IS testing is completed during the implementation and installation phases of construction. The RPS and SSLC/ESF implementation and installation testing includes adhering to the commitments of the software plans (see Subsection 14.3.3.2). The commitments of the software plans include such testing as FAT and Site Acceptance Tests (SAT). That which is not tested during the FAT, that which could change in transit, or that which is otherwise determined to need testing at the site is tested during the SAT.

The applicant added the above information to DCD Tier 2, Revision 6, Section 14.2.8.1.8. Therefore, RAI 14.2-73 S01 is resolved.

14.2.3.10.8 Neutron Monitoring System Preoperational Test

In RAI 14.2-74, the staff requested additional information regarding the NMS pre-operational test description in DCD Tier 2, Section 14.2.8.1.10. Specifically, the staff requested that the applicant describe pre-operational testing of the thermometer system and calibration of any local power range monitors (LPRMs).

In response, the applicant stated following:

DCD, Tier 2, Subsection 14.2.8.1.10, notes the prerequisite that the Startup Range Neutron Monitor (SRNM) and Power Range Neutron Monitor (PRNM) components have been calibrated per vendor instructions. The "Prerequisites" paragraph also notes that "required interfacing systems shall be available, as needed, to support the specified testing." The Automated Fixed In-core Probe (AFIP) subsystem is such a required interfacing system. The AFIP and LPRM sensors are contained within the LPRM assemblies, which are part of the PRNM subsystem. This prerequisite ensures that the AFIP detectors (gamma thermometers (GTs)) and the LPRMs will be pre-calibrated prior to in-situ preoperational testing.

Section 14.2.8.1.10, "General Test Methods and Acceptance Criteria" also notes that the following shall be demonstrated:

- Proper operation of detectors and associated cabling, preamplifiers, and power supplies.;
- Proper operation of system and subsystem self-test diagnostic and calibration functions.; and
- The ability to communicate and interface between appropriate plant systems and NMS subsystems.

These three items ensure that the AFIP detectors and the LPRMs will be calibrated during preoperational testing, including demonstration of the communications interfaces between the AFIP subsystem and the NMS. The LPRMs cannot be calibrated in-situ without the use of the AFIP subsystem.

The final calibration of the GTs and the application of GT calibration factors to the LPRMs can be accomplished only during reactor operation during startup and power testing.

The applicant did not revise DCD Tier 2, Section 14.2.8.1.10 in response to this RAI. However, the staff finds this response clarifies the testing requirements and is acceptable. Therefore, RAI 14.2-74 is resolved.

In RAI 14.2-75, the staff requested additional information regarding the NMS pre-operational test description contained in DCD Tier 2, Section 14.2.8.1.10. Specifically, the staff asked the applicant to provide additional details on the subsystems and the specific tests involved, such as the following:

- Verification of rod block monitor input matrix and trip output for correct functions.

- Verification of the oscillation power range monitor (OPRM) instrumentation for correct trip, alarm, and bypass functions.

In response, the applicant stated the following:

DCD, Tier 2, Subsection 14.2.8.1.10, notes the prerequisite that the PRNM “components have been calibrated per vendor instructions.” The “Prerequisites” paragraph also notes that “required interfacing systems shall be available, as needed, to support the specified testing.” The OPRM algorithms and tables are contained completely within the PRNM subsystem, and the Multichannel Rod Block Monitor (MRBM) subsystem is a required interfacing system. This prerequisite ensures that all of the PRNM, including the OPRM functions and the MRBM functions and interfaces, will be subjected to in-situ preoperational testing.

DCD, Tier 2, Subsection 14.2.8.1.10, “General Test Methods and Acceptance Criteria,” also notes that the following shall be demonstrated:

- Proper operation including rod block.
- Proper functioning of instrumentation, displays, alarms, and annunciators used to monitor system operation and status;
- The ability to communicate and interface between appropriate plant systems and NMS subsystems.

These three items ensure that the OPRM and MRBM functions and software tables will be verified prior to and during preoperational testing, including demonstration of the communications interfaces between the MRBM subsystem and the NMS.

In accordance with DCD, Tier 2, Subsections 7.2.2.2.7.4 and 7.2.2.2.7.5, the OPRM alarms and trips are bypassed in all reactor operation modes except run and when operating below the required power level (typically 30 percent). Therefore, the final checks of OPRM functions can be accomplished only during reactor operation during preoperational testing.

The staff finds this response clarifies the testing requirements and is acceptable. Therefore, RAI 14.2-75 is resolved.

14.2.3.10.9 Plant Automation System Preoperational Test

In RAI 14.2-76, the staff requested additional information regarding the PAS pre-operational test description in DCD Tier 2, Section 14.2.8.1.11. The staff asked the applicant to provide additional detail about the tests involved. Examples include the following:

- For redundant controllers, tests would be conducted to confirm a response to simulated controller failures.
- The capability of the PAS to automatically decouple from plant control and revert to plant operation in manual mode.

In response, the applicant indicated that it would make no changes to DCD Tier 2, Section 14.2.8.1.11. The staff determined that without the additional information on these tests in DCD Tier 2, Section 14.2.8.1.11, under the PAS pre-operational test methods and acceptance criteria it was not clear that the PAS testing would include all of the functions required to demonstrate that the system acceptance criteria will be met to satisfy design-basis requirements. DCD Tier 2, Section 14.2.8.1.11 should include testing of the instrumentation and control systems for the PAS in accordance with RG 1.68 Appendix A Item J, items (1) through (25).

The applicant stated that the PAS is a nonsafety-related system that does not perform or ensure any safety-related function and is not required to achieve or maintain a safe shutdown. The PAS is non-safety-related and has no safety design basis.

The applicant also stated that specific testing to be performed and the applicable acceptance criteria for each pre-operational test are documented in test procedures to be made available to the NRC approximately 60 days before their intended use and are in accordance with the system specification and associated equipment specifications. These tests will demonstrate that the installed equipment and systems perform within the limits of these specifications. Therefore, DCD Tier 2, Section 14.2.8.1.11 does not require revision.

The staff verified that the instrumentation and control testing of the PAS meets the guidance in RG 1.68, Appendix A, Item J. On the basis of this response and COL Information Item 14.2.2-A, NRC inspectors will inspect the Licensee's PAS pre-operational test procedures 60 days before their intended use. Therefore, RAI 14.2-76 is resolved.

14.2.3.10.10 Remote Shutdown System Preoperational Test

In RAI 14.2-10, the staff requested additional information regarding the remote shutdown system (RSS) pre-operational test description in DCD Tier 2, Section 14.2.8.1.12. Section 1.J of Appendix A to RG 1.68 recommends the testing of instrumentation and controls used for a shutdown from outside the control room. In reviewing the pre-operational test description of the RSS, the staff determined that DCD Tier 2, Section 14.2.8.1.12 did not clearly describe the testing adequately to demonstrate proper operation of individual systems and equipment when operated from the remote shutdown panel.

In response, the applicant stated that factory and pre-operational tests will be performed to demonstrate the proper functioning of the control and instrumentation associated with the RSS panel. To this end, the applicant revised Section 14.2.8.1.12 to include verification of RSS switches and override of main control room (MCR) functions during the performance of factory and pre-operational tests. The staff reviewed the applicant's response to this RAI. Based on this review, the staff determined that the revised text clarifies the RSS testing requirements in DCD Tier 2, Revision 3, Section 14.2.8.1.12. Accordingly, the staff concludes that the RSS test description follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-10 is resolved.

14.2.3.10.11 Fuel and Auxiliary Pools Cooling System Preoperational Test

In RAI 14.2-11, the staff requested additional information regarding the FAPCS pre-operational test description in DCD Tier 2, Section 14.2.8.1.14. Section 1.M of Appendix A to RG 1.68 recommends the testing of equipment and components used to handle or cool irradiated and nonirradiated fuel. In accordance with RG 1.68, the pre-operational test description should also

include verification of redundancy and electrical independence. In reviewing the FAPCS test description, the staff determined that DCD Tier 2, Section 14.2.8.1.14 did not have provisions for verifying electrical independence and redundancy. In addition, the staff noted that the FAPCS has eight modes of operation. Each of these modes requires a different flow path to achieve the design pool cleaning and cooling functions of the FAPCS. The FAPCS test description did not include provisions for testing these modes of operation.

In response, the applicant stated that factory and pre-operational tests will be performed to demonstrate the proper functioning of the control and instrumentation associated with the FAPCS and will include verification of redundancy and electrical independence of the safety-related instrumentation. The applicant also stated that tests will be performed for all modes of operation. To that end, the applicant revised DCD Tier 2, Section 14.2.8.1.14 to include the above testing.

The staff reviewed the applicant's response and the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.14. Based on this review, the staff finds that the revised text describes the necessary provisions for testing the FAPCS. Accordingly, the staff concludes that the FAPCS test description follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-11 is resolved.

14.2.3.10.12 Area Radiation Monitoring System Preoperational Test

In RAI 14.2-12, the staff requested additional information regarding the ARM system pre-operational test description in DCD Tier 2, Section 14.2.8.1.17. Section 1.K of Appendix A to RG 1.68 recommends testing the equipment and components used to monitor or measure radiation levels. In accordance with RG 1.68, the pre-operational test description should also include testing to verify redundancy and electrical independence. However, the staff determined that DCD Tier 2, Section 14.2.8.1.17 did not clearly describe the provisions for verifying electrical independence and redundancy during the pre-operational testing of the ARM system.

In response, the applicant stated that DCD Tier 1, Table 2.3.2-1 provided pre-operational testing information for the ARM system. The applicant also stated that redundancy at the monitor level was not required because the ARM system does not have a safety-related function. The applicant noted that the fail-safe design will initiate a local alarm and an alarm in the MCR on interruption of power, component failure, or loss of signal. The applicant revised DCD Tier 2, Section 14.2.8.1.17 to add the following to the ARM pre-operational test description:

Proper functioning following power interruption to each ARM monitor, including appropriate local and MCR alarms has no affect on the functionality of other ARM monitors.

The staff reviewed the applicant's response to this RAI. The staff verified this change in DCD Tier 2, Revision 3, Section 14.2.8.1.17 and determined that the revised text addresses the staff's concern. Accordingly, the staff concludes that the revised ARM system test description noted above follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-12 is resolved.

In RAI 14.2-92, the staff requested additional information regarding which ARM monitors listed in DCD Tier 1, Revision 4, and in Table 2.3.2-1 have associated system trips. The staff asked

the applicant to describe, for each radiation monitor that has an associated system trip, the purpose and function of the associated system trip.

In response, the applicant stated that since the ARM system is nonsafety-related and is for alarm and indication purposes only, it does not provide any trip or interlock to external devices. The applicant revised DCD Tier 2, Revision 5, Section 14.2.8.1.17 to replace the word “trips” with the words “indications and alarms are observed.” Therefore, RAI 14.2-92 is resolved.

14.2.3.10.13 Containment Monitoring System Preoperational Test

In RAI 14.2-77, the staff requested additional information regarding the CMS pre-operational test. Specifically, the staff requested that DCD Tier 2, Section 14.2.8.1.18 provide information on the tests involved.

In response, the applicant stated that under “General Test Methods and Acceptance Criteria” in DCD Tier 2, Section 14.2.8.1.18, it will add the following items:

- Proper operation of heat tracing and self-regulating functions used in each H2/O2 sample line;
- Proper operation of logic and bypass functions;
- Proper operation of oxygen and hydrogen analyzers per manufacturer’s instructions.

The applicant added this information in DCD Tier 2, Revision 5, Section 14.2.8.1.18. Therefore, RAI 14.2-77 is resolved.

In RAI 14.2-93, the staff requested additional information regarding the description of the purpose/function of the system trip associated with the subsystem of the CMS that monitors radiation levels in containment.

In response, the applicant stated that the portion of the CMS subsystem monitoring gamma radiation levels in the containment is nonsafety-related and is provided for alarm and indication only. Therefore, this subsystem does not provide trips or interlocks for external devices. The applicant added this information in DCD Tier 2, Revision 5, Section 14.2.8.1.18, as it replaced the words “system trips” with the words “indication and alarm” and specified that this acceptance criterion applies to the containment radiation and atmospheric monitoring subsystems. Therefore, RAI 14.2-93 is resolved.

14.2.3.10.14 Instrument Air and Service Air Systems Preoperational Test

In RAI 14.2-13, the staff requested additional information regarding pre-operational test descriptions of the the IA and SA systems in DCD Tier 2, Section 14.2.8.1.19. Section 1.N, “Auxiliary and Miscellaneous Systems,” of Appendix A to RG 1.68 recommends the testing of the compressed gas systems that are used to support the normal operation of the facility or are essential for the operation of standby safety equipment or ESFs. In accordance with RG 1.68, the test program should also include verification of redundancy and electrical independence of the compressed gas system. RG 1.68.3, “Preoperational Testing of Instrument and Control Air Systems,” provides guidance for conducting pre-operational testing of the instrument and control air systems. Specifically, Regulatory Position 9 of RG 1.68.3 calls for tests to

demonstrate that air supplies such as the SA supply would not be inadvertently tied into the IA system. In reviewing the pre-operational test description for the IA and SA systems, the staff noted that the test descriptions did not include provisions for verifying electrical independence and redundancy, nor did they include provisions to demonstrate that the air systems could not be inadvertently interconnected.

In response, the applicant stated that the IA and SA systems are nonsafety-related and, therefore, not required to have redundancy and electrical independence to support the safety design basis of the plant. The applicant added that the IA and SA systems are designed with redundant compressors in each system and are powered from separate buses, thus providing electrical independence. In addition, the applicant stated that pre-operational tests will be performed to ensure that the backup compressors in each system start as expected from their assigned power buses. DCD Tier 2, Section 14.2.8.1.19 reflected this in the following items:

- “Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip,”
- “Proper operation of compressors and motors in all design operating modes,” and
- “Ability of compressor(s) to maintain receiver at specified pressure(s) and to recharge within specified time under design loading conditions.”

Regarding provisions to demonstrate that both air systems cannot be inadvertently interconnected, the applicant stated that inadvertent interconnection between the IA and SA systems will be verified during pre-operational testing, as described by items in Section 14.2.8.1.19 requiring “Proper operation of instrumentation and equipment in all combinations of logic and instrument channel trip” and “Ability of the SAS to act as backup to the IAS.”

The staff reviewed the applicant’s response to this RAI. On the basis that the IA and SA systems will be tested against the requirements delineated in RG 1.68 and RG 1.68.3, including verification of redundancy, electrical independence, and the inadvertent operation of both systems, the staff finds the pre-operational test description of the IA and SA systems satisfies RG 1.68 and is acceptable. Therefore, RAI 14.2-13 is resolved.

14.2.3.10.15 Expansion, Vibration, and Dynamic Effects Preoperational Test

In RAI 14.2-24, the staff asked the applicant to discuss the expansion, vibration, and dynamic effects for conformance with RG 1.68, RG 1.56, RG 1.128, and RG 1.136 and to justify exceptions to the RG positions. The staff also referred the applicant to RG 1.20, “Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing,” Revision 3, for vibration assessment program guidance for reactor internals and potential adverse flow effects in steam and feedwater systems.

In response, the applicant stated, in part:

With regard to compliance with RG 1.68 relative to thermal expansion, vibration and dynamic effects for the preoperational test program, DCD, Tier 2, Subsections 3.9.2.1.1 and 3.9.2.1.2 have been revised to specifically address compliance with this regulation and other industry standards with respect to

safety-related piping. The test program conformance with RG 1.68 is described in DCD, Tier 2, Subsection 14.2.8.1, and Pre-operational Test Procedures. Where applicable, the Test Acceptance Criteria for the thermal expansion, vibration and dynamic effects for the preoperational and/or startup tests will also meet the requirements of the other RGs 1.56 and 1.128. RG 1.136 will not be listed in Chapter 14 of the DCD because it is not applicable and is referenced in Subsection 3.8.1.6. In addition, the development of the test criteria will require consideration of the potential adverse flow effects on piping systems recommended in RG 1.20, and in SRP Section 3.9.2 and SRP Section 3.9.5. RG 1.68, 1.56, and 1.20 have been referenced in DCD, Tier 2, Subsection 14.2.3 (Titled: Test Program's Conformance with Regulatory Guides). No exceptions to the regulatory positions in the applicable RGs are being requested by GEH.

Based on the applicant's response and the changes noted to DCD Tier 2, Revision 4, Section 14.2.3, the staff finds that the applicant provided sufficient information on conformance to RGs. Therefore, RAI 14.2-24 is partially resolved for pre-operational tests. The staff issued RAI 14.2-24 S01, which addresses the staff's concerns regarding vibration tests at power. Section 14.2.3.11.8 of this report discusses RAI 14.2-24 S01.

14.2.3.10.16 Nuclear Boiler System Preoperational Test

In RAI 14.2-40, the staff requested additional information regarding the NBS pre-operational test description in DCD Tier 2, Section 14.2.8.1.1. The staff determined that DCD Tier 2, Section 14.2.8.1.1 did not clearly specify provisions to verify whether the depressurization valve (DPV) tests had been completed.

In response, the applicant stated that the manufacturer of the DPV will perform DPV engineering development and operability tests. In addition, the applicant stated that it will revise the prerequisites portion of Section 14.2.8.1.1 to denote the completion of such testing. GEH confirmed that it will revise the DCD to include the previously completed DPV engineering development and operability tests, in the interest of document completeness. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.1 and determined that the revised text clarifies DPV testing requirements. Accordingly, the staff concludes that the NBS test description follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-40 is resolved.

14.2.3.10.17 Gravity-Driven Cooling System Preoperational Test

In RAI 14.2-41, the staff requested additional information regarding the GDCS pre-operational test description in DCD Tier 2, Section 14.2.8.1.65. The staff asked the applicant to provide information on test setup conditions (e.g., vessel and drywell pressures) and limiting conditions that will be considered in the tests. In addition, the staff asked whether GDCS testing will be performed with installed check valves and squib valves.

In response, the applicant stated that DCD Tier 1, Table 2.4.2-1 describes GDCS testing. The applicant stated that the test will be an open reactor vessel test at atmospheric conditions in both the drywell and vessel. In addition, the applicant stated that testing will be conducted with check valves and squib valves installed, using previously activated squib valves. The staff determined that the applicant had clarified that the GDCS tests will be conducted at atmospheric conditions in both the drywell and the vessel. The applicant also confirmed that testing will be conducted with check valves and squib valves installed, and previously activated squib valves

will be used. By design, the GDCS will be activated after reactor system depressurization. Therefore, the staff finds that the initial tests under atmospheric conditions are acceptable. On this basis, the staff concludes that the GDCS test description is acceptable. Therefore, RAI 14.2-41 is resolved.

14.2.3.10.18 Condensate and Feedwater System Preoperational Test

In RAI 14.2-46, the staff requested additional information regarding the CFS pre-operational test description in DCD Tier 2, Section 14.2.8.1.44. The staff asked the applicant to include condensate booster pumps to ensure consistency with Position C.1.a of RG 1.68.1, "Preoperational and Initial Startup Testing of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants," Revision 1.

In response, the applicant stated that the ESBWR does not have condensate booster pumps. The applicant also stated that because the reactor feed pump (RFP) has a booster pump and a main pump on the same shaft and motor, it will revise Section 14.2.8.1.44 to require the demonstration of "Proper operation of pumps and motors in all design operating modes (Condensate and RFP)." The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.44 and determined that the revised text is consistent with RG 1.68. Accordingly, the staff concludes that the CFS test description follows the guidance in RG 1.68 and is acceptable. Therefore, RAI 14.2-46 is resolved.

In RAI 14.2-47, the staff asked the applicant to clarify whether the feedwater flow control valve testing described in DCD Tier 2, Section 14.2.8.1.44 meets Regulatory Position C.1.d of RG 1.68.1, Revision 1. The staff was specifically interested in testing the proper response of the valves for the design operating range and the correct operation of protective features.

In response, the applicant stated that the ESBWR uses valve control for the low-flow control of feedwater flow and feed pump speed control for normal at-power feedwater flow rate control. DCD Tier 2, Section 14.2.8.1.2 describes the pre-operational testing of the FWCS. However, the applicant stated that it will revise the text in DCD Tier 2, Section 14.2.8.1.44 to include the following:

- Proper operation of system valves, including timing, under expected operating conditions, and proper response of flow control valves for the design operating range and correct operation of protective features.

The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.44 and determined that the revised text clarifies that the testing will verify proper valve response over the design operating range with the correct operation of protective features. Accordingly, the staff concludes that the CFS test description is acceptable. Therefore, RAI 14.2-47 is resolved.

In RAI 14.2-48, the staff noted that Section 14.2.8.1.44 does not include a comprehensive FWCS test as described in Regulatory Position C.1.f of RG 1.68.1, Revision 1. The staff asked the applicant to provide a justification or an alternative method for demonstrating the operability of the FWCS.

In response, the applicant stated that DCD Tier 2, Section 14.2.8.1.2 describes the FWCS pre-operational test that addresses the individual components of the FWCS but does not address the overall response of the control system as stipulated in RG 1.68.1. The applicant stated that it will add the following to Section 14.2.8.1.2:

- Proper overall response of the control system including the final control element.

The applicant noted that this will include control system response to simulated control system malfunctions and simulated plant transients at full flow, including MSIV closure and turbine trip without the bypass capability. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.2 and determined that the revised text clarifies the comprehensive FWCS testing recommended by RG 1.68. Accordingly, the staff concludes that the CFS test description is acceptable. Therefore, RAI 14.2-48 is resolved.

14.2.3.10.19 Circulating Water System Preoperational Test

In RAI 14.2-50, the staff requested additional information regarding the CIRC pre-operational test description in DCD Tier 2, Section 14.2.8.1.50. The staff asked the applicant to confirm whether the ESBWR pre-operational testing of the CIRC included verification of pump net positive suction head (NPSH) and verification of proper system operation, while powered from primary and alternate power sources.

In response, the applicant confirmed that pre-operational activities will include verification of acceptable NPSH under the most limiting design flow conditions, and that it will add a statement to DCD Tier 2 Section 14.2.8.1.50 to indicate such verification. The applicant also stated that the CIRC does not have a backup power supply or redundant power source specific to the system. The power source for the CIRC pumps is the unit auxiliary transformer, which will be backed up by the reserve auxiliary transformer. The staff reviewed the test abstract in DCD Tier 2 Revision 3, Section 14.2.8.1.50 and finds that the revised text clarifies the NPSH and alternate power source testing requirements. Accordingly, the staff concludes that the CIRC test description follows the guidance in RG 1.68 and is thus acceptable. Therefore, RAI 14.2-50 is resolved.

14.2.3.10.20 Main Turbine Control System Preoperational Test

In RAI 14.2-51, the staff requested additional information regarding the MTCS pre-operational test description in DCD Tier 2, Section 14.2.8.1.53. The staff asked the applicant to confirm whether the ESBWR pre-operational testing for the MTCS will verify the proper operation of trip devices for main stop and control valves and combined intermediate valves (CIVs).

In response, the applicant stated that Section 14.2.8.1.53 describes the general test methods and acceptance criteria for the turbine control system, including proper operation of the main stop and control valves and CIVs in response to simulated signals related to turbine speed, load, and pressure. The applicant also stated that the turbine main stop, control, and CIVs will be equipped with fast-acting solenoid valves (i.e., trip devices) to facilitate fast closure in response to an overspeed signal, although this section does not specifically discuss overspeed or trip devices. The applicant stated that DCD Tier 1, Table 2.11.4-1 included testing of the control logic of the as-built overspeed protection system with simulated overspeed signals to verify closure of the valves that supply steam to the turbine upon receipt of an overspeed signal. The applicant also stated that it will revise DCD Tier 2, Section 14.2.8.1.53 to specifically address the verification of proper operation of turbine valve overspeed trip devices. The staff determined that performance of this test makes it possible to verify the proper operation of the trip devices required to prevent a turbine overspeed. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.1.53 and finds that the revised text addresses the staff's

concerns and is acceptable. Accordingly, the staff concludes that the MTCS test description follows the guidance in RG 1.68 and is thus acceptable. Therefore, RAI 14.2-51 is resolved.

14.2.3.10.21 Main Turbine and Auxiliaries Preoperational Test

In RAI 14.2-53, the staff requested additional information regarding the main turbine and auxiliaries pre-operational test description in DCD Tier 2 Section 14.2.8.1.59. The staff asked the applicant to include testing of the overspeed trip system, which is consistent with the guidance in RG 1.68.

In response, the applicant indicated that it will add the following text to the DCD in a future revision:

Proper operation of the turbine overspeed protection system to provide mechanical overspeed trip and electrical backup overspeed trip as specified in Subsection 10.2.2.4 and the manufacturer's technical instruction manual. (During the preoperational test phase, simulated speed signals will be used for these tests.)

The staff reviewed the test abstract in DCD Tier 2 Revision 3, Section 14.2.8.1.59 and finds that the revised text addresses overspeed trip testing. Accordingly, the staff concludes that the main turbine and auxiliaries test description follows the guidance in RG 1.68 and is thus acceptable. Therefore, RAI 14.2-53 is resolved.

14.2.3.10.22 Direct Current Power Supply System Preoperational Test

In RAI 14.2-55, the staff requested additional information on DCD Tier 2, Revision 1, Section 14.2.8.1.35. Specifically, on page 14.2-34, the sixth bullet did not accurately reflect the newly revised DCD for Chapter 8 (i.e., the ESBWR design will utilize only Class 1E batteries with a 72-hour duty cycle).

In DCD Tier 2, Revision 3, Section 14.2.8.1.35, the applicant revised the acceptance criterion in the sixth bullet to read as follows:

- Verify that safety-related batteries have the capacity to support Safety-Related loads for a period of 72 hours.

The staff finds this change clarifies the acceptance criteria in DCD Section 14.2.8.1.35 and follows the guidance in RG 1.68. Therefore, the test description is acceptable and RAI 14.2-55 is resolved.

14.2.3.10.23 Alternating Current Power Distribution System Preoperational Test

In RAI 14.2-57, the staff requested additional information regarding the alternating current (ac) power distribution system pre-operational test description in DCD Tier 2, Section 14.2.8.1.36. Specifically, the staff asked the applicant to describe the system tests that demonstrate proper termination of power and control cables.

In response, the applicant stated that per Appendix A to RG 1.68, construction and preliminary tests, including wiring continuity and separation checks, will be performed before the start of pre-operational testing. These tests will verify the proper termination of power and control and

will include point-to-point continuity, high pot, and fiber optic optical checks as applicable. Therefore, no change to Section 14.2.8.1.36 is needed to address the demonstration that power and control cables will be properly terminated. No DCD change is required in response to this RAI. The staff finds this response sufficiently clarifies ac power distribution testing requirements and is acceptable. Therefore, RAI 14.2-57 is resolved.

In RAI 14.2-98, the staff noted that DCD Tier 2, Revision 5, Section 14.2.8.1.36 states the following:

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following: (1) Proper operation of initiating, transfer, and trip devices; (2) Proper operation of relaying and logic; (3) Proper operation of equipment protective devices, including permissive and prohibit interlocks; (4) Proper operation of instrumentation and alarms used to monitor system and equipment status; (5) Proper operation and load carrying capability of breakers, switchgear, transformers, and cables; (6) The capability of transfer between onsite and offsite power sources as per design; (7) The ability of emergency and vital loads to start in the proper sequence and to operate properly under simulated accident conditions; and (8) The adequacy of the plant emergency lighting system.

The staff asked the applicant to include the following additional items in the ITP or to justify their exclusion: (a) verification of analytically derived voltage values from voltage analyses of the onsite distribution system against actual measurements (Branch Technical Position 8-6), and (b) proper operation of the automatic transfer capability of normal preferred power source to the alternate preferred power source is verified. RAI 14.2-98 was being tracked as an open item in the SER with open items.

In response, the applicant stated the following:

GEH concurs with Item (a) noted above. GEH considers Item (b) to be satisfied by existing requirements in DCD, Tier 2, Subsection 14.2.8.1.36 as described below:

- (a) An item will be added to DCD, Tier 2, Subsection 14.2.8.1.36 to verify the analytical derived voltage values of the onsite distribution system against actual measurements.
- (b) The requested verification of the transfer capability from the normal to preferred power source to the alternate preferred power source is satisfied by the existing requirements in DCD, Tier 2, Subsection 14.2.8.1.36, that verifies "Proper operation of initiating, transfer and trip devices." This verification includes proper operation of controls, relays and breakers required for transfer from the normal preferred power source to the alternate preferred power source.

The applicant planned to revise DCD Tier 2, Section 14.2.8.1.36 by adding the following bullet, as noted below:

- Verify the analytical derived voltage values of the onsite distribution system against actual measurements.

The applicant added this information to DCD Tier 2, Revision 6, Section 14.2.8.1.36. Therefore, RAI 14.2-98 is resolved.

14.2.3.10.24 Standby Diesel Generator and Alternating Current Power System Preoperational Test

In RAI 14.2-59, the staff requested additional information regarding the standby DG and ac power system pre-operational test description in DCD Tier 2, Section 14.2.8.1.37. Specifically, the staff asked the applicant to describe the basis for the phrase “at a load equivalent to the continuous rating” that is used in the following quotation from DCD Tier 2, Revision 1, Section 14.2.8.1.37, on page 14.2-36:

Fuel Load carrying capability of the DG for a period of not less than 24 hours, of which 22 hours are at a load equivalent to the continuous rating of the DG and 2 hours are at the manufacturer’s 2 hour load rating, including verification that the diesel cooling system functions within design limits, and that the HVAC System maintains the DG room within design limits.

The staff’s understanding is that the continuous rating should include kilovolt-amperes and the power factor.

In DCD Tier 2, Revision 3, Section 14.2.8.1.37, the applicant added the following criterion under “General Test Methods and Acceptance Criteria”:

- The DGs will be tested at full power and rated power factor for a period of 24 hours. This will ensure all diesel cooling and HVAC systems perform their design functions.

The staff finds that the above change is responsive to its question and is acceptable. Therefore, RAI 14.2-59 is resolved.

14.2.3.10.25 Pressure Suppression Containment Bypass Leakage Tests

In DCD Tier 2, Revision 2, Section 14.2.8.1.32 the applicant stated that an objective of the pressure suppression containment bypass leakage tests is to “verify that the suppression pool bypass leakage rate is within limits for high pressure and low pressure tests.” In RAI 14.2-63, the staff asked the applicant to provide the values of the high and low pressures and explain their significance.

In response, the applicant stated the following:

A review of this RAI and Subsection 14.2.8.1.32 led, by reference, back to DCD, Chapter 6, Subsection 6.2.1.1.5 (Bypass Leakage and Surveillance). Subsection 6.2.1.1.5.4.1 (High Pressure Leak Test) was deleted in DCD, Tier 2, Revision 3. Chapter 14 will be revised to eliminate the description of high and low pressure tests. In addition, subsections under DCD, Chapter 6, Subsection 6.2.1.1.5 will be revised to be in line with the changes made in Chapter 14.

The testing for bypass leakage in Chapters 6 and 14 will consist of local leak rate testing at a single pressure plus visual inspections. Therefore, the request to

provide values for high and low pressure testing and their significance is no longer relevant.

In RAI 14.2-63 S01, the staff asked the applicant to measure the total bypass leakage without using unverified assumptions. The applicant subsequently revised DCD Tier 2, Section 14.2.8.1.32 to determine the overall suppression pool bypass leakage effective area and to confirm that the leakage value is within the limits of the low-pressure test acceptance criteria. The test method used will form the basis for leakage tests conducted at the same frequency as the integrated leak rate tests (ILRTs). In addition, the applicant revised the general test methods and acceptance criteria to verify that the calculated value of the overall suppression pool bypass leakage effective area (A/\sqrt{K}) is within the design limit specified in Section 6.2.1.1.5.

In response to RAI 14.2-63 S01, GEH proposed to update DCD Tier 2, Section 14.2.8.1.32 to include the statement that the “test method used will form the basis for use during subsequent leakage rate tests conducted at the same frequency as the ILRT.”

In RAI 6.2-145 S02, the staff asked GEH to provide additional justification for this proposed change. In RAI 14.2-63 S02, the staff asked that GEH make the responses to RAIs 14.2-63 and 6.2-145 consistent.

In response to RAI 6.2-145 S02 and RAI 14.2-63 S02, the applicant proposed to change the TS suppression pool bypass test frequency from two years to 10 years. The staff approved TS license amendment requests for surveillance test frequencies of 10 years in existing plants but has not approved this test frequency for new plants. RAI 6.2-145 was being tracked as an open item in the Chapter 6 SER with open items. Resolution of RAI 6.2-145 is discussed in Section 6.2 of this report. This issue does not affect the pre-operational pressure suppression containment bypass leakage tests in DCD Tier 2, Section 14.2.8.1.32, since these are one time pre-operational tests to satisfy the requirements of RG 1.68 and SRP Section 14.2 for the ITP. Therefore, RAI 14.2-63 S02 is resolved.

14.2.3.10.26 Feedwater Control System Preoperational Test

In RAI 14.2.-65, the staff noted that as part of DCD Tier 2, Section 14.2.8.1.2, the following tests should be added for attributes of the triplicate FTDCs to be consistent with RG 1.68:

- Single and Three Element control
- Independence of controllers by taking each one, and then all combinations of two, out of service and verifying that the system is functioning properly
- Manual Feedpump Control—verify that each RFP can be fully controlled through the FTDCs

To be consistent with RG 1.68, each parallel processing channel should be tested for various design attributes.

In response, the applicant noted the following:

Verification of the Single and Three Element controller is already encompassed within the statement to demonstrate the proper overall response of the control

system. This will be done while using simulated signals for inputs. No change to the DCD is required.

The applicant agreed to add a statement to verify, by demonstration, that the loss and then restoration of a single processor in the FTDCs will not cause substantial change to the system output signals, nor require operator action beyond recognition of an alarm when the processor is out of service. However, the simultaneous loss of two processors will not be demonstrated, as that condition goes beyond the fault-tolerant design of the FWCS. This position is consistent with DCD Tier 1, Revision 9, Chapter 2 (see DCD Tier 1, Revision 9, Table 2.2.3-2, Item 2).

The applicant agreed to add a statement to require pre-operational testing of each motor-driven reactor feed pump (MDRFP) using the manual control mode of the controller to the extent practical.

The applicant committed to add the following two bullets to DCD Tier 2, Section 14.2.8.1.2:

- Independence of system functional operation from loss of operation of one of the redundant channels of the FTDCs controllers/processors will be confirmed by test. Testing involves using simulated input signals and removing, then restoring the normal operation of each one of the three channels. During testing, important control system outputs are monitored and their response is used for confirming the system remains properly functional.
- Verification of each MDRFP will be made using the controller's manual control mode with a flow path through the long path recycle line. Maximum test flow rate to be consistent with the equipment limitations.

The applicant added this information in DCD Tier 2, Revision 5, Section 14.2.8.1.2. Therefore, this addition resolves RAI 14.2-65.

14.2.3.10.27 Rod Control and Information System Preoperational Test

In RAI 14.2-66, the staff requested additional information regarding DCD Tier 2, Section 14.2.8.1.5 where the proper functioning of instrumentation should include status signals from the HCUs and a failure indication of any one position detector for an individual fine motion control rod drive (FMCRD).

In response, the applicant provided the following conclusions and new criteria regarding testing of the HCU and FMCRD:

RC&IS and the N-DCIS, there are already tests and on-line diagnostics from both the RC&IS and the N-DCIS that provide proper functioning of the status signals from the HCUs and rod position detector failure for an individual FMCRD.

The applicant committed to revise the "General Test Methods and Acceptance Criteria" in Section 14.2.1.8.5 to add a new criterion after the third criterion as follows:

- Proper functioning of instrumentation used to monitor status signals from HCUs and failure indication of any one position detector for an individual FMCRD.

The applicant added this new information in DCD Tier 2, Revision 5, Section 14.2.8.1.5, thereby resolving RAI 14.2-66.

14.2.3.10.28 Radioactive Liquid Drainage and Transfer System Preoperational Test

In RAI 14.2-85, the staff requested additional information regarding the radioactive liquid drainage and transfer system pre-operational test description in DCD Tier 2, Section 14.2.8.1.40. Specifically, the staff asked the applicant to explain why the scope does not describe how the installation and operation of mobile waste processing systems will be integrated in this test.

In response, the applicant stated the following:

- a. DCD Subsection 14.2.8.1.62 "Prerequisites", states, the construction tests have been successfully completed. Included in the construction tests are individual component tests. Interfaces between liquid waste management system (LWMS) and mobile systems will be included in these tests. The mobile equipment is designed to the requirements of RG 1.143, which insures all mobile equipment has the same standard of design as the LWMS. As stated in the RAI, the solid and liquid radwaste process relies on both permanently installed plant systems and mobile waste treatment systems. The preoperational testing described in DCD, Subsection 14.2.8.1.62 addresses both liquid and solid radwaste systems. Test requirements include:
 - Acceptable system and component flow paths and flow rates, including pump capacities and tank volumes
 - Proper operation of equipment controls and logic, including prohibit and permissive interlocks
 - Proper functioning of instrumentation and alarms used to monitor system operation and status,

These tests could not be successfully completed if the plant systems and the mobile waste treatment systems were not interfacing as designed.

- b. The mobile systems are designed in accordance with RG 1.143 and installation of the systems will follow quality assurance requirements to ensure that the installation follows the design requirements. Controlling and monitoring effluent release is described in Subsection 14.2.8.1.62 which states proper operation of equipment protective features and automatic isolation functions, including those for ventilation systems and liquid effluent pathways; and proper functioning of instrumentation and alarms used to monitor system operation and status is verified. GEH response to RAI 11.5-23, MFN 07-030, dated April 10, 2007, revised DCD, Subsection 11.5.7.2 to require the COL Applicant to provide programmatic details, ODCM, for monitoring and controlling the release of radioactive material to the environment.

- c. The applicant's response to RAI 11.2.3-1, Supplement No. 1, MFN 07-371, dated July 13, 2007, changed DCD Tier 2, Table 11.2-3 to require filtration and adsorbent media meet or exceed the decontamination factors listed.
- d. The applicant's response to RAI 11.2.3-1 Supplement No. 1, MFN 07-371, dated July 13, 2007, changed DCD Tier 2, Table 11.2-3 to require filtration and adsorbent media meet or exceed the decontamination factors listed.

In response to this RAI, the applicant made no changes to DCD Section 14.2.8.1.40. On the basis of the preceding information, the staff agrees with the applicant's response, and RAI 14.2-85 is resolved.

14.2.3.10.29 Off-gas System Preoperational Test

In RAI 14.2-86, the staff requested additional information regarding the off-gas system pre-operational test description in DCD Tier 2, Section 14.2.8.1.48. Specifically, the staff requested that the applicant clarify the scope of this pre-operational test. The test does not describe the process that will be used in confirming the proper selection and performance characteristics of the media to treat gaseous process, waste, and effluent streams.

In response, the applicant stated the following:

DCD, Subsection 11.3.2.1, "Adsorption" provides design criteria for the charcoal media such as vendor tests of charcoal for krypton and xenon adsorption. During the preoperational test phase a prerequisite to off-gas testing is verification that the correct amount of charcoal has been loaded in the absorber beds and that the charcoal that is being used meets the requirements for charcoal described in DCD, Subsection 11.3.2.1. Off-gas performance can only be confirmed during startup testing when there are radionuclides in the waste stream. The startup test for the off-gas system is described in DCD, Subsection 14.2.8.2.29. Subsection 14.2.8.2.1 describes the samples taken to verify off-gas performance.

- a. The adsorbent media for the guard and charcoal beds is described in DCD, Subsection 11.3.1, Table 11.3-1. The charcoal mass is no less than 33,000 lbs for the guard beds and 490,000 lbs for the charcoal beds. The guard and charcoal beds are sized to process three times the source term without affecting delay time of the noble gases (30-minute).
- b. DCD, Subsection 14.2.8.2.29 describes the startup testing of the off-gas system. The performance of the charcoal absorbers is tested to verify that the radioactivity effluents meet the TS limits. COL Information Item 11.5.-2-A states the COL Applicant will develop an ODCM that will include programs for monitoring and controlling the release of radioactive material to the environment.

The response to this RAI was also tied to the disposition of RAIs 11.5-47 and 12.2-9 S02, which were resolved separately. The applicant did not revise DCD Section 14.2.8.1.48 to address this RAI. The staff agrees with the applicant's response, and RAI 14.2-86 is resolved.

In RAI 14.3-157, the staff requested additional information regarding the off-gas system test abstract in DCD Tier 2, Section 14.2.8.1.48. The staff determined that the acceptance criteria specified in DCD Tier 2, Revision 4, Section 14.2.8.1.48, were inconsistent with DCD Tier 1, Revision 4, Section 2.10.3, and DCD Tier 2, Revision 4, Section 11.5.3.2.2. Specifically, the test methods and acceptance criteria do not identify a test to demonstrate the proper closure of the isolation valve on high-radioactivity levels. Accordingly, the staff asked the applicant to revise the acceptance criteria listed in DCD Tier 2, Revision 4, Section 14.2.8.1.48 to include a confirmation of system isolation on high-radioactivity level signals. This issue is related to an ITAAC under DCD Tier 1, Section 2.10.3.

In response, the applicant added the following information in DCD Tier 2, Revision 5, Section 14.2.8.1.48, in the fourth bullet under “General Test Methods and Acceptance Criteria”:

- Proper operation of system valves, including isolation features, under expected operating conditions, including isolation of the off-gas system discharge valve upon receipt of high radioactivity level signals:

Since this addressed the operation of off-gas system isolation on a high-radioactivity level, the staff finds that this response is acceptable. Therefore, RAI 14.3-157 is resolved.

14.2.3.10.30 Nuclear Boiler System, Standby Liquid Control System, and Gravity Driven Cooling System Preoperational Tests

In RAI 14.2-64, the staff requested additional information regarding equipment or components that cannot be actuated without damage or without upsetting the plant. In the response to RAI 14.12-64, the applicant stated, in part, that actuation of equipment or components during either pre-operational or startup test programs should not cause damage or upset the plant to an extent that there would be damage. The applicant recognized that some components are designed for single-use actuation (e.g., squib valves). The applicant also agreed that it should acknowledge the acceptability of isolating these devices to prevent them from being actuated during pre-operational tests.

The applicant also stated that the ESBWR utilizes single-use squib valves in the ADS, GDCS, and SLCS. The applicant will add a statement allowing the isolation of these single-use components before the pre-operational tests of these three systems. Accordingly, the applicant will revise the “Prerequisite” sections of DCD Tier 2, Sections 14.2.8.1.1, 14.2.8.1.3, and 14.2.8.1.65 by adding the following statement:

- To prevent actuation of single use squib valves during the logic portion of this testing process, the valve(s) may be isolated electrically to prevent actuation. This isolation, verification of the firing signal during the test, and reconnection process must be controlled within the test document.

The applicant added this information to the sections mentioned above in DCD Tier 2, Revision 5, thus resolving RAI 14.2-64.

14.2.3.10.31 Preoperational Test Descriptions Conclusions

On the basis of its review of DCD Tier 2, Revision 9, Section 14.2.8.1, the staff finds that the test abstracts provided by the applicant are generally consistent with the pre-operational test criteria in RG 1.68 and SRP Section 14.2 and therefore acceptable. However, since the

Licensee will be responsible for the development of detailed test specifications and test procedures, the staff finds that it is acceptable to defer the development of these documents until the post COL phase.

14.2.3.11 Initial Startup Test Descriptions

In DCD Tier 2, Revision 6, Section 14.2.8.2 the applicant provided the following 38 test abstracts for the initial startup testing phase:

- (1) 14.2.8.2.1 Chemical and Radiochemical Measurements Test
- (2) 14.2.8.2.2 Radiation Measurements Test
- (3) 14.2.8.2.3 Fuel Loading Test
- (4) 14.2.8.2.4 Full Core Shutdown Margin Demonstration Test
- (5) 14.2.8.2.5 CRD System Performance Test
- (6) 14.2.8.2.6 NMS Performance Test
- (7) 14.2.8.2.7 Core Performance Test
- (8) 14.2.8.2.8 Nuclear Boiler Process Monitoring Test
- (9) 14.2.8.2.9 System Expansion Test
- (10) 14.2.8.2.10 System Vibration Test
- (11) 14.2.8.2.11 Reactor Internals Vibration Test (Initial Startup Flow-Induced Vibration (FIV) Testing)
- (12) 14.2.8.2.12 Feedwater Control Test
- (13) 14.2.8.2.13 Pressure Control Test
- (14) 14.2.8.2.14 Plant Automation and Control Test
- (15) 14.2.8.2.15 Feedwater System Performance Test
- (16) 14.2.8.2.16 Main Steam System Performance Test
- (17) 14.2.8.2.17 RWCU Cooling System Performance Test
- (18) 14.2.8.2.18 PSWS Performance Test
- (19) 14.2.8.2.19 HVAC System Performance Test
- (20) 14.2.8.2.20 Turbine Valve Performance Test
- (21) 14.2.8.2.21 MSIV Performance Test
- (22) 14.2.8.2.22 SRV [Safety/Relief Valve] Performance Test
- (23) 14.2.8.2.23 Loss of Feedwater Heating Test
- (24) 14.2.8.2.24 Feedwater Pump Trip Test
- (25) 14.2.8.2.25 Shutdown from Outside the MCR Test
- (26) 14.2.8.2.26 Loss of Turbine Generator and Offsite Power Test
- (27) 14.2.8.2.27 Turbine Trip and Generator Load Rejection Test
- (28) 14.2.8.2.28 Reactor Full Isolation Test
- (29) 14.2.8.2.29 Off-gas System Test
- (30) 14.2.8.2.31 Concrete Penetration Temperature Surveys Test
- (31) 14.2.8.2.32 Liquid Radwaste System Performance Test
- (32) 14.2.8.2.33 Steam and Power Conversion System Performance Test
- (33) 14.2.8.2.34 Isolation Condenser (IC) Performance Test
- (34) 14.2.8.2.35.1 Reactor Pre Critical Heatup with RWCU/SDC
- (35) 14.2.8.2.35.2 ICS Heatup and Steady State Operation
- (36) 14.2.8.2.35.3 Power Maneuvering in the FW Temperature Operating Domain
- (37) 14.2.8.2.35.4 Load Maneuvering Capability
- (38) 14.2.8.2.35.5 Defense-in-Depth Stability Solution Evaluation Test

In RAI 14.2-101, the staff identified the five FOAK tests in the final safety analysis report (FSAR), Section 14.2.8.2.35, as Tier 2* information that is subject to NRC review and approval.

The staff requested the applicant to identify these FOAK tests as Tier 2* information in DCD Tier 2, Section 14.2.8.3.35.

In response, the applicant revised Section 14.2.8.2.7, "Core Performance Test," Description Section to italicize the second paragraph and bracket Tier 2* information for a FOAK test observation of reactor stability. In addition, DC applicant revised all of Section 14.2.8.2.35, "ESBWR First of A Kind Tests," to italicize and bracket all Tier 2* information in this section.

The applicant added this change to DCD Tier 2, Revision 6, Section 14.2.8.2.35. Therefore, RAI 14.2-101 is resolved.

SRP Section 14.2 and RG 1.68 provide general guidance on the conduct of the ITP after the completion of pre-operational testing. Following verification of SSC functional capability during pre-operational testing, the ITP transitions to initial fuel loading, pre-critical testing, initial startup, low-power testing, and power ascension testing. After core loading, sufficient tests and checks will be performed to ensure that the facility will be in a final state of readiness to achieve criticality and perform low-power testing.

As described in RG 1.68, after the initial reactor startup, low-power testing will be conducted to: (1) confirm the design, (2) validate analytical models and verify, to the extent practical, that the assumptions used in the safety analysis are conservative, and (3) confirm the operability of plant systems and design features that could not be completely tested during the pre-operational test phase because of the lack of an adequate heat source for the reactor coolant system (RCS) and the main steam system. Power ascension testing will be conducted to demonstrate that the facility can be operated in accordance with the design during normal steady-state conditions, and, to the extent practical, during and following anticipated transients. SRP Section 14.2 contains criteria for startup and power ascension testing to ensure that test abstracts include objectives, prerequisites, test methods, and acceptance criteria to establish the functional adequacy of SSCs and design features.

The staff reviewed the initial startup test abstracts in DCD Tier 2, Section 14.2.8.2. In comparing the ESBWR initial startup testing to the testing recommended in RG 1.68, Appendix A Section 2, "Initial Fuel Loading and Precritical Tests"; Section 3, "Initial Criticality"; Section 4, "Low-Power Testing"; and Section 5, "Power-Ascension Tests"; the staff identified several areas where it required additional information to complete its review. Descriptions of the specific issues follow.

14.2.3.11.1 Chemical and Radiochemical Measurement Test

In RAI 14.2-90, the staff noted that DCD Tier 2, Revision 4, Section 14.2.8.2.1 provides an incomplete description of the criteria for radioactivity that are present in gaseous and liquid effluents. Specifically, Section 14.2.8.2.1 limits the criteria to "licensee limitations" and does not include the NRC effluent concentration limits in Table 2 of Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," to 10 CFR Part 20, "Standards for Protection Against Radiation." Accordingly, the staff asked the applicant to revise Section 14.2.8.2.1 (criteria) to include Table 2 of Appendix B to 10 CFR Part 20 as one set of criteria, and to change "license limitations" to "license conditions." This RAI also applied to the criteria identified for the off-gas system test (DCD Tier 2, Section 14.2.8.2.29) and the

LRT performance test (DCD Tier 2, Section 14.2.8.2.32). The staff requested that the applicant revise these sections accordingly.

In response, the applicant agreed to revise Sections 14.2.8.2.1, 14.2.8.2.29, and 14.2.8.2.32 to provide a complete description of the criteria for radioactivity that are present in gaseous and liquid effluents. The applicant added this information to these DCD sections in Revision 5, thereby resolving RAI 14.2-90.

In RAI 14.2-96, the staff asked the applicant to describe the scope of filter performance associated with radiochemical measurements. Specifically, the staff noted that the description should include charcoal media and should clarify that the filters include high-efficiency particulate air (HEPA) filters used for the purpose of controlling airborne radioactive effluent discharges. In addition, the staff noted that the description should include filters and strainers and the reverse osmosis subprocessing system used to process liquid effluents. Accordingly, the staff requested that the applicant revise DCD Tier 2, Section 14.2.8.2.1 (under "Description") to include HEPA filters, charcoal media, filters and strainers, and reverse osmosis subsystems.

In response, the applicant agreed that the "Purpose" description should be extended to include gaseous process streams, so that the Licensee could assess fuel performance for evidence of fission product leakage into the RCS. The applicant also stated that the testing of HEPA and charcoal filters is periodically performed as part of the plant TS. Therefore, it is not appropriate to add this detail to Section 14.2.8.2.1. The applicant also agreed to add carbon filters and reverse osmosis treatment units to Section 14.2.8.1.62. The applicant added the information discussed in the above response to DCD Tier 2, Revision 5, Sections 14.2.8.2.1 and 14.2.8.1.62, thus resolving RAI 14.2-96.

14.2.3.11.2 Radiation Measurements Test

DCD Tier 2, Revision 4, Section 14.2.8.2.2 includes the test descriptions of radiation measurements tests. To verify that the established radiation zones (which determine plant area accessibility) will be accurate, the staff requested in RAI 14.2-94 that the applicant perform radiation surveys throughout the plant for all accessible areas, including all potentially high and very high radiation areas.

In response, the applicant updated DCD Tier 2, Revision 5, Section 14.2.8.2.2 to state that radiation surveys will be performed in all potentially high and very high radiation areas, thus resolving RAI 14.2-94.

14.2.3.11.3 Fuel Loading Test

In RAI 14.2-42, the staff requested additional information regarding the fuel loading test description in DCD Tier 2, Section 14.2.8.2.3. Section 2 of Appendix A to RG 1.68 recommends tests to be performed after the core is fully loaded. Specifically, Item C in Section 2 of Appendix A to RG 1.68 recommends "final functional testing of the RPS to demonstrate proper trip points, logic, and operability of scram breakers and valves." It also recommends that testing "demonstrate operability of manual scram functions." However, in DCD Tier 2, Section 14.2.8.2.3, the testing recommended by RG 1.68 was planned to be conducted before (instead of after) commencing fuel loading. The staff asked the applicant to discuss whether the tests listed above will be conducted after the core is fully loaded or to justify the lack of such a plan.

In response, the applicant stated that Section 2 of Appendix A to RG 1.68 recommends a list of tests and verifications that should be conducted during or following initial fuel loading. The applicant stated that it would remove the bulleted item under Section 14.2.8.2.3 that describes the guidance recommended in Section 2 of Appendix A to RG 1.68 and add it to Section 14.2.8.1.9. The applicant agreed to move the subject tests to the RPS pre-operational test description and stated explicitly that those tests will be conducted during or following initial fuel loading. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Sections 14.2.8.2.3 and 14.2.8.1.9, and finds that the revised text is consistent with RG 1.68 and is acceptable. Accordingly, the staff concludes that the fuel loading test description follows the guidance in RG 1.68 and is therefore acceptable. Thus, RAI 14.2-42 is resolved.

In RAI 14.2-43, the staff requested additional information regarding the fuel loading test description. Section 2 of Appendix A to RG 1.68 recommends that a “prediction of core reactivity should be prepared in advance to aid in evaluating the measured responses to specified loading increments.” The staff asked the applicant to clarify whether it will be prepared to provide predictions of core reactivity and what actions it would take if the measured results deviate from expected values.

In response, the applicant stated that shutdown margin tests provide the greatest assurance of core subcriticality. To that end, the Licensee will make predictions of shutdown margin before initial fuel loading. In addition, the applicant stated that to comply with the requirements of Section 2 of Appendix A to RG 1.68, it will add to the description under DCD Tier 2, Section 14.2.8.2.3, the statement that “Criteria for and actions required to address any deviations from expected results will be delineated in the fuel loading procedures as described in Section 14.2.2.” The staff agreed that shutdown margin tests will provide the assurance of core subcriticality. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.2.3 and finds that the revised text clarifies subcriticality prediction criteria and is acceptable. Accordingly, the staff concludes that the fuel loading test description follows the guidance in RG 1.68 and is therefore acceptable. Thus, RAI 14.2-43 is resolved.

14.2.3.11.4 Neutron Monitoring System Performance Test

In RAI 14.2-78, the staff requested that the applicant provide additional information on the NMS performance test. The staff asked the applicant to include the GT system verification of the NMS performance test in DCD Tier 2, Section 14.2.8.2.6. Specifically, in the section titled “Criteria,” a sentence states, “The LPRMs shall be calibrated consistent with design specifications.” However, this statement does not specify how the LPRMs, including the GT system, will be calibrated.

In response, the applicant stated that in accordance with DCD Tier 2, Sections 7.2.2 and 7.7.6, the LPRMs will be calibrated based upon calibration factors provided by the AFIP GT subsystem. The accuracy of this calibration shall be consistent with the GT Licensing Technical Report in NEDE-33197P, GT System for LPRM Calibration and Power Shape Monitoring.

The applicant added this information in DCD Tier 2, Revision 5, Section 14.2.8.2.6. The staff finds this change acceptable. Therefore, RAI 14.2-78 is resolved.

In RAI 14.2-79, the staff requested that the applicant provide additional information in DCD Tier 2, Section 14.2.8.2.6. Specifically, the staff asked the applicant to clarify the criteria for the SRNM count rates under “design requirements” and the overlapping neutron flux indications under “design specification,” with regard to the criteria found in the TS.

The applicant provided the following response to RAI 14.2-79:

The ESBWR TSs do not specify numerical values for count rates, only “count rates indicative of neutron flux levels within the core.” (Reference DCD, Tier 2, Chapter 16, TS Basis B3.3.1.6, SRP Section 3.3.1.6.4)

DCD Tier 2, Table 7.2-2 provides specific count values required during the SRNM operation.

The ESBWR TSs do not specifically require that the SRNM and LPRM ranges overlap. However, the TS Bases do note the following requirements:

- “The SRNM cover the range of plant operation from source range through startup range (i.e., more than 10 percent of reactor rated power).”
- “The APRM cover the range of plant operation from a few percent to greater than rated power.”

(Reference DCD Tier 2, Chapter 16, TS Basis B3.3.1.6)

- Because “a few percent” APRM is less than “more than 10 percent” SRNM, then an overlap of the two instrument ranges does occur.
- A description of the SRNM and APRM LPRM overlapping ranges is provided in DCD Tier 2, Subsection 7.2.2.1 and on DCD Tier 2, Figure 7.2-3.

Revision 5 to the “Criteria” discussion in DCD Tier 2, Section 14.2.8.2.6, cross-references to DCD Tier 2, Section 7.2.2. On the basis of these changes to DCD Tier 2, Section 14.2.8.2.6, the staff finds that this response is acceptable, and RAI 14.2-79 is resolved.

14.2.3.11.5 Core Performance Test

In RAI 14.2-44, the staff requested additional information regarding the core performance test description in DCD Tier 2, Section 14.2.8.2.7. Specifically, the staff requested that the applicant describe the specific methods for calculating core flows and core power, including the variables that will be obtained from the in-vessel measurement to calculate core flows and core power. The staff also asked the applicant to provide a detailed test plan for testing vessel natural circulation at various power levels after fuel loading and during startup testing.

In response, the applicant provided derivations for the core mass flow rate and core power from mass and energy balance equations. The applicant clearly explained variables in the equations and noted that they will be obtained from in-vessel measurements or from measurements on the coolant systems connected to the reactor, or they will be evaluated based on correlations. This response answered the staff’s question concerning how to calculate core flows and core power, and the staff finds it acceptable.

For the test plan, the applicant clarified that a detailed startup test procedure will be written during the procedure preparation phase, in accordance with the description in DCD Tier 2, Section 14.2.8.2.7. This RAI response identifies the power range for the tests. The applicant will present the written startup test procedure to the NRC for formal review, in accordance with

the SAM preparation scheduling. This response resolves RAI 14.2-44. However, this startup test procedure will be developed as part of COL Information Items 14.2-2-A and 14.2-3-A.

In RAI 14.2-89, the staff asked the applicant to provide a startup testing plan to identify the impacts, if any, of operating at reduced power levels where flow-transition-induced flow oscillations may be possible. In response, the applicant stated that it will add the following information to DCD Tier 2, Section 14.2.8.2.7 under the “Description” section:

A FOAK test will be conducted for observation of reactor stability. The objective of this test is to characterize the stability performance during power ascension, where chimney partition may experience flow-regime-transition-induced flow oscillation. The test will begin at 20 percent thermal power and the first time the reactor achieves a new 5 percent power increment above that point. The test will collect pertinent LPRM data to identify stability performance characteristics and determine a decay ratio during the ascension to rated reactor power. The monitoring LPRM signals are filtered to remove noise components with frequencies above the range of stability related to power oscillation. This data will be collected at sufficient instances to capture the development of instability pattern (if any) that may occur during the ascent to rated power.

With this change in DCD Tier 2, Revision 5, Section 14.2.8.2.7, the staff finds that RAI 14.2-89 is resolved.

14.2.3.11.6 System Expansion Test

The purpose of the thermal expansion test is to confirm that the pipe suspension system is working as designed and the piping is free of obstructions during power changes. Upon completion of the thermal expansion test, the measured and observed pipe expansion should be in accordance with the design, and the piping should return to its approximate cold condition after cooldown. The staff could not determine whether the applicant’s testing program would achieve this objective.

In RAI 14.2-26, the staff asked the applicant to provide the type and source of design performance information that will be used in the development of detailed test procedures for system expansion testing. The staff found that DCD Tier 2, Section 14.2.8.2.9 did not contain sufficient information about the design performance and test procedures for the staff to assess the adequacy of the development of the system expansion test procedures.

In response, the applicant stated the following:

DCD, Tier 2, Subsection 14.2.8.2.9 describes the prerequisites and the acceptance criteria conditions for the thermal expansion testing. Additional detail and special requirements for a thermal expansion test will be performed in accordance with the test procedure that would be developed and evaluated against acceptance criteria.

In DCD Tier 2, Revision 3, Section 14.2.8.2.9, the applicant amended the section to include the test procedure requirements. Based on its review of the revised version of the DCD, the staff finds DCD Tier 2, Section 14.2.8.2.9 acceptable because the applicant provided the test procedure requirements, as requested. Thus, the staff determined that RAI 14.2-26 is resolved.

This is addressed by COL Information Item 14.2-3-A in DCD Tier 2, Revision 6, Section 14.2.2.2.

In RAI 14.2-29, the staff asked the applicant to provide additional information about the system expansion test program schedule and the sequence for conducting the tests planned for the startup test phase. Also, the staff requested that the applicant state the time available between the approval of testing procedures and their intended use.

In response, the applicant stated the following:

Table 14.2-1 provides the test matrix for various systems. DCD, Tier 2, Subsection 14.8.2.2 states that the power ascension test phase procedures will be made available to the NRC 60 days prior to the fuel loading. In addition, to insure the tests are conducted in accordance with the established methods and acceptance criteria, the associated plant testing specification(s) is made available to the NRC.

The staff finds the applicant's response acceptable. The Licensee will develop plant test specifications, test procedures, and acceptance criteria before the fuel loading and will make them available to the NRC. Therefore, the concerns related to RAI 14.2-29 are resolved. This is addressed by COL Information Item 14.2-2-A in DCD Tier 2, Revision 6, Section 14.2.2.1.

In RAI 14.2-30, the staff requested additional information regarding the special test of the effects of thermal stratification in the feedwater discharge piping. Specifically, the staff asked that the applicant address the staff's concern about DCD Tier 2, Section 14.2.8.2.9. The staff found that the section did not contain sufficient information regarding the special tests that will be conducted to monitor the effects of thermal stratification in the feedwater discharge piping to establish the functional adequacy of this piping.

In response, the applicant stated that it will revise DCD Tier 2, Section 14.2.8.2.9 to add requirements to include the acceptance criteria for the effects of thermal stratification in the test procedure for the feedwater discharge piping. In addition, the applicant stated that it will include requirements for thermal expansion testing as requested. The staff reviewed the test abstract in DCD Tier 2, Revision 3, Section 14.2.8.2.9 and finds that the revised text is acceptable. Accordingly, the staff concludes that the system expansion test description addresses the staff's concern, meets the guidance of RG 1.68, and is therefore acceptable. RAI 14.2-30 is resolved.

14.2.3.11.7 System Vibration Test

In RAI 14.2-32, the staff asked the applicant to provide the type and source of design performance information that will be used in the development of detailed system vibration test procedures. In response, the applicant stated that DCD Tier 2, Section 14.2.8.2.10 identifies the critical systems that would require vibration testing. In addition, the applicant revised DCD Tier 2, Section 14.2.8.2.10 to add requirements to the test procedure to include past experience with vibration testing of earlier BWR piping systems as guidance for developing a test procedure description and acceptance criteria. The staff finds that the bases for the development of detailed system vibration test procedures are reasonable and acceptable. Therefore, RAI 14.2-32 is resolved.

In RAI 14.2-35, the staff asked the applicant to provide information about the vibration test program schedule and sequence for the system vibration test phase. The applicant provided

this information in DCD Tier 2, Revision 4, Section 14.2.7, which states (in part) that nine months is allowed for conducting the pre-operational test phase before the fuel loading date, and three months is allowed for conducting the startup and power ascension that commences fuel loading. Test procedure preparations are scheduled such that approved procedures are available to the NRC 60 days before their intended use or 60 days before fuel load for power ascension test procedures. On the basis of this information, RAI 14.2-35 is resolved. This is addressed by COL Information Items 14.2-2-A and 14.2.4-A in DCD Tier 2, Revision 6, Sections 14.2.2.1 and 14.2.7.

14.2.3.11.8 Reactor Internals Vibrations Test (Initial Startup Flow-Induced Vibration Testing)

In RAI 14.2-24, the staff asked the applicant to discuss the expansion, vibration, and dynamic effects test programs for conformance with applicable RGs, including RG 1.20. In response to this RAI, the applicant stated that the development of the test criteria will require consideration of the potential adverse flow effects on piping systems, as recommended in RG 1.20 and in SRP Sections 3.9.2 and 3.9.5. The applicant did not request any exceptions to the regulatory positions recommended in the applicable RGs. In addition, nuclear power plant operating experience has revealed the potential for adverse flow effects from vibration caused by hydrodynamic loads and acoustic resonance within reactor coolant, steam, and feedwater systems, as well as reactor internal components such as steam dryers. However, the system vibration test for the piping systems discussed in DCD Tier 2, Revision 5, Section 14.2.8.2.10 does not address these potential adverse flow effects. Therefore, the staff asked the applicant to describe the implementation of the program to address potential adverse flow effects on safety-related piping and components in these systems. RAI 14.2-24 S01 was being tracked as an open item in the SER with open items.

In its response to RAI 14.2-24 S01, the applicant stated the following:

The following startup measurements, instrumentations and analyses address the potential adverse flow effects on safety-related piping and components in these systems applicable to RG 1.20 requirements:

The details of main steam line acoustic monitoring testing were provided in the response to RAI 3.9-134.

Vibration sensors on susceptible valve operators provide on-line condition monitoring to alert potential valve operator failure due to acoustic resonance. Normally sensors are installed at locations where higher acceleration responses due to dynamic loads, such as seismic and other building filtered loads are expected. The measured values will be compared with manufacturer's or IEEE allowable limits.

Instrumentation inside the safety-related flow systems are evaluated for responses due to vortex shedding and other potential acoustic effect. The thermal well, velocity and pressure sensors in the feedwater and main steam pipes are examples. Similarly, for components in non-safety-related systems where damage of such instrumentations might be carried into safety-related systems, and impact the performance of components such as isolation or check valves, an evaluation will also be performed. The analysis will be performed in

accordance with ASME Appendix N. The calculated stresses will meet American National Standard, ANSI/ASME OM-S/G criteria.

The preoperational and startup test requirements have been provided in the response to RAI 3.9-70. The test hold points are described in the response to RAI 3.9-68.

In accordance with the guidance for flow-induced vibration testing in RG 1.2, the staff reviewed the response to RAI 14.2-24 S01 and finds it acceptable. Therefore, RAI 14.2-24 S01 is resolved.

In RAI 14.2-97, the staff expressed concerns that the discussions of the test description and acceptance criteria for the reactor internals vibration test program (Initial Startup Flow Induced Vibration Testing) in ESBWR Revision 5, Section 14.2.8.2.11, are too broad and general. The staff also indicated that there is no reference to the GEH Licensing Topical Report NEDE-33259P, Revision 1, "Reactor Internals Flow Induced Vibration Program," which contains an item-by-item discussion of the components requiring testing during the startup test program of the first ESBWR, as well as the types and locations of the sensors for monitoring FIV behavior. The applicant should revise the test description in ESBWR Section 14.2.8.2.11 to include a discussion demonstrating conformance with this topical report and other applicable references in the ESBWR DCD. The applicant's current approach to steam dryer load definition is identified as the plant-based load evaluation method, which is discussed in Licensing Topical Report NEDC-33408P, "ESBWR Steam Dryer-Plant Based Load Evaluation Methodology." The development of the FIV loads, as described in this report, is in accordance with RG 1.20, Revision 3. The FIV loads will be used in combination with other design loads in qualifying the steam dryer as described in Licensing Topical Report NEDE-33313P, "ESBWR Steam Dryer Structural Evaluation." The staff requested that the applicant discuss conformance with these licensing topical reports in DCD Tier 2, Section 14.2.8.2.11.

RAI 14.2-97 was being tracked as an open item in the SER with open items.

The applicant provided the following response:

A description of the Flow Induced vibration program and associated startup testing is provided in DCD, Tier 2, Section 3L. Section 3L includes references to topical reports NEDE-33259P, Revision 1, NEDC-33408P, and NEDE-33313P. A reference to DCD Tier 2, Subsection 3.9.2.4 will be added to Subsection 14.2.8.2.11.

The applicant plans to revise DCD Tier 2, Section 14.2.8.2.11 to state:

A complete description of the reactor internals vibration test program is provided in Subsection 3.9.2.4.

The applicant added this information to DCD Tier 2, Revision 6, Section 14.2.8.2.11. Therefore, RAI 14.2-97 is resolved.

14.2.3.11.9 Feedwater Control Test

In RAI 14.2-80, the staff requested additional information regarding DCD Tier 2, Section 14.2.8.2.12. Specifically, the staff asked that the criteria section be expanded to include

open and closed loop testing to check the dynamic flow response of the main feedwater actuators and the dynamic response of the master level controller, respectively.

In response, the applicant stated the following:

During the preoperational test, FWCS open loop and closed loop testing will be performed.

In control system open loop testing, the demand of the low flow controller or the Adjustable Speed Drive feedwater pump speed controller will be adjusted and the feedwater flow will be monitored to check the dynamic response of the feedwater low flow control valve actuator position or variable frequency drive pump speed.

In control system closed loop testing, the master level controller's set point will be adjusted and the feedwater flow and reactor water level will be monitored to check the dynamic response of the FWCS.

In accordance with this response, the applicant plans to revise the "Criteria" description in DCD Tier 2, Section 14.2.8.2.12, as shown below:

The FWCS performance shall be stable such that any type of divergent response is avoided. Through the Open and Closed Loop testing, the response shall be sufficiently fast but with any oscillatory modes of response well damped, usually with decay ratios less than 0.25.

On the basis of this change in DCD Tier 2, Revision 5, Section 14.2.8.2.12, the staff finds this response acceptable. Therefore, RAI 14.2-80 is resolved.

14.2.3.11.10 Plant Service Water System Performance Test

In RAI 9.2-24, the staff requested that the applicant describe in Section 14.2.8.2.18 the automatic actuation of the PSWS standby loop or the actuation of both loops following a loss of power. The applicant should describe how this test will not result in a significant water-hammer event, with the PSWS return aligned to either the natural draft or mechanical draft cooling towers.

In response, the applicant modified a bullet in DCD Tier 2, Revision 6, Section 14.2.8.1.51 to state:

Proper operation of system valves, including automatic air release/vacuum valves, including timing, under expected operating conditions.

The staff finds that this addresses mitigation of water hammer while performing pre-operational testing of the PSWS. The air release/vacuum valves remove any air in the service water system to prevent water hammer before pre-operational testing begins (e.g., starting the service water pumps). The staff finds that the modified bullet in DCD Tier 2, Revision 6, Section 14.2.8.1.51 is acceptable, and it is unnecessary to modify DCD Tier 2, Section 14.2.8.2.18; therefore, this portion of RAI 9.2-24 is resolved.

14.2.3.11.11 Liquid Radwaste System Performance Test

The staff identified an inconsistency in DCD Tier 2, Revision 4, Section 14.2.9 and Table 14.2-1, with respect to the scope of the test matrix assigned during power ascension for the liquid radwaste system (LRS). Specifically, Table 14.2-1 did not include midpower as a testing plateau in confirming the performance of the LRS. This omission was inconsistent with the design objective of the liquid radwaste processing system of DCD Tier 2, Revision 4, Section 11.2, which stated that the system was designed to control, collect, process, handle, store, and dispose of liquid wastes generated during normal operation and anticipated occurrences, without making any distinctions among the various phases of power ascension or operation.

In RAI 14.2-91, the staff requested that in accordance with RG 1.68, the applicant revise DCD Tier 2, Table 14.2-1 to include midpower as a testing phase during reactor power ascension. This change to the LWMS test matrix would make it consistent with the text matrix assigned for the gas waste management system/off-gas system.

In response, the applicant agreed to identify performance testing of the LRS in the midpower plateau as a point to conduct LRS. The applicant added this information to DCD Tier 2, Revision 5, Table 14.2-1 thereby resolving RAI 14.2-91.

14.2.3.11.12 Steam and Power Conversion System Performance Test

In RAI 14.2-54, the staff requested additional information in DCD Tier 2, Section 14.2.8.2.33. Specifically, the staff asked the applicant to provide acceptance criteria for each of the power conversion systems and components, similar to the descriptions of Level 2 acceptance criteria in Section 14.2.12.2.39 of the advanced BWR DCD to ensure that all power conversion systems and components meet their design criteria.

In DCD Tier 2, Revision 3, Section 14.2.8.2.33 the applicant added the following information to the "Criteria" section:

Performance characteristics (such as pressures, flows, temperatures, voltage, amps) of the various systems in the power conversion systems and related subsystems will be monitored and the data obtained will be evaluated against the systems process flow diagrams or equivalent design basis information. Any deviations observed will be evaluated to determine the cause and significance of the deviation.

In addition, in its response to RAI 14.2-54, the applicant stated that the test specifications and test procedures to be created for each plant will provide the detailed test criteria, including the level of the criteria that defines the actions required if the test criteria are not met. This is COL Information Item 14.2-3-A, which will be available to the NRC 60 days before its intended use. The staff finds these changes to DCD Tier 2, Revision 3, Section 14.2.8.2.33 and the COL information item acceptable. Therefore, RAI 14.2-54 is resolved.

14.2.3.11.13 Turbine Trip and Generator Load Rejection Test

DCD Tier 2, Section 8.3.1.1 states that the unit auxiliary transformers provide normal preferred offsite power or generator island mode power to each of the plant's two power generation and plant investment protection load groups.

The applicant did not include a demonstration of the generator island mode operation. In RAI 14.2-100, the staff asked the applicant to include in DCD Tier 2, Section 14.2.8.2 the main generator island mode operation test or provide justification for not including this test in the startup test program.

In response, the applicant stated the following:

In DCD Tier 2, Subsection 14.2.8.2.27, the method of testing the turbine trip and generator load rejection will be clarified by adding a statement that delineates which breaker (generator output breaker or switchyard breaker) is open in which test. In addition, the test success criteria section that the plant shall not SCRAM following a turbine trip or generator load rejection testing will be removed.

The applicant revised DCD Tier 2, Section 14.2.8.2.27 to state:

From an initial power level of 100%, the main generator is tripped (generator output breaker is open for the turbine trip test and the switchyard breaker is opened for the generator load rejection test) in order to verify the proper reactor and integrated plant response.

The applicant also revised DCD Tier 2, Section 14.2.8.2.27 to state:

For high power turbine or generator trips, reactor dynamic response shall be consistent with predictions based on expected system characteristics and shall be conservative relative to analysis results based on design assumptions.

The applicant added this information to DCD Tier 2, Revision 6, Section 14.2.8.2.27,. Therefore, RAI 14.2-100 is resolved.

14.2.3.11.14 Isolation Condenser System Performance Test

In RAI 14.2-3, the staff requested additional information regarding the IC performance test description in DCD Tier 2, Section 14.2.8.1.63. The staff had concerns about the structural integrity and design of the ICS. The specific concern was leakage in the ICS during testing at the PANTHER-IC facility, which the staff considered an issue of ICS structural integrity that needed to be resolved for the ESBWR design certification. The applicant stated that the O-ring design has been changed to a Helicoflex self-energizing O-ring design that will be more resilient to distortion. The applicant further stated that closing the condensate return valve will be controlled to limit the gradients associated with the shutdown and cooldown of the ICS heat exchanger.

Further, in DCD Tier 2, Table 14.2-1 indicates that the ICS performance test will be conducted at the medium-power (MP) level but not at the high-power (HP) level. Since one of the objectives of the power ascension test should be to demonstrate ICS structural integrity, the staff believes that an ICS performance test at HP is more appropriate because the operating conditions at HP are expected to be more challenging to the structural integrity of the ICS. The staff, therefore, requested that the IC system performance test be conducted at the HP rather than MP level.

In response, the applicant stated that the ascension test matrix (DCD Tier 2, Table 14.2-1) proposes that the ICS be tested at medium (up to about 75 percent rated) power. The applicant

further stated that pressure and temperature, not the reactor power level, affect the structural integrity of the ICS. When the reactor startup begins, the reactor is brought to the rated pressure and temperature at approximately five percent power, as stated in DCD Tier 2, Section 14.2.1.3. As the power level increases, the same rated pressure and temperature will be maintained; therefore, conducting the ICS test at MP will be sufficient. The applicant also stated that testing at HP would not be more challenging from the viewpoint of structural integrity of the ICS. In addition, testing the ICS at MP, instead of HP, would avoid a potential HP transient resulting from IC system cold water injection into the RPV that could challenge thermal limits on the reactor core; therefore, testing the ICS at MP would be more appropriate. On the basis of this information, the staff finds that the applicant's response is acceptable. Therefore, RAI 14.2-3 is resolved.

14.2.3.11.15 Initial Test Program Test Abstract Conclusions

On the basis of its review, the staff determined that the test abstracts provided by the applicant in DCD Tier 2, Revision 9, Section 14.2.8, are consistent with the criteria in RG 1.68 and SRP Section 14.2. Further, since the Licensee will be responsible for the development of detailed test specifications and test procedures, the staff finds that it is acceptable to defer development of the test specifications and test procedures until the COL phase. COL Information Item 14.2-2-A encompasses this issue.

14.2.4 Site Specific Preoperational and Start Up Tests

In DCD Tier 2, Section 14.2.9, the applicant stated the COL Applicant will define any required site-specific pre-operational and startup testing. This is identified in DCD Revision 6 as COL Information Item 14.2-5-A.

In RAI 14.2-15, the staff requested additional information regarding the SSCs and design features listed in Section 14.2.9 of ESBWR DCD Tier 2, which the applicant identified as candidates for exemptions from operating license conditions requiring prior NRC approval for major test changes. The staff asked the applicant to provide the basis for an exemption for each of the listed SSCs.

In response, the applicant deleted the list of specific systems in DCD Tier 2, Section 14.2.9, and revised the section to denote that the COL Applicant will list any tests to be performed as part of the power ascension test phase that are proposed to be exempt from operating license conditions requiring prior NRC approval for major test changes and the basis for the exemption. The applicant included a list of systems that are related to site-specific aspects of the plant that need testing to demonstrate their capability to meet performance requirements and acceptance criteria. Below are the systems that may require such testing:

- Electrical switchyard and equipment
- Site security plan
- Personnel monitors and radiation survey instruments
- Automatic dispatcher control system (if applicable)

The applicant also stated that if tests are identified as requiring an exemption from operating license conditions after the COL application has been submitted, the Licensee will identify the tests requiring an exemption and the basis for the exemption.

The staff reviewed the applicant's response to this RAI. Regulatory Position C.1 of RG 1.68 specifies criteria for determining which SSCs and design features must be tested. Certain tests during the initial startup test phase may be subject to license conditions requiring prior NRC approval for major test changes. For such instances, the applicant deferred this responsibility to the COL Applicant. The staff finds that this was consistent with RG 1.68 and therefore acceptable. The staff also reviewed DCD Tier 2, Revision 3, Section 14.2.9, and finds that the revised text appropriately addresses the staff concern and is acceptable. Therefore, RAI 14.2-15 is resolved.

14.2.5 Summary of COL Information Items

The staff finds that all ITP COL information items are in accordance with RG 1.68 and SRP Section 14.2; therefore, they are acceptable.

14.2.1-A Description - Initial Test Program Administration

A description of the initial test program administration is developed and made available to the NRC by the COL Applicant (Section 14.2.2.1).

14.2.2-A Startup Administrative Manual

The COL Applicant will provide milestones for completing the SAM and will make it available for NRC inspection (Section 14.2.2.1).

14.2.3-A Test Procedures

The COL Applicant will provide milestones for making available to the NRC approved test procedures that satisfy the requirements for the ITP (Section 14.2.2.2).

14.2.4-A Test Program Schedule and Sequence

The COL Applicant will provide a milestone for completing the detailed testing schedule and for making it available to the NRC (Section 14.2.7).

14.2.5-A Site-Specific Tests

The COL Applicant will define any required site-specific pre-operational and startup testing (Section 14.2.9).

14.2.6-A Site-Specific Test Procedures

The COL Applicant will provide milestones for making available to the NRC approved test procedures that satisfy the requirements for the ITP (Section 14.2.9).

14.2.6 Conclusions

The staff reviewed the RAIs noted below and finds that these RAIs: (1) were outside the scope of RG 1.68 and SRP Section 14.2, (2) resulted in a change to another DCD section and were addressed in those sections of this report, (3) did not result in any change or were very minor editorial comments on DCD Tier 2, Section 14.2, or (4) were already discussed in another RAI in Section 14.2 of this report. Therefore, Section 14.2 of this report does not discuss RAIs 14.2-1, 14.2-2, 14.2-14, 14.2-22, 14.2-23, 14.2-25, 14.2-27, 14.2-28, 14.2-31, 14.2-33, 14.2-34, 14.2-45, 14.2-49, 14.2-52, 14.2-56, 14.2-58, 14.2-60, 14.2-61, 14.2-62, 14.2-67, 14.2-69, 14.2-71, 14.2-72, 14.2-83, 14.2-84, 14.2-87, and 14.2-88. The staff considers the RAIs listed above to be resolved.

The staff completed its review of the ESBWR ITP in accordance with the requirements of 10 CFR 52.47; 10 CFR 50.34; 10 CFR 52.79; and Criterion XI, of Appendix B to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities". The staff concludes that the applicant has provided sufficient information in the ITP to test all SSCs important to safety and adequately addressed the methods and guidance in SRP Section 14.2 and in RG 1.68. The staff concludes that the applicant has resolved all open items related to the ITP; therefore, the applicant's ITP is acceptable.

14.3 Inspections, Tests, Analyses, and Acceptance Criteria

This section provides the selection criteria and processes used to develop the ESBWR ITAAC. This section addresses ESBWR DCD Tier 2, Revision 9, Section 14.3 and ESBWR DCD Tier 1, Revision 9.

14.3.1 Selection Criteria and Methodology for Tier 1

Summary of Application

DCD Tier 2, Revision 9, Section 14.3, discusses the criteria and methodology for selecting the SSCs to be included in the ITAAC. This section includes definitions and general provisions, design descriptions, ITAAC, significant site parameters, and significant interface requirements. It specifically addresses the ITAAC for the SSCs within the scope of the ESBWR DCD. In addition, this section addresses the proposed ESBWR design acceptance criteria (DAC) for specific areas for which a design process has been prescribed to produce predictable and acceptable designs. DCD Tier 2, Revision 9, Section 14.3 also includes a proposed approach for completing the design-related ITAAC (i.e., DAC).

DCD Tier 1, Revision 9, provides the results of the implementation of DCD Tier 2, Section 14.3, selection criteria and methodology for determining the SSCs described throughout DCD Tier 2. These need to be included in the ESBWR DCD Tier 1 verification program to ensure that an ESBWR facility has been constructed and will operate in accordance with the design certification.

Regulatory Basis

10 CFR 52.47(b)(1) requires that the design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act, and the rules and regulations of the NRC.

Office of the Secretary of the Commission (SECY)-90-377, "Requirements for Design Certification under 10 CFR Part 52," dated November 8, 1990 and its associated staff requirements memorandum (SRM) dated February 15, 1991 provide Commission guidance on the level of detail that a design certification application should reflect. In addition, SECY-90-241, "Level of Detail Required for Design Certification under Part 52," and its associated SRM; SECY-91-178, "Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for Design Certifications and Combined Licenses;" SECY-91-210, "Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) Requirements for Design Review and Issuance of a Final Design Approval (FDA)," dated July 16, 1991, and SECY-92-214, "Development of Inspections, Tests,

Analyses, and Acceptance Criteria (ITAAC) for Design Certifications,” dated June 11, 1992, provide Commission guidance on the development and use of ITAAC included in the licensing process described in 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants.” In SECY-92-053, “Use of Design Acceptance Criteria During 10 CFR Part 52 Design Certification Process,” dated February 19, 1992, the staff discussed a method for using the DAC, together with detailed design information, during the 10 CFR Part 52 process for reviewing and approving designs. The NRC intended the DAC to be used for applications that do not provide design and engineering information at a level of detail customarily considered by the staff in reaching a final safety decision, and primarily for areas of design that are subject to rapidly changing technologies. Finally, SECY-05-0197, “Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria,” dated October 28, 2005, discussed the use of programmatic emergency planning ITAAC.

Section 14.3 of NUREG-0800, except as noted in this report, establishes the regulatory basis for acceptance of the ITAAC associated with a design certification application and, specifically in this case, the ESBWR DCD. RG 1.206 gives COL Applicants guidance for the development of site-specific ITAAC and the use of ITAAC contained in a certified design.

In DCD Tier 2, Revision 9, Section 14.3, the applicant provided the selection criteria and processes used to develop the DCD Tier 1 ITAAC. The DCD Tier 1, Revision 9, information provides the principal design bases and design characteristics that are certified by the 10 CFR Part 52 rulemaking process and that would be included in the ESBWR design certification rule.

Technical Evaluation

The staff reviewed DCD Tier 2, Revision 9, Section 14.3 for conformance with the guidance contained in SRP Section 14.3.

In DCD Tier 2, Sections 14.3.1 and 14.3.2, the applicant discussed the NRC regulatory guidance it used to develop the selection methodology for DCD Tier 1 information. These sections describe the content and format of the DCD Tier 1 information and include a table of contents; lists of tables, illustrations, abbreviations, and acronyms; an introduction section; design descriptions and ITAAC; non-system-based material; interface material; and site parameters. The sections also discuss in detail the selection criteria and DCD Tier 2 review methodology for including the SSCs in DCD Tier 1, Section 2.0. These sections discuss the format and content of the ITAAC; the criteria for developing and selecting the design commitments; the inspections, tests, and analyses that are prescribed to verify that the design commitment was met; and the acceptance criteria for determining the successful completion of the verification method. The applicant also discussed the interface between the verification performed under DCD Tier 1 and the initial plant test program. The staff reviewed the information provided by the applicant in DCD Tier 2, Sections 14.3.1 and 14.3.2 in accordance with SRP Section 14.3. The staff finds it consistent with the staff review guidance and concludes that it is acceptable. As a result, the staff concludes that the applicant’s implementation of the selection criteria and methodology will result in the design descriptions and ITAAC necessary to demonstrate that the facility has been constructed and will operate in accordance with the certified design.

In DCD Tier 2, Section 14.3.3, the applicant discussed non-system-based material included in DCD Tier 1, Section 3.0, whose design descriptions and associated ITAAC for design and

construction activities apply to more than one system. This section includes the basis for using the DAC and discusses the limited use of DAC for piping systems and components, software development for I&C, and human factors engineering (HFE). In addition, this section provides summary discussions of DCD Tier 1 information associated with radiation protection, the ITP, the design reliability assurance program (D-RAP), post-accident monitoring instrumentation, and environmental qualification (EQ) of mechanical and electrical equipment. The staff reviewed the information provided by the applicant in DCD Tier 2, Section 14.3.3 in accordance with the guidance contained in SRP Section 14.3, as well as the Commission policy on the use of DAC contained in SECY-90-241, SECY-91-178, SECY-91-210, SECY-92-053, and SECY-92-214 and their associated SRMs. The staff finds the applicant's use of the DAC to be consistent with NRC guidance and established NRC policy. As a result, the staff concludes that the information provided by the applicant in DCD Tier 2, Section 14.3.3 is acceptable.

In DCD Tier 2, Section 14.3.4, the applicant discussed the interface material included in DCD Tier 1, Section 4.0. This section explains the regulatory basis for the interface requirements, the scope of these requirements with respect to the use of site-specific designs to support the ESBWR system designs, and the selection criteria and methodology for the interface requirements. This section specifies that applicants for a license that references the ESBWR standard design are responsible for ensuring that their applications include site-specific designs that comply with these interface requirements, along with any necessary verification requirements included in site-specific ITAAC. In DCD Tier 2, Section 14.3.5, the applicant discussed the site parameters included in DCD Tier 1, Section 5.0. This section describes the site parameters as the basis for the ESBWR standard design and represents them as a bounding envelope of site conditions for any license application referencing the ESBWR design. The discussion provides the regulatory basis for the inclusion of site parameters in DCD Tier 1 and requires any license applicant that references the ESBWR standard to demonstrate that the characteristics for the selected site are within the ESBWR certification envelope. The staff reviewed the information provided by the applicant in DCD Tier 2, Sections 14.3.4 and 14.3.5, in accordance with SRP Section 14.3. The staff finds it consistent with the staff's review guidance and concludes that it is acceptable. As a result, the staff finds that the applicant's criteria for establishing interface requirements and site parameters are acceptable.

In DCD Tier 2, Section 14.3.6, the applicant summarized the application of its selection criteria and methodology for generating DCD Tier 1 information and presenting DCD Tier 1 results. In DCD Tier 2, Section 14.3.7, the applicant discussed the regulatory basis and evaluation process for changing the design descriptions and the ITAAC provided in DCD Tier 1 for the ESBWR design and for determining site-specific ITAAC. The applicant provided specific criteria for determining the appropriate level of detail and content for general DCD Tier 1 content, design descriptions, and ITAAC. In DCD Tier 2, Section 14.3.8, the applicant described the regulatory basis and the overall ITAAC content for COL applications. This section reiterates the guidance provided in RG 1.206 and specifies that the overall ITAAC content for a COL application must include site-specific ITAAC as well as ITAAC for design certification, emergency planning, and physical security hardware. In DCD Tier 2, Section 14.3.9, the applicant provided a more detailed discussion of the site-specific ITAAC, along with references to the appropriate guidance contained in RG 1.206. DCD Tier 2, Section 14.3.10 contains a consolidated list of the information items that any COL application referencing the ESBWR standard design must contain. This section includes COL information items for emergency planning ITAAC and site-specific ITAAC for systems not included in the scope of an ESBWR design certification. The applicant provided references in DCD Tier 2, Section 14.3.11. The staff reviewed the information provided by the applicant in DCD Tier 2, Sections 14.3.6 through 14.3.11, in

accordance with SRP Section 14.3. The staff finds the information consistent with the staff's review guidance contained in SRP Section 14.3. The staff concludes that it is acceptable.

The applicant provided a tabulation summarizing the types of systems described in DCD Tier 2 and their graded treatment for inclusion in the design descriptions and ITAAC in DCD Tier 1. A separate tabulation summarizes the test, inspection, or analysis approach used to verify ITAAC design commitments and the application of this approach for complying with the ITAAC acceptance criteria. The staff reviewed these tables in accordance with SRP Section 14.3. The staff finds the information consistent with the staff's review guidance and concludes that it is acceptable.

The applicant provided selection criteria and a process for including SSCs in DCD Tier 1 at an appropriate level of detail, in accordance with a graded approach commensurate with the safety significance of the SSCs for the ESBWR design. The applicant selected this top-level information from the design descriptions provided in DCD Tier 2 of the ESBWR DCD, identified the principal performance characteristics and safety functions of the SSCs to be verified appropriately by the ITAAC, and included design-specific and unique features of the ESBWR, as appropriate. The ITAAC included those SSCs that were determined to be risk-significant in the probabilistic risk assessment (PRA), including SSCs that were selected for special treatment in accordance with the regulatory treatment of nonsafety systems (RTNSS). In addition, the selection criteria and process included important insights and assumptions from the PRA; integrated plant safety analyses such as those for fires, floods, and severe accidents; and shutdown risk. Based on its review of the applicant's selection criteria and process for identifying DCD Tier 1 information contained in DCD Tier 2, Section 14.3, the staff finds that the applicant's process is consistent with the guidance contained in SRP Section 14.3 and is therefore acceptable. The applicant did not, however, provide cross-references in DCD Tier 2, Section 14.3 showing where key parameters from the analyses discussed above are addressed in the DCD Tier 1 information. These analyses include the safety analyses of design-basis accidents, severe accidents, flooding, overpressure protection, containment, core cooling, fire protection, transients, shutdown risk, anticipated transient without scram (ATWS), Three Mile Island action plan items, PRAs, and RTNSS. The staff asked GEH in RAI 14.3-405 to provide these cross-references. RAI 14.3-405 was being tracked as an open item in the SER with open items.

In response, GEH added Tables 14.3-1A, 14.3-1B, and 14.3-1C to DCD Tier 2, Section 14.3. Table 14.3-1A includes a list of DCD Tier 1 contents, with an indication of which systems have ITAAC. In Table 14.3-1B, GEH included those design features that are related to a specific transient and accident analysis such as ATWS, overpressure protection, containment, and emergency core cooling. Table 14.3-1C addresses the design features key to the PRA and severe accident insights, including core cooling, flooding, fire, management of molten debris, and RTNSS. In its response, GEH also indicated that during the development of Table 14.3-1C, it determined that additional ITAAC were needed and existing ITAAC needed to be changed to address the key design features. The staff issued RAI 14.3-405 S01, identifying minor changes that GEH needed to make to the tables for clarity and consistency. In response, GEH revised the tables to address the staff's comments. Based on the above discussion, therefore, RAI 14.3-405 and the associated open items are resolved.

During its review of the criteria provided in DCD Tier 2, Section 14.3, the staff identified concerns with criteria for identifying and depicting the basic configuration of the portions of systems that are safety significant, including any components located in those portions of the systems, ensuring consistency between the information provided in the introductory section of

Tier 1 and the criteria provided in DCD Tier 2, Section 14.3, and ensuring that references to NRC guidance included final guidance instead of draft guidance. The applicant adequately addressed these issues in its responses to RAIs 14.3-338, 14.3-339, and 14.3-340. Therefore, these RAIs are resolved.

In DCD Tier 2, Appendix 14.3A, the applicant proposed a DAC closure process for the ITAAC. For a design certification application, NRC regulations neither require nor prohibit such a closure process. However, 10 CFR 52.99 describes a general ITAAC closure process that requires a Licensee to submit an initial schedule for completing the ITAAC and to provide periodic updates throughout construction. The Licensee must submit the initial schedule within one year of the COL issuance or at the start of construction, whichever is later. The applicant discussed the options for closing the DAC following certification of the design through an amendment of the design certification rule, through the COL application review process, and through the DAC after the COL issuance. The applicant chose the latter option after COL issuance and its proposed approach to achieve closure of the DAC will apply to not only the first standard ESBWR plant but to all subsequent ESBWR plants as well.

This standard approach is voluntary on the part of each Licensee referencing the standard ESBWR design. The process envisions an NRC review, inspection, or audit of the DAC completion that applies the “one issue, one review, one position” concept as discussed in RG 1.206, Section C.III.5, to the DAC resolution for the first and subsequent ESBWR plants. A COL Applicant can apply this standard approach to each of the ESBWR design areas that include DAC (i.e., piping design, digital I&C design, and HFE design). The staff finds that this standard approach is consistent with the NRC policy of a design-centered-review approach and is therefore acceptable. In addition, the applicant included a COL information item (COL Information Item 14.3A-1-1), whereby each COL Applicant must provide a DAC closure schedule in the COL application and identify whether the standard approach will be used. Inclusion of this COL information item resolves RAI 14.3-210 and will provide the staff with the information necessary to facilitate its review, inspection, or audit of the DAC resolution.

In addition to its review in accordance with SRP Section 14.3, the staff reviewed ESBWR DCD Tier 1 in accordance with the following SRP Section 14.3 subsections:

- 14.3.2, “Structural and Systems Engineering”
- 14.3.3, “Piping Systems and Components”
- 14.3.4, “Reactor Systems”
- 14.3.5, “Instrumentation and Controls”
- 14.3.6, “Electrical Systems”
- 14.3.7, “Plant Systems”
- 14.3.8, “Radiation Protection”
- 14.3.9, “Human Factors Engineering”
- 14.3.10, “Emergency Planning”
- 14.3.11, “Containment Systems”
- 14.3.12, “Physical Security Hardware”

Organization of Safety Evaluation Report and Reference to Appendix A

The applicant’s DCD Tier 1 document, which was organized based on SSCs, does not provide for direct correlation to the SRP staff review guidance shown above. However, the applicant’s organization of DCD Tier 1 information is acceptable, because it is consistent with previous

design certification applications to the NRC and it facilitates a more efficient staff review of DCD Tier 1 information in conjunction with the DCD Tier 2 information from which it is derived. The information in DCD Tier 1 is cross-cutting in nature and required several staff technical review branches to provide a comprehensive review. To facilitate this comprehensive review of the DCD Tier 1 information, the staff developed a review matrix and included it as Appendix A to this section. Appendix A identifies the SRP sections used to evaluate the SSCs covered in DCD Tier 1, Revision 9, Sections 2 and 3 and the associated sections of this report in which the evaluation is documented.

In DCD Tier 1, the applicant provided the results of its implementation of the selection criteria and methodology used to develop DCD Tier 1 information and ITAAC, as described in DCD Tier 2, Section 14.3. The applicant provided the following information in DCD Tier 1:

- A table of contents and a list of tables, figures, abbreviations, and acronyms
- An introduction that provides definitions of terms used in the DCD Tier 1 information and discusses the treatment of individual items, the implementation of the ITAAC, matters related to operation, the interpretation of figures and a figure legend, and the rated reactor core thermal power
- A section containing the design descriptions including associated tables and figures, and the ITAAC necessary to demonstrate that the facility referencing the ESBWR standard design has been constructed and will operate in accordance with the design certification
- A section containing non-system-based material that discusses the use of the DAC for piping systems and components; digital I&C software development; HFE (including the necessary design completion ITAAC and installation verification ITAAC for these areas); and areas of the ESBWR standard design that are applicable to more than one system including radiation protection, ITP, D-RAP, post-accident monitoring instrumentation, and the EQ of mechanical and electrical equipment
- A section containing the provisions and/or specifications for interface material that license applicants referencing the ESBWR standard design must provide in their applications
- A section containing the site parameters upon which the ESBWR standard design is based and that applicants must demonstrate are parameters enveloping the site characteristics for the locations where they have chosen to build and operate the ESBWR design

The staff's review of the DCD Tier 1 information resulted in a large number of RAIs that included requests for clarification, completeness, and consistency as well as format issues. These requests are summarized as follows:

- Provide complete and correct lists of acronyms.
- Provide clarifications of definitions included in the DCD Tier 1 introduction by expanding and/or adding definitions.
- Ensure accuracy and consistency of the scope of ITAAC verification activities that reference tables and figures in the design description.
- Ensure identification of all DAC within the appropriate ITAAC tables.

- Clarify changes to DCD Tier 1 from previous revisions of the DCD.
- Ensure consistency between the design descriptions in DCD Tier 1 and the design information in DCD Tier 2.
- Ensure consistency of terminology and language between the design descriptions and the “design commitment” entries in the ITAAC table.
- Ensure clear and consistent use of numbering schemes for ITAAC entries that will allow for greater clarity when documenting successful ITAAC completion.
- Ensure consistency of terminology and language across the entries in the “design commitment”; “inspections, tests, analyses”; and “acceptance criteria” columns of ITAAC.
- Clarify ambiguities in the design descriptions, design commitments, and acceptance criteria to facilitate objectivity and to avoid subjective interpretations about whether compliance with the acceptance criteria has been achieved.
- Ensure that cross-references between ITAAC tables are consistent and accurate (e.g., for functions such as minimum inventory of alarms, displays, controls, and status indications in the main control room [MCR]; equipment qualification; digital instrumentation; and control software development).
- Clarify the use of simulated signals versus actual signals for verifying the proper functioning of I&C items such as alarms and detectors (e.g., radiation source calibration versus simulated signal calibration).
- Clarify whether testing of components is in-situ or via a test facility (i.e., shop testing or type-testing).
- Provide consistency in the use of terminology related to regulatory requirements, industry standards, and guidance (e.g., “complies with” versus “conforms to”; “retains its pressure boundary integrity at its design pressure” versus “retains its pressure boundary integrity at internal pressures that will be experienced during service”).
- Clarify measurements of timing and/or other performance values where measurement tolerances, minimums, maximums, or ranges of values are necessary to clarify acceptance criteria.

For the sake of brevity, the individual RAI numbers are not provided here. However, the RAIs that were tracked as open items in the SER with open items are discussed in the following sections of this report. The following discussions consider other areas of staff inquiry and evaluation. In Sections 14.3.2 through 14.3.12 of this report, the staff discusses its review of DCD Tier 1 in accordance with SRP Sections 14.3.2 through 14.3.12 and focuses its discussions primarily on the RAIs that dealt with specific SSC performance requirements.

ITAAC for ASME Code Systems

The staff identified several issues during its review of ITAAC for systems designed to meet the requirements in Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (referred to as the ASME Code). The staff requested greater clarity,

consistency, and organizational separation of the design completion and installation verification activities in the ITAAC tables. In addition, the staff requested that the acceptance criteria clearly identify requirements applicable to design completion and installation. In particular, the staff requested that the applicant included specific reference to the requirements of the ASME Code, such as design reports, ASME Code reconciliations, and data reports. These staff requests applied to all ASME Code systems included in the ITAAC. In addition, the staff requested that the associated definitions for “reports” and ASME Code Reports be clearly articulated in the definition section for Tier 1 information. Several RAIs addressed format, content, and consistency of the ITAAC for ASME Code systems and structures. The following sections of this report discuss these RAIs, which include RAIs 14.3-131, 14.3-213, 14.3-351, 14.3-352, 14.3-353, 14.3-354, 14.3-368, and 14.3-384. The staff discussed with the applicant its efforts to refine these ITAAC. The staff was tracking these RAIs as open items in the SER with open items.

Technical Evaluation for “No Entry” Systems

The applicant included a number of systems in DCD Tier 1 that have no safety-related, risk-significant, or regulatory compliance function. The applicant identified these systems in DCD Tier 1 by title only and indicated that no ITAAC are necessary. The staff identified these “no entry” systems in Appendix A to this report and reviewed them in accordance with the guidance contained in SRP Section 14.3. The staff finds the inclusion of these “no entry” systems in DCD Tier 1, without any associated ITAAC, to be in conformance with SRP Section 14.3 and therefore acceptable.

Technical Evaluation of Initial Test Program

In DCD Tier 1, Section 3.5, the applicant provided an overview of the ITP and a commitment that states that COL Applicants referencing the certified design will implement an ITP that meets the objectives presented in DCD Tier 2, Section 14.2. As stated by the applicant, ITAAC intended to verify ITP implementation are neither necessary nor required.

The staff reviewed the DCD Tier 1 information in accordance with the guidance provided in SRP Section 14.3. The staff noted that in DCD Tier 1, the applicant made a high-level commitment to an ITP in accordance with SRP Section 14.3.10. In addition, the applicant provided a general description of its pre-operational and power ascension test programs and the administrative controls that will govern the conduct of the ITP. The applicant also provided adequate justification in DCD Tier 2, Section 14.3 for not including an ITAAC for the ITP in DCD Tier 1.

Current regulations do not require ITAAC for the ITP for several reasons:

- The system-specific ITAAC delineate the specific testing necessary to verify design features and performance aspects of the design. DCD Tier 1 certified design material (CDM), when applied to the ITP, should consist of a high-level commitment to an ITP and a description of the program and major program documents that constitute an acceptable ITP (i.e., a site-specific SAM, test specifications, and test procedures).
- The ITP covers a broader spectrum of time than the ITAAC cover. Although the applicant must complete pre-operational testing before fuel load, it will conduct the ITP startup and power ascension testing after fuel load. As the ITP involves testing after fuel load, it is not appropriate to define associated ITAAC entries, as 10 CFR Part 52 specifies that the ITAAC will be completed before fuel load.

On the basis of the staff's review of the material in ESBWR DCD Tier 1 and a review of the selected methodology and criteria for the development of DCD Tier 1 contained in ESBWR DCD Tier 2, Section 14.3, the staff concludes that the ITP is appropriately described in DCD Tier 1 and is therefore acceptable.

Technical Evaluation Design Reliability Assurance Program

The staff's review of the D-RAP information in DCD Tier 1 was being tracked as an open item in the SER with open items.

In DCD Tier 1, Revision 4, Section 3.6 the applicant provided the design description and associated ITAAC for the D-RAP. Section 3.6 specified a design commitment that the D-RAP will provide reasonable assurance that the design of risk-significant SSCs is consistent with their risk analysis assumptions. The associated D-RAP ITAAC acceptance criteria ensure that the reliability of each as-built risk-significant SSC is consistent with the reliability assumed in the ESBWR Design PRA.

The staff reviewed the information provided in DCD Tier 1, Section 3.6, in accordance with the guidance provided in SRP Section 14.3. The staff noted that the D-RAP ITAAC should not solely be based on numerical values, because some numerical estimates (e.g., estimated reliability, assumed reliability) may not be available, and additional aspects of the D-RAP are needed in the D-RAP ITAAC in order to address other key assumptions and risk insights. Therefore, the applicant's D-RAP ITAAC may not be practical or effective in providing reasonable assurance that the plant is designed and constructed in a manner that is consistent with the key assumptions and risk insights for the SSCs within the scope of D-RAP. It is important to have a process that would control reliability/availability of risk-significant SSCs. The staff requested in RAI 14.3-437 that the applicant consider revising the D-RAP ITAAC in DCD Tier 1, Section 3.6 taking into consideration the staff's comments provided above. In response, the applicant revised DCD Tier 1, Section 3.6 and associated D-RAP ITAAC, where the D-RAP ensures that the design of the SSCs within the scope of the reliability assurance program (RAP) is consistent with the risk insights and key assumptions. In the associated D-RAP ITAAC acceptance criteria, all RAP SSCs are designed in accordance with the applicable reliability assurance activities for the D-RAP. The staff concludes that this proposed revision is consistent with the recommendations in Item E of SECY-95-132, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs, SECY-94-084," and is therefore acceptable. The staff confirmed that this revision was incorporated into DCD Tier 1, Revision 7, Section 3.6. Therefore, RAI 14.3-437 is resolved.

Technical Evaluation of Interface Material

In DCD Tier 1, Section 4.0, regarding interface material, the applicant discussed the requirement in 10 CFR 52.79(c) (now 52.79[d]) for a COL Applicant that references the ESBWR design to provide design features or characteristics that comply with the interface requirements for the ESBWR plant design and to provide ITAAC for the site-specific portion of the facility design. In accordance with 10 CFR 52.47(a)(26), the applicant provided site interface requirements for the PSWS, since this system is necessary to support the post-72-hour cooling requirements of the ESBWR plant. The applicant specified the heat removal requirements for the PSWS design as 2.02×10^7 megajoules (MJ) (1.92×10^{10} British thermal units [BTU]) over a period of 7 days without active makeup. The staff reviewed the interface material proposed by the applicant for the PSWS design, in accordance with the guidance provided in SRP Section 14.3 and the applicable SRP Section 14.3 subsections and concludes that it is acceptable.

During the review, the staff identified the lack of interface requirements for the offsite power system as a concern in RAI 14.3-394. Section 14.3.6 of this report discusses this issue.

Technical Evaluation of Site Parameters

Every COL Applicant referencing the ESBWR standard plant design must demonstrate that the site characteristics specific to its COL application fall within the site parameters contained in DCD Tier 1, Section 5.0, which are intended to apply to a wide range of sites for the construction and operation of this plant. The tabulation in DCD Tier 1, Section 5.0, is a consolidation of the site parameters contained in ESBWR DCD Tier 2, Chapter 2. The staff reviewed the tabulation of the ESBWR site parameters provided by the applicant in DCD Tier 1, Section 5.0 for conformance with SRP Section 14.3 and the applicable SRP Section 14.3 subsections. The staff concludes that they are acceptable and consistent with those parameters contained in ESBWR DCD Tier 2, Chapter 2 and are evaluated in Section 2.0 of this report.

14.3.2 Structural and Systems Engineering

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1 information described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR SSCs. The applicant organized its DCD Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1 table of contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A and in accordance with SRP Section 14.3.2.

To facilitate completion of its review, the staff issued a number of RAIs (discussed below) that describe some of its concerns.

RAI 14.3-97: In RAI 14.3-97, the staff requested that the applicant include Types B and C leak rate tests as part of the ITAAC associated with DCD Tier 1, Table 2.15.1. In response, GEH stated, in part, that Type B and C local leak rate testing, as required by Appendix J to 10 CFR Part 50, would be added to DCD Tier 1, Revision 4, Table 2.15.1-1 as ITAAC Items 12 and 13, respectively. In reviewing Tables 2.15.1-1 and 2.15.1-2 of DCD Tier 1, Revision 4, the staff could not confirm that GEH had added ITAAC Items 12 and 13, as indicated in the response. However, the staff noted that ITAAC Item 7 of Table 2.15.1-2 appeared to address the same issue discussed in the GEH response to the RAI. In RAI 14.3-97 S01, the staff requested the applicant to clarify and resolve the above noted inconsistency and omission of ITAAC Items 12 and 13 in Table 2.15.1-2 and confirm, as appropriate, its intent with respect to ITAAC Item 7 in Table 2.15.1-2.

GEH responded that the original response to this RAI indicated that two ITAAC items would be added to Table 2.15.1-1: one for Type B testing and one for Type C testing. In finalizing Revision 4 of the DCD, two changes were made relative to its response to RAI 14.3-97. First, Table 2.15.1-1 was renumbered to become Table 2.15.1-2. Second, instead of adding two new ITAAC items (Item 12 for Type B testing and Item 13 for Type C testing), GEH revised ITAAC Item 7 (Item 4 in DCD Revision 3) to include all Appendix J containment leakage testing. This approach was used because it was recognized that the "design commitment" associated with containment leakage testing is that the containment provides a barrier against the release of fission products, and the performance of all Type A, B, and C tests are necessary to verify the design commitment. Hence, the revision of the DCD was intended to keep the inspections,

tests, and analyses the same, as indicated in the initial response, but to more accurately state the design commitment associated with Appendix J leak testing.

The staff reviewed ITAAC Item 7 in DCD Tier 2, Revision 4, Table 2.15.1-2 and determined that it included the appropriate Type B and C local leak rate testing information. On the basis of the above information, RAI 14.3-97 is resolved.

RAI 14.3-178: In RAI 14.3-178, the staff requested that GEH clarify its intent for verification of diaphragm floor and vent wall structures. Specifically, DCD Tier 1, Revision 4, Section 2.15.3 (page 2.15-24) states, in part, that “(5) The diaphragm floor and vent wall structures that separate the DW (drywell) and WW (wetwell) retain their integrity when subject to pressure at or above design pressure.” The staff was not clear as to the exact meaning and intent of the phrase: “...when subject to pressure at or above design pressure.” The staff asked GEH to clearly define the meaning of the term “above design pressure” and justify its use. GEH responded that the design commitment for the diaphragm floor and vent wall structures is to retain their integrity when subjected to the design differential pressures as defined in DCD Tier 2, Table 6.2-1. The associated inspections, tests, and analyses describe testing as part of the structural integrity test, which is specified for the containment system boundary in DCD Tier 1, Section 2.15.1, in accordance with Article CC-6000 of ASME Code, Section III, Division 2. The code specifies a test pressure of at least 1.15 times the design pressure for the containment structure and a differential test pressure for the internal structures to be at least 1.0 times the design differential pressure. GEH committed to revise DCD Tier 1, Section 2.15.3, Item (5) and Table 2.15.3-2 to clarify these requirements.

The staff reviewed the response to RAI 14.3-178, including GEH’s markup of DCD Tier 1, Section 2.15.3, Item 5, and Table 2.15.3-2, and determined that the applicant provided adequate clarification. The staff checked DCD Tier 1, Revision 9, Section 2.15.3 item (5) and Table 2.15.3-2 to confirm that the modified text properly reflected the GEH response. Based on the above information, RAI 14.3-178 is resolved.

RAI 14.3-179: In RAI 14.3-179, the staff requested GEH to address an ambiguous statement related to the decay of fission products in the reactor building (RB). Specifically, DCD Tier 1, Revision 4, Section 2.16.5, RB, states, in part, that “(4) The RB offers some holdup and decay of fission products that may leak from the containment after an accident. Assuming a loss-of-coolant accident (LOCA), the offsite dose limits and the control room dose limits are met based on a 50 wt percent per day leakage rate from the RB.” The staff determined that the sentence “The RB offers some holdup and decay of fission products...” stated above was ambiguous and needed additional clarification regarding item (4) above. GEH responded that the first sentence in item (4) would be revised to read as follows: “The RB provides holdup which allows time for radioactive decay of fission products that may leak from the containment after an accident.”

The staff reviewed the above response, including the GEH markup of DCD Tier 1, Section 2.16.5, and determined that the applicant had provided adequate clarification. The staff checked DCD Tier 1, Revision 9, Section 2.16.5 item (4) to confirm that the modified text properly reflected the GEH response. Based on the above information, RAI 14.3-179 is resolved.

RAIs 14.3-296, 14.3-297, 14.3-383 and 14.3-386 discussed staff requests for the applicant to clarify its terminology in order to achieve greater specificity and reduce the potential for misinterpretation of whether or not the ITAAC have been met:

With respect to ITAAC Table 2.1.2-3, RAI 14.3-296 requested the applicant either to provide a definition for “Nuclear Island” or revise it to refer to the RB or another seismic Category I structure, as applicable. The staff noted that the use of the term “Nuclear Island” is typical throughout the ITAAC and indicated that the applicant should ensure that all other applicable ITAAC are appropriately revised.

With respect to ITAAC Table 2.1.2-3, RAI 14.3-297 requested that the applicant clarify the meaning of “a seismic structure” or refer to a specific building (e.g., the RB or other building, as appropriate, which has its own ITAAC to verify its seismic pedigree) in the acceptance criteria.

With respect to ITAAC Table 2.15.4-2, RAI 14.3-383 requested that the applicant either provide a definition for “Nuclear Island” or replace it with a reference to the appropriate seismic Category I structure (e.g., the RB) for which another ITAAC is provided to verify its seismic pedigree.

With respect to ITAAC Table 2.15.7-2, RAI 14.3-386 requested that the applicant either provide a definition for “Nuclear Island” or replace it with a reference to the appropriate seismic Category I structure (e.g., the RB) for which another ITAAC is provided to verify its seismic pedigree.

GEH provided responses to RAIs 14.3-296, 14.3-297, 14.3-383, and 14.3-386 and indicated that it would modify DCD Tier 1 to replace the terms “Nuclear Island” or “seismic structure” with the term “seismic Category I structure” throughout the ITAAC Tables. GEH also clarified that the seismic Category I structures discussed in DCD Tier 2, Section 3.8 include the concrete containment, RB, control building (CB), fuel building (FB) and fire water service complex.

The staff reviewed the above responses, including the GEH markup of DCD Tier 1, Tables 2.1.1-3, 2.1.2-3, 2.2.4-6, 2.3.1-2, 2.4.1-3, 2.4.2-3, 2.5.10-1, 2.6.1-2, 2.15.4-2 and 2.15.7-2, and determined that the applicant provided adequate clarification. Based on the above information, RAIs 14.3-296, 14.3-297, 14.3-383, and 14.3-386 are resolved.

RAI 14.3-358: For ITAAC Item 3 in Table 2.5.5-1, the staff requested that the applicant provide clear criteria for successful performance of a load test. In response, the applicant stated that the test should be performed in accordance with American National Standards Institute (ANSI) N14.6, “Radioactive Materials—Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4,500 kg) or More,” issued January 1993. The staff finds the applicant’s response acceptable, and RAI 14.3-358 is resolved.

RAI 14.3-360: For ITAAC Item 7 in Table 2.5.5-1, the staff requested that the applicant provide clear criteria for successful performance of a load test, such as those provided by an industry standard. The applicant responded by stating that in accordance with its practice, it would load test the fuel handling machine auxiliary hoist(s) to 125 percent of rated capacity. The staff finds the applicant’s response acceptable, and this RAI 14.3-360 is resolved.

RAI 14.3-380: For ITAAC Item 8 in Table 2.15.1-2, the staff requested that the applicant include the specific design pressure in the acceptance criteria to demonstrate compliance with the ASME Code and requested that the design commitment include a reference to ASME Code Section III Division 2, design and construction requirements. In response, the applicant changed the design commitment to state that the containment system pressure boundary retains its integrity at a design pressure of 310 kPa gauge (45 psig). The applicant also changed the acceptance criteria to state that a test pressure at or above 310 kPa gauge

(45 psig) does not affect containment integrity. In RAI 14.3-380 S01, the staff asked the applicant whether the design and test pressures were the same, since ASME does not treat them as such. The staff also asked the applicant to include a reference to the ASME Code that governs the requirements of concrete and steel containments. In response, the applicant made the appropriate revisions by using the term “design pressure” in both the design commitment and the acceptance criteria and by changing the acceptance criteria to state, “Test report documents that the containment system pressure boundary retains its structural integrity when tested and evaluated in accordance with ASME Code, Section III, Division 2, at a test pressure of at least 115 percent of the design pressure of 310 kPa gauge (45 psig).” The staff finds this modification acceptable, because it clarifies the relationship between the design and test pressures and references the correct ASME Code section. Therefore, RAI 14.3-380 is resolved.

RAI 14.3-381: For ITAAC Item 2 in Table 2.15.3-2, the staff requested that the applicant provide a reference to the containment internal structures identified in Table 2.15.3-1. The applicant should have both “inspection and analyses” performed in the inspections, tests, and analyses and should delete the phrase “as documented in the design reports.” In addition, the applicant should clarify the acceptance criteria to state that inspection reports and analyses document the fact that the as-built components of the containment internal structures comply with the requirements in ANSI-AISC N690-06, “Specification for Safety-Related Steel Structures for Nuclear Facilities” The applicant made the requested changes. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-381 is resolved.

RAI 14.3-382: For ITAAC Item 3i in Table 2.15.3-2, the staff requested that the applicant provide a reference to the containment internal structures identified in Table 2.15.3-1 in the inspections, tests, and analyses and acceptance criteria. In addition, the applicant should revise the inspections, tests, and analyses to state, “analyses will be performed on the containment internal structures identified in Table 2.15.3-1 to ensure they meet seismic Category I requirements and can withstand seismic design-basis loads and suppression pool hydrodynamic loads without loss of structural integrity and safety function.” In response, the applicant made the requested revisions but also stated that the containment internal structures can withstand loads generated by design-basis LOCAs, hydrodynamic loads, and annulus pressurization loads in the design commitment and the ITAAC without losing the structural integrity and safety function. The applicant made the other requested changes. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-382 is resolved.

Based on the staff’s review as set forth above, as well as on the applicant’s implementation of the selection criteria and methodology for the development of the DCD Tier 1 information in DCD Tier 2, Section 14.3 the staff concludes that DCD Tier 1 appropriately describes the top-level design features and performance characteristics of the SSCs; the DCD Tier 1 design descriptions associated with the scope of SRP Section 14.3.2 can be verified adequately by the ITAAC; and the DCD Tier 1 information associated with the scope of SRP Section 14.3.2 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1 design descriptions within the scope of SRP Section 14.3.2 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.2 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.3 Piping Systems and Components

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection methodology for DCD Tier 1 as described in Tier 2, Section 14.3, to support the ITAAC for the ESBWR SSCs. The applicant organized its Tier 1 information in the systems, structures, and topical areas format shown in the Tier 1 table of contents. The staff reviewed the DCD Tier 1, Revision 9, information provided by the applicant using the review matrix provided in Appendix 14.3A, in accordance with the SRP Section 14.3.3.

In SECY-92-053, the staff provided the Commission with a method for using the DAC, together with detailed design information, during the 10 CFR Part 52 process for reviewing and approving designs. The staff used this method for design certification applications that did not provide design and engineering information at a level of detail customarily considered by the staff in reaching a final safety decision on the design. The Commission previously issued guidance on the level of design detail required for design certification. The SRM to SECY-90-377 provided the level of detail that the design should reflect.

14.3.3.1 Generic Piping Design

Section 3.12 of this report evaluates the piping design aspects of the ESBWR design provided in DCD Tier 2, Chapter 3. GEH did not provide the complete design information in this design area before design certification because the piping design is dependent upon as-built and as-procured information. Instead, GEH provided the processes and acceptance criteria by which it would develop, design, and evaluate the details of the piping design. GEH provided amplifying information regarding the processes in this area in DCD Tier 2, Section 14.3.3.1. The material in DCD Tier 1, Section 3.1 applies to ESBWR piping systems classified as safety-related systems, as specified in the DCD Tier 1 material for the individual systems in DCD Tier 1, Section 2.

The staff used the SRP guidelines to evaluate the piping design information in DCD Tier 1 and DCD Tier 2 and performed a detailed audit of the piping design criteria, including sample calculations. The staff evaluated the adequacy of the structural integrity and functional capability of safety-related piping systems. The review was not limited to ASME Code Class 1, 2, and 3 piping and supports but included buried piping, instrumentation lines, the interaction of nonseismic Category I piping with seismic Category I piping, and any safety-related piping designed to industry standards other than the ASME Code. The staff's evaluation included the methods of analysis, design procedures, acceptance criteria, and related ITAAC that are to be used for the completion and verification of the ESBWR piping design. The staff's evaluation included both methods to be used for completing the piping design, modeling techniques, pipe stress analysis criteria, pipe support design criteria, and high-energy line break criteria. The staff discussed the development of the DAC in this area in a memorandum to the Commission entitled, "Evaluation of Potential Recommendations to Reduce the Future Use of Design Acceptance Criteria," dated May 6, 2008.

During a public meeting held on October 18, 2007, the staff asked how the piping DAC would be implemented. In response, GEH reworked the ITAAC used to address the piping design and documented a process in DCD Tier 2, Section 14.3.A.1. This section describes the design and the implementation of the process, which is the responsibility of the COL Applicant or Licensee. In multiple RAIs, the staff questioned the process and the terminology used in the ITAAC, including the meaning of the terms used, the documents specified, how they compared with those specified in the ASME Code, and how the piping DAC were differentiated from the other

ITAAC. Through multiple responses, GEH modified the ITAAC so that the actions to be taken were better defined and the ITAAC were more uniform throughout the document. DCD, Tier 1, Revision 5, Section 2 provides component ITAAC on a system basis. In reviewing these ITAAC, the staff identified a number of errors, both in the text and in the tables. In RAI 14.3-414, the staff requested GEH to correct the identified errors in the following six items, as well as others that may have existed in the component ITAAC programs throughout the entire Section 2:

- (1) In Table 2.2.2-7 Item 2.a2, the description of inspections, tests, and analyses for as-built ITAAC was not consistent with the intended revision. In Item 2.a3, the description of the entire fabrication and installation ITAAC was missing.
- (2) In Section 2.4.1 Item 2.a2, the description of the as-built ITAAC was not consistent with the intended revision.
- (3) In Table 2.6.2-2 Item 2.a3, the description of the entire fabrication and installation portion of the ITAAC was missing.
- (4) Section 2.11.1 provided no description of the component ITAAC.
- (5) Table 2.11.1-1 included no component ITAAC.
- (6) In Table 2.15.1-2 Item 2.c1, descriptions of the inspections, tests, and analyses and acceptance criteria for the fabrication and installation portion of the ITAAC were not consistent with the intended revisions.

RAI 14.3-414 was being tracked as an open item in the SER with open items.

The applicant provided a response that addressed all six items in Tier 1 stated above. The applicant revised the ITAAC to include the missing information and to address the identified concerns, and the staff verified that the modifications were made correctly. Accordingly, the staff finds the applicant's response acceptable. Therefore, RAI 14.3-414 is resolved.

The material in DCD Tier 1, Section 3.1 describes the process to develop the piping and component designs for the nuclear safety-related (seismic Category I) systems of the ESBWR design and provides a list of the specific Tier 1 sections that contain ITAAC relevant to the piping and component design. Piping systems that must remain functional during and following a safe-shutdown earthquake (SSE) are designated as seismic Category I and are further classified as ASME Code Class 1, 2, or 3. The piping systems and their components are designed and constructed in accordance with the ASME Code requirements identified in the individual systems of the ESBWR design. DCD Tier 1 ensures that the applicant will design the piping systems to perform their safety-related functions under all postulated combinations of normal operating conditions, system operating transients, postulated pipe breaks, and seismic events. The material in this DCD Tier 1 section also addresses the consequential effects of pipe ruptures such as jet impingement, potential missile generation, and pressure and temperature effects.

GEH has specified six ITAAC in DCD Tier 1 to ensure that the design description includes the design process for piping systems. Four of the ITAAC were placed in each of the systems specified in DCD Tier 1, Section 3.1 as applicable. The first ITAAC requires an ASME Code design report to ensure that components identified as ASME Code, Section III are designed in

accordance with ASME Code, Section III requirements and seismic Category I requirements. The second ITAAC requires that piping identified as ASME Code, Section III be designed in accordance with Section III and seismic Category I requirements. The ASME Code gives the specific contents and requirements of the certified design report. As used in this report, an ASME-certified design report is the design document required by ASME Code, Section III, Subarticle NCA-3550. A certified design report provides assurance that requirements of ASME Code, Section III for design, fabrication, installation, examination, and testing have been met and that the design complies with the design specifications. The third and fourth ITAAC require that the as-installed components and piping identified as ASME Code, Section III be reconciled with the design requirements.

Two of the ITAAC remain in DCD Tier 1, Section 3.1. In the third ITAAC in that section (the first two were moved to the systems sections), SSCs that are required to be functional during and following an SSE are to be protected against or qualified to withstand the dynamic and environmental effects associated with the analyses of postulated failures in seismic Category I and non-safety-related piping systems. In the sixth ITAAC (the fourth and fifth were moved to the systems sections), on an individual component and/or system basis, the as-built SSCs are to be reconciled with the analysis results of the postulated failures in seismic Category I and non-safety-related piping systems.

The staff generated RAIs on the issues discussed below. They were being tracked as open items in the SER with open items.

RAIs 14.3-212 and 14.3-131: In DCD Tier 2, Revision 4, the applicant revised Sections 3.6.2.5 and 3.6.5-1-A. Specifically, DCD Tier 2, Revision 4, Section 3.6.5-1-A stated that the COL Applicant shall provide the information identified in Section 3.6.2.5, while Section 3.6.2.5 lists the information that will be included in the pipe break evaluation report. The applicant also stated that the pipe break evaluation report will be completed in conjunction with closure of ITAAC Item 3 in Table 3.1-1. Furthermore, in response to RAI 14.3-131 S01, the applicant proposed to delete Section 3.6.5-1-A regarding the COL information item, which would have required that the COL Applicant provide details of pipe break analysis results and protection methods. Based on its review of the above information, the staff, in RAI 14.3-212, requested the applicant to provide additional information concerning the pipe break evaluation report. Specifically, the staff noted that ITAAC Item 3 in Table 3.1-1 would require inspection of the as-built pipe break analysis report as opposed to the as-designed pipe break hazards analysis. In RAI 14.3-131 S01, the staff also requested the applicant to address similar pipe break-related issues as contained in ITAAC Table 3.1-1. In response, GEH modified ITAAC Item 3 in Table 3.1-1 to apply to the “as-designed” rather than the “as-built” pipe analysis. The write-up referred to ITAAC 1 through 6, but only five ITAAC were included.

Based on its review of the information provided by the applicant, the staff requested in RAI 14.3-131 S02, Question 4, that the applicant provide additional modifications to ITAAC Table 3.1-1. Specifically, the staff requested that the ITAAC should be revised to state, “as-designed pipe break analysis results” as opposed to “pipe analysis.” The staff requested that this change should also be made under “Inspections, Tests, and Analyses” to refer to the report specified in Section 3.6.2.5 of the DCD. Further, the staff requested that Item 6 should remain and be modified to address the reconciliation with the report specified in Section 3.6.2.5.

GEH provided its response to RAI 14.3-131 S02. Based on its review of that RAI response, as well as on the information provided in Revision 5 of the DCD, the staff found that the “as-built” wording was changed to “as-designed” in Revision 5 of DCD ITAAC Table 3.1-1. In addition,

the staff found that Item 6 was included in that table. However, the staff determined that GEH did not address the staff's concern pertaining to the wording "pipe analysis" of the ITAAC table, and the wording of the ITAAC failed to fully address the COL information item. As written, the new ITAAC called for a report to document the conclusions of the as-designed pipe analysis: (1) that, for each postulated piping failure, the reactor can be shut down safely, and (2) that the reports document the results of the analyses to determine where protection features are necessary to mitigate the consequences of a pipe break. The COL information item would have required the applicant to provide the information identified in DCD Section 3.6.2.5. This section called for a pipe break evaluation report to be completed in conjunction with the closure of ITAAC 3.1-1. The report was to include the following:

- A summary of the dynamic analyses applicable to high-energy piping systems in accordance with Section 3.6.2.5 of RG 1.70, Revision 3. These include sketches of applicable piping systems showing the location, size, and orientation of postulated pipe breaks; the location of pipe whip restraints and jet impingement barriers; and a summary of the data developed to select postulated break locations, including calculated stress intensities, cumulative usage factors, and stress ranges as delineated in the Branch Technical Position 3-4, Revision 2, "Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment." issued March 2007
- For failure in the moderate-energy piping systems, descriptions showing how safety-related systems are protected from the resulting jets, flooding, and other adverse environmental effects.
- Identification of protective measures provided against the effects of postulated pipe failures for protection of each of the systems listed in Tables 3.6-1 and 3.6-2.
- The details of how the functional capability of the MSIV is protected against the effects of postulated pipe failures.
- Typical examples, if any, where protection for safety-related systems and components against the dynamic effects of pipe failures include their enclosure in suitably designed structures or compartments (including any additional drainage system or equipment EQ needs).
- The details of how the functional capabilities of the feedwater line check and feedwater isolation valves are protected against the effects of postulated pipe failures.

Since the information discussed above is associated with the completion of the DAC and the deleted COL information item was previously found acceptable to the staff, the staff requested that the ITAAC require the same design information as previously discussed in the deleted COL information item. RAI 14.3-131 S02, Question 4, was being tracked as an open item in the SER with open items.

In RAI 14.3-131 S03, the staff requested the applicant to modify the ITAAC table to address the above concern of the staff. In response, GEH provided two marked-up pages of DCD Tier 1, ITAAC Table 3.1-1. Specifically, the applicant changed the wording "as-designed pipe analysis report" of Items 3 and 6 of the ITAAC table into "as-designed pipe break analysis results report." The applicant further stated that DCD Tier 2, Section 14.3A states that the content of the pipe break analysis results report referred to in ITAAC Table 3.1-1 is discussed in DCD Tier 2, Section 3.6.2.5, which provides the details of the information required in the pipe break analysis

results report. Based on its review of the information provided by the applicant, the staff determined that the applicant's proposed changes to ITAAC Table 3.1-1 adequately addresses the staff's concerns, because the revised wording in ITAAC Table 3.1-1 is now consistent with the title of the pipe break analysis report included in DCD Tier 2, Section 3.6.2.5. In addition, the revised DCD Tier 2, Section 14.3.A now clearly refers to DCD Tier 2, Section 3.6.2.5. The staff concludes that RAI 14.3-131 S03, RAI 14.3-212, and the associated open items are resolved.

The following RAIs were being tracked as open items in the SER with open items:

RAI 14.3-368: For ITAAC Item 5a in Table 2.6.2-2, the staff requested the applicant to revise the design commitment to use the term "equipment" to be in agreement with the referenced table(s). The staff requested that the safety-related equipment be stated to be seismic Category I and be able to withstand seismic design-basis loads without a loss of safety function. RAI 14.3-368 was being tracked as an open item in the SER with open items.

The applicant's response includes the changes suggested by the staff. The definition of "equipment" in Revision 6 of the DCD also applies to this ITAAC and to any changes in it. The Design Commitment states that the safety-related equipment as listed in Table 2.6.2-1 withstands seismic Category I loads without a loss of safety function.

The three inspections, tests, and analyses respectively, verify: (1) by inspection, that the equipment, including the piping in Table 2.6.2-1, is located in a seismic Category I structure, (2) that the type tests, analyses, and/or a combination of them are performed on the seismic Category 1 equipment using analytical assumptions or stated conditions that bound the seismic Category I design requirements, and (3) by inspection and analyses that the seismic response of the installed equipment, including piping and anchorages, is bounded by the tested or analyzed conditions.

These three acceptance criteria respectively require that: (i) the equipment in Table 2.6.2-1 is located in a seismic Category I structure, (ii) the seismic Category I equipment, including associated piping, can withstand seismic design-basis loads without a loss of safety function, and (iii) the as-installed equipment, including anchorages, have been tested or analyzed under conditions necessary to ensure compliance with seismic Category I design requirements. The staff agrees with the applicant's response and the revisions made to this ITAAC. Therefore, RAI 14.3-368 and the associated open items are resolved.

RAI 14.3-387: For ITAAC Item 3b in Table 2.16.2-2, the staff asked the applicant to clarify in the inspections, tests, and analyses that the "testing or analyzed conditions bound the seismic Category I design requirements."

The inspections, tests, and analyses verify: (1) by inspection that the components in Table 2.16.2-2 are located in a seismic Category I structure, not just a seismic structure, (2) that the type tests, analyses, and/or a combination of both are performed using analytical assumptions or stated conditions that bound the seismic Category I design requirements, and (3) by inspection and analyses that the installed components, including anchorage, are seismically bounded by the tested or analyzed conditions.

Also, the staff requested that the applicant have reports for the three acceptance criteria that conclude: (1) by inspection, that the components are located in a seismic Category I structure, not just a seismic structure, (2) by type tests and/or analysis that the seismic Category I

components can withstand seismic design-basis loads without a loss of safety function, and (3) by inspection and analysis, that the installed components, including anchorage, are seismically bounded by tested or analyzed conditions. RAI 14.3-387 was being tracked as an open item in the SER with open items.

The applicant in its response revised this ITAAC and other ITAAC tables to address the staff's concerns. The staff agrees with the applicant's response and the revisions made to this ITAAC. Therefore, RAI 14.3-387 and the associated open items are resolved.

Additionally, the following RAIs were being tracked as open items in the SER with open items and are similar in nature to RAIs 14.3-368 and 14.3-387 but were associated with different ITAAC tables:

RAI 14.3-352 (associated with ITAAC Item 13 in Table 2.2.4-6)

RAI 14.3-353 (associated with ITAAC Item 5 in Table 2.4.1-3)

RAI 14.3-354 (associated with ITAAC Item 5 in Table 2.4.2-3)

RAI 14.3-384 (associated with ITAAC Item 5 in Table 2.15.4-2)

As with the responses to RAIs 14.3-368 and 14.3-387, the staff agrees with the applicant's response to these RAIs. The above RAIs and associated open items are resolved.

RAI 14.3-349: For ITAAC Item 1 in Table 2.2.2-7, the staff requested that the applicant revise the acceptance criteria for the CRD system to address the results of inspections, tests, and type tests, not just inspections. The applicant revised the acceptance criteria to state, "A report exists that documents the results of inspection(s), test(s), and type test(s) that confirm the as-built CRD system conforms with the functional arrangement defined in Table 2.2.2-1 and as shown in Figure 2.2.2-1." The staff finds the applicant's response acceptable. Therefore, RAI 14.3-349 is resolved.

RAI 14.3-357: For ITAAC Item 2 in Table 2.5.5-1, the staff requested that it include both inspections and analyses. When the applicant made this change, the staff asked if this ITAAC was consistent with the Tier 2 material. The applicant then changed Tier 2 to state that the refueling machine in the RB was seismic Category I. The staff finds these responses to be acceptable. Therefore, RAI 14.3-357 is resolved.

RAI 14.3-359: For ITAAC Item 6 in Table 2.5.5-1, the staff asked the applicant to include a design commitment for the seismic qualification of the fuel handling machine in the FB. In addition, the staff requested that the applicant modify the inspections, tests, and analyses portion of the ITAAC to clearly state that "inspections and analyses... will both be performed." The applicant stated that it would revise the design commitments for ITAAC Items 2 and 6 in Table 2.5.5-1 to show that both the FB fuel handling machine and the RB refueling machine are seismic Category I. The applicant also revised the inspections, tests, and analyses for Item 6 to include both inspections and analyses. The staff asked if this ITAAC was consistent with Tier 2 material. The applicant later changed Tier 2 to state that the RB refueling machine was seismic Category I. The staff finds these responses to be acceptable. Therefore, RAI 14.3-359 is resolved.

RAI 14.3-366: For ITAAC Item 2 in Table 2.6.2-2, the applicant should (1) verify design completion in an ASME design report; (2) reconcile the as-built installation with the design documents in an ASME design report; and (3) verify in an ASME data report that the SSCs are fabricated, constructed, and installed in accordance with the design documents. The applicant,

in response to RAI 14.3-131 S02, provided a revision that added the previously missing steps. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-366 is resolved.

RAI 14.3-377: For ITAAC Item 2 in Table 2.15.1-2, the applicant should ensure that the ITAAC includes the performance of the following three steps for each of the components and piping: (1) verifies the design and documents that are in an ASME design report, (2) verifies the reconciliation of the design with as-built installation and documents that are in an ASME design report, and (3) verifies that the SSC is fabricated, constructed, and installed per the design and documents that are in an ASME data report. The applicant provided a response that addressed all three elements stated above. The staff finds the applicant's response to be acceptable. Therefore, RAI 14.3-377 is resolved.

RAI 14.3-378: For ITAAC Item 4i in Table 2.15.1-2, the design commitment referred to "components and piping," while the inspections, tests, and analyses and acceptance criteria referred only to "components." The staff requested that the applicant make the design commitment, inspections, tests, and analyses, and acceptance criteria consistent in scope. Also, the inspections, tests, and analyses referred to a "hydrostatic or pressure test," while the acceptance criteria referred only to a "pressure test." The staff requested that the applicant ensure consistency between the inspections, tests, and analyses and acceptance criteria and noted that this ITAAC involves ASME equipment, whereas the hydrostatic test requirements (not pressure testing) would normally be the applicable requirement. The applicant revised the inspections, tests, and analyses and acceptance criteria to use the phrase "components and piping" and changed the acceptance criteria to refer to "hydrostatic testing." The staff finds the applicant's response to be acceptable. Therefore, RAI 14.3-378 is resolved.

RAI 14.3-388: For ITAAC Item 1 in Table 3.1-1, the staff requested that the applicant (1) provide a reference table that would list all of the safety-related piping for which this ITAAC is applicable, (2) clarify or provide a distinction between design commitment and as-built verification (the ASME Code Certified Stress Report only provides verification of the design of the system), and (3) provide an ITAAC to verify the as-built system was constructed in accordance with the ASME Code. The applicant provided a list of systems and components in Section 3.1 of its DCD that are subject to ASME Code, Section III requirements. The applicant also specified in the respective ITAAC for the other sections of the DCD that ASME Code Design Reports will be used to close the DAC ITAAC and to verify that the as-built piping, components, and/or structures subject to Section III of the ASME Code meet the design requirements. In addition, separate ITAAC will be used to verify that those same piping, components, and structures are fabricated, installed, and inspected based on the results recorded in ASME Code Data Reports. The applicant deleted ITAAC Items 1 and 2 in Table 3.1-1 and developed ITAAC in other sections of the DCD to address the applicant's responses for this RAI. The staff finds the applicant's responses to be acceptable. Therefore, RAI 14.3-388 is resolved.

Based on the staff's review as set forth above,, as well as on the applicant's implementation of the selection criteria and methodology for the development of the DCD Tier 1 information in Section 14.3 of DCD Tier 2, the staff concludes that the top-level design features and performance characteristics of the SSCs are appropriately described in Tier 1, and the Tier 1 information associated with the scope of SRP Section 14.3.3 is acceptable.

Furthermore, the staff concludes that the Tier 1 design descriptions within the scope of SRP Section 14.3.3 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.3 are necessary and sufficient to assure

that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, then a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.3.2 Verifications of Components and Systems

In addition to addressing piping and component design, the staff confirmed that DCD Tier 1 addresses the verification of piping and component classification, fabrication, dynamic and seismic qualification, and selected testing and performance requirements through specific ITAAC in the individual DCD Tier 1 systems.

In RAI 14.3-180, the staff questioned ASME Code applicability to the chimney and partitions, the chimney head and steam separator assembly, and the steam dryer assembly. In its response to RAI 14.3-180, GEH modified the design description, equipment list, and ITAAC to include the internal structures of concern. The staff finds that the changes addressed its concerns. Therefore, RAI 14.3-180 is resolved.

The following examples discuss some of the other concerns that the staff identified during its review that were resolved as a result of RAI responses:

In RAI 14.3-210, the staff requested that GEH provide a COL information item requiring the applicant to provide a closure schedule for the DAC in its COL application. In its response to RAI 14.3-210, GEH included a COL information item to address the staff's concerns. COL Information Item 14.3A-1-1 requires each applicant to provide a DAC ITAAC closure schedule in the COL application and identify whether the standard approach will be used. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-210 is resolved.

RAI 14.3-367: For ITAAC Item 4 in Table 2.6.2-2, the design commitment referred to "piping and components;" however, the inspections, tests, and analyses and acceptance criteria referred only to "components." The staff requested that the applicant ensure consistency among the associated design commitment, inspections, tests, and analyses, and acceptance criteria. In addition, the staff requested clarification of the phrase "a hydrostatic or pressure test" used in the inspections, tests, and analyses. The staff discerned no need for a distinction when ASME Code Section III requirements are applied. Likewise, the use of the term "pressure test" in the acceptance criteria should be clarified or modified to be consistent with the inspections, tests, and analyses. The applicant made some of the requested modifications. However, in its response, the applicant used the term "pressure test" instead of the more acceptable term "hydrostatic test," which is the preferred test of the ASME Code. The applicant made the requested modifications in the DCD for the ESBWR in Revision 5 by modifying the inspections, tests, and analyses and acceptance criteria to use the term "hydrostatic test." The staff finds the applicant's responses to be acceptable. Therefore, RAI 14.3-367 is resolved.

RAI 14.3-371: For ITAAC Item 2 in Table 2.10.1-2, the staff requested that the applicant revise the acceptance criteria to (1) identify the components omitted from the test, and (2) document the reason the component was omitted from hydrostatic testing and indicate whether an alternative test (alternative to hydrostatic testing) was conducted to verify pressure boundary integrity. The applicant revised the acceptance criteria to explain that the LWMS piping systems will be hydrostatically pressure tested in conformance with the requirements in the American Petroleum Institute or ASME Codes and in accordance with RG 1.143, Revision 2, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed

in Light-Water-Cooled Nuclear Power Plants,” issued November 2001. The ITAAC meets the recommendations of RG 1.143, Section 4.4. The applicant stated it would make an assessment of any components that might be omitted from the hydrostatic test, when developing the test procedure for hydro-testing the system, since the determination of appropriate alternate testing could only be made based on the specific system design configuration. Pneumatic or manufacturer type testing are examples of alternative testing that could be used to demonstrate system leak integrity.

The staff did not find the applicant’s response completely acceptable and requested the following revisions. The inspections, tests, and analyses should include a hydrostatic test on the LWMS piping systems with exceptions that are in accordance with RG 1.143, Revision 2, and the applicant should revise the acceptance criteria to document: (1) that the results of the hydrostatic test of the LWMS piping systems was in accordance with ASME/ANSI B31.3, (2) that it conformed to the requirements of the ASME Code and RG 1.143, Revision 2, and (3) that no unacceptable pressure boundary leakage occurred. The applicant made these revisions in ESBWR DCD Tier 2, Revision 5. The staff finds the applicant’s responses to be acceptable. Therefore, RAI 14.3-371 is resolved.

RAI 14.3-372: For ITAAC Item 4b in Table 2.10.3-1, the staff requested that the applicant modify the acceptance criteria to specifically define “treat mode alignment” to mean that a MCR alarm will sound and gas will flow through the charcoal beds. An alternative was to define “treat mode alignment” in the design description for the LWMS. The applicant chose to define the term “treat mode alignment” within the ITAAC itself. The staff finds the applicant’s response to be acceptable. Therefore, RAI 14.3-372 is resolved.

RAI 14.3-373: For ITAAC Item 1 in Table 2.12.1-1, the staff asked the applicant to provide a list of the makeup water system penetrations and isolation valves referred to in the ITAAC as being in Section 2.15.1 or provide a suitable justification for not including such a list. The applicant included a new Table 2.15.1-1a that lists the valves and penetrations. The staff finds the applicant’s response to be acceptable. Therefore, RAI 14.3-373 is resolved.

Based on the staff’s review as set forth above, as well as on the applicant’s implementation of the selection criteria and methodology for the development of the DCD Tier 1 information in DCD Tier 2, Section 14.3, the staff concludes that the top-level design features and performance characteristics of the SSCs are appropriately described in Tier 1, and the Tier 1 information associated with the scope of SRP Section 14.3.3 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.3 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.3 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria met, then a facility referencing the certified (ESBWR) design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.4 Reactor Systems

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1, Revision 9, information, as described in Tier 2, Revision 9, Section 14.3, to support the ITAAC for the ESBWR SSCs. The applicant organized the Tier 1 information using the systems, structures,

and topical areas format shown in the DCD Tier 1, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A and in accordance with SRP Section 14.3.4.

The staff found that many of the systems within the scope of review of SRP Section 14.3.4 were classified as safety-related, and thus many of the characteristics and features of these systems were judged to have safety significance. This is reflected in a higher level of detail in the ITAAC for these systems. The staff reviewed the ITAAC to verify that plant safety analyses, such as for core cooling, transients, overpressure protection, and anticipated transients without scram, were adequately addressed. The staff used the tables contained in DCD Tier 2, Sections 6.3, 15.2, and 15.3 to determine if the important input parameters used in the transient and accident analyses were verified by the ITAAC. The staff also interacted with specialists in PRA and severe accident analyses to ensure that the ITAAC incorporated the important insights and design features from these analyses. For the severe accident analyses, in particular, the basis for the staff's review was the Commission guidance in SECY-90-016, "Evolutionary Light-Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," dated January 12, 1990, and SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs." dated April 2, 1993.

For both PRA and severe accident analyses, design features important for severe accident prevention and mitigation resulting from these analyses were selected for treatment in the ITAAC. The supporting information regarding the detailed design and analyses remain in DCD Tier 2. The staff determined that the detailed supporting information in DCD Tier 2 for the nuclear fuel, fuel channel, and control rod CDM, if considered for a change by a COL Applicant or Licensee that references the certified ESBWR design, would require prior staff review under the criteria of 10 CFR 50.59. Thus, the staff has concluded that the fuel cycle and control rod design criteria in DCD Sections 4B and 4C, the first cycle fuel, control rod and core design, and the methods used to analyze these components, may not be changed without prior NRC review and approval. (This information is designated as Tier 2* in the DCD.) The specific fuel, control rod, and core designs presented in DCD Chapter 4 will constitute, based on the staff's review and approval, an approved design that may be used for the COL first cycle core loading without further NRC review. If any other core design is requested for the first cycle, the COL Applicant or Licensee will be required to submit, for the staff's review, specific fuel, control rod, and core design analyses as described in DCD Tier 2, Revision 9, Chapters 4, 6, and 15.

Based on the guidance provided in SRP Section 14.3, Tier 2* information is information that is generally not appropriate for treatment in Tier 1 because it is subject to change. As such, the staff believes that no ITAAC are required for the CDM information in the areas discussed above. In addition, the ITAAC must be performed prior to fuel load. Therefore, verification that the actual core performs in accordance with the analyzed core design are addressed in post-fuel-load testing programs (e.g., startup testing and power ascension testing).

As a result of its review, the staff identified a number of RAIs involved in requests for the applicant to provide additional definitions in DCD Tier 1, Sections 1 and 2 and to further clarify ITAAC Items 1, 3, 4, 5, and 7 for RPV systems in DCD Tier 1, Table 2.1.1-3. The requested information was to improve overall understanding of the design commitment and ITAAC stated in Table 2.1.1-3. The applicant incorporated the definitions in the appropriate sections and modified Table 2.1.1-3 accordingly. The staff finds that these changes are acceptable.

The applicant resolved several staff concerns through the RAI process, including the following examples:

RAI 14.3-356: For ITAAC Item 8a in Table 2.4.2-3, the staff asked the applicant to modify the inspections, tests, and analyses to include “analysis” and to modify the acceptance criteria to include test results, in addition to the analysis results. The staff also asked the applicant to provide specific acceptance criteria to determine acceptability. The applicant made the revisions in the inspections, tests, and analyses and the acceptance criteria, except for including specific acceptance criteria for acceptability. The applicant stated that existing acceptance criteria for acceptability were appropriate. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-356 is resolved.

RAI 14.3-370: For ITAAC Item 7b in Table 2.6.2-2, the inspections, tests, and analyses specifies the performance of a test for both the flow path and capacity, while the acceptance criteria only refers to flow path. The staff requested that the applicant modify the acceptance criteria to include the flow rate criteria for acceptance. The applicant modified the acceptance criteria to include the flow rate. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-370 is resolved.

In response to RAI 14.3-180, GEH added Chimney and partitions, Chimney head, steam separator assembly, and steam dryer assembly to Table 2.1.1-1. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-180 is resolved.

In response to RAI 14.3-189, GEH added the pressure loss coefficient in Table 2.1.2-3 for the following components: Steam Separator, Fuel Bundle, Fuel support piece orifice, Control Rod Guide Tubes, and Shroud Support. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-189 is resolved.

DCD Tier 1, Revision 9, Section 2.2.2 includes the design description and associated ITAAC for the CRD system (Table 2.2.2-1) and a detailed system drawing (Figure 2.2.2-1). In its response to RAI 4.6-21 regarding an unspecified electric-motor drive speed, GEH revised ITAAC No. 3 to verify the specified motor speed. The staff considers the applicant’s response to be acceptable. Therefore, RAI 4.6-21 is resolved. Since the “electric scram” is a backup to the hydraulic scram, the motor speed is not safety significant. Hence, the ITAAC for the motor speed was deleted.

In its response to RAI 4.6-24 regarding the clarification of scram insertion requirements, GEH revised the DCD to require verification testing of the “maximum allowable scram insertion times for each FMCRD,” instead of the “average of all FMCRDs.” The applicant revised DCD Tier 1, Section 2.2.2 and Table 2.2.2-1 and DCD Tier 2, Section 4.6.1.2.4 to clarify the scram insertion requirements. The staff considers the RAI response acceptable, since defining the maximum scram insertion time for each FMCRD is consistent with the same requirements in the standard TS for the current fleet of operating BWRs. Therefore, RAI 4.6-24 is resolved.

DCD Tier 1, Section 2.2.2 states that each HCU “also provides the flow path for purge water to the associated drives during normal operation.” In response to RAI 4.6-24 regarding this mode and any other CRD system lineup and their potential impact on scram insertion, the applicant stated that “as long as the scram accumulator remains charged, there is no operating mode of the CRD system that can impact the scram insertion mode.” The response subsequently described the features of the system that maintain the capability of the scram function. The CRD system design description provided in DCD Tier 1, Section 2.2.2, along with the ITAAC in Table 2.2.2-1, provide sufficient design specification and validation testing to ensure that the

ESBWR CRD system will satisfy the applicable regulatory criteria. DCD Tier 2, Section 4.6.3.2 offers additional details on the CRD system design. Based on this information, RAI 4.6-25 is resolved.

The staff reviewed DCD Tier 1, Section 2.2.4, SLCS, including the ITAAC presented in Table 2.2.4-6. In RAI 9.3-15, the staff requested that GEH add an ITAAC in Table 2.2.4-6, to verify that the initial SLC injection flow rate is consistent with the assumptions in the safety analysis. In DCD Tier 1, Revision 5, the acceptance criteria for ITAAC Item 7 in Table 2.2.4-6 specified that the first and second 5.4 m³ of boron solution injects in less than or equal to 519 seconds during the ATWS. In addition, in DCD Tier 1, Revision 5, the acceptance criteria for ITAAC Item 8 in Table 2.2.4-6 specified that test and analysis reports exist and conclude that the as-built SLC system (both accumulators) injects a total volume of 15.6 m³ boron solution in response to a LOCA. Based on the revisions provided in DCD, Revision 5, as described above, the staff finds the response to RAI 9.3-15 acceptable.

In response to RAI 14.3-202, GEH revised the acceptance criteria for ITAAC Item 13 in Table 2.4.1-3 to include the ICS condensate return valve opening time of no less than 7.5 seconds and no greater than 31 seconds. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-202 is resolved.

In response to RAI 14.3-149, GEH added GDCS deluge system functions in the design description and included associated ITAAC Items 22, 25, 26, and 27 to verify these functions in Table 2.4.2-3. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-149 is resolved.

The following RAIs were being tracked as open items in the SER with open items:

RAI 14.3-397: In RAI 14.3-397 regarding DCD Tier 1, Figure 2.1.1-2, the staff requested the applicant to indicate the relative locations of the startup range neutron monitors, low-power range monitors, neutron sources, and spare source locations in a manner similar to DCD Tier 2, Figure 4.1-1. In addition, the staff requested the applicant to include the quantities in the figure legend. In response, GEH revised DCD Tier 1, Figure 2.1.1-2 indicating the relative locations of the NMS and the quantities. Therefore, RAI 14.3-397 and the associated open item are resolved.

RAI 14.3-398: In DCD Tier 1, Table 2.1.1-3, Item 9, the ITAAC acceptance criteria for flow-induced vibration testing of fuel bundles is given as one order of magnitude. The staff did not believe that this value was well supported and asked the applicant to provide supporting information in DCD Tier 2 to justify the value. The staff sent supplementary RAIs 4.8-7 S01 to S04 to GEH requesting additional information. In response to the RAIs, GE provided additional information. The staff SER for NEDC-33240P, "GE 14E Mechanical Design Report," includes the discussion for the resolution of this issue. DCD Tier 1, Table 2.1.1-3, Item 9 was revised to delete the criterion of "one order of magnitude." The revised acceptance criterion included in Revision 6 of the DCD is acceptable. Therefore, RAI 14.3-398 and the associated open item are resolved.

RAI 14.3-399: In RAI 14.3-399 regarding DCD Tier 1, Table 2.1.1-3, Item 11, the staff requested the applicant to revise the ITAAC acceptance criteria for the RPV to state... "A report exists and concludes that the as-built reactor system fuel bundle, control rod, instrumentation, and neutron source locations conform to the locations shown on Figure 2.1.1-2." In response, GEH revised the acceptance criteria in Revision 6 of the DCD to verify the as built arrangement.

Since the revised acceptance criteria provides that the installed equipment location conform to the design, it is acceptable. Therefore, RAI 14.3-399 and the associated open item are resolved.

RAI 14.3-400: In DCD Tier 1, Revision 5, Table 2.2.4-5 and Table 2.4.1-2, the “Active Function” column was deleted. The response to RAI 14.3-354 was given as the basis for the deletion. However, the response to RAI 14.3-354 is related to mechanical equipment rather than electrical equipment. Therefore, the staff requested a clarification on the applicability of the response to electrical equipment. As a comparison, the active safety function column was maintained in Table 2.1.2-2. The staff requested that the applicant explain this inconsistency. In response, GEH clarified that the “Active Safety Function” is provided in Table 2.1.2-1 (valve safety-related position). Therefore, RAI 14.3-400 and the associated open item are resolved.

RAI 14.3-401: In RAI 14.3-401 regarding DCD Tier 1, Section 2.4.1, the staff requested that GEH include a statement to indicate that the ICS minimum inventory of alarms, displays, controls, and status indications in the MCR are addressed in DCD Tier 1, Table 3.3-1a, which includes the ICS minimum inventory of MCR alarms, displays and controls. The staff determined the response is acceptable. Therefore, RAI 14.3-401 and the associated open item are resolved.

RAI 14.3-350: For ITAAC Item 9 in Table 2.2.2-7, the staff requested that the applicant modify the inspections, tests, and analyses and acceptance criteria to include verification that the associated interfacing systems specified in Table 2.2.2-3 were functional, based on other ITAAC, and that the list of interfacing systems was complete. The initial change only addressed; (1) the conformance of the CRD system in regard to automatic initiators, functions, and associated interfacing systems, and (2) the use of tests and type tests to generate simulated signals from all interfacing systems. The staff found the content of the initial change to be acceptable, as far as it goes, but requested that this ITAAC be reformatted to resemble the ITAAC for RAI 14.3-348. The applicant could do this by using tests and type tests to generate simulated signals of the initiators to perform the automatic functions of the CRD system listed in Table 2.2.2-3.

In response, the applicant indicated that the two steps in the inspections, tests, and analyses and in the acceptance criteria indicate: (i) that tests and type tests show that the CRD is capable of performing the functions defined in Table 2.2.2-3 using simulated signals initiated from all the interfacing systems specified in Table 2.2.2-3, and (ii) that inspections show that the as-installed CRD system conforms with all the automatic initiators, functions, and associated interfacing systems defined in Table 2.2.2-3. The staff agrees with the applicant’s response and the revisions made to this ITAAC. Therefore, RAI 14.3-350 and the associated open item are resolved.

RAI 14.3-351: For ITAAC Item 12 in Table 2.2.4-6, the staff requested that the applicant identify the type of ASME report that is required (i.e., whether it is a design report or a data report). The staff requested that the applicant review all of its ITAAC associated with ASME systems and components and make the same change, as appropriate.

The applicant revised these ITAAC and similar ones in its response by changing their Design Commitments as requested. The staff also requested the applicant identify the type of ASME report referred to in the ITAAC. The applicant revised the ITAAC to refer to an ASME Code Data Report. The staff agrees with the applicant’s responses and the revisions made to these

ITAAC and other similar ones. Therefore, RAI 14.3-351 and the associated open item are resolved.

Based on the staff's review as set forth, as well as on the applicant's implementation of the selection criteria and methodology for the development of the DCD Tier 1 Revision 9, information in DCD Tier 2, Revision 9, Section 14.3, the staff concludes that DCD Tier 1, Revision 8 appropriately describes the top-level design features and performance characteristics of the SSCs and that the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.4 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.4 can be adequately verified by the ITAAC. Therefore, the staff concludes that the ITAAC within the scope of SRP Section 14.3.4 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.5 Instrumentation and Controls

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection methodology for DCD Tier 1 as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR SSCs. The applicant organized the DCD Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, "Table of Contents." The staff reviewed the DCD Tier 1 information provided by the applicant using the review matrix provided in Appendix 14.3A, in accordance with SRP Section 14.3.5.

In SECY-92-053, the staff provided the Commission with a method for using the DAC, together with detailed design information, during the 10 CFR Part 52 process for reviewing and approving designs. The staff used this method for design certification applications that did not provide design and engineering information at a level of detail customarily considered by the staff in reaching a final safety decision on the design. The Commission previously issued guidance on the level of design detail required for the design certification. The SRM to SECY-90-377 provided the level of detail that the design should reflect.

The applicant may provide the DAC in lieu of detailed system design information in areas where the technology is rapidly changing, such as I&C. The COL licensee must verify the implementation of the DAC as part of the ITAAC performed to demonstrate that the as-built facility conforms to the certified design. In this case, the DAC should be sufficiently detailed to provide an adequate basis for the staff to make a final safety determination regarding the design, subject only to the satisfactory verification of completion of the design (i.e., verification of the DAC) and installation of the completed design by the COL Applicant or Licensee.

The specific areas of review are as follows:

- DCD Tier 1 information on I&C systems involving reactor protection and control, ESF actuation, and other systems using I&C equipment
- DCD Tier 1 information related to the design process of digital computers in I&C systems
- Selected interface requirements related to I&C issues

- Functional requirements of IEEE Std 603 and the GDC when implementing the safety system

The staff reviewed the ITAAC associated with I&C found in ESWBR DCD Tier 1, Sections 2.2.1 through 2.2.15, 2.15.7, 2.3.1, 2.3.2 and 3.2. Other DCD Tier 1 sections and specific ITAAC entries refer to DCD Tier 1, Section 2.2.15 and 3.2 for I&C quality requirements. The staff also considered additional information provided in DCD Tier 1, Sections 3.3, 3.7, and 3.8.

As a result of the staff's review and the RAI process, the applicant refocused on conformance with IEEE Std 603 requirements, as documented in DCD Tier 1, Section 2.2.15.

The following paragraphs provide examples of staff concerns that were resolved through the RAI process.

RAI 14.3-251: In DCD Tier 1, Revision 4, Section 2.2.3 it stated that the FWCS is nonsafety-related and the FWCS is a triple-redundant, fault-tolerant digital controller. The staff asked the applicant to discuss the mode(s) that can control that function and to include the mode(s) in DCD Tier 1, Table 2.2.3-3. To address the staff's concerns, the applicant clarified the intent of DCD Tier 1, Table 2.2.3-1, and in Revision 5 of the DCD, the applicant changed the title of Table 2.2.3-1 to "FWCS Functional Arrangement." The staff finds this change to the table to be an acceptable and satisfactory response to the RAI. Therefore, RAI 14.3-251 is resolved.

RAI 14.3-252: In RAI 14.3-252 regarding DCD Tier 1, Revision 4, Table 2.2.3-1, the staff requested clarification on whether the applicant is taking credit for the triple redundant characteristic in the accident analysis. If so, then an adequate design description should be provided in the DCD Tier 1 information. To address the staff's concern, the applicant clarified the intent of the triple redundant characteristic, as requested. Therefore, RAI 14.3-252 is resolved.

RAI 14.3-247: The staff requested that the electrical separation criterion discussed in the Tier 1 information and the associated ITAAC be specific. In Revision 5 of the DCD, the applicant updated the Tier 1 information and the associated ITAAC to specify that the electrical separation criterion complies with the separation requirements in RG 1.75, Revision 3, "Criteria for Independence of Electrical Safety Systems," issued February 2005. The staff finds the response acceptable. Therefore, RAI 14.3-247 is resolved.

RAI 14.3-260: The staff requested the applicant to include the requirement for the controllers in the steam bypass and pressure control (SB&PC) system to be fault tolerant in the design description and associated ITAAC provided in DCD Tier 1. In DCD Tier 1, Revision 5, Section 2.2.9 the applicant included a design commitment for the SB&PC controllers to be fault tolerant in the design description and associated ITAAC table. The staff considers the response to be satisfactory. Therefore, RAI 14.3-260 is resolved.

RAI 14.3-265: The staff requested that all IEEE Std 603 requirements and the method of compliance be addressed in DCD Tier 2, and the ITAAC to verify these compliances should be documented in DCD Tier 1. In Revision 6 of the DCD, the applicant rewrote Section 2.2.15 entirely in response to the concerns raised in RAI 14.3-265. Based on the staff's review of DCD Tier 1, Section 2.2.15, RAI 14.3-265 is resolved.

The following provides a summary of the staff's evaluation of each portion of DCD Tier 1, Section 2.2:

(1) In DCD Tier 1, Section 2.2.1, the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR RC&IS. DCD Tier1, Section 2.2.1 includes the following:

- Table of functional arrangement
- Table of major functional groups
- Table of automatic functions, initiators, and associated interfacing systems
- Table of rod block functions
- Table of controls, interlocks, and bypasses

As an example of the staff's review, the staff requested the following in RAI 14.3-348:

For ITAAC Item 3 in Table 2.2.1-6, the staff requested that the applicant modify the inspections, tests, and analyses and acceptance criteria to include verifications that the associated interfacing systems specified in DCD Tier 1, Table 2.2.1-3 are functional, based on other ITAAC, and that the list of interfacing systems is complete. The applicant's initial change only addressed the conformance of the RC&IS with regard to automatic initiators, functions, and associated interfacing systems and tests and type tests used to generate simulated signals from all interfacing systems. The staff did not find this initial change acceptable, because the simulated signals from the interfacing systems were not shown to generate the stated RC&IS functions in Table 2.2.1-3. In Revision 5 of the DCD, the applicant updated the inspections, tests, and analyses to specify tests and type tests that generate simulated signals for the initiators to perform the automatic functions of the RC&IS listed in DCD Tier 1, Table 2.2.1-3. The staff finds this change acceptable and the issue is resolved.

In summary, the staff reviewed the information in DCD Tier 1, Section 2.2.1 for consistency with the information provided in DCD Tier 2, Sections 7.7.2.2.5, 7.7.2.2.6, 7.7.2.2.7, 7.7.2.3, 7.7.2.4 and 7.7.2.5. The staff finds that the design description provided in DCD Tier 1, Section 2.2.1 and the associated ITAAC specified in DCD Tier 1, Table 2.2.1-6 are sufficient to verify the design of the RC&IS.

(2) In DCD Tier 1, Section 2.2.2, the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR CRD system. DCD Tier 1, Section 2.2.2 includes the following:

- Table of functional arrangement
- Table of CRD maximum allowable scram times
- Table of automatic functions, initiators, and associated interfacing systems
- Table of controls and interlocks
- Tables of mechanical and electrical equipment, including design bases

The staff reviewed the information provided in DCD Tier 1, Section 2.2.2 for consistency with the information provided in DCD Tier 2, Sections 3.9.4, 7.7.2.2, and 7.8.1. The staff finds that the design description provided in Section 2.2.2 and the associated ITAAC specified in Table 2.2.2-7 are sufficient to verify the design of the CRD system.

(3) In DCD Tier 1, Section 2.2.3, the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD

Tier 1 information, as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR FWCS. DCD Tier 1, Section 2.2.3 includes the following:

- Table of functional arrangement
- Table of automatic functions, initiators, and associated interfacing systems
- Table of FWCS controls

The staff reviewed the information provided in DCD Tier 1, Section 2.2.3 for consistency with the information provided in DCD Tier 2, Section 7.7.3. The staff finds that the design description provided in DCD Tier 1, Section 2.2.3 and the associated ITAAC specified in DCD Tier 1, Table 2.2.3-4 are sufficient to verify the design of the FWCS.

- (4) In DCD Tier 1, Section 2.2.4, the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR SLC system. DCD Tier 1, Section 2.2.4 includes the following:

- Table of SLC system automatic functions, initiators, and associated interfacing systems
- Table of SLC system controls and interlocks
- Tables of SLC system mechanical and electrical equipment including design bases

The staff reviewed the information provided in DCD Tier 1, Section 2.2.4 for consistency with the information provided in DCD Tier 2, Sections 7.4.1 and 7.8.1. The staff finds that the design description provided in Section 2.2.4 and the associated ITAAC specified in Table 2.2.4-6 are sufficient to verify the design of the SLC system.

- (5) In DCD Tier 1, Section 2.2.5, the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR NMS. DCD Tier 1, Section 2.2.5 includes the following:

- Table of NMS functional arrangements
- Table of NMS functions, initiators, and associated interfacing systems
- Table of NMS controls, interlocks, and bypasses

The staff reviewed the information provided in DCD Tier 1, Section 2.2.5 for consistency with the information provided in DCD Tier 2, Section 7.2.2. The staff finds that the design description provided in DCD Tier 1, Section 2.2.5 and the associated ITAAC specified in DCD Tier 1, Table 2.2.5-4 are sufficient to verify the design of the NMS.

- (6) In DCD Tier 1, Section 2.2.6 the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR RSS. DCD Tier 1, Section 2.2.6 includes the following:

- Table of RSS functional arrangement
- Table of RSS controls

The staff reviewed the information provided in DCD Tier 1, Section 2.2.6, for consistency with the information provided in DCD Tier 2, Section 7.4.2. The staff finds that the design description provided in DCD Tier 1, Section 2.2.6 and the associated ITAAC specified in DCD Tier 1, Table 2.2.6-3 are sufficient to verify the design of the RSS.

- (7) In DCD Tier 1, Section 2.2.7 the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR RPS. DCD Tier 1, Section 2.2.7 includes the following:

- Table of RPS functional arrangement
- Table of RPS automatic functions, initiators, and associated interfacing systems
- Table of RPS controls, interlocks (system interfaces), and bypasses

In DCD Tier 1, Revision 4, Figure 2.2.7-1 was removed. The staff review guidance in SRP Section 14.3 states the following:

The amount of design information is proportional to the safety-significance of the structures and systems of the design. The level of detail in DCD Tier 1 is governed by a graded approach to the SSCs of the design, based on the safety significance of the functions they perform. The design descriptions include the figures associated with the systems.

The staff's explained this guidance in RAI 14.3-259 and the staff asked the applicant to include a figure depicting the RPS basic configuration block diagram and associated information necessary to verify the functional arrangement of the RPS. RAI 14.3-259 was being tracked as an open item in the SER with open items.

In response to RAI 14.3-259 S01, the applicant stated that it had determined that detailed information, such as in DCD Tier 1, Revision 3, Figure 2.2.7-1, is not appropriate for Tier 1 content and rulemaking based on NRC guidance in NUREG-0800, Section 14.3, regarding the items that are subject to change. After further review, the staff agrees with the applicant's determination. Therefore, RAI 14.3-259 and the associated open item are resolved.

In DCD Tier 2, Revision 5, the applicant modified Section 7.2.1.3.1, to include an anticipatory reactor trip to comply with the requirement of 10 CFR 50.34(f)(2)(xxiii)[II.K.2.10], which states that the reactor will trip in response to the loss of main feedwater. In the ESBWR, this feature is designed as an anticipatory trip actuated upon the loss of power to two of the four main feedwater pumps. This design feature was not included in DCD Tier 1, Section 2.2.7 or in Table 2.2.7-2. In RAI 14.3-403, the staff requested the applicant to include this anticipatory trip in the design description and ITAAC for the RPS. Therefore, RAI 14.3-403 was being tracked as an open item in the SER with open items.

In DCD Tier 1, Revision 6, Section 2.2-7 and Table 2.2.7-2 were revised to add the phrase "Loss of all feedwater event" in parentheses after the "Power Generation Bus Loss" scram initiator. The loss of feedwater flow event is detected by the loss of the power generation bus. This revision clarifies that the loss of all feedwater event is the same as the power generation bus loss scram initiator. DCD Tier 2, Sections 7.2.1.2.4.2, 7.2.1.3, 7.2.1.5.4,

7.3.5.3.1, and 7.4.4.3.1 document this clarification. The staff considers this issue resolved. The staff finds that the design description provided in Section 2.2.7 and the associated ITAAC specified in Table 2.2.7-4 are sufficient to verify the design of the RPS.

- (8) In DCD Tier 1, Section 2.2.8, the applicant did not provide a design description and associated ITAAC. The staff finds this acceptable because no credit is taken for the PAS in the safety analyses nor does failure of the system affect any safety function. The expected design basis accidents analyzed in Chapter 15 envelope the failure modes associated with the PAS digital controls.
- (9) In DCD Tier 1, Section 2.2.9 the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR SB&PC system. DCD Tier 1, Section 2.2.9 includes the following:
- Table of SB&PC functional arrangement
 - Table of SB&PC functions and initiating conditions

The staff reviewed the information provided in DCD Tier 1, Section 2.2.9 for consistency with the information provided in DCD Tier 2, Section 7.7.5. The staff finds that the design description provided in DCD Tier 1, Section 2.2.9 and the associated ITAAC specified in DCD Tier 1, Table 2.2.9-3 are sufficient to verify the design of the SB&PC system.

- (10) In DCD Tier 1, Section 2.2.10 the Q-DCIS is the designation given to the collection of hardware and software that comprises the safety-related portion of the following systems and the associated ITAAC specified in the corresponding DCD Tier 1 sections:
- Platform for the RTIF/NMS
 - Platform for the SSLC/ESFs
 - Independent Control Platform for Vacuum Breaker Isolation Function, ATWS/SLC, and HP CRD Isolation Bypass Function

In its response to RAI 14.3-241, the applicant included a crosswalk to connect the DCD Tier 1 system I&C ITAAC with the software development program described in DCD Tier 1, Section 3.2. With this cross-reference, the staff finds that the design description in DCD Tier 1, Section 2.2.10 and the associated ITAAC are sufficient to verify the Q-DCIS design.

- (11) In DCD Tier 1, Section 2.2.11, the N-DCIS is the designation given to the collection of hardware and software that comprises the non-safety-related I&C of the following systems and the associated ITAAC specified in the corresponding DCD Tier 1 sections:
- N-DCIS Network Segment for diverse protection system (DPS)
 - N-DCIS Network Segment of plant investment protection (PIP) A and PIP B for FAPCS and supporting systems
 - N-DCIS Network Segment of PIP A and PIP B for reactor water cleanup Suction Backup Isolation

In response to RAI 14.3-241, the applicant included a crosswalk to connect the DCD Tier 1 system I&C ITAAC with the software development program described in DCD Tier 1, Section 3.2. With this cross-reference, the staff finds that the design description in DCD Tier 1, Section 2.2.11 and the associated ITAAC are sufficient to verify the N-DCIS design.

(12) In DCD Tier 1, Section 2.2.12, the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR LD&IS. DCD Tier 1, Section 2.2.12, includes the following:

- Table of LD&IS isolation function monitored variables
- Table of LD&IS leakage source monitored variables
- Table of LD&IS controls, interlocks, and bypasses

The staff reviewed the information provided in DCD Tier 1, Section 2.2.12, for consistency with the information provided in DCD Tier 2, Section 7.3.3. The staff finds that the design description provided in DCD Tier 1, Section 2.2.12, and the associated ITAAC specified in DCD Tier 1, Table 2.2.12-5 are sufficient to verify the design of the LD&IS.

(13) In DCD Tier 1, Section 2.2.13, the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR SSLC/EFS. DCD Tier 1, Section 2.2.13 includes the following:

- Table of SSLC/ESF functional arrangement
- Table of SSLC/ESF automatic functions, initiators, and associated interfacing systems
- Table of SSLC/ESF controls, interlocks, and bypasses

The staff reviewed the information provided in DCD Tier 1, Section 2.2.13 for consistency with the information provided in DCD Tier 2, Section 7.3.5. The staff finds that the design description provided in DCD Tier 1, Section 2.2.13 and the associated ITAAC specified in DCD Tier 1, Table 2.2.13-4 are sufficient to verify the design of the SSLC/ESF.

(14) In DCD Tier 1, Section 2.2.14 the applicant provided design-basis information, including associated tables, in accordance with selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR diverse instrumentation and control systems (DICS). DCD Tier 1, Section 2.2.14 includes the following:

- Table of DICS functional arrangement
- Table of DICS functions, initiators, and associated interfacing systems
- Table of DICS controls, interlocks, and bypasses

As a result of its review, the staff noted a concern with the last line in Table 2.2.14-1 that stated, "DPS [diverse protection system] uses hardware and software that is separate and independent from that used by the RPS and SSLC/ESF." The staff stated that it believed that the hardware and software should be diverse in addition to being separate and independent from the RPS and SSLC/ESF. DCD Tier 1, Section 2.2.14, Table 2.2.14-1 did not document the "diverse" design feature. In RAI 14.3-404, the request that the applicant identify the design requirement of diversity in Table 2.2.14-1, RAI 14.3-404 was being tracked as an open item in the SER with open items. In DCD Tier 1, Revision 6,

Section 2.2.14, Item (18) documents that the DPS network segment uses hardware and software diverse from that used by the RPS and SSLC/ESF. The staff finds the clarification acceptable. Therefore, RAI 14.3-404 and the associated open item are resolved.

The staff reviewed the information provided in DCD Tier 1, Section 2.2.14 for consistency with information provided in DCD Tier 2, Section 7.8. The staff finds that the design description provided in DCD Tier 1, Section 2.2.14 and the associated ITAAC specified in DCD Tier 1, Table 2.2.14-4 are sufficient to verify the design of the ESBWR DCIS.

- (15) In DCD Tier 1, Section 2.2.15 the applicant provided design-basis information, including associated tables, in accordance with selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for ESBWR I&C compliance with IEEE Std 603. Section 7.1.1.3.10 of this report addresses the detailed evaluation of the compliance of the ESBWR I&C design with IEEE Std 603.

The staff followed the guidance provided in SRP Chapter 7, Appendix 7.1-C and Appendix 7.1-D to verify that the ESBWR I&C design has addressed all of the criteria listed in IEEE Std 603, as required by 10 CFR 50.55a(h). Because the I&C design has not yet been completed, the applicant is unable to demonstrate conformance to the IEEE Std 603 criteria. The applicant provided the DAC in the ITAAC specified for the systems referenced in DCD Tier 1, Section 2.2.15. The staff reviewed DCD Tier 1, Section 2.2.15, design completion commitments documented as DAC, and determined that the DAC and ITAAC specified in DCD Tier 1, Table 2.2.15-2 are sufficient to verify conformance to the IEEE Std 603 criteria when the design is complete.

- (16) In DCD Tier 1, Section 2.2.16 the applicant provided design-basis information, including associated tables, in accordance with selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR HP CRD isolation bypass function (IBF). DCD Tier 1, Section 2.2.16 includes the following:

- Table of HP CRD IBF functional arrangement
- Table of HP CRD IBF automatic functions, initiators, and associated interfacing systems
- Table of controls, interlocks, and bypasses

The staff reviewed the information provided in DCD Tier 1, Section 2.2.16 for consistency with the information provided in DCD Tier 2, Section 7.4.5. The staff finds that the design description provided in DCD Tier 1, Section 2.2.16 and the associated ITAAC specified in DCD Tier 1, Table 2.2.16-4 are sufficient to verify the design of the HP CRD IBF.

- (17) In DCD Tier 1, Section 3.2 the applicant provided design-basis information including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR I&C software development. Section 7.1.2 of this report addresses the detailed evaluation of ESBWR I&C software development. The staff follows the guidance provided in SRP Chapter 7, Branch Technical Position 7-14, "Guidance on Software Reviews for Digital Computer-based Instrumentation and Control Systems." Because the I&C design

and the associated software development have not yet been completed, the applicant is unable to demonstrate the detailed life cycle design process. The applicant provided the DAC in the ITAAC specified for the systems referenced in DCD Tier 1, Section 3.2, Table 3.2-1. The staff reviewed the DCD Tier 1, Section 3.2 design completion commitments documented as the DAC and ITAAC specified in DCD Tier 1, Table 3.2-1 and finds that the specified DAC are sufficient to verify conformance with design requirements and the SRP review guidance when the design is complete.

- (18) In DCD Tier 1, Section 2.15.7, the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR CMS. DCD Tier 1, Section 2.15.7 includes a table of CMS electrical equipment design bases.

The staff reviewed the information provided in DCD Tier 1, Section 2.15.7 for consistency with the information provided in DCD Tier 2, Sections 7.3, 7.7 and 7.8. The staff finds that the design description provided in DCD Tier 1, Section 2.15.7 and the associated ITAAC specified in DCD Tier 1, Table 2.15.7-2 are sufficient to verify the design of the CMS.

- (19) In DCD Tier 1, Section 2.3.1 the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3 to support the ITAAC for the ESBWR process radiation monitoring system (PRMS). DCD Tier 1, Section 2.3.1 includes a table and figure of the PRMS functional arrangement.

The staff reviewed the information provided in DCD Tier 1, Section 2.3.1 for consistency with the DCD information provided in Section 7.5. The staff finds that the design description provided in DCD Tier 1, Section 2.3.1 and the associated ITAAC specified in DCD Tier 1, Table 2.3.1 are sufficient to verify the design of the PRMS.

- (20) In DCD Tier 1, Section 2.3.2, the applicant provided design-basis information, including associated tables, in accordance with the selection criteria and methodology for DCD Tier 1 information as described in DCD Tier 2, Section 14.3, to support the ITAAC for the ESBWR ARM system. DCD Tier 1, Section 2.3.2 includes a table of ARM system locations.

The staff reviewed the information provided in DCD Tier 1, Section 2.3.2 for consistency with the DCD information provided in DCD Tier 2, Section 7.5. The staff finds that the design description provided in DCD Tier 1, Section 2.3.2 and the associated ITAAC specified in DCD Tier 1, Table 2.3.2 are sufficient to verify the design of the ARMS.

Based on the staff's review as set forth above, as well as on the applicant's application of the selection methodology and criteria for the development of DCD Tier 1 information in Section 14.3 of DCD Tier 2, the staff concludes that the top-level design features and performance characteristics of the SSCs are appropriately described in DCD Tier 1, Revision 9, and the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.5 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.5 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.5 are necessary and

sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, then a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.6 Electrical Systems

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1 information, as described in DCD Tier 2, Section 14.3 to support the ITAAC for ESBWR SSCs. The applicant organized the DCD Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A of this report and SRP Section 14.3.6.

The staff's review generated a number of RAIs which the applicant resolved satisfactorily. The following paragraphs provide examples of several RAIs which have been resolved.

RAI 14.3-129: In RAI 14.3-129, the staff requested that the applicant add design commitments and ITAAC to address the seismic design of the mounting of the components of the four safety-related divisions of the direct current (dc) systems by including the following recommended wording: "Design Commitment - The mounting of the components of the four safety-related divisions of the dc system (batteries, battery chargers, inverters, buses, etc.) conform to seismic Category I requirements; Inspections, Tests and Analyses - An inspection will be performed of the mounting of the components of the four safety-related divisions of the direct current system (batteries, battery chargers, inverters, buses, etc.) to verify that the installed equipment including anchorage is seismically bounded by the tested and/or analyzed condition; acceptance criteria - A report exists and concludes that the as-installed equipment including anchorage is seismically bounded by the tested and/or analyzed conditions." The applicant added a new ITAAC item to address seismic requirements for mounting. The staff finds the applicant's response to be acceptable. Therefore, RAI 14.3-129 is resolved.

RAI 14.3-376: In RAI 14.3-376, the staff requested that the applicant modify the acceptance criteria for ITAAC Item 1 in DCD Tier 1, Table 2.13.3-3 to be consistent with the design certification, either by adding conformance to DCD Tier 1, Table 2.13.3-1 in the acceptance criteria or by revising Table 2.13.3-1 to Section 2.13.3 in the design certification. The applicant modified the acceptance criteria to be consistent with the design certification by adding conformance to DCD Tier 1, Table 2.13.3-1 in the acceptance criteria. The staff finds the applicant's response to be acceptable. Therefore, RAI 14.3-376 is resolved.

RAI 9.5-60 S02: In response to RAI 9.5-60 S01, GEH stated that emergency lighting in the remote shutdown area is fed from the safety-related uninterruptible power supply (UPS) for 72 hours, similar to the power supply arrangement for the MCR emergency lighting. As a result, the staff responded that the ITAAC for the lighting power supply (Section 2.13.8) should be revised to indicate that emergency lighting in the RSS is fed from the safety-related UPS for 72 hours. Specifically, ITAAC Table 2.13.8-1 Items 1 thru 4 should be modified to include the RSS emergency lighting; the design description of Section 2.13.8 should be modified to indicate control room and RSS emergency lighting; and an ITAAC item for electrical isolation between the safety-related power supply and the nonsafety-related emergency lighting in the MCR and RSS should be provided. In response, GEH stated that the emergency lighting in the RSS and MCR is fed from the safety-related UPS. As a result, the applicant committed to the following:

ITAAC for the lighting power supply (DCD Tier 1, Section 2.13.8) would be revised to state the source of emergency lighting power as safety-related UPS; the design description of Section 2.13.8 and the description of ITAAC Table 2.13.8 Items 1 thru 4 would be updated to include MCR and RSS emergency lighting; and, a new item number 6 would be added in ITAAC DCD Tier 1, Table 2.13.8-1 to state that the electrical isolation between the nonsafety-related control room and the RSS emergency lighting circuits from the safety-related UPS is accomplished by using two isolation devices in series. The staff finds that DCD Tier 1, Revision 5, Section 2.13.8 was revised in accordance with the GEH response to RAI 9.5-60 S02. Therefore, RAI 9.5-60 S02 is resolved.

RAI 14.3-206: The ITAAC for the EQ of Mechanical and Electrical Equipment in DCD Tier 1, Section 3.8 includes safety-related mechanical, electrical and digital I&C equipment. In DCD Tier 2, Section 3.11, GEH stated that electrical equipment within the scope of this section includes all three categories of 10 CFR 50.49(b). Staff review determined the ITAAC did not include 10 CFR 50.49(b)(2) and (b)(3) equipment. As a result, the staff requested in RAI 14.3-206 that the applicant include 10 CFR 50.49(b)(2) and (b)(3) equipment in the ITAAC or provide justification for not including that equipment in the ITAAC. In response the applicant stated that DCD Tier 1, Section 3.8 is consistent with SRP Section 14.3 and included safety-related equipment in harsh environments and digital I&C. The staff found that this response to RAI 14.3-206 was not adequate and requested the applicant to ensure that DCD Tier 1, Section 3.8 includes: (1) safety-related electrical equipment, (2) safety-related mechanical equipment, and (3) safety-related digital I&C equipment governed by EQ requirements in 10 CFR 50.49(b)(1), (b)(2), and (b)(3). SRP Section 14.3.6 provides guidance on the EQ of electrical equipment important to safety and states that applicants must ensure that safety-related, certain nonsafety-related, and certain post-accident monitoring equipment can perform their functions in various anticipated environments. The applicant subsequently provided Revision 5 of the ESBWR DCD. Based upon the staff's review of DCD Tier 1, Revision 5, Section 3.8 the staff finds that the applicant had revised Section 3.8 accordingly, and the RAI is closed.

RAI 14.3-345: In RAI 14.3-345, the staff requested the applicant to clarify ITAAC Item 21 in Table 2.2.15-2 to indicate that: each mechanical/electrical division for the systems listed in Table 2.2.15-1 receives power from safety-related power supplies in the same division, and that the means for verification should be tests of each mechanical/electrical division one at a time, along with inspections to verify that the electrical one-line diagrams indicate the correct power sources. The staff also requested that the acceptance criteria for ITAAC Item 5 in Table 2.1.2-3 be revised to indicate that the required reports exist. In addition, the staff requested that ITAAC Item 6b in Table 2.1.2-3 be revised to verify that both physical and electrical independence are provided between the divisions of the NBS and other mechanical systems and between the safety-related equipment of the NBS system and nonsafety-related equipment. Therefore, RAI 14.3-345 was being tracked as an open item in the SER with open items.

The applicant's response provided a DAC and an ITAAC that performed a function similar to that of the original ITAAC. ITAAC Item 21 in Table 2.2.15-2 and the new DAC and ITAAC became Items 22a and 22b in Table 2.2-15-2, respectively. The subject matter of both items is I&C "software projects" (a specific type of microprocessor-based digital architecture unique to one vendor) and not each I&C system. The staff deemed DAC Item 22a acceptable because the Licensee will verify by the review of a design phase summary baseline review record that the vendor had incorporated into design of the software projects the capability to supply the electrical components of each division of the software projects by separate power supplies, and that design aspect was to be further verified by the implementation of ITAAC 22b. The applicant's response also indicated that ITAAC Item 22b was added for which actual tests will

be performed during the installation phase on the as-built software project's electrical components, by providing test signals in one safety-related division at a time to verify that the components receive power from their respective, divisional, safety-related power supplies. The staff accepts the applicant's response for this revised ITAAC because the test provides a direct and visible means for verifying the design capability stated in the Design Commitment of this ITAAC that only the electrical components connected to a power supply in the same division receive the designated test signal, when it is applied to each division of the software projects one at a time. RAI 14.3-345 and the associated open item are resolved.

RAI 14.3-379: In RAI 14.3-379, the staff requested that the applicant clarify the inspections, tests, and analyses and acceptance criteria because there was no clear correlation between the subject matter of the design commitment, which was concerned with the sources of electrical power for the safety-related components listed in DCD Tier 1, Table 2.15.1-1, and the oblique references provided in the inspections, tests, and analyses and the acceptance criteria to just "Tier 1, Section 2.13" of the DCD. The references in the inspections, tests, and analyses and acceptance criteria did not indicate the actions to be taken or the conditions to be met in order to implement or perform this ITAAC. Originally, this ITAAC was Item 6b in DCD Tier 1, Table 2.15.1-2 instead of item 6a. Therefore, RAI 14.3-379 was being tracked as an open item in the SER with open items.

In response, the applicant changed the following: (1) Item 6b became Item 6a, (2) Table 2.15.1-1 was divided into different sections, (3) the design commitment now referred to the "safety-related components associated with actuation and status monitoring of the final control elements of the Containment System components listed in DCD Tier 1, Table 2.15.1-1," (4) the inspections, tests, and analyses was modified to require that tests be performed by providing a test signal in only one safety-related division at a time, and (5) the acceptance criteria stated that test reports indicate that the test signal exists only in the single, safety-related division (or at the equipment powered by the safety-related division) under test. The staff requested GEH to revise the design commitment, inspections, tests, and analyses, and acceptance criteria to refer to "electrical safety-related components" instead of just "safety-related components." The intent of the ITAAC remained the same. In its response, the applicant made the requested change. The staff agrees with the applicant's response because it correlates to the design commitment with the ITAAC and identifies the actions and conditions needed to implement the ITAAC. Therefore, RAI 14.3-379 and the associated open item are resolved.

RAI 14.3-407: In RAI 14.3-407, the staff asked the applicant to include containment electrical penetrations in Tables 2.15.1-1. In response, the applicant stated that the purpose of DCD Tier 1, Tables 2.15.1-1a, 1b, and 1c is to list the containment isolation valves and summarize their functions and positions. The containment electrical penetrations are not operated and do not isolate or reposition on a containment isolation signal. Their containment isolation function is to passively maintain pressure boundary. Because of this, the requirements apply equally to all of the containment electrical penetration assemblies, and they can be addressed on a generic basis. DCD Tier 2, Table 8.1-1 summarizes the applicable design criteria for the design of ESBWR electrical systems. This table indicates that RG-1.63 and IEEE Std 317 are applicable to the ESBWR design. IEEE Std 317, among other things, requires the mechanical design, materials, fabrication, examinations, and testing of the pressure boundary of the electrical penetration assembly to be in accordance with the requirements of ASME Boiler and Pressure Vessel Code Division 1, Section III, Subsection NE for Class MC Components. The applicant stated that a new ITAAC will be added to DCD Tier 1, Section 2.15.1 and Table 2.15.1-2 to verify the ASME pressure boundary and seismic Category I requirements as they apply to the containment electrical penetration assemblies. The staff finds the applicant's response

acceptable, and therefore, RAI 14.3-407 is resolved. The staff confirmed that DCD Revision 6, incorporated the changes as discussed above.

RAI 14.3-408: In RAI 14.3-408, the staff asked the applicant to include the following items in DCD Tier 1, Table 2.13.1-1 or provide justification for not including them: (1) breaker to regulating transformer and relay (degraded voltage and under-frequency) compartments, and (2) ancillary diesel buses. Therefore, RAI 14.3-408 was being tracked as an open item in the SER with open items.

In response, the applicant stated that DCD Tier 1, Table 2.13.1-1 will be revised to add the isolation power centers' protective relaying and isolation power center breakers to the ancillary diesel buses. The applicant further stated that the regulating transformer and the breaker to the regulating transformer are deleted in response to RAI 8.2-14 S01. The staff finds the applicant's response to RAI 8.2-14 S01 acceptable because the applicant made a design change to delete the regulating transformers, thus eliminating the potential for disruptive voltages and frequencies to reach the safety-related loads. The staff's evaluation of the response to RAI 8.2-14 S01 is discussed in Section 8.3.1.3 of this report. Based on the above and the staff's evaluation in Section 8.3.1.3 of this report, RAI 14.3-408 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes discussed above.

RAI 14.3-409: In RAI 14.3-409, the staff requested the applicant to update Sheet 2 of Figure 2.13.1-1 to correct the following: (a) the ancillary diesel bus is missing, (b) 480V buses do not include all loads (e.g., UPS rectifiers, regulating transformers, etc.), (c) PIP bus A feeds to Isolation Power Center Bus A alternate feed is incorrect, and (d) PIP bus B feeds to Isolation Power Center Bus D alternate feed is incorrect. Therefore, RAI 14.3-409 was being tracked as an open item in the SER with open items.

In response, the applicant stated that all the items except the regulating transformers are included in Figure 2.13.1-1 Sheet. 2. The applicant deleted the regulating transformers in response to RAI 8.2-14 S01. The staff finds the applicant's response acceptable, and therefore, RAI 14.3-409 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-410: In RAI 14.3-410, the staff requested the applicant to include the ITAAC for the following in DCD Tier 1, Table 2.13.4-2 or provide justification for not including them: (1) verification of automatic load sequencing, (2) verification that controls exist in the MCR to start and stop each standby diesel generator (SDG), and (3) verification that the ancillary DGs and associated auxiliaries (e.g., controls, electrical buses, fuel tanks, etc.) are seismic Category II. Therefore, RAI 14.3-410 was being tracked as an open item in the SER with open items.

In response, the applicant stated that DCD Tier 1, Section 2.13.4 and ITAAC Item 2.a of Table 2.13.4-2 would be modified to include the verification of SDG load sequencing. Additionally, GEH would add ITAAC to verify the existence of control in the MCR to start and stop each SDG and to verify that each ancillary DG and associated auxiliaries, buses, fuel tanks, and fuel transfer pumps are seismic Category II. The applicant provided a revised DCD Tier 1, Section 2.13.4. The staff determined that the response was inadequate because DCD Tier 1, Table 2.13.4-2, Item 2.a did not include testing of automatic load sequencer and load stepping intervals.

In RAI 14.3-410 S1, the staff asked the applicant to add the following language under "Inspections, Tests, Analyses": "An actual or simulated signal is initiated to start the load

sequencer operation. Output signals will be monitored to determine the operability of the load sequencer. Time measurements are taken to determine the load stepping intervals.” Additionally, the staff asked the applicant to add the following language under “Acceptance Criteria”: “The load sequencer initiates a closure signal with ± 5 seconds of the set intervals to connect the load.” In response, the applicant stated that sequencing of the nonsafety-related SDG-backed PIP buses will be controlled by N-DCIS logic. Upon receiving a DG ready-to-load signal, auto loading would be initiated by the auto load sequencing logic (N-DCIS) signaling each system load to close into the bus in its predetermined order, with feedback as a precondition to move to the next load. This feedback could consist of further ready-to-load signals based on DG and PIP bus voltage and frequency returning to desired levels. This logic for monitoring voltage and frequency and enabling the next load closure would also be within the N-DCIS. Therefore, signals from N-DCIS controllers to sequence loads onto the SDG would not be based solely on programmed time intervals, but instead would be based on the DG being ready to accept the next load before signaling. Once N-DCIS logic allows the closure of the next predetermined load, the only delay in sending the closure signal would be that of the N-DCIS response time, which is expected to be on the order of tens of milliseconds. Alarms will be generated if sequencing does not occur as expected. Sequencing of the ESBWR SDG need not follow the procedures typically applied to traditional safety-related emergency diesel generators, because the ESBWR design does not require ac power to achieve and maintain a safe shutdown for 72 hours. Therefore, the requested additions to the existing ITAAC to specifically test automatic load sequencers and load starting intervals are not necessary. The applicant will add a clarification to the inspections, tests, and analyses of DCD Tier 1, Revision 6, Section 2.13.4, ITAAC Item 2.a to state that subsequently generated signals will start load sequencing. The staff finds the applicant’s response acceptable. Therefore, RAI 14.3-410 and the associated open item are resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-411: In RAI 14.3-411, the staff requested that the applicant should make corrections to the ITAAC by including the following or provide justification for their exclusion: (1) CB and RB distribution panels are missing from DCD Tier 1, Table 2.13.5-1, (2) in Table 2.13.5-2, Item 6 should include maximum and minimum battery terminal voltages in the design commitment, and the associated acceptance criteria for Item 6 should specify the voltage and frequency tolerances, and (3) an item should be added for the regulating transformers, since the regulating transformer and other inverter will supply power in the case of one inverter problem. The staff also asked the applicant to include the synchronization scheme to be used for this case and add it as another ITAAC item. Therefore, RAI 14.3-411 was being tracked as an open item in the SER with open items.

In response, the applicant stated that CB and RB distribution panels should not be added to the table since the exact number and location of the distribution panels will not be finalized until completion of the final design. The safety-related loads are shown as “typical.” The applicant stated that it will revise DCD Tier 1, Table 2.13.5-2, Item 6 to state that each safety-related inverter can supply its ac load at both minimum and maximum battery terminal voltages in the design commitment. GEH will revise the acceptance criteria to specify that the inverter will supply its rated load, while maintaining its rated voltage at its rated frequency, within tolerances acceptable for its ac loads. Additionally, the applicant stated that regulating transformers have been deleted and thus, ITAAC to address regulating transformers are not necessary. The staff finds the applicant’s response acceptable; and therefore, RAI 14.3-411 and the associated open item are resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-413: In response to RAI 8.2-14 regarding the effects of a voltage spike on the electrical distribution system components after a loss of the electrical grid during islanding, GEH stated that fast transients on the ac input to the UPS input rectifiers and battery chargers can result in high dc voltages and, if the rectifiers and inverter trips are not coordinated, subsequent inverter trips and the loss of power to safety-related loads can occur. Since trip coordination of battery chargers and UPS input rectifiers with inverters is critical for the proper operation of the UPS under excessive ac input voltage conditions during the islanding mode, an ITAAC is necessary to verify the trip coordination of safety-related battery chargers and UPS input rectifiers with inverters. The staff reviewed this RAI response and requested that the applicant provide an ITAAC to address the proper operation of the above devices. Therefore, RAI 14.3-413 was being tracked as an open item in the SER with open items.

In response, the applicant stated that it will revise DCD Tier 1, Section 2.13.5 and Table 2.13.5-2 to include the requirement to verify trip coordination of the safety-related battery chargers and UPS input rectifiers with the inverters. This new DCD Tier 1 ITAAC is based on new information to be added to DCD Tier 2, Section 8.3.1.1.3, which discusses coordination of the rectifier and inverter high dc voltage trips. The applicant stated that the safety-related battery chargers and UPS input rectifier high dc voltage trips are coordinated such that the associated inverters do not trip on high dc input voltage during voltage transients on the ac distribution system. The trips are coordinated such that the inverter high dc input voltage trip setpoint is greater than the associated battery charger and the UPS input rectifier high dc output trip setpoints. In addition, the time delay for the inverter high dc input voltage trip is greater than the time delay for the battery charger and the UPS input rectifier high dc output voltage trips. In this way, the high dc voltage protection is coordinated in both magnitude and time so the battery charger and UPS input rectifier always trip before their dc output voltage reaches the level that would cause an inverter trip on high dc input voltage. The actual trip magnitude and time margins are a function of the vendor-specific equipment design. The staff finds the applicant's response acceptable because the operation of the protective devices will be coordinated and the UPS inverter will be available for its operation. Therefore, RAI 14.3-413 and the associated open item are resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-394 S01: DCD Tier 1, Revision 4, Section 4 stated that an applicant for a COL that references the ESBWR certified design must provide design features or characteristics that comply with the interface requirements for the plant design and ITAAC for the site-specific portion of the facility design, in accordance with 10 CFR 52.79(c) (now 52.79(d)). However, the applicant identified no interface requirements for the offsite power system in the certified design. RG 1.206, CIII.7.2, "Site-Specific ITAAC," recommends that applicants develop ITAAC for the site-specific systems that are designed to meet the significant interface requirements of the standard certified design; that is, the site-specific systems that are needed for operation of the plant (e.g., offsite power).

As indicated in DCD Tier 2, Section 8.1.5.2.4, the ESBWR standard design complies with the requirements of GDC 17, "Electric power systems," with respect to two independent and separate offsite power sources. Therefore, an ITAAC to verify that the required circuits from the transmission network satisfy the requirements of GDC 17 is needed in regard to offsite power source capacity and capability, regardless of its low-risk significance in the ESBWR design. The staff requested that the applicant revise DCD Tier 1, Section 4 to include interface requirements for the offsite power system. COL Applicants should provide site-specific ITAAC for offsite power to satisfy the interface requirements. In response, GEH revised DCD Tier 1, Section 4 to include a new Section 4.2 that included requirements for the COL Applicant to develop an ITAAC to verify, by inspection, that two physically independent circuits will supply

electric power from the transmission network to the onsite electrical distribution system. However, GEH did not add an interface requirement demonstrating the capacity and capability of the offsite power system. In RAI 14.3-394 S01, the staff requested that GEH modify the DCD to add this interface requirement. Therefore, RAI 14.3-394 was being tracked as an open item in the SER with open items.

In response, the applicant stated that it had added new ITAAC for demonstrating the capacity and capability of the normal and alternate preferred power supplies to DCD Tier 1, Section 2.13.1. GEH also added interface requirements for demonstrating the capacity and capability of the site-specific portions of the normal and alternate preferred power supplies to DCD Tier 1, new Section 4.2. The interface requirements for offsite power system will include the following:

- (1) At least two independent circuits supply power from the transmission network to the interface with the onsite portions of the preferred power supply (PPS).
- (2) Each offsite circuit interfacing with the onsite portions of the PPS is adequately rated to supply the load requirements during design-basis operating modes.
- (3) During steady-state operation, the offsite portions of the PPS are capable of supplying voltage at the interface with the onsite portions of the PPS that will support the operation of safety-related loads during design-basis operating modes.
- (4) During steady-state operation, the offsite portion of the PPS is capable of supplying the required frequency at the interface with the onsite portions of the PPS that will support the operation of safety-related loads during design-basis operating modes.
- (5) The fault current contribution of the offsite portion of the PPS is compatible with the interrupting capability of the onsite fault current interrupting devices.

Additional supporting information has been added to DCD Tier 2, Chapter 8. On the basis of its review, the staff finds that the interface requirements specified above will provide assurance that the offsite power system has adequate capacity and capability to satisfy GDC 17. Therefore, RAI 14.3-394 and the associated open item are resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-424: In RAI 14.3-424, staff asked the applicant to include an ITAAC to address the fault current withstand capability of cables for: (a) onsite ac power, (b) dc power, (c) DG power, and (d) uninterruptible ac power. In response, the applicant stated that it addressed the cables for the applicable portions of the onsite ac power supply, specifically the preferred power supply in response to RAI 14.3-394 S01 and included the ITAAC in response to that RAI.

GEH stated that it will add ITAAC Item 12 to DCD Tier 1, Table 2.13.3-3 to address the fault current withstand capability of cables for the safety-related portions of the dc power supply system.

Portions of the onsite DG power supply systems capable of supporting the safety-related loads are covered by ITAAC provided for the onsite ac power supply. DCD Tier 1, Table 2.13.1-2, ITAAC Item 10 addresses the fault current withstand capability.

Furthermore, the applicant will add ITAAC Item 12, to DCD Tier 1, Table 2.13.5-2 to address the fault current withstand capability of cables for the safety-related portions of the UPS system.

The staff finds the applicant's response acceptable. Therefore, RAI 14.3-424 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-425: In RAI 14.3-425, the staff asked the applicant to include ITAAC to address equipment protective devices for: (a) onsite ac, (b) dc power, (c) DG power, and (d) uninterruptible power. In response, the applicant stated that it had addressed the protective devices for the applicable portions of the onsite ac power supply, specifically the preferred power supply, in response to RAI 14.3-394 S01 and had provided ITAAC in response to the RAI.

The applicant will add ITAAC Item 13 in DCD Tier 1, Table 2.13.3-3 to address the fault withstand capability of protective devices for the safety-related portions of the dc power supply system.

Portions of the onsite DG power supply systems capable of supporting the safety-related loads are covered by ITAAC provided for the onsite ac power supply. DCD Tier 1, Table 2.13.1-2, ITAAC Item 10, addresses the fault current interrupting capability.

Furthermore, the applicant will add ITAAC Item 13 in DCD Tier 1, Table 2.13.5-2 to address the fault current withstand capability of protective devices for the safety-related portions of the UPS system.

The staff finds the applicant's response acceptable. Therefore, RAI 14.3-425 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-427: In RAI 14.3-27, the staff asked the applicant to include ITAAC to address the grounding and lightning protection system. In response, the applicant stated that it will add DCD Tier 1, Section 2.13.9 and Table 2.13.9-1 to address the design description and ITAAC for the lightning protection and grounding system. In addition, GEH will revise DCD Tier 2, Appendix 8A.1.1 to delete the statement that lightning protection ground rods would be separate from the normal grounding system. The ITAAC will verify that a connection exists between the lightning protection system and the station ground grid. This change, and allowing the lightning protection ground rods to tie to the ground grid, will make the lightning protection system more robust by providing additional volume to adequately dissipate lightning strikes. The staff finds the applicant's response acceptable and therefore, RAI 14.3-427 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-429: In RAI 14.3-429, the staff asked the applicant to include ITAAC to address cable tray loading. In response, the applicant stated that it will add ITAAC Item 14 to DCD Tier 1, Table 2.13.3-3 to address the raceway sizing and loading for the safety-related portions of the dc power supply system. The applicant will also add ITAAC Item 14 to DCD Tier 1, Table 2.13.5-2 to address the raceway sizing and loading for the safety-related portions of the UPS system. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-429 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-431: In RAI 14.3-431, the staff asked the applicant to include ITAAC to address utilization voltage adequacy. In response, the applicant stated that it will add an ITAAC to DCD Tier 1, Section 2.13.5 to address utilization voltage adequacy for loads on the safety-related UPS 120 volt buses. The as-built safety-related UPS 120 volt distribution system will be analyzed to confirm that the voltage at the terminals of the loads is within the utilization

equipment voltage tolerance limits. Factory testing will document that the utilization equipment functions properly at the established maximum and minimum terminal voltage. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-431 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

RAI 14.3-448: In RAI 14.3-448, the staff asked the applicant to provide an ITAAC associated with the coordination of interrupting devices so that the circuit interrupter closest to the fault opens before other devices. The coordination study should include all voltage levels. In response, the applicant stated that it had added an ITAAC to DCD Tier 1, Revision 6, Section 2.13.1 for the coordination of interrupting devices in response to RAI 14.3-443. The applicant further stated that interrupting devices at all voltage levels will be coordinated to ensure that the interrupter closest to a fault opens before other devices, as described in DCD Tier 2 Section 8.3.1.1.6. Additionally, the applicant revised the ITAAC for both Sections 2.13.3 and 2.13.5 and the design description for Item 13 to state, "Protective devices for the safety-related 250 V dc (or UPS) system are rated to interrupt analyzed fault currents and are coordinated to only trip the protective device closest to the fault," as is appropriate for both the inverter ac loads and the single dc load. The applicant stated that its response to RAI 14.3-448, Revision 1, supersedes its response to RAI 14.3-425. The staff finds the applicant's response acceptable. Therefore, RAI 14.3-448 is resolved. The staff confirmed that DCD, Revision 6, incorporated the changes as discussed above.

Based on the staff's review as set forth above, as well as on the applicant's implementation of the selection criteria and methodology for the development of the Tier 1 information in DCD Tier 2, Section 14.3, the staff concludes that DCD Tier 1, Revision 9, appropriately describes the top-level design features and performance characteristics of the SSCs, and the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.6 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.6 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.6 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.7 Plant Systems

The applicant provided design-basis information including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1, Revision 9, information, as described in DCD Tier 2, Revision 9, Section 14.3 to support the ITAAC for the ESBWR SSCs. The applicant organized its Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Revision 9, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A of this report and in accordance with SRP Section 14.3.7.

The staff's review of the plant systems generated several RAIs regarding the regulatory treatment of the standby DG support systems and their inclusion in the ITAAC. These included RAIs 19.1.0-2, 22.5.4, 14.3-151, and their supplements and RAI 14.3-177. The applicant included all DG supporting systems as RTNSS; Chapter 19 of this report discusses these systems further. The applicant committed to providing ITAAC for each of the DG supporting systems and included ITAAC entries for each DG supporting system, including the DG cooling

water system, lubrication system, and combustion air and exhaust system in DCD Revision 5. The staff finds the applicant's response to be acceptable, and this RAI is resolved.

The staff reviewed DCD Tier 1, Sections 2.12.3, 2.12.5, and 2.12.7 for the ITAAC. In its review, the staff requested additional information in RAI 14.3-69, RAI 22.5-1, RAI 22.5-1 S01, and RAI 9.2-24. All of these RAIs were resolved. Sections 9.2.1.3.4, 9.2.2.3.4, and 9.2.7.3.4 of this report document the staff's detailed evaluations of these RAIs.

RAI 14.3-369: For ITAAC Item 7a in DCD Tier 1, Table 2.6.2-2, the staff requested that the applicant appropriately modify the item so that both the FAPCS flow path and the capacity are verified in the inspections, tests, and analyses and confirmed in the acceptance criteria. The applicant's response addressed flow path and capacity in both the inspections, tests, and analyses and acceptance criteria. In addition, the acceptance criteria had the actual flow rate in both cubic meters per hour and gallons per minute. The staff finds the applicant's response to be acceptable, and therefore RAI 14.3-369 is resolved.

The staff generated several RAIs to complete its review of the fire protection systems. The following paragraphs discuss RAIs associated with fire protection that have been resolved and are considered significant to the conclusions of the safety evaluation of the ESBWR fire protection program:

RAI 14.3-7: In this RAI, the staff directed GEH to include ITAAC for the fire barriers. The staff based this request on the requirement for new reactor fire protection programs to provide fire barrier separation between redundant trains (except inside the containment and in the MCR), as well as verification that all fire barriers and barrier penetration seals and other closure devices are constructed in accordance with the applicable approved designs, including verification that the design-basis integrity of each barrier is provided. RAI 14.3-7 S01 directed GEH to include ITAAC to verify that the area in which the fire occurs is separated by a fire barrier from any circuits for which a fire-induced failure could cause a spurious actuation that would prevent the protected train (the train outside the area in which the fire occurs) from performing its required post fire, safe-shutdown function. In response, the applicant revised DCD Tier 1, Section 2.16.3.1 and Table 2.16.3.1-1 to include an acceptable design description and related ITAAC for fire barriers. The staff finds the applicant's response to be acceptable, and RAI 14.3-7 is resolved.

RAI 14.3-11: This RAI directed GEH to include an ITAAC to verify that the appropriate seismic analyses had been performed to demonstrate that the SSE function is provided and that the piping and equipment have been installed in accordance with the design. The staff based this request on the fire protection acceptance criteria in RG 1.189, which require a seismically qualified (i.e., must remain functional during and following an SSE) source of fire water supply to standpipes and hose stations in areas with safe-shutdown equipment. The staff finds the applicant's response to be acceptable, and RAI 14.3-11 is resolved.

RAI 14.3-393: This RAI directed GEH to include an ITAAC to verify that the fire-proofing of exposed structural steel in safety-related areas is installed in accordance with the approved design. GEH stated that it would not respond specifically to this RAI but would incorporate the request in Revision 5 of the DCD. The staff finds the associated change to Revision 5 of the DCD to be acceptable and therefore, RAI 14.3-393 is resolved.

RAI 14.3-395: The staff requested that GEH address the impact of a nonseismic failure during an SSE on the ability to ensure that adequate water flow and pressure reach areas containing

equipment relied upon for a safe plant shutdown in the event of an SSE. The staff describes its concern as follows: DCD Tier 1, Table 2.16.3-1 provides the seismic classification of all fire protection pumps, with the exception of the standpipe booster pumps. DCD Tier 2, Section 9.5.1.4 states that booster pumps maintain minimum standpipe pressure. If these pumps are relied upon to meet the post-SSE requirement for hose station protection, equipment such as the pumps, motors, and power supply should be seismic Category I to ensure that they will function following an SSE. The booster pumps should be included in Table 2.16.3-1, with the appropriate seismic category indicated. If the pumps are not seismic Category I, a justification should be provided that including any provisions for bypassing the pumps, if required. This RAI was being tracked as an open item in the SER with open items.

GEH agreed to add the following to DCD Tier 2, Revision 6, Section 9.5.1.4:

THE ESBWR design does not require the use of booster pumps to maintain minimum standpipe pressure for the post-SSE requirements for hose station protection. Booster pump installation will be limited to the secondary circuit to ensure failure will not impact areas containing equipment performing any safe shutdown function

The staff finds this change acceptable since the booster pumps are not needed to maintain minimum standpipe pressure. Therefore, RAI 14.3-395 and the associated open item are resolved.

RAI 14.3-396: The change in DCD Tier 1, Revision 5, Table 2.16.3-2, Item 3, called for the applicant to verify that hose station protection will be provided for locations outside the containment that contain or could present a hazard to safe-shutdown equipment. GDC 3, "Fire protection," requires that the fire protection program provide protection for SSCs important to safety. Safe-shutdown equipment is a subset of equipment important to safety. Consequently, this ITAAC does not adequately verify compliance with the GDC 3 requirements. In RG 1.189, Revision 1, "Fire Protection for Nuclear Power Plants," issued March 2007, Regulatory Position 3.4.1 states, "Interior manual hose installations should be able to reach any location that contains, or could present a fire exposure hazard to, equipment important to safety...." While RG 1.189 contains some specific guidance for the protection of safe-shutdown SSCs (e.g., hose station coverage following an SSE), the fire protection program must protect SSCs important to safety to ensure compliance with GDC 3. This RAI was being tracked as an open item in the SER with open items.

GEH revised the DCD Tier 1, Sections 2.16.3, 2.16.3.1, as well as Tables 2.16.3-2 and 2.16.3.1-1 to change "safe shutdown" to "safety-related." The staff finds this change acceptable. Therefore, RAI 14.3-396 and the associated open item are resolved.

DCD Tier 1, Section 2.3.1 for the PRMS and Section 2.10 for the Radioactive Waste Management System (RWMS) contain the supporting information for verification of the RWMS design aspects of the ESBWR standard design. The RWMS includes the LWMS, the gaseous waste management system (GWMS), and the solid waste management system (SWMS). These systems are involved in the management of radioactive wastes (liquid, gas, and wet and dry solids) produced during normal operation and anticipated operational occurrences. The PRMS includes subsystems used to collect process and effluent samples during normal operation, during anticipated operational occurrences, and under post-accident conditions.

Areas of the staff's review included implementation of the selection criteria and methodology for developing DCD Tier 1 information, as discussed in DCD Tier 2, Section 14.3, and the resultant DCD Tier 1 information associated with the RWMS. The areas of review included design objectives, design criteria, identification of all expected releases of radioactive effluents, methods of treatment, and operational programs for controlling and monitoring effluent releases and for assessing associated doses to members of the public. In addition, the review included an evaluation of the PRMS, which is used to monitor liquid and gaseous process streams and effluents and the solid wastes generated by these systems. The staff generated a number of RAIs (not listed here for the sake of brevity) during its review of the design certification application. In summary, the RAIs involved requests for the applicant to (1) provide clarifications for technical completeness, (2) provide details supporting the design descriptions and functional arrangements for demonstrating compliance with regulatory requirements, (3) revise and update tables and drawings for consistency with DCD Tier 2 system descriptions, (4) revise technical and regulatory references, and (5) provide information to enable the staff to conduct further evaluations of supporting topics presented in DCD Tier 2 to support DCD Tier 1 design descriptions and the associated ITAAC. The RAIs addressed the following major technical and regulatory topics:

- Descriptions, functional arrangements, application, and scope of ITAAC for the LWMS, GWMS, SWMS, and PRMS
- Design descriptions and ITAAC addressing the initiation and closure of valves and isolation of systems in controlling and limiting releases of radioactive liquid and gaseous effluents into the environment
- Scope of tests and acceptance criteria to confirm that radiation monitors would alarm and initiate valve closures or isolation of systems upon receipt of a high-radiation signal, exceeding a setpoint value, from a radiation detector
- Basis of criteria for the inclusion and application of ITAAC that, although for non-safety-related systems, are required to demonstrate compliance with 10 CFR Part 20 effluent concentration limits for members of the public and the design objectives in Appendix I to 10 CFR Part 50
- Criteria for verifying the nominal capacities of the major processing tanks of the SWMS, including the high- and low-activity resin holdup tanks, the condensate resin holdup tank, the phase separator tanks, and the concentrated waste tank
- Criteria for installing steel liners in cubicles housing LWMS tanks and vessels to ensure that, in the event of a tank rupture, the effluent concentration limits of Table 2 (Column 2) in Appendix B to 10 CFR Part 20 will not be exceeded at offsite locations
- Initial installation of appropriate types and amounts of absorbent and filtration media in LWMS (demineralizers) and GWMS/off-gas system charcoal beds (guard and main beds) in demonstrating compliance with 10 CFR Part 20 effluent concentrations and dose limits for members of the public and with the design objectives in Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50

- Correction of internal inconsistencies in DCD Tier 1 design descriptions and the design commitments specified in the associated ITAAC

The applicant resolved 16 RAIs, including RAIs 14.3-138 through 14.3-143, RAI 14.3-145, RAIs 14.3-154 through 14.3-161, and RAI 14.3-391. An example of one such resolved RAI is RAI 14.3-161, described below.

RAI 14.3-161: The staff noted that DCD Tier 1, Revision 4, Section 2.3.1 did not include ITAAC assigned to PRMS subsystems that are used to monitor compliance with the liquid and gaseous effluent concentration limits found in 10 CFR Part 20, Appendix B, Table 2. The lack of ITAAC for nonsafety-related yet essential subsystems used in demonstrating compliance with 10 CFR Part 20 is not consistent with the criteria and application process described in DCD Tier 2, Revision 4, Section 14.3.7.3, on design features used to comply with the NRC regulations. Accordingly, the staff requested that the applicant revise DCD Tier 1, Section 2.3.1 to include the necessary ITAAC for all PRMS subsystems that are used to monitor, control, and terminate radioactive effluent releases into the environment. The applicant revised Table 2.3.1-2 to include an ITAAC for nonsafety-related radiation monitors included in the plant to actively/automatically restrict offsite doses to below the limits in 10 CFR Part 20. The staff finds this response acceptable, and RAI 14.3-161 is resolved.

The ITAAC reviewed by the staff in accordance with SRP Section 14.3.7 also include systems that are nonsafety-related but are used to ensure compliance with the regulatory requirements of 10 CFR Part 20, Sections 20.1301 and 20.1302; 10 CFR 50.34a; 10 CFR 50.36a; the dose objectives in Appendix I to 10 CFR Part 50; GDC 60, "Control of releases of radioactive material to the environment", GDC 63, "Monitoring fuel and waste storage", and GDC 64, "Monitoring radioactivity releases" in Appendix A to 10 CFR Part 50; and the waste form characteristics in 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." In demonstrating compliance with the above regulatory requirements, the operation of these systems is governed by operational programs that are mandated under license conditions. These operational programs include the ODCM for confirming that instrumentation alarm setpoints are established in limiting radioactive release rates or radionuclide concentrations in the environment; the PCP for ensuring that radioactive wastes meet waste form characteristics for disposal; and the REMP for confirming that liquid and gaseous effluent releases meet the 10 CFR Part 20 dose and effluent concentration limits and the as-low-as-reasonably-achievable (ALARA) design objectives in Appendix I to 10 CFR Part 50. DCD Tier 2, Section 13.4 addresses, as COL commitments, the milestones for the development and implementation of the ODCM, PCP, and REMP. The proposed ITAAC, once performed by a COL Applicant and having met their respective acceptance criteria, provide reasonable assurance that a plant incorporating the requirements of the ESBWR design certification will operate in accordance with the design certification and the provisions of the Atomic Energy Act and the NRC regulations.

Based on the staff's review as set forth above, as well as on the applicant's implementation of the selection criteria and methodology for the development of the DCD Tier 1, Revision 9, information in DCD Tier 2, Revision 9, Section 14.3, the staff concludes that DCD Tier 1 appropriately describes the top-level design features and performance characteristics of the SSCs, and the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.7 is acceptable.

Furthermore, the staff concludes that the ITAAC can adequately verify the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.7. Therefore, the staff concludes

that the ESBWR ITAAC associated with the scope of SRP Section 14.3.7 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.8 Radiation Protection

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1, Revision 9, information, as described in DCD Tier 2, Revision 9, Section 14.3, to support the ITAAC for ESBWR SSCs. The applicant organized the Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Revision 9, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A of this report and in accordance with SRP Section 14.3.8.

The documents that contain the supporting information for the verification of the radiation protection aspects of the ESBWR design are DCD Tier 1, Revision 9, Section 2.3.1 for the PRMS; Section 2.3.2 for the ARM system; and Section 3.4 for radiation protection. The PRMS includes a description of the airborne radioactivity system used to monitor airborne radioactivity levels in various areas within the plant. The ARM system continuously monitors the gamma radiation levels within the various areas of the plant and provides an early warning to operating personnel when high radiation levels are detected, so the appropriate action can be taken to minimize occupational exposure. The ITAAC on radiation protection provide a verification of the means by which the plant is designed to maintain radiation exposures ALARA (i.e., through the use of ventilation flow and the containment of airborne radioactive materials, the use of area radiation monitoring to measure radiation levels throughout the plant, and the incorporation of radiation shielding to obtain radiation dose rates in each plant area commensurate with that area's occupancy requirements).

Areas of the staff's review included implementation of the selection criteria and methodology for developing DCD Tier 1 information, as discussed in DCD Tier 2, Revision 9, Section 14.3, and the resultant DCD Tier 1 information associated with the ARM systems, airborne radioactivity monitoring systems, and radiation shielding provided by structures and components for normal and emergency conditions. In addition, the review included an evaluation of the PRMS with respect to the airborne radioactivity monitors used to measure airborne radioactivity levels within the plant. The staff generated a number of RAIs requesting the applicant to provide clarifications for technical completeness, revisions and updates to tables for consistency with the DCD Tier 2 system descriptions, and information on which the staff could base further evaluations of supporting topics presented in DCD Tier 2 to support DCD Tier 1 design descriptions and the associated ITAAC. The RAIs generated by the staff addressed the following topics:

- Incorporation of an ITAAC on radiation shielding to be consistent with the guidance in the SRP
- Identification of those ARM systems located in areas where the dose rate increase can exceed 1 millisievert per hour (100 millirem per hour)
- Inconsistencies in the DCD Tier 1 design descriptions and the design commitments specified in the associated ITAAC

- Corrections of inconsistencies between information provided in DCD Tier 1 and Tier 2 tables and text regarding the listing of area radiation monitors

All of these RAIs have been resolved. Some examples of these resolved RAIs are RAIs 14.3-343, 14.3-174 S01, and RAI 14.3-175 S01, which are described below:

RAI 14.3-343: For ITAAC Item 1 in Table 3.4-1, although the design commitment addressed two functions for the system containing airborne radioactive materials and maintaining the concentration of airborne radionuclides at levels consistent with personnel access needs, the inspections, tests, and analyses and acceptance criteria only verified the latter. The applicant revised the inspections, tests, and analyses to address testing of isolation dampers and revised the acceptance criteria to state that “A test report documents that isolation dampers close within the designed time frame and limit leakage to a rate below the design assumed leakage rate.” The staff finds the applicant’s response acceptable, and RAI 14.3-343 is resolved.

RAI 14.3-174 S01: In this RAI supplement, the staff asked the applicant to provide additional details and clarifications regarding airborne radioactivity monitoring. Specifically, the staff requested the applicant to clearly identify the airborne radioactivity monitors that meet the sensitivity and location criteria to ensure that plant personnel are not inadvertently exposed to airborne contaminants in excess of the limits provided in 10 CFR Part 20. The staff requested that the applicant include a list of these monitors in the ITAAC. In addition, the staff requested that the applicant provide a table in the appropriate part of the DCD specifying the airborne radioactivity monitors that meet the sensitivity and location criteria. The staff also asked the applicant to provide acceptance criteria for the location of these airborne radioactivity monitors. Therefore, RAI 14.3-174 S01 was being tracked as an open item in the SER with open items.

In response to RAI 14.3-174 S01, GEH did not identify the specific airborne radioactivity monitors that meet the sensitivity and location criteria to ensure that plant personnel are not inadvertently exposed to airborne contaminants in excess of the limits provided in 10 CFR Part 20. In GEH’s revised response to this supplemental RAI, GEH committed to revise DCD Tier 2, Revision 9, Section 12.3.4 to state that portable airborne radiation monitors will be used to provide the local airborne radioactivity monitoring to meet requirements for worker protection. These portable continuous air monitors (CAMs) will provide a means to observe trends in airborne radioactivity concentrations. CAMs equipped with a local alarm capability are used in occupied areas where needed to alert personnel to sudden changes in airborne radioactivity concentrations. In order to warn personnel of changing airborne conditions, CAM alarm setpoints are set at a fraction of the concentration values given in 10 CFR Part 20 Appendix B, Table 1, Column 3, for radionuclides expected to be encountered. The number of CAMs used, as well as the placement of these portable monitors, will be the responsibility of the COL Applicant. Since the operational considerations and placement of the monitors to be used for airborne radioactivity monitoring will be the responsibility of the COL Applicant (as is specified in COL Information Item 12.3-2-A, Operational Considerations), no ITAAC are necessary for these portable monitors. The staff finds the applicant’s response to this supplemental RAI to be acceptable because the applicant stated that portable airborne radiation monitors used to meet requirements for worker protection in the local areas will meet the sensitivity and location criteria specified in SRP Section 12.3-12.4 to ensure that plant personnel are not inadvertently exposed to airborne contaminants in excess of the limits provided in 10 CFR Part 20. Since these matters are not within the scope of the ESBWR design certification as described above, RAI 14.3-174 is resolved.

RAI 14.3-175 S01: In this RAI supplement, the staff requested that the applicant revise the numbering of the area radiation monitors in Figures 12.3-23 through 12.3-42 to provide specific ARM identifiers that are clear and objective and that cannot be misidentified with ARMs in different building locations. The staff also requested the applicant to clarify the acronyms used in Tables 12.3-2 through 12.3-6 that are associated with the monitoring range to ensure they are clear and objective. Therefore, RAI 14.3-175 was being tracked as an open item in the SER with open items.

In response, GEH explained that in the final design, the component numbers are uniquely assigned using GEH design control procedures. The component ID identifies the system and building so that each radiation monitor is uniquely differentiated. GEH provided examples of how the ARMs located in different building will be numbered. GEH further stated in their response that DCD Tier 2, Section 12.3.4.2 identifies the channel monitoring range, and the acronym for each area radiation channel is found in DCD Tier 2, Table 12.3-7, so a clarification in each table is not necessary. On the basis of the applicant's response, RAI 14.3-175 and the associated open item are resolved.

The ITAAC reviewed by the staff in accordance with SRP Section 14.3.8 also included systems that are nonsafety-related but are used to ensure compliance with the regulatory requirements of 10 CFR 20.1101, 10 CFR 20.1201, 10 CFR 50.34a, 10 CFR 50.34(f), and GDC 19, "Control room", in Appendix A to 10 CFR Part 50. Programs that will be mandated by license conditions govern the operation of these systems to demonstrate compliance with the above regulatory requirements. These operational programs include the radiation protection program, which addresses plant management policy, organization, facilities, instrumentation, and equipment and procedures sufficient to ensure that occupational doses and doses to the public areas remain ALARA. DCD Tier 2, Revision 8, Section 13.4 addresses, as COL commitments, the milestones for developing and implementing the operational Radiation Protection Program. The proposed ITAAC, in conjunction with the implementation of these operational programs, once performed by a COL Applicant and having met their respective acceptance criteria, provide reasonable assurance that a plant incorporating the requirements of the ESBWR design certification has been constructed and will operate in accordance with the design certification and the provisions of the Atomic Energy Act and the NRC regulations.

Based on the staff's review as set forth above, as well as on the applicant's implementation of the selection criteria and methodology for the development of the DCD Tier 1 information in DCD Tier 2, Revision 9, Section 14.3 the staff concludes that DCD Tier 1 appropriately describes the top-level design features and performance characteristics of the SSCs, and the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.8 is acceptable.

Furthermore, the staff concludes that the Tier 1 design descriptions within the scope of SRP Section 14.3.8 can be verified adequately by the ITAAC. Therefore, the staff concludes at this time that the ESBWR ITAAC within the scope of SRP Section 14.3.8 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, then a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.9 Human Factors Engineering

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1, Revision 9, information, as described in DCD Tier 2, Revision 9, Section 14.3 to support the ITAAC for the ESBWR SSCs. The applicant organized the Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Revision 9, Table of Contents. The staff reviewed the Tier 1 information provided by the applicant in accordance with the review matrix provided in Appendix 14.3A of this report and in accordance with SRP Section 14.3.9.

In SECY-92-053, the staff provided the Commission with a method for using the DAC together with detailed design information, during the 10 CFR Part 52 process for reviewing and approving designs. The staff has used this method for design certification applications that did not provide design and engineering information at a level of detail customarily required by the staff to reach a final safety decision on the design. The Commission previously issued guidance on the level of design detail required for the design certification. The SRM to SECY-90-377 provided the level of detail that the design should reflect.

The applicant may provide the DAC in lieu of detailed system design information in areas such as HFE, where technology is rapidly changing and applicants believe it is unwise to prematurely freeze the design. The DAC are a set of prescribed limits, parameters, procedures, and attributes upon which the NRC relies in a limited number of technical areas, in making a final safety determination in support of the design certification. The acceptance criteria for the DAC should be objective; that is, they should be able to be inspected, tested, or subjected to analysis using preapproved methods and should be verified as a part of the ITAAC performed to demonstrate that the as-built facility conforms to the certified design. Thus, the acceptance criteria for the DAC are specified together with the related ITAAC in DCD Tier 1, Revision 9, and both are part of the design certification.

Design certification applicants should provide the design-related processes and associated DAC in DCD Tier 1 that a COL Applicant or Licensee would follow to complete the design. The COL licensees must verify implementation of the DAC as part of the ITAAC performed to demonstrate that the as-built facility conforms to the certified design. In this case, the DAC should be sufficiently detailed to provide an adequate basis for the staff to make a final safety determination regarding the design, subject only to the satisfactory verification of completion of the design (i.e., verification of the DAC) and the installation of the completed design by the COL licensee.

For the control room and the RSS design (human factors), the design descriptions and DAC provided in Tier 1 delineate the process and requirements that a COL Applicant or Licensee must implement to develop the design information required in each area. The ITAAC specifies the acceptance criteria for the development process at various stages of detailed design and subsequent construction and testing. The NRC requires the COL Applicant or Licensee to develop the procedures and test programs necessary to demonstrate that the DAC requirements are met at each stage. Since the DAC are considered to be design-completion ITAAC, the COL Applicant or Licensee must certify to the NRC that the design through that phase is in compliance with the design criteria specified in the certified design. The NRC reviews, audits, and/or inspects the work to confirm that the COL Applicant or Licensee has adequately implemented the commitments of the DAC in these phases.

The staff issued a number of RAIs to facilitate the completion of its review. The RAIs discussed below describe some of the concerns of the staff with respect to its review of the DCD Tier 1 information associated with HFE.

RAI 14.3-85: DCD Tier 1, Table 3.3-1, Item 10.a. calls for a “Procedure Implementation Plan,” which the applicant has completed and the NRC is reviewing as part of the ESBWR design certification. Therefore, Item 10.a does not belong in the ITAAC. Item 10.b relates to the implementation of the “Procedure Development Plan” and is appropriate, but it should be modified to perhaps be similar to the HFE ITAAC used for AP1000. In response, GEH stated that “In Revision 2 to DCD, Tier 1, Item 10.a was deleted and Item 10.b (now Item 7) was modified considering the suggested guidance.” The staff reviewed the revision to the DCD and finds that the applicant’s response adequately addresses its concern; RAI 14.3-85 is resolved.

RAI 14.3-86: DCD Tier 1 ITAAC for “Training Development,” Table 3.3-1, Item 11.a. requires a Training Program Development Implementation Plan that the applicant has completed and the NRC is reviewing as part of the ESBWR design certification. Therefore, Item 11.a does not belong in the ITAAC. Item 11.b relates to the implementation of the training program itself. Since the training is an operational program, this ITAAC is not needed. The applicant responded stating that, “In Revision 2 to DCD, Tier 1, Item 11.a was deleted and Item 11.b (now Item 8) was modified to contain a results summary report describing the training program.” The staff reviewed the revision to the DCD and finds that the applicant’s response adequately addressed its concern; RAI 14.3-86 is resolved.

RAI 14.3-87: The ITAAC for “Verification and Validation (V&V)” in DCD Tier 1, Revision 1, Table 3.3-1, Item 12.a required a V&V plan, which the applicant has completed and which the NRC is reviewing as part of the ESBWR design certification. Therefore, Item 12.a does not belong in the ITAAC. Item 12.b relates to the implementation of the V&V itself. The applicant should modify it so that it refers to the implementation of the V&V plan and construct it following the guidance in SRP Section 14.3. The applicant responded stating that, “[i]n Revision 2 to DCD Tier 1, Item 12.a was deleted and Item 12.b (now Item 9) was modified considering the suggested guidance.” The staff reviewed the revision to the DCD and finds that the applicant’s response adequately addressed its concern. RAI 14.3-87 is resolved.

RAI 14.3-88: The ITAAC for design implementation in DCD Tier 1, Revision 1, Table 3.3-1, Item 13.a, relates to the development of an implementation plan, which the applicant has completed and which the NRC is reviewing as part of the ESBWR design certification. Therefore, Item 13.a does not belong in the ITAAC. Item 13.b relates to the implementation of the V&V itself. This should be modified to be the implementation of the V&V Plan and should be constructed following the guidance in SRP Section 14.3. The applicant responded and indicated that, “In Revision 2 to DCD, Tier 1, Item 13.a was deleted and Item 13.b (now Item 10) was modified considering the suggested guidance.” The staff reviewed the revision to the DCD and finds that the applicant’s response adequately addressed its concern. RAI 14.3-88 is resolved.

RAI 14.3-89: The ITAAC for human performance engineering in DCD Tier 1, Revision 1, Table 3.3-1, Item 14.a relates to the development of an implementation plan, which the applicant has completed and which the NRC is reviewing as part of the ESBWR design certification. Therefore, Item 14.a does not belong in the ITAAC. Item 14.b relates to the implementation of the monitoring program itself, which is a COL responsibility subsequent to plant startup. The applicant should modify this ITAAC to refer to the establishment of the human performance monitoring program by the COL licensee and should follow the guidance in

SRP Section 14.3. The applicant responded stating that “In Revision 2 to DCD, Tier 1, Item 14.a was deleted and Item 14.b (now Item 11) was modified to contain a results summary report describing the HPM [human performance monitoring] program.” The staff reviewed the revision to the DCD and finds that the applicant’s response adequately addressed its concern. RAI 14.3-89 is resolved.

RAI 14.3-355: For ITAAC Item 6 in Table 2.4.2-3, the staff requested that the applicant clarify both its method of deriving the “minimum set of displays” and the correlation between the “minimum set of displays” in the design commitment and its retrievability in the acceptance criteria. In response, the applicant stated that the issues associated with the “minimum set of displays” and the “retrievability of them” are addressed by the HFE DAC ITAAC in Tier 1, Section 3.3. In DCD Tier 1, Section 1.1.1, the term “Inspect for Retrievability” of a display means to visually observe that the specified information appears on a monitor when summoned by the operator. The staff finds this response acceptable, and RAI 14.3-355 is resolved.

RAI 14-210, Supplement 1: Because DAC closure could be performed in several design phases, the NRC requires information on the closure schedule to plan its related activities appropriately. This COL information item will ensure that every COL Applicant referencing the ESBWR DCD provides the NRC with a schedule for DAC closure, even if the initial response to the COL information item is to make a commitment to provide such a schedule at a time when information is mature enough to be able to make reasonable schedule commitments. As such, the staff requested that GEH include a COL information item in the DCD for the COL Applicants/ Holders to provide a schedule for DAC closure. The applicant responded that it had updated DCD Tier 2, Revision 5, Section 14.3, Appendix A and had included a COL information item to address the staff’s concerns. The staff finds the applicant’s response acceptable, and RAI 14.3-210 S01 is closed.

RAI 14.3-211: ITAAC Table 3.3-1 contains 11 items, one for each element of NUREG–0711, “Human Factors Engineering Program Review Model,” Revision 2, and the corresponding ESBWR element implementation plan. However, the design commitment column in the ITAAC for each element refers to the overall man-machine interface system and the HFE Implementation Plan, rather than to the specific implementation plans of the pertinent elements. The staff requested that the applicant update the 11 design descriptions provided in Tier 1 to refer to the applicable implementation plans. The applicant responded stating that “GEH will revise the design commitment column in ITAAC Table 3.3-1 in DCD Tier 1, Revision 5, to reference the respective implementation plans.” RAI 14-211 was being tracked as an open item in the SER open items. In Revision 6 of the DCD, GEH changed Table 3.3-1 to reference the applicable implementation plans. Therefore, RAI 14-211 is resolved.

RAI 14.3-271: In this RAI, the staff requested the applicant to update the inspections, tests, and analyses and acceptance criteria columns in Table 3.3-1 to ensure that they accurately reflect the methodology described in the final versions of the approved implementation plans. In addition, the staff asked the applicant to review all of the items in the acceptance criteria column to ensure that the text is complete. For example, in DCD Tier 1, Table 3.3-1 Item 1, the acceptance criteria states the following:

Summary report documents:

- a. The OER team members and backgrounds.
- b. The scope of the OER.
- c. The sources of the operating experience reviewed and documented results.
- d. The process for issue analysis, tracking and review.

Because the staff determined the above list was incomplete and thus did not provide acceptable acceptance criteria, the staff asked the applicant to update its ITAAC. RAI 14.3-271 was being tracked as an open item in the SER with open items. Revision 6 of the DCD accurately captured the methodology described in final versions of the implementation plans. GEH adjusted the acceptance criteria to reflect complete and meaningful measurements accordingly. Therefore, RAI 14.3-271 and the associated open item are resolved. Subsequent to this change, the ITAAC for procedures and training were deleted because these elements are associated with operational programs. Commission guidance (SECY-02-0067, "Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for Operational Programs (Programmatic ITAAC)," April 15, 2002, and the related SRM, dated September 11, 2002; SECY-04-0032, "Programmatic Information Needed for Approval of a Combined License Without Inspections, Tests, Analyses and Acceptance Criteria," February 26, 2004, and the related SRM, dated May 14, 2004; and SECY-05-0197 and the related SRM, dated February 22, 2006.) indicates that operational programs remain subject to inspection and do not require ITAAC.

Based on the staff's review as set forth above, as well as the applicant's implementation of the selection criteria and methodology for the development of the DCD Tier 1, Revision 9, information in DCD Tier 2, Revision 9, Section 14.3, the staff concludes that DCD Tier 1 appropriately describes the top-level design features and performance characteristics of the SSCs, and the DCD Tier 1, Revision 9, information associated with the scope of SRP Section 14.3.9 is acceptable.

Furthermore, the staff concludes that the DCD Tier 1, Revision 9, design descriptions within the scope of SRP Section 14.3.9 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.9 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.10 Emergency Planning

The applicant did not provide emergency planning ITAAC in DCD Tier 1. As discussed in DCD Tier 2, Revision 9, Section 14.3.8 of the ESBWR DCD, the COL Applicant is responsible for providing the emergency planning ITAAC, and this requirement is consistent with the guidance provided in RG 1.206. In addition, in DCD Tier 2, Section 14.3.10, the applicant provided a COL information item (COL Information Item 14.3.1-A) specifying that the COL Applicant shall provide emergency planning ITAAC based on industry guidance. The staff finds the inclusion of COL Information Item 14.3.1-A in DCD Tier 2, Revision 9, Section 14.3 and the absence of ITAAC for emergency planning in Tier 1, to be acceptable and consistent with the NRC guidance provided in RG 1.206.

14.3.11 Containment Systems

The applicant provided design-basis information, including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1 information, as described in DCD Tier 2, Section 14.3 to support the ITAAC for ESBWR SSCs. The applicant organized the Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A of this report and in accordance with SRP Section 14.3.11.

The staff's review generated a number of RAIs, several of which the applicant has resolved satisfactorily. The RAIs discussed below are examples of some of the staff's concerns that were resolved.

RAI 14.3-230: The staff considered the following in evaluating the effect of LOCA-generated and latent debris effects on decay heat removal and containment cooling: (a) the GDCS pool consists of a stainless steel liner (DCD Tier 2, Revision 4, Table 6.1-1), (b) the suppression pool consists of a stainless steel liner (DCD Tier 2, Revision 4, Table 6.1-1), (c) "Suppression pool equalization lines have an intake strainer to prevent the entry of debris material into the system that might be carried into the pool during a large break LOCA" (DCD Tier 2, Revision 4, Section 6.2.2.7.2), (d) "The GDCS pool airspace opening to the DW will be covered by a perforated steel plate to prevent debris from entering pool and potentially blocking the coolant flow through the fuel" (DCD Tier 2, Revision 4, Section 6.2.2.7.2), and (e) "The Passive Containment Cooling System (PCCS) heat exchanger inlet pipe is provided with a debris filter with holes no greater than 25 mm (1 inch) to prevent entrance of missiles into the pipe and protection from fluid jets during a LOCA condition" (GEH response to NRC RAI 6.3-42).

However, the staff could not find information in DCD Tier 1, Revision 4, to document and verify these important assumptions. Therefore, the staff asked GEH to add these assumptions to DCD Tier 1, Table 2.15.3-1 and to identify them in DCD Tier 1, Figure 2.15-1. In response, GEH agreed to revise DCD Tier 1 to include this information. The staff considers this response acceptable. The staff confirmed that GEH has made the above changes in DCD Tier 1, Revision 5. The staff considers this response acceptable, and RAI 14.3-230 is resolved.

RAI 14.3-232: DCD Tier 1, Revision 4, did not have an ITAAC to verify that the reactor vessel shield wall is able to withstand the design differential pressure between the reactor vessel annulus and the drywell. Therefore, in RAI 14.3-232, the staff requested that GEH add an ITAAC to DCD Tier 1, Table 2.15.3-2 to verify this design commitment. In response, GEH agreed to update DCD Tier 1, Table 2.15.3-2, ITAAC Item 3, by adding the annulus pressurization loads to verify the structural integrity of the containment internal structures identified in DCD Tier 1, Table 2.15.3-1, which includes the reactor shield wall. The staff confirmed that GEH has made the above changes in DCD Tier 1, Revision 5. RAI 14.3-232 is resolved.

RAI 14.3-233: The acceptance criteria for Item 8 of DCD Tier 1, Revision 4, Table 2.15.3-2, state that "[t]est report(s) demonstrate that each as-built vacuum breaker proximity sensor indicates an open position with the vacuum breaker fully open and indicates a closed position when the vacuum breaker is in the fully closed position." DCD Tier 2, Revision 4, Section 6.2.1.1.2 states that "[t]he vacuum breaker is provided with redundant proximity sensors to detect its closed position." Based on the above, the staff determined that the proximity sensor should identify when the vacuum breaker is open and causing a drywell to wetwell bypass leakage that exceeds the design capacity. That is, the proximity sensor should be able to identify the vacuum breaker open position before it is "fully open." In RAI 14.3-233, the staff asked GEH to revise DCD Tier 1, Table 2.15.3-2, to verify this design feature. In response, GEH agreed that the proximity sensors should be able to identify the vacuum breaker open position before it is fully open. GEH stated that the ITAAC acceptance criteria had been changed from "fully open" to "open". The staff considers the applicant's response to be acceptable, and RAI 14.3-233 is resolved.

RAI 14.3-234: DCD Tier 1, Revision 4, did not provide information needed to verify the following aspects of containment analyses: (a) vacuum breaker area, (b) total number of vertical vents,

and (c) relative elevation of spillover holes. Therefore, in RAI 14.3-234, the staff requested GEH to provide this information in DCD Tier 1. In response, GEH agreed to add the following information to DCD Tier 1 Figure 2.15.1-1: (1) vacuum breaker area: 0.2 square meters (2.2 square feet) each, (2) total number of vertical vents: , 12, and (3) relative elevation of spillover holes, 12,370 mm (40.6 feet). The staff considers the applicant's response to be acceptable and RAI 14.3-234 is resolved.

RAI 14.3-237: The staff found a discrepancy in the PCCS design pressure given in DCD Tier 1 and Tier 2. DCD Tier 1, Revision 4, Table 2.15.4-2, states that "[t]he pressure boundary of the PCCS retains its integrity under the design pressure of 310 kPa gauge (45 psig)." However, in DCD Tier 2, Revision 4, Table 6.2-10 states that "the PCCS design pressure as 758.5 kPa gauge (110 psig)." Based on the above, the staff requested in RAI 14.3-237 that GEH correct this discrepancy. In response, GEH agreed to revise DCD Tier 1, Revision 4, Table 2.15.4-2 to state that "[t]he pressure boundary of the PCCS retains its integrity under the containment design pressure of 310 kPa gauge (45 psig)." The staff considers the applicant's response to be acceptable, and RAI 14.3-237 is resolved.

RAI 14.3-238: DCD Tier 2, Revision 4, Table 6.2-10 provides PCCS design parameters. The staff could not find the necessary information in DCD Tier 1, Revision 4, to verify the following PCCS design parameters: (a) The heat removal capacity for each loop is 11 MWt nominal for pure saturated steam at a pressure of 308 kPa (absolute) (45 psia) and a temperature of 134 degrees C (273.2 degrees F) condensing inside tubes with an outside pool water temperature of 102 degrees C; and (b) The system design temperature is 171 degrees C (340 degrees F). As a result, the staff requested in RAI 14.3-238 that GEH explain how the above design parameters are to be verified.

In response, GEH stated the following: (a) both the inspections, tests, and analyses and the acceptance criteria in DCD Tier 1, Table 2.15.4-2, Item 7 will be revised to include requirements that clearly demonstrate and confirm the capacity of the PCC condensers and design-basis assumptions, and (b) the ITAAC associated with the design and construction of system piping and components (e.g., Table 2.15.4-2, Items 2a and 2b) demonstrate that the system is designed and constructed to meet its design requirements, including system design temperature. ASME code design reports will provide appropriate confirmation of compliance with the design temperature. DCD Tier 2, Revision 9, Section 14.3 describes the process for identification of ITAAC items. The focus of the ITAAC is intended to be on the verification of numeric performance values, in lieu of numeric design values. The staff considers the applicant's response to be acceptable, and RAI 14.3-238 is resolved.

As a result of its review, the staff identified the following issues in RAIs and tracked them as open items in the SER with open items

RAI 14.3-229: Drywell to wetwell bypass leakage capacity is an important assumption used in the containment analyses, but the staff could not find information in DCD Tier 1, Revision 4, to verify the bypass leakage capacity. Therefore, in RAI 14.3-229, the staff requested GEH to add: (1) an item to DCD Tier 1, Section 2.15.3 giving the drywell to wetwell bypass leakage capacity, and (2) an ITAAC to DCD Tier 1, Table 2.15.3-2 to verify this value.

In response, GEH agreed with the NRC request to revise the DCD to add an ITAAC for drywell to wetwell (suppression pool) bypass leakage. GEH proposed to update ESBWR DCD Tier 1, Table 2.15.1-2 to include an acceptance criteria for drywell to wetwell bypass leakage tests that states, "[r]eport(s) document that the results of the drywell to wetwell bypass leakage is less

than or equal to 50 percent of the assumed value in the containment capability design-basis containment response analysis.”

In RAI 6.2-145 S02, the staff requested GEH to provide additional justification for this proposed change. In RAI 14.3-229 S01, the staff requested GEH to make the responses to RAIs 14.3-229 and 6.2-145 consistent. RAI 14.3-229 S01 was being tracked as an open item in the SER with open items.

In response to RAI 14.3-229 S01, GEH stated that DCD Tier 1, Section 2.15.1-2 was revised in Revision 5 to be consistent with the bypass leakage acceptance criteria described in DCD Tier 2, Section 6.2.1.1.5.4.3.

GEH’s response addresses the staff’s concerns and is acceptable to the staff. RAI 14.3-229 and the associated open item are resolved.

Based on the staff’s review as set forth above, as well as on the applicant’s implementation of the selection criteria and methodology for the development of the DCD Tier 1, Revision 9, information in DCD Tier 2, Revision 9, Section 14.3, the staff concludes that DCD Tier 1, Revision 9, appropriately describes the top-level design features and performance characteristics of the SSCs, and the information associated with the scope of SRP Section 14.3.11 is acceptable.

Furthermore, the staff concludes that the Tier 1 design descriptions associated with the scope of SRP Section 14.3.11 can be verified adequately by the ITAAC. Therefore, the staff concludes that the ESBWR ITAAC with the scope of SRP Section 14.3.11 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.12 Physical Security

The applicant provided design-basis information including associated tables and figures, in accordance with the selection criteria and methodology for developing DCD Tier 1 information, as described in DCD Tier 2, Revision 9, Section 14.3 to support the ITAAC for ESBWR SSCs. The applicant organized the DCD Tier 1 information in the systems, structures, and topical areas format shown in the DCD Tier 1, Revision 9, Table of Contents. The staff reviewed the DCD Tier 1 information provided by the applicant, in accordance with the review matrix provided in Appendix 14.3A of this report and in accordance with SRP Section 14.3.12, Revision 1, issued January 2010.

The NRC regulation for protecting nuclear power reactors is provided in 10 CFR Part 73, “Physical Protection of Plants and Materials.” The regulation includes specific security and performance requirements that when adequately implemented, are designed to protect nuclear power reactors against acts of radiological sabotage, prevent the theft or diversion of special nuclear material, and protect safeguards information against unauthorized release.

The performance requirements for the physical protection of nuclear power reactors are provided in 10 CFR 73.1(a)(1), which bounds the adversarial characteristics of the design-basis threat (DBT), and 10 CFR 73.55. Pursuant to 10 CFR 50.34(c)(2), 50.34(d), 50.54(p)(1) and (p)(2), and 73.55(c)(4), as referenced in 10 CFR Part 52, applicants are required for facility

licenses to prepare and maintain security plans that describe the security-related actions that they will take to protect their facilities against acts of radiological sabotage.

Regulatory requirements and acceptance criteria related to physical protection systems or hardware are, in part, applicable to design certification (i.e., within scope of the design) or may only be applicable to a COL Applicant (outside of a design certification design scope) and are specified in NUREG-0800, SRP Section 14.3.12.

The COL Applicant is required to describe commitments for establishing and maintaining a physical protection system (engineered and administrative controls), organization, programs, and procedures for implementing a site-specific strategy that demonstrates, if adequately implemented, a high assurance of protection of the plant against the DBT. The site-specific physical protection system described must be reliable and available and must implement the concept of defense-in-depth protection in order to provide a high assurance of protection. The security operational programs and the physical protection system are required to meet specific performance requirements of 10 CFR Part 26, "Fitness For Duty Programs", 10 CFR Part 74, "Material Control and Accounting of Special Nuclear Material", and 10 CFR 73.55, 73.56, 73.57, and 73.70. The COL Applicant's security program and planning for a safeguard contingency are required to meet 10 CFR 50.34(d) and Appendix C of 10 CFR Part 73, "Physical Protection of Plants and Materials". Nuclear Power Plant Safeguards Contingency Plans". The training and qualification program for security personnel and responders is required to meet performance and specific requirements of 10 CFR Part 73, Appendix B, "General Criteria for Security Personnel". Within this context, the applicant need only address those elements or portions of physical protection systems or features that are considered within the scope of the certified portion of the design. The technical basis for physical protection hardware within the scope of the certified portion of the design must provide the basis for ITAAC acceptability and adequacy.

GEH submitted the following ITAAC for detection and assessment hardware in ESBWR DCD Tier 1, Section 2.19:

2. Physical barriers for the protected area perimeter are not part of the vital area barrier.
3. Isolation zones exist in outdoor areas adjacent to the physical barrier at the perimeter of the protected area that allows 20 feet of observation on either side of the barrier.
4. The intrusion detection system can detect penetration or attempted penetration of the protected area barrier.
6. The external walls, doors, ceiling, and floors in the MCR, the central alarm station (CAS), and the last access control function for access to the protected area are resistant to at least an Underwriter's Laboratories (UL) level-IV round.
9. An access control system with numbered picture badges is installed for use by individuals who are authorized access to protected areas without escort.
10. Unoccupied vital areas are locked and alarmed with activated intrusion detection systems that annunciate in the Central and Secondary Alarm Stations upon intrusion into a vital area.

11. Security alarm annunciation occurs in the central alarm station and in at least one other continuously manned station not necessarily onsite.
14. Equipment exists to record onsite security alarm annunciation including the location of the alarm, false alarm, alarm check, and tamper indication and the type of alarm, location, alarm circuit, date, and time.

As a result of its review of the ITAAC for Detection and Assessment Hardware, the staff determined that GEH had submitted ITAAC within the DCD that are not within the scope of the design certification and that should be submitted as part of a COL application. Furthermore, the staff needed additional information to complete its review.

In RAI 14.3-440, the staff requested in part that GEH revise the physical security hardware ITAAC in Tier 1 of the DCD in accordance with the approach discussed with the Nuclear Energy Institute (NEI) on October 21, 2008, and consistent with SRP Section 14.3.12. In the RAI, staff indicated that ITAAC Items 2, 3, 4, and 9 for Detection and Assessment Hardware are not within the scope of the certified design.

In response, GEH proposed to revise DCD Tier 1, Section 2.19 and DCD Tier 2, Section 13.6 to delete any items that are outside the scope of the certified design. GEH removed ITAAC Items 3, 4, and 9, which will be submitted by COL Applicants using the same wording. For Item 2, the second required barrier will be addressed by the COL Applicant in an ITAAC that will be provided for the site-specific design elements of Plant Security. In this case, the COL submittal for Item 2, which the applicant deleted in response to this RAI, will have words to the effect of "Physical barriers for the protected area perimeter are not part of vital area barrier and provide one of the two required physical barriers to vital equipment access." GEH revised Item 6 to remove the specificity of bullet resistance of the last access control function for access to the protected area and to apply bullet resistance to at least a UL level-4 round to the external walls, doors, ceiling, and floors of the MCR and the CAS. The applicant revised Item 10 to exclude the secondary alarm station from the locations where the intrusion alarm will annunciate. The COL Applicant will submit new information for Items 6 and 11 to cover the information deleted.

Upon review of the response to RAI 14.3-440, the staff finds the revision to the ITAAC for detection and assessment hardware to be acceptable because it is in conformance with the staff's definition of physical security hardware ITAAC that is within the scope of the design certification, and the ITAAC are sufficient to verify that the hardware, as finally installed and constructed will function as design.

GEH submitted the following ITAAC for Delay or Barrier Design Features in ESBWR DCD Tier 1, Section 2.19:

5. Isolation zones and exterior areas within the protected area are provided with illumination to permit observation of abnormal presence or activity of persons or vehicles.
7. The vehicle barrier system is installed and located at the necessary stand-off distance to protect against the DBT vehicle bombs.
8. Access control points are established to:
 - a. Control personnel and vehicle access into the protected area.

- b. Detect firearms, explosives, and incendiary devices at the protected area access points.
13. Security - all alarm devices including transmission lines to annunciators are tamper indicating and self-checking (e.g., an automatic indication is provided when the failure of the alarm system or a component occurs, or when on standby power). Alarm annunciation shall indicate the type of alarm (e.g., intrusion alarms, emergency exit alarm, etc.) and location.

As a result of its review of the ITAAC for delay or barrier design features, the staff determined that GEH submitted ITAAC within the DCD that are not within the scope of the design certification and should be submitted as part of a COL application. Furthermore, the staff needed that additional information to complete its review.

In RAI 14.3-440, the staff also indicated that ITAAC Items 7 and 8 for delay or barrier design features are not within the scope of the certified design.

In response to portions of RAI 14.3-440, GEH proposed to revise DCD Tier 1, Section 2.19 by deleting ITAAC Items 7 and 8. GEH indicated that ITAAC Items 7 and 8 will be submitted by the COL Applicants. GEH also deleted ITAAC Item 5 since it was outside the scope of the certified design, even though DCD Tier 2, Section 13.6 provides design criteria for the illumination levels. COL Applicants will submit ITAAC Items 5, 7, and 8 using the same wording. The applicant revised ITAAC Item 13 for clarity.

Upon review of the applicant's response to RAI 14.3-440, the staff finds the revised ITAAC for delay or barrier design features to be acceptable because they conform to the staff's definition of physical security hardware ITAAC that is within the scope of the design certification, and the ITAAC are sufficient to verify that the hardware, as finally installed and constructed, will function as designed.

GEH submitted the following ITAAC for systems, hardware, or features facilitating a security response and neutralization in ESBWR DCD Tier 1, Section 2.19.

- 1. Vital equipment:
 - a. Vital equipment shall be located only within a vital area.
 - b. Access to vital equipment requires passage through at least two physical barriers.
- 12. A secondary security power supply system for alarm annunciator equipment and non-portable communications equipment is located within a vital area.
- 15. Emergency exits through the protected area perimeter and vital area boundaries are alarmed.
- 16. Central and secondary alarm stations:
 - a. Central and secondary alarm stations have conventional (land line) telephone service and other communication capabilities with local law enforcement authorities.

- b. Central and secondary alarm stations are capable of continuous communication with security personnel.

As a result of its review of the ITAAC for systems, hardware, or features facilitating security response and neutralization, the staff determined that GEH has submitted ITAAC within the DCD that are not within the scope of the design certification and that should be submitted as part of a COL application. Furthermore, the staff needed additional information to complete its review.

In RAI 14.3-440, the staff requested that GEH revise the physical security hardware ITAAC in Tier 1 of the DCD regarding systems, hardware, or features facilitating security response and neutralization in accordance with the approach discussed with NEI on October 21, 2008, and consistent with SRP Section 14.3.12.

In response, GEH revised ITAAC Item 1 to indicate that access to vital equipment requires passage through a vital area barrier that prevents unauthorized access. GEH provided a revision to DCD Tier 2, Section 13.6.1.1.2 to add the performance standard submitted in response to other areas of RAI 14.3-440.

GEH also revised Item 12 to specify that the secondary security power supply for alarm annunciator equipment and non-portable communications equipment in the CAS is located in a vital area.

GEH revised Item 15 by removing the requirement that protected area perimeter emergency exits are alarmed.

GEH revised Item 16 by removing communication requirements for the secondary alarm station.

GEH further indicated that the COL Applicant will submit new ITAAC Items 12, 15, and 16 to cover the deleted information.

In RAI 14.3-440 S01, the staff requested that GEH revise the physical security hardware ITAAC in Tier 1 of the DCD to address the Part 73 Power Reactor Security Requirements Final Rule and to reflect these changes in Tier 1 and Tier 2 of the ESBWR DCD. In the same RAI, the staff requested that GEH describe the ITAAC that are not within the scope of the ESBWR design.

In response to RAI 14.3-440 S01, GEH revised DCD Tier 1, Section 2.19 with the following ITAAC:

- 1 a. Vital equipment is located only within a vital area.
- 1 b-1. Access to vital equipment requires passage through a vital area barrier.
- 6 a. The external walls, doors, ceiling, and floors in the MCR and CAS are bullet resistant to at least a UL 752 (2006) Level 4.
- 10 a. Unoccupied vital areas are locked and alarmed with activated intrusion detection systems that annunciate in the central alarm station.
- 11 b-1. The central alarm station is located inside a protected area and the interior is not visible from the perimeter of the protected area.

- 12 a. The secondary security power supply system for alarm annunciator equipment contained in the central alarm station and non-portable communications equipment contained in the central alarm station is located within a vital area.
- 13 a. Security alarm devices including transmission lines to annunciators are tamper indicating and self-checking (e.g., an automatic indication is provided when the failure of the alarm system or of a component occurs or when on standby power) and alarm annunciation shall indicate the type of alarm (e.g., intrusion alarms, emergency exit alarms) and the location.
- 13 b-1. Intrusion detection and assessment systems provide visual display and audible annunciation of the alarm in the central alarm station.
- 14 a. Intrusion detection systems recording equipment exists to record onsite security alarm annunciation including the location of the alarm, false alarm, alarm check, and tamper indication and the type of alarm, location, alarm circuit, date, and time.
- 15 a. Emergency exits through the vital area boundaries are alarmed and secured by locking devices that allow prompt egress during an emergency.
- 16 a-1. The central alarm station has conventional (land line) telephone service and other communication capabilities with the control room and local law enforcement authorities.
- 16 b-1. The central alarm station is capable of continuous communication with security personnel.
- 16 c-1. Non-portable communications equipment in the central alarm station must remain operable from an independent power source in the event of the loss of normal power.

In response to RAI 14.3-440 S01, GEH also added a COL information item to DCD Tier 2, Section 13.6.3. COL Information Item 13.6-20-A indicates that the COL Applicant shall provide the plant and site-specific physical security ITAAC not covered by DCD Tier 1, Section 2.19.

The staff concludes that the GEH has adequately described the Tier 1 ITAAC physical security hardware to be incorporated as part of the standard design. GEH adequately described the plant layout and protection of vital equipment in accordance with the requirements of 10 CFR 73.55 and provided the technical bases for establishing a physical protection system for protection against acts of radiological sabotage. GEH adequately described requirements specific to the design for alarm annunciation records in accordance with 10 CFR 73.70(f). The applicant provided adequate descriptions of objectives, prerequisites, test methods, data required, and acceptance criteria for security-related ITAAC for the certification the ESBWR design. Therefore, the staff concludes that the ESBWR ITAAC within the scope of SRP Section 14.3.12 are necessary and sufficient to assure that with respect to these ITAAC, if the inspections, tests, and analyses are performed and the acceptance criteria are met, a facility referencing the certified ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

14.3.13 Conclusion

This report documents the staff's review of ESBWR DCD Tier 1, Revision 9, and DCD Tier 2, Section 14.3 which was performed in accordance with the SRP. Based on its review of the ESBWR DCD and the applicant's responses to RAIs issued on Tier 1 and Tier 2 material, the staff finds that the applicant's selection criteria and methodology for the development of Tier 1 information, the implementation of this selection criteria and methodology, and whether the resultant ITAAC are adequate to verify that a facility referencing the ESBWR design has been constructed and will be operated in compliance with the design certification and applicable regulations.

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.1.1	Reactor Pressure Vessel System	14.3.2 14.3.4	CIB2, EMB, SRSB
2.1.2	Nuclear Boiler System	14.3.3 14.3.4	EMB, CIB2, SRSB
2.2.1	Rod Control and Information System	14.3.5	ICE2
2.2.2	Control Rod Drive System	14.3.3 14.3.4 14.3.5	SRSB CIB2 EMB
2.2.3	Feedwater Control System	14.3.4 14.3.5	ICE2
2.2.4	Standby Liquid Control System	14.3.3 14.3.4 14.3.5	SRSB EMB CIB2
2.2.5	Neutron Monitoring System	14.3.4 14.3.5	ICE2 SRSB
2.2.6	Remote Shutdown System	14.3.5	ICE2
2.2.7	Reactor Protection System	14.3.5	ICE2
2.2.8	Plant Automation System	No Entry	ICE2
2.2.9	Steam Bypass and Pressure Control System	14.3.5	ICE2
2.2.10	Safety-Related Distributed Control and Information System	14.3.5	ICE2
2.2.11	Non-Safety-Related Distributed Control and Information System	14.3.5	ICE2
2.2.12	Leak Detection and Isolation System	14.3.3 14.3.4 14.3.5	ICE2
2.2.13	Engineered Safety Features System Logic and Control System	14.3.5	ICE2
2.2.14	Diverse Instrumentation and Controls	14.3.5	ICE2
2.2.15	Instrumentation and Control Compliance with IEEE Std 603	14.3.5	ICE2
2.3.1	Process Radiation Monitoring System	14.3.5 14.3.8	ICE2 CHPB

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.3.2	Area Radiation Monitoring System	14.3.5 14.3.8	ICE2 CHPB
2.4.1	Isolation Condenser System	14.3.2 14.3.3 14.3.4	SRSB EMB CIB2
2.4.2	Emergency Core Cooling System – Gravity-Driven Cooling System	14.3.2 14.3.3 14.3.4	SRSB EMB CIB2
2.5.1	Fuel Servicing Equipment	No Entry	
2.5.2	Miscellaneous Servicing Equipment	No Entry	
2.5.3	Reactor Pressure Vessel Servicing Equipment	No Entry	
2.5.4	RPV Internals Servicing Equipment	No Entry	
2.5.5	Refueling Equipment	14.3.2 14.3.7	SBPB SRSB
2.5.6	Fuel Storage Facility	14.3.2 14.3.7	SBPB SRSB
2.5.7	Under-Vessel Servicing Equipment	No Entry	
2.5.8	FMCRD Maintenance Area	No Entry	
2.5.9	Fuel Cask Cleaning	No Entry	
2.5.10	Fuel Transfer System	14.3.7	SBPB
2.5.11	Deleted		
2.5.12	Deleted		
2.6.1	Reactor Water Cleanup/Shutdown Cooling System	14.3.3 14.3.4	SRSB CIB2 EMB
2.6.2	Fuel And Auxiliary Pools Cooling System	14.3.3 14.3.7	SBPB EMB CIB2
2.7.1	Main Control Room Panels	14.3.5 14.3.9	COLP
2.7.2	Radioactive Waste Control Panels	No Entry	
2.7.3	Local Control Panels And Racks	14.3.5 14.3.9	ICE 2

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.8.1	Fuel Rods and Bundles (DELETED)		
2.8.2	Fuel Channel (DELETED)		
2.9	Control Rods (DELETED)		
2.10.1	Liquid Waste Management System	14.3.7 14.3.8	SBPB CHPB
2.10.2	Solid Waste Management System		SBPB CHPB
2.10.3	Gaseous Waste Management System	14.3.7 14.3.8	SBPB CHPB
2.11.1	Turbine Main Steam System	14.3.3 14.3.7	SBPB CIB2 EMB
2.11.2	Condensate and Feedwater System	14.3.3 14.3.4 14.3.7	SBPB EMB
2.11.3	Condensate Purification System	No Entry	CSGB SBPB
2.11.4	Main Turbine System	14.3.6 14.3.7	SBPB CIB2
2.11.5	Turbine Gland Seal System	14.3.7	SBPB
2.11.6	Turbine Bypass System	14.3.3 14.3.7	SBPB
2.11.7	Main Condenser	14.3.7	SBPB
2.11.8	Circulating Water System	No Entry	SBPB
2.11.9	Power Cycle Auxiliary Water Systems	No Entry	SBPB
2.12.1	Makeup Water System	14.3.3 14.3.7	SBPB
2.12.2	Condensate Storage and Transfer System	No Entry	
2.12.3	Reactor Component Cooling Water System	14.3.3 14.3.7	SBPB
2.12.4	Turbine Component Cooling Water System	No Entry	
2.12.5	Chilled Water System	14.3.3 14.3.7	SBPB

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.12.6	Oxygen Injection System	No Entry	
2.12.7	Plant Service Water System	14.3.3 14.3.7	SBPB
2.12.8	Service Air System	14.3.3 14.3.7	SBPB
2.12.9	Instrument Air System	No Entry	
2.12.10	High Pressure Nitrogen Supply System	14.3.3 14.3.7	SBPB
2.12.11	Auxiliary Boiler System	No Entry	
2.12.12	Potable Water System	No Entry	
2.12.13	Hydrogen Water Chemistry System (option)	No Entry	
2.12.14	Process Sampling System	No Entry	
2.12.15	Zinc Injection System	No Entry	
2.12.16	Freeze Protection	No Entry	
2.12.17	Station Water System	No Entry	
2.13.1	Onsite AC Power System	14.3.6	EEB
2.13.2	Electrical Wiring Penetrations (see 2.15.1 and 2.16.3.1) (DELETED)	14.3.2 14.3.6 14.3.11	EEB
2.13.3	Direct Current Power Supply	14.3.5 14.3.6	EEB
2.13.4	Onsite Diesel Generator Power Supply Systems	14.3.5 14.3.6	EEB
2.13.5	Uninterruptible AC Power Supply	14.3.5 14.3.6	EEB
2.13.6	Instrument and Control Power Supply	Deleted	
2.13.7	Communication System	No Entry	ICE 2
2.13.8	Lighting Power Supply	14.3.5 & 6	EEB
2.14	Power Transmission	No Entry	EEB

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.15.1	Containment System	14.3.2 14.3.3 14.3.6 14.3.11	SEB2 EMB SBCV CIB2 EEB
2.15.2	Containment Vessel (see 2.15.1)	-	NA
2.15.3	Containment Internal Structures	14.3.2 14.3.3 14.3.4 14.3.11	SEB2 SBCV
2.15.4	Passive Containment Cooling System	14.3.3 14.3.4 14.3.11	SBCV EMB CIB2
2.15.5	Containment Inerting System	14.3.11	SBCV
2.15.6	Drywell Cooling System	No Entry	SBCV
2.15.7	Containment Monitoring System	14.3.11 14.3.8	ICE2 SBCV
2.16.1	Cranes, Hoists and Elevators	14.3.7	SBPB
2.16.2	Heating, Ventilating and Air-Conditioning Systems	14.3.7	SBCV
2.16.3	Fire Protection System	14.3.7	SFPB
2.16.4	Equipment and Floor Drain System	14.3.7	SBPB
2.16.5	Reactor Building	14.3.2 14.3.5 14.3.6 14.3.7	RSAC SFPB SBPB SEB2 SBCV
2.16.6	Control Building	14.3.2 14.3.5 14.3.6 14.3.7	SBCV, SFPB, SBPB, EGCB
2.16.7	Fuel Building	14.3.2 14.3.7	SFPB, SBPB, SEB2 SBCV
2.16.8	Turbine Building	No Entry	
2.16.9	Radwaste Building	No Entry	
2.16.10	Other Buildings and Structures	No Entry	

ITAAC SECTION	DCD TIER 1 SECTION TITLE	SRP SECTION	BRANCH(ES)
2.17.1	Intake and Discharge Structure	No Entry	
2.18.1	Oil Storage and Transfer Systems	No Entry	
2.18.2	Site Security	No Entry	
2.19	Plant Security System	14.3.12	NSIR
3.1	Design of Piping Systems and Components	14.3.3	EMB
3.2	Software Development	14.3.5 14.3.9	ICE2
3.3	Human Factors Engineering	14.3.9	COLP
3.4	Radiation Protection	14.3.8	CHPB
3.5	Initial Test Program	14.2	CQVB
3.6	Design Reliability Assurance Program	14.3	SPLB
3.7	Post Accident Monitoring Instrumentation	14.3.5	ICE2
3.8	Environmental Qualification of Mechanical and Electrical Equipment	14.3.3 14.3.5 14.3.6 14.3.7	EEB CIB2
4	Interface Requirements	1.0	
4.1	Plant Service Water System	1.0 14.3.7	SBPB
5	Site Parameters	2.0	RSAC RGS1 RHEB