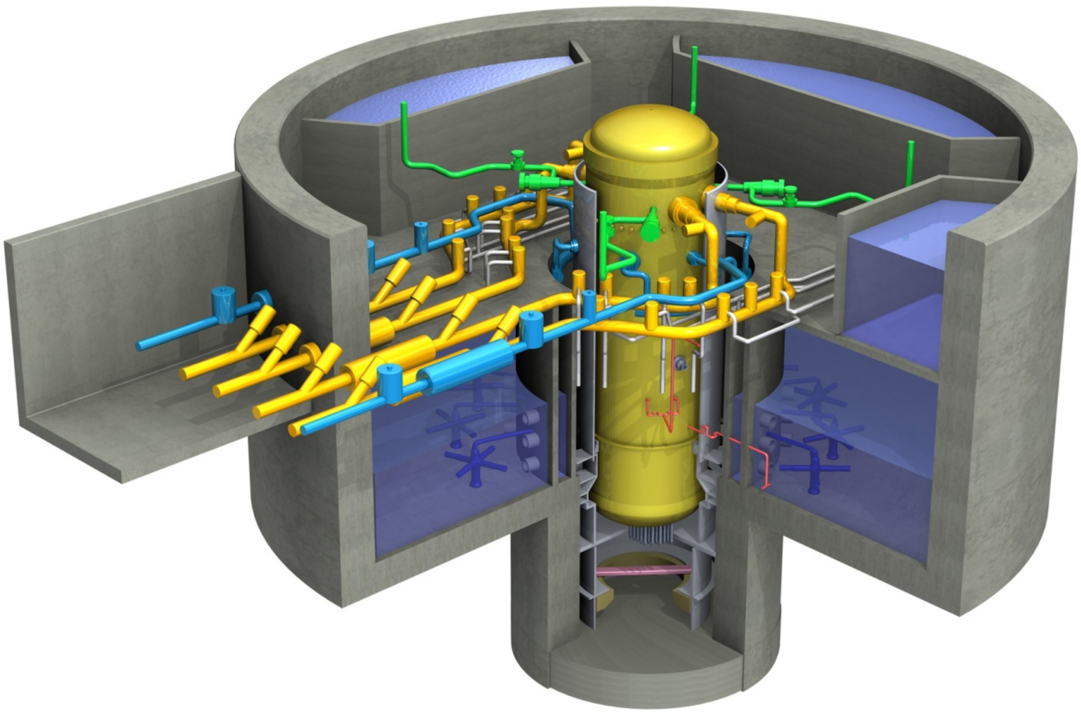
GE Hitachi Nuclear Energy

26A6642BN
Revision 10
April 2014



# ESBWR Design Control Document
*Tier 2*

## Chapter 14
*Initial Test Program*

# Contents

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None.

# 14. INITIAL TEST PROGRAM

## 14.1 INITIAL TEST PROGRAM FOR PRELIMINARY SAFETY ANALYSIS REPORTS

The standard review plan for this section has been deleted.

# 14.2 INITIAL PLANT TEST PROGRAM FOR FINAL SAFETY ANALYSIS REPORTS

## 14.2.1 Summary of Test Program and Objectives

The Initial Test Program (ITP) consists of a series of tests categorized as preoperational and initial startup tests. Construction acceptance tests serve as prerequisites for preoperational tests. Preoperational tests are those tests normally conducted prior to fuel loading to demonstrate the capability of plant systems to meet performance requirements. Initial startup tests begin with fuel loading and demonstrate the capability of the integrated plant to meet performance requirements.

The objectives of the ITP are to:

- Ensure that the construction is complete and acceptable;
- Demonstrate the capability of structures, systems, and components to meet performance requirements;
- Effect fuel loading in a safe manner;
- Demonstrate, where practical, that the plant is capable of withstanding anticipated transients and postulated accidents;
- Evaluate and demonstrate, to the extent practical, plant operating procedures to provide assurance that the operating group is knowledgeable about the plant and procedures and fully prepared to operate the facility in a safe manner; and
- Bring the plant to rated capacity and sustained power operation.

### *14.2.1.1 Construction Test Objectives*

Construction tests are performed to demonstrate that components and systems are correctly installed and operational. These tests may include, but are not limited to, flushing and cleaning, hydrostatic testing, initial calibration of instrumentation, checks of electrical wiring and equipment, valve testing, and initial energization and operation of equipment and systems. Completion of this phase assures systems are ready for preoperational testing.

### *14.2.1.2 Preoperational Test Objectives*

Preoperational tests are conducted prior to fuel loading in order to verify that plant systems are capable of operating in a safe and efficient manner compatible with the system design bases. The general objectives of the preoperational test phase are as follows:

- Ensure design specification and test acceptance criteria are met;
- Provide documentation of the performance and safety of equipment and systems;
- Provide baseline test and operating data on equipment and systems for future reference;
- Run-in new equipment for a sufficient period so that design, manufacturing, or installation defects can be detected and corrected;
- Ensure plant systems operate together on an integrated basis to the extent practical;

- Give opportunity to the permanent plant operating staff to obtain practical experience in the operation and maintenance of equipment and systems;
- Establish and evaluate normal, abnormal, and emergency operating procedures to the extent practical;
- Establish and evaluate surveillance testing procedures; and
- Demonstrate that systems and safety-related equipment are operational and that it is possible to proceed to fuel loading and to the startup phase.

### *14.2.1.3 Startup Test Objectives*

After the preoperational test phase has been completed, the startup phase begins with fuel loading and extends to commercial operation. This phase may be generally subdivided into the following four parts:

(1) Fuel loading and shutdown power level tests;

(2) Testing during nuclear heatup to rated temperature and pressure (approximately 5% power);

(3) Power testing at low power, mid-power and high power; and

(4) Warranty demonstration.

The tests conducted during the startup phase consist of major and minor plant transients, steady-state tests, and process control system tests. These tests are directed towards demonstrating correct performance of the nuclear boiler and the various plant systems while at power.

The general objectives of the startup phase are to:

- Achieve an orderly and safe initial core loading;
- Accomplish testing and measurements necessary to assure the approach to initial criticality and subsequent power ascension is safe and orderly;
- Conduct low-power physics tests sufficient to ensure test acceptance criteria have been met;
- Conduct initial heatup and an orderly safe power ascension program, with requisite physics and systems testing, to ensure that integrated plant operation at power meets test acceptance criteria; and
- Conduct a successful warranty demonstration.

### *14.2.1.4 Organization and Staffing*

#### *Normal Plant Staff*

Normal plant staff responsibilities, authorities, and qualifications are given in Chapter 13. During the construction cycle and the various testing phases, the plant owner/operator, GE Hitachi Nuclear Energy (GEH), and others supply additional staff.

***Startup Group***

The startup group is an organization created for the purpose of ensuring that the ITP of preoperational and startup tests is conducted in an efficient, safe, and timely manner. The startup group is responsible for the planning, executing and documenting of the startup and testing related activities that occur between the completion of the construction phase and commencement of commercial operation of the plant. At approval to load fuel, the plant operations organization assumes complete responsibility for the plant. The licensed reactor operators/senior reactor operators have legal responsibility. The startup organization will report to the operations department for testing support. At completion of the startup program, the startup group is dissolved and the normal plant operating staff assumes complete responsibility for the plant. Ideally, the startup group includes individuals assigned temporarily from the various departments and disciplines within the normal plant and utility organization. This assures maximum transfer and retention of experience and knowledge gained during the startup program for the subsequent commercial operation of the plant. The normal plant staff is included in as many aspects of the test programs as is practical considering their normal duties in the operation and maintenance of the plant.

***GE Hitachi Nuclear Energy Company***

GEH is the designer and supplier of the ESBWR power plant. During the construction and testing phases of the plant, GEH personnel are onsite to direct the work of the constructor and to offer consultation and technical direction. The GEH resident site manager is responsible for these activities, and is the official site spokesperson for GEH. This manager coordinates with the Combined License (COL) Holder's normal and augmented plant staff in the performance of duties, which include:

- Reviewing and approving test procedures, changes to test procedures, and test results for equipment and systems within the plant;
- Providing technical direction to the station staff;
- Managing the activities of the GEH site personnel in providing technical direction to shift personnel in the testing and operation of the plant;
- Providing liaison between the site and the GEH home office to provide rapid and effective solutions for problems which cannot be solved onsite; and
- Participating as a member of the Startup Coordinating Group (SCG). [Note: The official designation of this group may differ for the plant owner/operator referencing the ESBWR design, and SCG is used throughout this discussion for illustrative purposes only.]

***Others***

Other concerned parties (outside the plant staff organization) such as the constructor, the turbine-generator supplier, and vendors of other systems and equipment, are involved in the testing program to various degrees. Such involvement may be in a direct role in the startup group as discussed above or in an indirect capacity offering consultation or technical direction concerning the testing, operation, or resolution of problems or concerns with equipment and systems for which they are responsible or with which they are uniquely familiar .

*Interrelationships and Interfaces*

Effective coordination between the various site organizations involved in the test program is achieved through the SCG, which is composed of representatives of the plant owner/operator, GEH, and others. The duties of the SCG are to review and approve project testing schedules and to effect timely changes to construction or testing in order to facilitate execution of the preoperational and initial startup test programs.

## 14.2.2 Startup Administrative Manual/Test Procedures/Program/Results/Reports

### *14.2.2.1 Startup Administrative Manual*

A description of the initial test program administration is developed and made available to the NRC by the COL Applicant. This includes a discussion and description of the process and organizational controls and requirements that are included in the Startup Administrative Manual. See Subsection 14.2.10, COL Information item 14.2-1-A.

The COL Applicant will provide a milestone for completing the Startup Administrative Manual and making it available for Nuclear Regulatory Commission (NRC) inspection (COL 14.2-2-A). [Note: The official designation of this manual may differ for the plant owner/operator referencing the ESBWR design; the term Startup Administrative Manual is used throughout this discussion for illustrative purposes only.]

This manual:

- Describes the responsibilities of the organization that will carry out the test program, methods and plans for providing the necessary staff, description of the staff responsibilities, authorities, and personnel qualifications for conducting the ITP.
- Delineates the development, review and approval of test procedures per Appendix C of Regulatory Guide (RG) 1.68. These site-approved test procedures are to be made available approximately 60 days before their intended use.
- Delineates utilization of reactor operating and testing experience in the development of the test procedures.
- Requires the development of plant operating and emergency procedures prior to fuel loading, and their application during the test program, consistent with Section C.7 of RG 1.68.
- Defines requirements for the test program schedule consistent with Section C.5 of RG 1.68 and the test sequence, consistent with Sections 1 through 5 in Appendix A of RG 1.68.
- Defines requirements for the test methodology, prerequisites, testing conditions, acceptance criteria, and analysis techniques consistent with RG 1.68.
- 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.

Regulatory Guide 1.68 specifies criteria (see Regulatory Position C.1) for determining what structures, systems, components and design features are required to be tested during the power

ascension test phase in accordance with the requirements therein. Testing of such structures, systems, components and design features is then subject to license conditions requiring NRC prior approval for major test changes.

#### *14.2.2.2 Test Procedures*

In general, testing during the ITP is conducted using detailed, step-by-step written procedures to control the conduct of each test. These specifically include safety precautions and limits as needed for the test to supplement those in the normal operating procedure. Such test procedures:

- Specify testing prerequisites,
- Describe desired initial conditions,
- Include appropriate methods to direct and control test performance (including the sequencing of testing),
- Specify acceptance criteria by which the test is to be evaluated, and
- Provide for or specify the format by which data or observations are to be recorded.

The procedures are developed and reviewed by personnel with appropriate technical backgrounds and experience. This includes the participation of principal design organizations (including GEH) to establish test performance requirements and acceptance criteria. Specifically, GEH provides the COL Holder with scoping documents (plant preoperational and startup test specifications) containing testing objectives and acceptance criteria applicable to the plant design. Such documents also include, as appropriate, delineation of specific plant operational conditions at which tests are to be conducted, testing methodologies to be utilized, specific data to be collected, and acceptable data reduction techniques. Available information on operating and testing experiences of operating power reactors is factored into test procedures as appropriate. Test procedures are reviewed by the SCG and receive final approval by designated plant management personnel. The COL Applicant will provide milestones for making available to the NRC approved test procedures satisfying the requirements for the ITP (COL 14.2-3-A).

#### *14.2.2.3 Conduct of Test Program*

The startup group conducts the ITP in accordance with the Startup Administrative Manual. This manual contains the administrative procedures and requirements that govern the activities of the startup group and their interface with other organizations. The Startup Administrative Manual receives the same level of review and approval, as do other plant administrative procedures. It defines the specific format and content of preoperational and startup test procedures, as well as the review and approval process for both initial procedures and subsequent revisions or changes. The Startup Administrative Manual also specifies the process for review and approval of test results and for resolution of failures to meet acceptance criteria and of other operational problems or design deficiencies noted. It describes the various phases of the ITP and establishes the requirements for progressing from one phase to the next, as well as those for moving beyond selected holdpoints or milestones within a given phase. It also describes the controls in place that assure the as-tested status of each system is known and that track modifications, including retest requirements, deemed necessary for systems undergoing or already having completed specified testing. Additionally, the Startup Administrative Manual delineates the qualifications

and responsibilities of the different positions within the startup group. The Startup Administrative Manual is intended to supplement normal plant administrative procedures by addressing those concerns that are unique to the startup program or that are best approached in a different manner. To avoid confusion, the startup program attempts to be consistent with normal plant procedure where practical. The plant staff typically performs their duties according to normal plant procedures. However, in areas of potential conflict with the goals of the startup program, the Startup Administrative Manual or the individual test procedures address the required interface.

#### *14.2.2.4 Review, Evaluation, and Approval of Test Results*

Individual test results are evaluated and reviewed by members of the startup group. Test exceptions or acceptance criteria violations are communicated to the affected and responsible organizations who help resolve the issues by suggesting corrective actions, design modifications, and retests. As appropriate, GEH and others outside the plant staff organization have the opportunity to review the results for conformance to predications and expectations. Test results, including final resolutions, are then reviewed and approved by designated startup group supervisory personnel. Final approval is obtained from the SCG and the appropriate level of plant management, as defined in the Startup Administrative Manual. The SCG and the designated level of plant management also have responsibility for final review and approval of overall test phase results and of selected milestones or hold-points within the test phases.

#### *14.2.2.5 Test Records*

Initial test program results are compiled and maintained according to the startup manual, plant administrative procedures, and applicable regulatory requirements. Test records that demonstrate the adequacy of safety-related components, systems and structures shall be retained for the life of the plant. Retention periods for other test records are based on consideration of their usefulness in documenting initial plant performance characteristics.

### 14.2.3 Test Program Conformance with Regulatory Guides

The development of the ITP uses NRC Regulatory Guides listed below:

- Regulatory Guide 1.68 — “Initial Test Programs for Water-Cooled Nuclear Power Plants;”
- Regulatory Guide 1.68.1 — “Preoperational and Initial Startup Testing of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants;”
- Regulatory Guide 1.68.2 — “Initial Startup Test Program to Demonstrate Remote Shutdown Capability for Water-Cooled Nuclear Power Plants;”
- Regulatory Guide 1.68.3 — “Preoperational Testing of Instrument and Control Air Systems;”
- Regulatory Guide 1.20 — “Comprehensive Vibration Assessment Program for Reactor Internals During Preoperation and Initial Startup Testing;”
- Regulatory Guide 1.41 — “Preoperational Testing of Redundant On-site Electric Power Systems to Verify Proper Load Group Assignments;”

- Regulatory Guide 1.56 — "Maintenance of Water Purity in Boiling Water Reactors;"
- Regulatory Guide 1.128 – "Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants;" and
- Regulatory Guide 1.140 — "Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

### 14.2.4 Utilization of Reactor Operating and Testing Experience in the Development of Test Program

Because every reactor/plant in the GEH Boiling Water Reactor (BWR) product line is an evolutionary development of the previous plant in the product line (and each product line is an evolutionary development from the previous product line), it is evident that the ESBWR plants have the benefits of experience acquired with the successful and safe startup of more than 30 previous BWR and Advanced Boiling Water Reactor (ABWR) plants. The operational experience and knowledge gained from these plants and other reactor types have been factored into the design and test specifications of ESBWR systems and equipment that are demonstrated during the preoperational and startup test programs. Additionally, reactor operating and testing experience of similar nuclear power plants obtained from NRC Licensee Event Reports, Institute of Nuclear Power Operations (INPO) correspondence, and through other industry sources are utilized to the extent practicable in developing and carrying out the ITP.

### 14.2.5 Use of Plant Operating and Emergency Procedures

To the extent practicable throughout the preoperational and initial startup test program, test procedures utilize operating, surveillance, emergency, and abnormal procedures where applicable in the performance of tests. The use of these procedures is intended to do the following:

- Prove the specific procedure or illustrate changes which may be required;
- Provide training of plant personnel in the use of these procedures; and
- Increase the level of knowledge of plant personnel on the systems being tested.

A testing procedure may use a combination of references to operating, emergency, or abnormal procedure or repeat a series of steps from the procedure in order to accomplish the above goals while efficiently performing the specified testing.

### 14.2.6 Initial Fuel Loading and Initial Criticality

Fuel loading and initial criticality are conducted in a controlled manner in accordance with specific written procedures as part of the startup test phase (Subsection 14.2.8.2). However, unforeseen circumstances may arise that would prevent the completion of the preoperational testing (including the review and approval of the test results), but that would not necessarily justify the delay of fuel loading. Under such circumstances, the COL Holder may decide to request permission from the NRC to proceed with fuel loading. If portions of any preoperational tests are intended to be conducted, or their results approved, after commencement of fuel loading, then the following will be documented in such a request:

- List each test;
- State which portions of each test are delayed until after fuel loading;
- Provide technical justification for delaying these portions; and
- State when each test would be completed and the results approved.

***Pre-Fuel Load Checks***

Once the plant has been declared ready to load fuel, a number of specific checks are made prior to proceeding, including a final review of the preoperational test results and the status of any design changes, work packages, or retests that were initiated as a result of exceptions noted during this phase. Also, the Technical Specifications surveillance program requirements (Chapter 16) are instituted at this time to ensure the operability of systems required for fuel loading. Prior to the initiation of fuel loading, proper vessel water level and chemistry are verified and the calibration and response of nuclear instruments are checked.

***Initial Fuel Loading***

Fuel loading requires the movement of the full-core complement of assemblies from the fuel pool to the core, with each assembly being identified by serial number before being placed in the correct coordinate position. The fuel loading procedure ensures safe loading increments by specifying the predetermined intervals to check the shutdown margin and subcriticality. In-vessel neutron monitors provide continuous indication of the core flux level as each assembly is added. A complete check is made of the fully loaded core to ascertain that the assemblies are properly installed, correctly oriented, and occupying their designated positions.

***Pre-Criticality Testing***

Prior to initial criticality, the shutdown margin will be verified for the fully loaded core. The control rods will be functional and scram-tested with the fuel in place. Additionally, a final verification that the required Technical Specification (TS) surveillances have been performed will be made.

***Initial Criticality***

During initial criticality, the full-core shutdown margin will be verified as specified in Subsection 14.2.8.2.4. Initial criticality is achieved in an orderly, controlled fashion following specific detailed procedures in a prescribed rod withdrawal sequence that has been approved by the plant management. Core neutron flux is continuously monitored during the approach to critical and the rod pattern at critical is compared to prediction to allow early detection and evaluation of potential anomalies.

## 14.2.7 Test Program Schedule and Sequence

The schedule, relative to the initial fuel load date, for conducting each major phase of the ITP will be provided by the COL Holder. This will include the timetable for generation, review, and approval of procedures, as well as the actual testing and analysis of results. As a minimum, approximately nine months is allowed for conducting the preoperational phase prior to the fuel loading date, and approximately three months is allowed for conducting the startup and power ascension testing that commences with fuel loading. To allow for NRC review, test procedure preparation is scheduled such that approved procedures are available approximately 60 days

prior to their intended use or 60 days prior to fuel load for power ascension test procedures. Although there is considerable flexibility available in the sequencing of testing within a given phase, there is also a basic order that results in the most efficient schedule.

The ESBWR utilizes a Distributed Control and Information System (DCIS) which must be functional before many pre-op tests can begin. The DCIS Pre-Op Test (see Subsection 14.2.8.1.7) can begin early and would control scheduling for other tests. During the preoperational phase, testing should be performed as system turnover from construction allows. However, the interdependence of systems should also be considered so that common support systems, such as electrical power distribution, DCIS, service and instrument air, and the various makeup water and cooling water systems are tested as early as possible.

Testing sequence during the startup phase depends primarily on specified power conditions and intersystem prerequisites. To the extent practicable, the schedule establishes that, prior to exceeding 25% power, the test requirements are met for those plant structures, systems, and components that are relied on to prevent, limit, or mitigate the consequences of postulated accidents.

Power ascension testing is conducted in essentially three phases:

(1) Initial fuel loading and open-vessel testing;

(2) Testing during nuclear heatup to rated temperature and pressure (less than 5% power); and

(3) Power operation testing from 5% to 100% rated power.

The power operation testing plateaus consist of low power testing at less than 25% power, mid-power testing up to about 75% power, and high power testing up to rated power. Thus, there are a total of five different testing plateaus designated; Table 14.2-1 indicates in which testing plateaus the various power ascension tests are performed. Although the order of testing within a given plateau is somewhat flexible, the normal recommended sequence of tests is:

(1) Core performance analysis;

(2) Steady-state tests;

(3) Control system tuning;

(4) System transient tests; and

(5) Major plant transients (including trips).

For a given testing plateau, testing at lower power levels is generally performed prior to that at higher power levels.

The COL Applicant will provide a milestone for completing the detailed testing schedule and making it available to the NRC (COL 14.2-4-A).

## 14.2.8 Individual Test Descriptions

### *14.2.8.1 Preoperational Test Procedures*

The following general descriptions relate the objectives of each preoperational test. During the final construction phase, it may be necessary to modify the preoperational test methods as

operating and preoperational test procedures are developed. Consequently, methods in the following descriptions are general, not specific.

Specific testing to be performed and the applicable acceptance criteria for each preoperational test is documented in test procedures available to the NRC approximately 60 days prior to their intended use. Preoperational tests are in accordance with the system specifications and associated equipment specifications for equipment in those systems provided as part of scoping documents to be supplied by GEH and others as described in Subsection 14.2.2. The tests demonstrate that the installed equipment and systems perform within the limits of these specifications. To ensure the test procedures are written in accordance with established methods and appropriate acceptance criteria, the plant and system preoperational test specifications will also be made available to the NRC.

The preoperational tests anticipated for the ESBWR are described in the following paragraphs. Preoperational and startup testing of systems outside the scope of the standard ESBWR design are discussed in Subsection 14.2.9.

#### 14.2.8.1.1 Nuclear Boiler System Preoperational Test

***Purpose***

The objective of this test is to verify that the valves, actuators, instrumentation, trip logic, alarms, annunciators, and indications associated with the Nuclear Boiler System (NBS) function as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The Depressurization Valve (DPV) engineering development tests have been completed as described in Subsection 5.4.13.3. The DPV factory operability tests, including response tests and flow tests, have been completed. The Reactor Pressure Vessel (RPV) and Main Steamlines (MSL) can accept water during the test. The nitrogen gas and instrument air are available to support operation of Main Steam (MS) valves. Electrical power is available to support MS valves, instrumentation, and system operation. To the extent necessary, the interfacing systems are available to support the specific system testing and the appropriate system configurations. 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 process of isolation, verification of the firing signal during the test, and subsequent reconnection must be controlled within the test document.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Verification that the sensing devices respond to actual process variables and provide alarms and trips at specified values;
- Proper operation of system instrumentation and any associated logic, including that of the Automatic Depressurization System (ADS);

- Proper operation of Main Steam Isolation Valves (MSIVs) and main steamline drain valves, including verification of closure time in the isolation mode;
- Proper operation of the Feedwater (FW) isolation valves and FW check valves, including verification of closure times in isolation mode and testability features, if present;
- Verification of appropriate Safety Relief Valve (SRV) and MSIV accumulator capacity;
- Proper operation of SRV air piston actuators and discharge line vacuum breakers;
- Verification of the acceptable leaktightness and overall integrity of the reactor coolant pressure boundary via the leakage rate and hydrostatic testing as described in Section 5.2;
- Proper operation of DPV and SRV including verification of position indication; and
- Acceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.

Other checks shall be performed, as appropriate, to demonstrate that design requirements, such as those for sizing or installation, are met via as-built calculations, visual inspections, review of qualification documentation or other methods. For instance, SRV setpoints and capacities shall be verified from certification or bench tests consistent with applicable requirements.

#### 14.2.8.1.2 Feedwater Control System Preoperational Test

***Purpose***

The objective of this test is to verify that the Feedwater Control System (FWCS) operates properly and performs within limits of specifications.

***Prerequisites***

The construction tests have been successfully completed, and the Condensate and Feedwater System preoperational test (Subsection 14.2.8.1.44) has been completed. The Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) System and Feedwater System low flow control valve are available to support FWCS testing. The SCG has reviewed the test procedures and approved the initiation of testing. FWCS components shall have an initial calibration in accordance with vendor instructions. Factory acceptance tests of Fault-Tolerant Digital Controller (FTDC) features and requirements as described in Subsection 7B.1 have been successfully completed. Required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

***General Test Methods and Acceptance Criteria***

Testing of the FWCS during the preoperational phase may be limited by the absence of an acceptable feedwater recirculation flow path and therefore comprehensive flow testing is conducted during the startup phase.

Performance shall be observed and recorded during a series of individual component and overall system response tests to demonstrate the following:

- Proper operation of instrumentation and controls in the required combinations of logic and instrument channel trips, including verification of setpoints;

- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves, including timing and stroke, in response to control demands (including RWCU/SDC dump valve response to the low-flow controller);
- Proper operation of interlocks and equipment protective devices within the FWCS;
- Verification of loss of feedwater heating signal to initiate Selected Control Rod Run-In (SCRRI) and Select Rod Insertion (SRI);
- Verification of feedwater level control level setdown logic on reactor low water level (Level 3) signal;
- Verification of feedwater runback on reactor high level (Level 8) signal;
- Verification of feedwater runback on Anticipated Transient Without Scram (ATWS) trip signal;
- Proper communication and interface with other control systems and related equipment;
- Proper overall response of the control system including the final control element. 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 bypass capability (control system response will be verified, and mechanical / electrical component responses will be tested to the extent practical under preoperational test conditions);
- Independence of system functional operation from loss of operation of one of the redundant channels of the FTDC controllers/processors (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); and
- Verification of each Motor Driven Reactor Feed Pump (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).

#### 14.2.8.1.3 Standby Liquid Control System Preoperational Test

***Purpose***

The objective of this test is to verify that the operation of the Standby Liquid Control (SLC) system, including accumulator, tanks, control, logic, and instrumentation, is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The reactor vessel shall be available for injecting demineralized water. Required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations. 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 process of isolation, verification of the firing signal during the test, and subsequent reconnection must be controlled within the test document.

*General Test Methods and Acceptance Criteria*

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper calibration of instrumentation;
- Proper operation of instrumentation and equipment in the required combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper functionality of redundant accumulator equipment room electric heaters;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of the nitrogen pressurization system;
- Proper system flow paths and discharge (with demineralized water substituted for the neutron absorber mixture);
- Proper operation of interlocks and equipment protective devices in valve controls;
- Proper operation of the squib-type injection valves; and
- Acceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.

Note: Proper volume and concentration of the neutron absorber solution (refer to Table 9.3-3) will be surveilled prior to entry in the TS mode in which the SLC system is required to be operable.

**14.2.8.1.4 Control Rod Drive System Preoperational Test**

***Purpose***

The objective of this test is to verify that the Control Rod Drive (CRD) System, including the CRD hydraulic and fine motion control rod subsystems, performs within limits of specifications.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The CRD Factory Quality Control Tests, Functional Tests, and Operational Tests have been successfully completed as described in Subsection 4.6.3. The control blades and temporary guides in the RPV shall be installed and the Fine Motion Control Rod Drives (FMCRDs) are ready to be stroked and scrammed. Reactor component cooling water, instrument air, and other required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

Additionally, the Rod Control and Information System (RC&IS) shall be functional when needed, with the applicable portion of its specified preoperational testing complete.

***General Test Methods and Acceptance Criteria***

The CRD pumps take suction from the condensate system (preferred source) or the Condensate Storage Tank (CST) (backup). This test must include testing both sources and the transfer between sources. Performance shall be observed and recorded during a series of individual component and integrated system, factory, and preoperational tests to demonstrate the following:

- Proper functioning of instrumentation and alarms used to monitor system operation and status, including control room video panels designed to display CRD positions and other operational information;
- Proper communication with, and response to demands from, the RC&IS and the Reactor Protection System, including that associated with Alternate Rod Insertion (ARI), alternate rod run-in (post-scram), and select control rod run-in functions;
- Proper functioning of system valves, including purge water pressure control valves, under expected operating conditions;
- Proper operation of CRD pumps and motors in all design operating modes;
- Proper operation of CRD makeup to reactor pressure vessel on reactor low level signal;
- Proper logic and operation of HP CRD isolation, termination of HP CRD isolation, and bypass of HP CRD isolation;
- Acceptable pump Net Positive Suction Head (NPSH) under the most limiting design flow conditions;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper system flow paths and flow rates, including sufficient pump capacity and discharge head;
- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Verification of charging water low pressure input to the reactor protection system;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of fine motion motors and drives and associated control units, including verification of acceptable normal insert and withdraw timing; and
- Proper operation of hydraulic control units and associated valves, including CRD scram timing demonstrations against atmospheric pressure.

**14.2.8.1.5 Rod Control and Information System Preoperational Test**

***Purpose***

The objective of this test is to verify that the RC&IS operates properly and performs within limits of specifications.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All electrical connections for rod position indication and RC&IS have been completed. All RC&IS cabinet power is available and system power supplies calibrated.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of tests to demonstrate the following:

- Proper operation of rod blocks and associated alarms and annunciators in appropriate design combinations of logic and instrument channel trip, including all positions of the reactor mode switch;
- Proper system response to control rod run-in logic, including that associated with Alternate Rod Insertion (ARI), SCRRI and normal post-scram follow;
- Proper functioning of instrumentation used to monitor Fine Motion Control Rod Drive (FMCRD) subsystem status such as rod position indication instrumentation and that used to monitor rod/drive separation status;
- Proper functioning of instrumentation used to monitor status signals from hydraulic control units (HCUs) and failure indication of any one position detector for an individual FMCRD;
- Proper operation of RC&IS software including verification of gang and group assignments and Automated Thermal Limit Monitors (ATLM), Rod Worth Minimizer (RWM) and automatic rod selection and movement functions; and
- Proper communication with Plant Automation System (PAS).

**14.2.8.1.6 Safety System Logic and Control Engineered Safety Feature Preoperational Test**

***Purpose***

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 (Q-DCIS) and nonsafety-related (N-DCIS) plant Distributed Control and Information System (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.

***Prerequisites***

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. The commitments of the software plans include such testing as Factory Acceptance Tests and Site Acceptance Tests. Site Acceptance Testing includes elements not tested during Factory Acceptance Testing, elements that could change in transit, and elements otherwise determined to need testing at the site. The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The required alternating current (AC) and direct current (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 consists of the following:

- Verify the self-test portion of the SSLC/ESF, including the proper reporting of detected failures;
- Verify the non-interaction of the SSLC/ESF self-test system to confirm that the self-test system does not cause a false indication;
- Verify the correct activation of the inputs to the SSLC/ESF such as pushbutton switches, control operating switches, key-operated switches and analog inputs;
- Verify the local indication devices on the SSLC/ESF properly indicate the correct status;
- Verify the proper interface with diverse protection system;
- Verify proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip; and
- Verify bypass logic and bypass indications.

**14.2.8.1.7 DCIS System Preoperational Test**

***Purpose***

The objective of this testing is to verify proper functioning of both the safety-related (Q-DCIS) and nonsafety-related (N-DCIS) plant Distributed Control and Information System (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 phases of construction. The DCIS implementation and installation testing includes adhering to the commitments of the software plans. The commitments of the software plans include such testing as Factory Acceptance Tests and Site Acceptance Tests. Site Acceptance Testing includes elements not tested during Factory Acceptance Testing, elements that could change in transit, and elements otherwise determined to need testing at the site.

DCIS construction tests have been successfully completed and the SCG has both reviewed the 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 consists 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 system preoperational testing.

#### 14.2.8.1.8 Leak Detection and Isolation System Preoperational Test

***Purpose***

The objective of this test is to verify proper response and operation of the Leak Detection and Isolation System (LD&IS) logic, the safety-related (Q-DCIS), and nonsafety-related (N-DCIS) plant Distributed Control and Information System (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.

***Prerequisites***

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. The commitments of the software plans include such testing as Factory Acceptance Tests and Site Acceptance Tests. Site Acceptance Testing includes elements not tested during Factory Acceptance Testing, elements that could change in transit, and elements otherwise determined to need testing at the site.

SSLC/ESF construction tests have been successfully completed and the SCG has reviewed the 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***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper installation and calibration of instrumentation and controls;
- Proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of indications, annunciators, and alarms used to monitor system operation and status;
- Proper operation of leakoff and drainage measurement functions such as those associated with the reactor vessel head flange and drywell cooler condensate;
- Proper interface with related systems in regard to the input and output of leak detection indications and isolation initiation commands;
- Proper operation of bypass switches and related logic; and
- Acceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.

#### 14.2.8.1.9 Reactor Protection System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the Reactor Protection System (RPS), including complete channel logic and response time.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The CRD, Instrument Air System (IAS), and the required AC and DC electrical power sources are operational. The other required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip, including those associated with all positions of the reactor mode switch;
- Proper functioning of instrumentation and alarms used to monitor sensor and channel operation and availability;
- Proper calibration of primary sensors;
- Proper operation of bypass switches, including related logic;
- Proper operation of permissive and prohibit interlocks;
- Proper function of the interface to diverse displays and controls;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational;
- Acceptability of instrument channel response times, as measured from each applicable process variable (except for neutron sensors and suppression pool temperature sensors) to the deenergization of the scram pilot valve solenoids; and
- Final functional testing of the RPS to demonstrate proper trip points, logic, operability of scram breakers and valves, and operability of manual scram functions will be conducted during or following initial fuel loading.

**14.2.8.1.10 Neutron Monitoring System Preoperational Test**

***Purpose***

The objective of this test is to verify the proper operation of the Neutron Monitoring System (NMS), including the Startup Range Neutron Monitor (SRNM), Power Range Neutron Monitoring (PRNM), and automated fixed incore probe subsystems and related hardware and software.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All SRNM subsystem components and PRNM subsystem components have been calibrated per vendor instructions. Additionally, required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip, including rod block and scram signals;
- Proper functioning of instrumentation, displays, alarms, and annunciators used to monitor system operation and status;
- Proper operation of detectors and associated cabling, preamplifiers, and power supplies;
- Proper operation of interlocks and equipment protective devices;
- Proper operation of permissive, prohibit, and bypass functions;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational;
- 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.

**14.2.8.1.11 Plant Automation System Preoperational Test**

***Purpose***

The objective of this test is to verify the proper operation of the PAS including the Power Generation and Control Subsystem (PGCS) and their related functions.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The PGCS, RC&IS, Turbine Control System, and other required system interfaces shall be available to support the specific system testing. The required input and output devices and various system interfaces shall be connected and available, as needed, for supporting the specified testing configurations.

***General Test Methods and Acceptance Criteria***

Proper performance of system hardware and software is verified by a series of individual and integral tests that include the following demonstrations:

- Proper connection and calibration of input signals;
- Proper operation of data logging and transient data recording features, including verification of data rate requirements;
- Verification of computer printouts;
- Verification of operability of control room video display units which are driven by the PAS;

- Proper communication and interface with other plant equipment, computers and control systems; verify that output signals (analog and digital) are correct; and
- Proper operation of operator guidance and prompting functions, including alarms and status messages, in all operating modes for plant startup, shutdown and power maneuvering iterations.

Much of the testing performed during the preoperational phase is done utilizing simulated conditions and inputs via system hardware and software. Final system performance during actual plant conditions is evaluated during the startup phase.

#### 14.2.8.1.12 Remote Shutdown System Preoperational Test

***Purpose***

The objective of this test is to verify the feasibility and operability of intended remote shutdown functions from the remote shutdown panel and other local and remote locations outside the Main Control Room (MCR), which are utilized during a safe shutdown from outside the MCR.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, control power shall be supplied to the remote shutdown panel and the required system and component interfaces shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

The Remote Shutdown System (RSS) consists of the control and instrumentation available at the dedicated remote shutdown panel(s) and other local and remote locations intended to be used during a safe shutdown from outside the control room.

Much of the specified testing can be accomplished in conjunction with, or as part of, the individual system and component preoperational testing. However, the successful results of such testing shall be documented as part of this test, as applicable. Performance shall be observed and recorded during a series of individual component and integrated system, factory, and preoperational tests to demonstrate the following:

- Proper functioning of the control and instrumentation associated with the RSS;
- Proper operation of pumps and valves, including establishment of system flow paths using RSS control;
- Proper functioning of RSS switches, including verification of proper override of MCR functions and proper indication in the MCR that these functions have been overridden;
- Proper operation of prohibit and permissive interlocks and bypass functions after transfer of control;
- Proper system operation while powered from primary and alternate electrical sources; and
- The ability to establish and maintain communication among personnel performing the remote shutdown operation.

#### 14.2.8.1.13 Reactor Water Cleanup/Shutdown Cooling System Preoperational Test

The RWCU/SDC system provides both the reactor water cleanup function and the shutdown cooling function.

***Purpose***

The objective of this test is to verify that the operation of the reactor water cleanup and shutdown cooling subsystem, including pumps, valves, heat exchangers and demineralizer equipment, is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Resin material for filter demineralizers shall be available. Reactor component cooling water, instrument air, CRD purge supply, and other required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and controls in appropriate design combinations of logic and instrument channel trip, including those associated with the LD&IS;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions; this is repeated during startup tests with the reactor hot;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Proper switch over of the RWCU and SDC mode of operation;
- Acceptability of pump/motor vibration levels at all pump speeds and system piping movements during both transient and steady-state operation;
- Proper operation of the RWCU demineralizers and associated support facilities; and
- Proper operation of heatup function.

#### 14.2.8.1.14 Fuel and Auxiliary Pools Cooling System Preoperational Test

***Purpose***

The objective of this test is to verify that the operation of the Fuel and Auxiliary Pools Cooling System (FAPCS), including the pumps, heat exchangers, controls, valves, and instrumentation, is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system, factory, and preoperational tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip, including isolation and bypass of the nonsafety-related fuel pool cleanup filter/demineralizers;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability, including those associated with pool water level;
- Proper redundancy and electrical independence of the safety-related FAPCS controls and instrumentation;
- Proper operation of system valves, including timing, under expected operating conditions;
- Verification that drywell spray nozzles, headers and piping are free of debris;
- Proper operation of pumps and motors;
- Acceptable pump NPSH under the most limiting design flow conditions; verification of NPSH acceptability during cooling of the Isolation Condenser System (ICS) pool will be accompished during the ICS startup testing phase;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper water levels are maintained in Gravity-Driven Cooling System (GDCS) pools when the system is operating in the GDCS cooling and cleanup mode;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Proper operation of permissive, prohibit, and bypass functions;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper functioning of pool anti-siphon devices and acceptable leakage from pool drains, sectionalizing devices, and gaskets or bellows;

- Proper operation of FAPCS during all design modes of operation;
- Proper operation of filter/demineralizer units and their associated support facilities; and
- Smooth transfer from one pool to another.

**14.2.8.1.15 Process Sampling System Preoperational Test**

***Purpose***

The objective of this test is to verify the proper operation and the accuracy of equipment and techniques used for on-line and periodic sampling and analysis of overall plant water systems as well as that of individual plant process streams.

***Prerequisites***

Construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Adequate laboratory facilities and appropriate analytical procedures shall be in place. The systems are available to provide required flow to associated sample panel. Instrument air, and closed cooling water are available to support testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of tests to demonstrate the following:

- Proper calibration of on-line sampling and monitoring equipment, indication and alarm/functions;
- Proper operation of the sample coolers;
- Capability of obtaining grab samples of designated process streams at the desired locations;
- Proper functioning of personnel protective devices (fume hoods and interlocks) at local sampling stations; and
- Adequacy of the procedures and methods used to draw samples.

**14.2.8.1.16 Process Radiation Monitoring System Preoperational Test**

***Purpose***

The objective of this test is to verify the ability of the Process Radiation Monitoring System (PRMS) to indicate and alarm normal and abnormal radiation levels, and to initiate, if appropriate, isolation functions upon detection of high radiation levels in any of the process streams that are monitored.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The various process radiation monitoring subsystems, including the sensors, the digital radiation monitors and associated sampling racks have been calibrated according to instructions. The required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

The PRMS consists of a number of subsystems that monitor various liquid and gaseous process streams, building and area ventilation exhausts, and plant and process effluents. The offgas system and the main steamlines are also monitored.

Performance shall be observed and recorded during a series of individual component and integrated subsystem tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using a standard radiation source or portable calibration unit;
- Proper functioning of radiation monitors and alarms;
- Proper system trips in response to high radiation and downscale/inoperative conditions;
- Proper operation of the isolation functions; and
- Proper operation of the sampling functions.

#### 14.2.8.1.17 Area Radiation Monitoring System Preoperational Test

***Purpose***

The objective of this test is to verify the ability of the Area Radiation Monitoring (ARM) System to indicate and alarm normal and abnormal general area radiation levels throughout the plant.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Sensors and digital radiation monitors have been calibrated according to vendor instructions.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of channel tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using a standard radiation source or portable calibration unit;
- Proper functioning of sensors, monitors, displays, and alarms;
- Proper system indication and alarms are observed in response to high radiation and downscale/inoperative conditions; and
- Power interruption to a single local ARM monitor will create a local alarm and an alarm will appear in the MCR, but functionality of other ARM monitors will not be affected.

#### 14.2.8.1.18 Containment Monitoring System Preoperational Test

***Purpose***

The objectives of this test are:

- Verify the ability of the Containment Monitoring System to monitor oxygen, hydrogen, and gross gamma radiation levels in the wetwell and drywell airspace regions of the containment; and
- Verify the proper operation of the other functions of the system including drywell-wetwell differential pressure monitoring, suppression pool water level and temperature monitoring, drywell (post Loss-of-Coolant-Accident [LOCA]) pool level monitoring and post-accident sampling.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Initial system installation and setup has been accomplished per instructions. The required interfacing systems shall be available, as needed, to support the specified testing and the appropriate system configurations.

***General Test Methods and Acceptance Criteria***

The Containment Monitoring System consists of radiation, oxygen and hydrogen, suppression pool water level and temperature, drywell-wetwell differential pressure monitoring and post accident sampling subsystems. Performance of each of these subsystems shall be observed and recorded during a series of individual subsystem tests to demonstrate the following:

- Proper calibration of detector assemblies and associated equipment using the standard source or portable calibration unit and gas calibration sources;
- Proper functioning of indications, sampling racks, displays, and alarms including those monitoring system availability;
- Proper indication and alarm in response to high and low setpoints and/or downscale/inoperative conditions for the containment radiation and atmospheric monitoring subsystems;
- Proper initiation and operation of detection and sampling functions, including pump start and valve sequencing, if appropriate, in response to a LOCA signal;
- Proper operation of calibration gas supply systems and self-calibration functions;
- 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;
- Proper operation of the suppression pool temperature to provide signals to initiate scram on high temperature;
- Proper operation of the suppression pool temperature to initiate the suppression pool cooling mode of FAPCS on high temperature; and
- Proper operation of post accident sampling valves.

#### 14.2.8.1.19 Instrument Air and Service Air Systems Preoperational Tests

***Purpose***

The objective of this test is to verify the ability of the Instrument Air System (IAS) and Service Air Systems (SAS) to provide the design quantities of clean dry compressed air to user systems and components.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, the supplied system and components loads, and component closed cooling water system to provide cooling to the compressor units are available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

The IAS and the SAS are specified as separate systems sharing four 100% compressors at the front of the systems. However, the preoperational test requirements are essentially the same because they are so closely related.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of compressors and motors in all design operating modes;
- Ability of compressor(s) to maintain receiver at specified pressure(s) and to recharge within specified time under design loading conditions;
- Proper system flow paths and acceptable flow rates to system loads at specified air temperatures, moisture content and pressures under design loading conditions, including a determination that the total air demand at steady-state conditions, including leakage for the system, is in accordance with design;
- Proper operation of interlocks and equipment protective devices in compressor and valve controls;
- Acceptability of compressor/motor vibration levels and system piping movements during both transient and steady-state operation;
- Ability of the air to meet end user cleanliness requirements with respect to oil, water, and particulate matter content;
- Continued operability of supplied loads in response to credible failures that result in an increase in the supply system pressure;
- Ability of the SAS to act as backup to the IAS; and

- Separate from the integrated system Instrument and Service Air Preoperational tests, individual components will be tested for proper "failure" (open, close, or as is) to both instantaneous (pipe break) and slow (plugging or freezing) simulated air losses.

#### 14.2.8.1.20 High Pressure Nitrogen Supply System Preoperational Test

***Purpose***

The objective of this test is to verify the ability of the High Pressure Nitrogen Supply System (HPNSS) to furnish compressed nitrogen to user systems at design quantity and quality.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. User system loads and other required system interfaces shall be available, as needed, to support the specified system testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper system flow paths and acceptable flow rates to system loads at specified nitrogen gas temperatures, moisture content and pressures under design loading conditions;
- The ability of the nitrogen gas to meet end use cleanliness requirements with respect to oil, water, and particulate matter content;
- Proper "failure" (open, close, or as is) of supplied components to both instantaneous (pipe break) and slow (plugging or freezing) simulated nitrogen gas supply losses; and
- Proper switch over nitrogen supply to bottled nitrogen on low pressure.

#### 14.2.8.1.21 Reactor Component Cooling Water System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the Reactor Component Cooling Water System (RCCWS) including its ability to supply design quantities of cooling water, at the specified temperatures, to assigned loads, as appropriate, during normal, abnormal, and accident conditions.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, plant service water, instrument air, and other required supporting systems shall be available, as needed, for the

specified testing configurations. The cooled components shall be operational and operating to the extent practical during heat exchanger performance evaluation.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system and component flow paths, flow rates, and pressure drops, including pump capacity and discharge head;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of system surge tanks and chemical addition tanks and their associated functions; and
- Acceptable performance of heat exchangers, to the extent practical.

Because of insufficient heat loads during the preoperational phase, the final system flow balancing and heat exchanger performance evaluation is performed during the startup phase.

**14.2.8.1.22 Makeup Water System Preoperational Test**

***Purpose***

The objective of this test is to verify the ability of the Makeup Water System (MWS) to supply the designated plant systems with design quantity and quality for each system.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Final interconnection with the supplied systems is complete and those systems are ready to accept transfer of design quantities of makeup water.

***General Test Methods and Acceptance Criteria***

System performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of pumps, motors, and valves under expected operating conditions;
- Proper functioning of interlocks and equipment protective devices in pump, motor, and valve controls;
- The adequacy of system flow paths and flow rates, including pump and tank capacities;
- Proper functioning of water treatment facilities and equipment;
- Proper functioning of freeze protection methods and devices, if applicable; and
- Acceptability of pumps and motor vibration levels and system piping movements during both transient and steady state operations.

#### 14.2.8.1.23 (Deleted )

#### 14.2.8.1.24 Chilled Water System Preoperational Test

The Chilled Water System serves the Heating, Ventilation and Air Conditioning (HVAC) for the following:

- Reactor Building;
- Control Building;
- Turbine Building;
- Fuel Building;
- Radwaste Building;
- Electrical Building; and
- Drywell Coolers.

***Purpose***

The objective of this test is to verify the ability of the chilled water system to supply the design quantities of chilled water at the specified temperatures to the various cooling coils of the HVAC systems serving rooms and areas that require conditioned air.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, Reactor Building (RB) and turbine building closed cooling water systems, the applicable HVAC system cooling coils, and other required system interfaces shall be available, as needed, to support the specified system testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including isolation functions, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Proper system flow paths and flow rates to all supplied loads, including pump capacity and discharge head;
- Proper operation of the chiller units;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation; and
- Proper functioning of system surge tank and chemical addition features.

It is not possible to fully evaluate the capacity of the chiller units with inlet and outlet temperatures and flow data during the preoperational phase because of limited heat sources. The final chiller evaluation will be performed in the startup test phase.

**14.2.8.1.25 Heating, Ventilation, and Air Conditioning Systems Preoperational Test**

There are several HVAC systems in the plant, including those serving the following:

- Control Building;
- Fuel Building;
- Turbine Building;
- Reactor Building;
- Electrical Building; and
- Radwaste Building.

The preoperational tests for these systems and dedicated systems for the drywell and the MCR will be conducted in multiple separate tests.

***Purpose***

The objective of this test is to verify the ability of the various HVAC systems to establish and maintain the specified environment, with regards to temperature, pressure, and airborne

particulate level, in the applicable rooms, areas, and buildings throughout the plant, supporting equipment, and systems.

***Prerequisites***

The construction tests, including initial flow balancing, have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. Additionally, the normal and backup electrical power sources, the applicable heating, cooling, and chilled water systems, and any other required system interfaces are available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Because the various HVAC systems are similar in design of equipment and function, they are subject to the same basic testing requirements.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves and dampers, including isolation functions, under expected operating conditions;
- Proper operation of fans and motors in all design operating modes;
- Proper system flow paths and flow rates, including individual component and total system capacities and overall system flow balancing;
- Proper operation of interlocks and equipment protective devices;
- Proper system operation while powered from primary and alternate sources, including transfers, and in degraded modes for which the system is expected to remain operational;
- The ability to maintain the specified positive or negative pressure(s) in the designated rooms and areas and to direct local and total air flow, including any potential leakage, relative to the anticipated contamination levels;
- The ability of exhaust, supply, and recirculation filter units to maintain the specified dust and contamination free environment(s);
- The ability of the control room habitability function to detect the presence of airborne radioactive material, smoke or toxic gas and to remove or prevent in-leakage of such;
- Proper operation of High Efficiency Particulate Air (HEPA) filters and charcoal adsorber sections, if applicable, including relative to the in-place testing requirements of Regulatory Guide 1.140 regarding visual inspections and airflow distribution, dioctyl phthalate penetration and bypass leakage testing; and
- The ability of HVAC systems to provide sufficient purge, exhaust, and recirculation flows in support of drywell inerting and deinerting operations.

It is not possible to fully evaluate the cooling and heating coil performance of the HVAC during the preoperational phase because of limited heat sources. The final system evaluation will be performed in the startup test.

#### 14.2.8.1.26 Containment Inerting System Preoperational Test

***Purpose***

The objective of this test is to verify the ability of the Containment Inerting System (CIS) to establish and maintain the specified inert atmosphere in the containment during expected plant conditions.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. The containment is intact, the drywell coolers and RB HVAC systems are operational, and the steam evaporator and electric heater in the nitrogen supply are available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper nitrogen/air flow paths and flow rates both into and out of the containment;
- Proper operation of interlocks and equipment protective devices; and
- Ability to inert and de-inert containment atmosphere conditions within the designated interval to within designated oxygen concentrations.

#### 14.2.8.1.27 Containment Isolation Valve Leakage Rate Tests

***Purpose***

The objective of this test is to verify that the leakage rate through each containment isolation valve meets the limit specified in the Containment Leakage Rate Testing Program.

***Prerequisites***

Required test instrumentation, for example, pressure sensors, temperature sensors, and flowmeters are installed, calibrated, and functionally tested. Each containment isolation valve to be tested is operable. Each valve is closed by normal operation and without any preliminary exercising or adjustments (for example, no manual tightening of valve after closure by valve actuator). Pneumatic (air or nitrogen) supply to the air operated valves is available. Test

connections for pressurizing or venting (or both) the test volume of each valve to be tested are available. Test equipment used for this test are calibrated.

***General Test Methods and Acceptance Criteria***

The containment isolation valves that require leakage rate testing and acceptance criteria are discussed in Subsection 6.2.6.3. Containment isolation valve leakage rate testing may be accomplished using plant surveillance testing or be included in the applicable system preoperational test.

#### 14.2.8.1.28 Containment Penetration Leakage Rate Tests

***Purpose***

The objective of this test is to verify that the leakage rate through each containment penetration meets the limit specified in the Containment Leakage Rate Testing Program.

***Prerequisites***

Permanent or temporary system consisting of a pressurized gas source (air or nitrogen), manifold, and valves used as pressurizing equipment. Calibrations of the required test instruments within the scope of this test, for example, temperature and pressure sensors, flowmeters, are current.

***General Test Methods and Acceptance Criteria***

Those containment penetrations requiring Containment Penetration Leakage Rate Test (Type B Test) are indicated in Table 6.2-47. Containment penetrations will be leak rate tested by performing the surveillance testing as required in the Containment Leakage Rate Testing Program. Containment penetrations leak rate test and acceptance criteria are performed as described in Subsection 6.2.6.2.

#### 14.2.8.1.29 Containment Airlock Leakage Rate Tests

***Purpose***

The objective of this test is to verify that the leakage rate through each airlock meets the criteria specified in the Technical Specifications.

***Prerequisites***

Permanent or temporary system consisting of a pressurized gas source (air or nitrogen), manifold, and valves used as pressurizing equipment. Installation and calibration of required test instrumentation, for example, temperature and pressure sensors, and flowmeters, are complete.

***General Test Methods and Acceptance Criteria***

Descriptions of and criteria for testing the containment air lock leakage rate are given in Subsection 6.2.6.2. Containment air locks leak rate and acceptance criteria are performed as required in the Containment Leakage Rate Testing Program.

#### 14.2.8.1.30 Containment Integrated Leakage Rate Test

***Purpose***

The objectives of this test are to:

- Demonstrate that the integrated leakage rate of the containment at the design basis accident pressure is within the design limits; and
- Obtain baseline data for use during subsequent leak rate tests as described in Section 6.2.6.1.

***Prerequisites***

Construction is completed to the extent necessary to perform this test. The SCG has reviewed the test procedures and approved the initiation of testing. Reactor vessel, GDCS Pools, Isolation Condenser/Passive Containment Cooling System (IC/PCCS) Pools, reactor cavity, equipment storage pool, spent fuel pool and suppression pool are filled with water to the normal operating level. Pressurizing and test equipment is checked out and ready for the test. Individual leak rate tests, Type B and C of 10 CFR 50, Appendix J, have been completed. A general inspection of the accessible interior and exterior surfaces of the containment structures and components is performed and corrective actions are taken if evidence of structural deterioration exists. Containment isolation valves are functionally tested and aligned in accordance with Containment Leakage Rate Testing Program.

***General Test Methods and Acceptance Criteria***

Description of the preoperational containment integrated leakage rate tests and acceptance criteria are provided in Subsection 6.2.6.1.

During the Type A test, the drywell to suppression pool gas space differential pressure test will be performed as required by the Technical Specifications.

#### 14.2.8.1.31 Containment Structural Integrity Test

***Purpose***

The objective of this test is to verify that the design and construction of the containment is capable of withstanding specified internal pressure loads as described in Subsection 3.8.6.3.

***Prerequisites***

The containment construction is complete to the extent necessary to perform this test. Construction turnover of the system is completed. The SCG has reviewed the test procedures and approved the initiation of testing. Reactor vessel, GDCS Pools, IC/PCCS Pools, reactor cavity, equipment storage pool, spent fuel pool and suppression pool are filled with water to the normal operation level. The instruments and controls within the scope of this test are calibrated. The structural integrity measurement and pressurizing equipment is available for use to support the test. Equipment incapable of withstanding the test pressure are removed from containment or otherwise protected.

***General Test Methods and Acceptance Criteria***

The internal pressure in the containment will be increased from atmospheric pressure to the test pressure in uniformly spaced pressure increments. The drywell and containment are depressurized in the same increments. During the test, the radial and vertical displacements of the drywell and containment structure are measured, and crack patterns and crack widths of the containment exterior surface at prescribed locations are observed. Pertinent system performance

data are recorded and compared with the predicted response. During the analysis, verify that system performance test data satisfy the requirements as specified in Subsection 3.8.6.3.

#### 14.2.8.1.32 Overall Suppression Pool Bypass Leakage Test

***Purpose***

The objective of this preoperational test is to determine the overall suppression pool bypass leakage effective area and to confirm this value is within limits of the low-pressure test acceptance criteria. The test method used will form the basis for subsequent leakage tests conducted at the same frequency as the Integrated Leak Rate Test.

***Prerequisites***

The SCG has reviewed the test procedures and approved the initiation of testing. Containment structural integrity test has been performed as described in Subsection 14.2.8.1.31. A pressurizing source for the drywell and temporary high precision test equipment has been installed in both drywell and wetwell gas space. This instrumentation is within the established calibration interval, has been fully checked out and is ready for the test. The suppression pool level has been established at the high end of normal range. All penetrations from the drywell to the reactor building and from the wetwell to the reactor building will be isolated. The PCCS vent line spectacle flanges have been installed in the closed position. The vacuum breakers between the wetwell gas space and the drywell are in their normal closed position and the associated isolation valves are open. The reactor building ventilation system is operational.

***General Test Methods and Acceptance Criteria***

The overall suppression pool bypass leakage test will be performed at low-pressure conditions to detect leakage from the drywell to wetwell gas space that bypasses the assumed flow path through the horizontal vent pipes into the suppression pool. The test will be performed in the following manner: Ensure any and all paths between the drywell and wetwell gas space have been closed. Vent the wetwell gas space to the reactor building and confirm at zero pressure. Establish drywell pressure at a value ≥ 2 psig, but less than a value that would allow venting through the highest horizontal vents, which are submerged in the suppression pool. After this pressure has been established for the minimum stabilization time defined in the test procedure, close the vent from the wetwell gas space to the reactor building and isolate the air supply to the drywell. Monitor and record the pressure, temperature, and humidity for both drywell and wetwell at the prescribed intervals for the necessary test period. Ensure the suppression pool water level remains constant during the test period.

Using the data collected and the data reduction method provided in the test procedure, calculate the value of the effective area ($A/\sqrt{K}$) for the overall suppression pool bypass leakage. Verify the calculated value of overall suppression pool bypass leakage effective area ($A/\sqrt{K}$) is within the design limit specified in Subsection 6.2.1.1.5.

#### 14.2.8.1.33 Containment Isolation Valve Functional and Closure Timing Tests

***Purpose***

The objective of this test is to verify proper function of the containment isolation valves, including the required closure timing is met.

***Prerequisites***

Permanently installed equipment and instrumentation have been functionally tested and calibrated.

***General Test Methods and Acceptance Criteria***

The Containment Isolation System is discussed in Section 6.2 with characteristics of and requirements for individual valves listed in Tables 6.2-16 through 6.2-45. Preoperational functional and closure timing tests of valves performing containment isolation functions will be done as part of the testing of the systems to which such valves belong (see Tables 6.2-16 through 6.2-45 for system affiliation of individual valves). Overall containment isolation initiation logic is a function of the LD&IS that is described in Subsection 14.2.8.1.8.

#### 14.2.8.1.34 Wetwell-to-Drywell Vacuum Breaker System Preoperational Test

***Purpose***

The objective of this test is to verify proper functioning of the wetwell-to-drywell vacuum breakers. The leakage rate test of the vacuum breakers are performed in conjunction with suppression pool bypass described in Subsection 14.2.8.1.32.

***Prerequisites***

The visual inspections of the mechanical components on the vacuum breakers have been completed and the SCG has reviewed the test procedure and approved the initiation of testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of vacuum breaker valves, including verification of opening and closing;
- Proper functioning of valve positive closure, including verification of adequate valve leak tightness; and
- Proper operation of instrumentation and alarms used to monitor valve position indication.

#### 14.2.8.1.35 DC Power Supply System Preoperational Test

***Purpose***

The objective of this test is to verify the ability of DC power supply systems to supply reliable, uninterruptible power for instrumentation, logic, control, lighting and other normal and emergency loads that must remain operational during and after a loss of AC power.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedures and approved the initiation of testing. Permanently installed and test instrumentation are properly calibrated and operational. The power supply and battery charger are available. Additionally, a test load is available for the performance of battery capacity test. Adequate ventilation to battery rooms is available and operational. All interfacing systems and equipment

required to support system operation shall be available, as needed, for the specified testing configurations.

***General Test Methods and Acceptance Criteria***

The DC power supply systems consist of safety-related and nonsafety-related equipment, including batteries, battery chargers, inverters, static transfer switches, and associated instrumentation and alarms, that are used to supply both normal and emergency loads. Performance shall be observed and recorded during a series of individual component and integrated systems tests to demonstrate the following:

- Capability of each battery bank to supply its design load for the specified time without the voltage dropping below minimum battery or cell limits;
- Capability of each battery charger to fully recharge its associated battery (or bank), from the discharged state, within the specified time while simultaneously supplying the specified loads;
- Verification that actual loading of each DC bus is consistent with battery sizing assumptions;
- Verification that each DC bus meets the specified level of redundancy and electrical independence for its particular application;
- Proper functioning of transfer devices, breakers, cables, and inverters (including load capability);
- Verification that safety-related batteries have the capacity to support safety-related loads for a period of 72 hours;
- Proper calibration and trip settings of protective devices, including relaying, and proper operation of permissive and prohibit interlocks;
- Voltage spikes between rails and rails to ground in the loaded system are within design parameters assumed for connected electronics;
- Proper operation of instrumentation and alarms associated with undervoltage, overvoltage, and ground conditions;
- Proper operation of emergency DC lighting, including capacity of self-contained batteries; and
- Verification during the battery charging cycle, the battery room ventilation system prevents accumulation of hydrogen gas in amounts greater than an acceptable level.

#### 14.2.8.1.36 AC Power Distribution System Preoperational Test

***Purpose***

The objective of this test is to verify the ability of the AC power distribution system to provide a means for supplying AC power to plant auxiliary equipment, from both offsite and onsite sources, via independent distribution subsystems for each redundant load group.

### *Prerequisites*

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. All the necessary permanently installed and test instrumentation have been calibrated and operational. Adequate ventilation to both switchgear and battery rooms are available and operational. All interfacing systems and equipment required to support system operation shall be available, as needed, for the specified testing configurations.

### *General Test Methods and Acceptance Criteria*

The AC power distribution system is comprised of the equipment required for transformation, conversion, and regulation of voltage to the buses, the switchgear and motor control centers required for the individual loads served, and the coordinated system protective relaying. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of initiating, transfer, and trip devices;
- Proper operation of relaying and logic;
- Proper operation of equipment protective devices, including permissive and prohibit interlocks;
- Proper operation of instrumentation and alarms used to monitor system and equipment status;
- Proper operation and load carrying capability of breakers, motor controllers, switchgear, transformers, and cables;
- The capability to transfer between onsite and offsite power sources as per design;
- The adequacy of the plant emergency lighting system; and
- Verify the analytically derived voltage values of the onsite distribution system against actual measurements.

#### 14.2.8.1.37 Standby Diesel Generator & AC Power System Preoperational Test

### *Purpose*

The objective of this test is to demonstrate the capability of the standby diesel generators (SDGs) to provide electrical power to plant nonsafety-related loads when the normal offsite power sources are unavailable.

### *Prerequisites*

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The diesel generator auxiliary systems (for example, diesel fuel oil transfer, diesel-generator starting air supply, jacket cooling water, and lube oil) are operable to support continuous diesel operation. Appropriate electrical power sources, cooling water supply, diesel generator room HVAC and equipment required to support system operation shall be available, as needed, for the specified testing configuration. Additionally, sufficient diesel fuel shall be available onsite to perform the scheduled tests.

### *General Test Methods and Acceptance Criteria*

Performance is observed and recorded during a series of individual component and integrated system tests which demonstrate the following:

- Proper automatic startup and operation of the SDGs upon Loss of Preferred Power (LOPP) and attainment of the required frequency and voltage within the specified time limits;
- Proper operation of the SDGs during load shedding, load sequencing, and load rejection, including a test of the loss of the largest single load and of the complete loss of load, verifying that voltage and frequency are maintained within design limits and that overspeed limits are not exceeded;
- That termination of parallel operations (test mode from either the main control room or local panel) of the SDG when a LOPP, or a LOCA signal appears is consistent with the design description of these events. See Subsection 8.3.1.1.7 for this description;
- That the engine speed governor and the generator voltage regulator automatically return to an isochronous (constant speed) mode of operation upon initiation of a LOPP signal;
- The SDGs will be tested at full load and rated power factor for a period of 24 hours. This will ensure diesel cooling and HVAC systems perform their design functions;
- The ability to synchronize the SDGs with offsite power while connected to the standby load, transfer the load from the diesel generators to the offsite power, isolate the diesel generators, and restore them to standby status;
- The rate of fuel consumption and the operation of the fuel oil transfer pumps, while operating at the design-basis load, meets the requirements for 7-day storage inventory for each SDG;
- The proper function of the SDG protective devices;
- That permissive and prohibit interlocks, controls, and alarms (both local and remote) operate in accordance with design specifications;
- Proper operation of auxiliary systems such as those used for starting, cooling, heating, ventilating, lubricating, and fueling the SDGs; and
- Proper operation of the breakers on the input of the safety-related 480-volt Isolation Power Centers, which act as isolation devices between the nonsafety-related power sources and the safety-related loads.

#### 14.2.8.1.38 Plant Communications System Preoperational Test

### *Purpose*

The objective of this test is to verify the proper operation and adequacy of plant communications systems and methods that are used during normal and abnormal operations, including those needed to carry out the plant emergency plan.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Initial system and component settings (gains, volumes, and speaker properties) shall be adjusted based on expectations of the acoustic environment and background noise levels for each location and for all designed modes of operation.

***General Test Methods and Acceptance Criteria***

The communications systems to be tested include the plant paging system, telephone systems, portable radio systems, and the plant emergency alarms. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper functioning of transmitters and receivers without excessive interference levels;
- Proper operation of controls, switches, and interfaces, including silencing and muting features;
- Proper isolation and independence of various channels and systems;
- Proper operation of systems under multiple user and fully loaded conditions as per design;
- Proper operation of plant emergency alarms;
- Audibility of speakers and receivers under anticipated background noise levels;
- The ability to establish the required communications with outside agencies; and
- Proper functioning of dedicated use systems and of those systems expected to function under abnormal conditions such as loss of electrical power or shutdown from outside the control room scenarios.

**14.2.8.1.39 Fire Protection System Preoperational Test**

***Purpose***

The objectives of this test are to verify the ability of the Fire Protection System to:

- Detect and alarm the presence of combustion, smoke or fire within the plant and to initiate the appropriate suppression systems or devices;
- Provide the required volume of water to make-up to the IC/PCCS and Spent Fuel Pool up to seven days following an accident; and
- Provide the required volumetric flow rate using the diesel driven fire pump for make-up to the IC/PCCS and Spent Fuel Pool following an accident.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power and makeup water sources, diesel fuel oil system for the diesel driven fire pump, and other appropriate interfaces and support systems, are available as needed for the specified testing.

### *General Test Methods and Acceptance Criteria*

The Fire Protection System is but one part of the overall fire protection program. This program is an integrated effort involving components, procedures, and personnel utilized in carrying out all activities of fire protection, in accordance with Criterion 3 of 10 CFR 50 Appendix A. It includes systems and components, facility design, fire prevention, detection, annunciation, confinement, suppression, administrative controls, fire brigade organization, training, quality assurance, inspection, testing, and maintenance. Fire Protection System testing in accordance with the criteria in codes and standards listed in Table 9.5-1 demonstrates the equipment and facilities designed for the detection, annunciation, and suppression of fires, operate properly and meet all functional requirements described in Subsection 9.5.1.1. This testing shall include the following demonstrations:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and control;
- Proper operation of system valves, pumps, motors and pump-driving diesel under expected operating conditions;
- Proper system and component flow paths, flow rates and capacities;
- Verification of proper installation of all fire protection equipment, including sprinkler heads, spray nozzles, fire detectors, annunciators, hose stations, and portable fire extinguishers;
- Where practical, proper operation of water-based suppression systems such as sprinkler, deluge, and hose stations and other suppression systems such as foams and dry chemicals;
- Proper operation of freeze protection methods and devices, if applicable;
- Proper functioning of fire detection devices;
- Proper operation of both local and remote alarms, including those interfacing with outside agencies;
- Proper operation of primary and secondary electrical power sources;
- Verification of proper installation and integrity of fire barriers, including penetration seals, fire doors and fire dampers;
- Proper installation and operation of HVAC systems used for smoke control and exhaust; and
- Verification of proper post-accident make-up capability to the IC/PCCS and Spent Fuel Pools.

#### 14.2.8.1.40 Radioactive Liquid Drainage and Transfer Systems Preoperational Tests

### *Purpose*

The objective of this test is to verify the proper operation of the various equipment and pathways of the radioactive liquid drainage and transfer system.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. An adequate supply of demineralized water, the necessary electrical power, and other required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

The performance of the radioactive liquid drain system is observed and recorded during the individual component and system test that characterizes the various modes of system operation. Also included are dedicated systems for the handling of liquids that require special collection and disposal considerations such as detergents.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of automatic isolation function of radwaste system containment isolation valves;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Acceptable system and component flow paths and flow rates, including pump capacities and sump or tank volumes;
- Proper operation of filter and demineralizer regeneration cycles of the liquid radwaste system and the associated support facilities; and
- Proper functioning of drains and sumps, including those dedicated for handling of specific agents such as detergents.

#### 14.2.8.1.41 Fuel-Handling and Reactor Servicing Equipment Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the fuel-handling and reactor component servicing equipment. This includes cranes, hoists, grapples, trolleys, platforms, hand tools, viewing aids, and other equipment used to lift, transport, or otherwise manipulate fuel, control rods, neutron instrumentation, and other in-vessel and undervessel components. Also included is equipment needed to lift and relocate structures and components necessary to provide access to fuel, vessel internals, and reactor components during the refueling and servicing operations.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power sources and sufficient lighting shall be available undervessel, and on the refueling floor. The refueling floor (including the fuel storage pool and reactor cavity), and drywell and undervessel areas shall be capable of supporting load and travel testing of the various cranes, bridges, and hoists. Other interfacing systems shall be available as required to support the specified testing.

***General Test Methods and Acceptance Criteria***

Fuel-handling and reactor component servicing equipment testing described herein includes that of the reactor building crane, the refueling machine, fuel-handling platform and the fuel transfer system, the auxiliary platform, and the associated hoists and grapples, as well as other lifting and rigging devices. Also included are specialized hand tools and viewing aids. Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation for each crane, bridge, trolley, or platform through its full travel and up to its maximum speed, including verification of braking action and overspeed or overtravel protection devices;
- Proper operation of the various cables, grapples, and hoists, including brakes, limit switches, load cells, and other equipment protective devices;
- Proper functioning of control, instrumentation, logic, interlocks and alarms;
- Proper operation of reactor servicing equipment, including reactor vessel servicing tools; main steamline plugs; shroud head stud wrench; RPV head tensioning and de-tensioning; dryer and separator strongback; chimney lifting strongback; and reactor head strongback;
- Proper functioning of fuel handling servicing equipment such as fuel preparation machine, new fuel inspection stand, channel handling tools, refueling platform and inclined fuel transfer system;
- Proper operation of under-vessel servicing equipment, including FMCRD servicing tools and handling equipment, in-core flange seal test plugs;
- Proper operation of various servicing aids such as underwater lights, viewing tubes, and viewing aids;
- Proficiency in fuel movement operations using dummy fuel (prior to actual fuel loading); and
- Dynamic and static load testing of cranes, hoists, and associated lifting and rigging equipment, including static load testing at 125% of rated load and full dynamic operational testing at 100% of rated load.

**14.2.8.1.42 Expansion, Vibration and Dynamic Effects Preoperational Test**

***Purpose***

The objective of this test is to verify that critical components and piping runs are properly installed and supported such that expected steady-state and transient vibration and movement due to thermal expansion does not result in excessive stress or fatigue.

***Prerequisites***

Hydro testing and flushing of the piping systems have been completed. The SCG has reviewed the test procedure and approved the initiation of testing. Inspect and determine that piping and components and their associated supports and restraints are installed per design. Additionally, verify that support devices such as snubbers and spring cans are in their expected cold, static

positions, and observe that temporary restraining devices such as hanger locking pins are removed.

***General Test Methods and Acceptance Criteria***

Vibration and thermal expansion testing is conducted on plant systems and components of the following classifications:

- American Society of Mechanical Engineers (ASME) Section III Code Class 1, 2 and 3 systems;
- High energy piping systems inside Seismic Category I structures;
- High energy portions of systems whose failure could reduce the functioning of any Seismic Category I plant features to an unacceptable level; and
- Seismic Category I portions of moderate energy piping systems located outside containment.

Thermal expansion testing during the preoperational phase is limited to those systems, which during operation, will heat up significantly above ambient temperatures to approximately their normal operating temperatures. The testing is in conformance with Reference 14.2-1, Part 7 as discussed in Subsection 3.9.2.1.2, and consists of a combination of visual inspections and local and remote displacement measurements. Visual inspections are performed to identify actual or potential constraints to free thermal growth. Displacement measurements are made utilizing specially installed instruments and also using the position of supports such as spring hangers and snubbers. Results of the thermal expansion testing are acceptable when systems move as predicted and there are no observed restraints to free thermal growth or when additional analysis shows that any unexpected results would not produce unacceptable stress values.

Vibration testing is performed on system components and piping during preoperational function and flow testing. This testing is in accordance with Reference 14.2-1, Part 3 as discussed in Subsection 3.9.2.1.1, and includes visual observation and local and remote monitoring in critical steady-state operating modes and during transients such as pump starts and stops, valve stroking, and significant process flow changes. Results are acceptable when visual observations show no signs of excessive vibration and when measured vibration amplitudes are within acceptable levels to assure no failures from fatigue over the life of the plant as calculated based on expected steady-state and transient operation.

#### 14.2.8.1.43 Deleted

#### 14.2.8.1.44 Condensate and Feedwater Systems Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the various components that comprise the Condensate and Feedwater System and their capability to deliver the required flow from the condenser hotwell to the NBS.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. The required interfacing systems shall be

available, as needed, to support the specified testing. For flow testing there shall be an adequate suction source available and an appropriate flow path established. The main condenser shall be intact and the hotwell water level is in the normal range.

***General Test Methods and Acceptance Criteria***

Preoperational testing of the Condensate and Feedwater System includes the piping, components, and instrumentation between the condenser and the nuclear boiler, but not the condensate filters or demineralizers nor the feedwater heaters, which are tested separately per the specific discussions provided for those features.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- 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;
- Proper operation of pumps and motors in all design operating modes (Condensate and Reactor Feed Pumps);
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor, and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation; and
- Proper operation of controllers for pump drivers and flow control valves, including those in minimum flow recirculation lines.

**14.2.8.1.45 Condensate Purification System Preoperational Test**

***Purpose***

The objective of this test is to verify proper operation of the condensate filters and demineralizers, and the associated support facilities.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The condensate system shall be operational with an established flow path capable of supporting condensate filter and demineralizer flow. Adequate supplies of ion exchange resin should be available, and the radwaste system shall be

capable of processing the expected quantities of water and spent resins. Other required interfacing systems shall also be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper individual vessel and overall system flow rates and pressure drops, including bypass capabilities (for both filter and demineralizer units);
- Proper operation of interlocks and equipment protective devices;
- The ability to perform on-line exchange of standby and spent filter units and demineralizer vessels; and
- Proper operation of filter/demineralizer support facilities such as those used for regeneration of resins or for handling of wastes.

#### 14.2.8.1.46 Reactor Water Chemistry Control Systems Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the Oxygen Injection System .

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. The required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Preoperational testing concentrates on verifying proper operation of the equipment skids and the various individual components. Actual oxygen injection demonstrations and/or simulations shall be limited to only those cases where it is deemed practicable or appropriate with regards to the aforementioned precautions.

Performance shall be observed and recorded during a series of individual component and integrated system tests (to the extent practical) to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;

- Proper operation of system valves, including timing and sequencing, under expected operating conditions;
- Proper system flow paths, flow rates and pressures; and
- Proper operation of system interlocks and equipment protective devices.

**14.2.8.1.47 Condenser Air Removal System Preoperational Test**

***Purpose***

The objective of this test is to verify the ability of the mechanical vacuum pumps and steam jet air ejectors to establish and maintain vacuum in the main condenser as designed. The test of the steam jet air ejectors is performed in conjunction with offgas system described in Subsection 14.2.8.1.48.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, instrument air, electrical power, cooling water, turbine gland sealing steam, and other required system interfaces shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests. The test demonstrate the mechanical vacuum pump operates as designed through the following testing:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of the mechanical vacuum pumps, if condenser integrity and auxiliary systems permit, including the ability to establish the required vacuum within the design time frame;
- Proper operation of remote-operated valves, including position indications; and
- Proper operation of the mechanical vacuum pump trip function and its discharge valve closure on simulated main steamline radiation signal.

**14.2.8.1.48 Offgas System Preoperational Test**

***Purpose***

The objective of this test is to verify proper operation of the offgas system, including steam jet air ejectors, valves, recombiner, condensers, coolers, filters, and hydrogen analyzers.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Additionally, instrument air, electrical power,

cooling water, turbine gland sealing steam, auxiliary boiler system and other required system interfaces shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of the steam jet air ejectors, including their ability to maintain the specified vacuum in the main condenser (while accounting for the source of the driving steam used);
- 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;
- Proper operation of components in all design operating modes;
- Proper system and component flow paths and flow rates;
- Proper operation of interlocks and equipment protective devices;
- Proper operation of permissive, prohibit, and bypass functions; and
- Proper operation of the isolation valve closure of the offgas system on the simulated low steam flow signal.

**14.2.8.1.49 Condensate Storage and Transfer System Preoperational Test**

***Purpose***

The objective of this test is to verify the ability of the Condensate Storage and Transfer System to provide an adequate reserve of condensate quality water for makeup to the condenser, CRD, RWCU/SDC system, Fuel Pool system and for other uses as designed.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic;
- Proper functioning of permissive and prohibit interlocks;

- Proper operation of the condensate storage and transfer pumps;
- Proper functioning of instrumentation and alarms used to monitor system operation and status, including CST volume and/or level;
- Proper operation of main condenser water level control;
- Proper operation of the freeze protection and flood protection, if applicable; and
- Ability of the system to provide desired flow rates and volumes to the applicable systems and/or components.

#### 14.2.8.1.50 Circulating Water System Preoperational Test

***Purpose***

The objective of this test is to verify the proper operation of the Circulating Water System and its ability to circulate cooling water through the tubes of the main condenser in sufficient quantities to condense the steam exhausted from the main turbine under expected operating conditions.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The main condenser, the cooling water source, pump bearing lubricating and shaft sealing water, vacuum priming for the water boxes, electrical power source and other required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Because of insufficient heat loads during the preoperational test phase, condenser and cooling water source performance evaluation are performed during the startup phase with the turbine-generator on line.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Verifying acceptable pump suction under the most limiting design flow conditions;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;

- Proper operation of permissive, prohibit, and bypass functions;
- Proper operation of freeze protection methods and devices, if applicable; and
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady state operation.

#### 14.2.8.1.51 Plant Service Water System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the Plant Service Water System (PSWS) and its ability to supply design quantities of cooling water to the RCCWS and Turbine Component Cooling Water System (TCCWS) heat exchangers.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power, the RCCWS and TCCWS (including heat exchangers), instrument air, cooling towers, and other required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves including automatic air release/vacuum valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump suction under the most limiting design flow conditions;
- Proper operation of motorized self cleaning strainers;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor and valve controls;
- Proper operation of freeze protection methods and devices, if applicable; and
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady state operation.

The heat exchangers, which serve as interface with the RCCWS and TCCWS, are considered part of those systems and are tested as such. However, due to insufficient heat loads during the

preoperational test phase, the heat exchanger performance verification is deferred until the startup phase.

#### 14.2.8.1.52 Turbine Component Cooling Water System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the TCCWS and its ability to supply design quantities of cooling water, at the specified temperatures, to designated plant loads.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electric power, PSWS, instrument air, and other required supporting systems shall be available, as needed, for the specified testing configurations. The cooled components shall be operating to the extent practical during heat exchanger performance evaluation.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump NPSH under the most limiting design flow conditions;
- Proper system and component flow paths, flow rates, and pressure drops, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump and valve controls;
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady-state operation;
- Proper operation of system surge tanks and chemical addition tanks and their associated functions; and
- Acceptable performance of TCCWS heat exchangers, to the extent practical.

Because of insufficient heat loads during the preoperational phase, the final system flow balancing and heat exchanger performance evaluation is performed during the startup phase.

#### 14.2.8.1.53 Main Turbine Control System Preoperational Test

***Purpose***

The objective of this test is to verify the proper operation of the Main Turbine Control System which operates the turbine stop valves, control valves, intermediate stop and intercept valves, and bypass valves through their associated actuators and hydraulic control to the extent that it can be done without steam.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electrical power supply to motors, control circuits, and instrumentation are available, the steam bypass and pressure control system shall be operational and other required interfacing systems are available, as needed, to support the specific testing. The turbine manufacturer's instruction manual is available to identify the necessary supporting systems and to define the test steps.

***General Test Methods and Acceptance Criteria***

This test and those other turbine tests detailed in Subsection 14.2.8.1.57 are probably performed as a set. The turbine manufacturer's instruction manual shall be used to prepare a detailed procedure for testing the hydraulic system in manual and automatic modes, all turbine trip paths, stop and control valves, combined intermediate valves, extraction nonreturn valves, local I&C room instrumentation.

This test demonstrates main turbine control system functions properly through the following testing:

- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of the hydraulic control subsystem, including hydraulic fluid pumps and accumulators, and power supplies;
- Proper operation of the main stop and control valves, intermediate stop and intercept valves in response to simulated signals related to turbine speed, load, and pressure;
- Proper operation of the trip devices for the main stop and control valves, intermediate stop and intercept valves in response to simulated overspeed signals;
- Proper operation of the main stop and control valves, intermediate stop and intercept valves upon loss of the control system electrical power or hydraulic system pressure;
- Capability of manual operation of the turbine valves, including position indications and stroke rate adjustments;
- Proper interface with Steam Bypass and Pressure Control (SB&PC); and
- Verification that various component alarms used to monitor system operation.

#### 14.2.8.1.54 Main Turbine Bypass System Preoperational Test

***Purpose***

The objective of this test is to verify the proper operation of the Main Turbine Bypass System (MTBS) to the extent that it can be done without steam.

***Prerequisite***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The turbine manufacturer’s instruction manual is available to identify the necessary supporting systems and to define the test steps.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of component and system tests. This test shall demonstrate that the turbine bypass system operates properly through the following testing:

- Proper functioning of instrumentation and system controls in appropriate design combinations of logic and instrument channel trip;
- Capability of manual bypass operation, including stroke rate adjustments and position indications;
- Proper operation of the bypass valve closure in response to loss of condenser vacuum, control system electrical signal or hydraulic power;
- Proper bypass valve response following a simulated turbine and generator trip initiation signal, including the fast opening timing to avoid the reactor trip; and
- Proper interface with the SB&PC system.

#### 14.2.8.1.55 Steam Bypass and Pressure Control (SB&PC) System Preoperational Test

***Purpose***

The objective of this test is to verify the proper operation of the SB&PC System, including turbine valves and turbine bypass valve control and the PAS.

***Prerequisite***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The preoperational tests of the turbine valves and bypass valves have been completed to the extent necessary to support integrated system testing. All SB&PC system components have been calibrated. The turbine manufacturer’s instruction manual is available to identify the necessary supporting systems and to define the test steps.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and overall system response tests to demonstrate the following:

- Preliminary adjustments of controllers for prescribed open-loop frequency response or step response;

- Proper operation of redundant controller upon simulated operating controller failure;
- Proper calibration of redundant pressure sensors to within the prescribed limits as specified in the system design specification;
- Proper operation of permissive, prohibit, and bypass functions; and
- Proper communication and interface with other control systems and related equipment.

#### 14.2.8.1.56 Heater Drain and Vent System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the feedwater heaters and their associated drains and vents, including heater level control capabilities.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Method and Acceptance Criteria***

The feedwater heater and drain system includes the feedwater heaters, internal and external drain coolers, normal and emergency dump valves, shell and tube side isolation valves, shell side vents and safety/relief valves, and associated instrumentation, control and logic.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves and actuators under expected operating conditions;
- Proper operation of interlocks and equipment protective devices; and
- Proper operation of heater level controls, including response of the associated drain/dump valves.

#### 14.2.8.1.57 Extraction Steam System Preoperational Test

***Purpose***

The objective of this test is to verify proper operation of the components, which comprise the extraction steam system.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power

to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

*General Test Methods and Acceptance Criteria*

Comprehensive testing of the extraction steam system requires the turbine generator to be on-line with a substantial amount of steam flow available. The preoperational testing of the extraction steam system without main turbine generator on-line is limited.

Performance shall be observed and recorded during a series of component and system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves under expected operating conditions, including response of air-assisted non-return check valves to a turbine trip signal; and
- Proper operation of interlocks and equipment protective devices.

#### 14.2.8.1.58 Moisture Separator Reheater System Preoperational Test

*Purpose*

The objective of this test is to verify proper operation of the turbine Moisture Separator Reheater (MSR) and the associated drain pathways, steam extraction lines, and isolation and non-return check valves.

*Prerequisites*

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing.

*General Test Methods and Acceptance Criteria*

Comprehensive testing of the extraction steam system require the turbine generator to be on-line with a substantial amount of steam flow available. The preoperational testing of the moisture separator system without main turbine generator on-line is limited.

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip including turbine trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Proper operation of system valves and actuators (including isolation and non-return check valves) under expected operating conditions;

- Proper operation of interlocks and equipment protective devices; and
- Proper sloping of moisture separator drain pathways.

### 14.2.8.1.59 Main Turbine and Auxiliaries Preoperational Test

***Purpose***

The objective of this test is to verify that the operation of the main turbine and its auxiliary systems, including the gland sealing system, lube oil system, turning gear, supervisory instrumentation, and turbine protection system (including overspeed protection), is as specified. Testing of the turbine valves and associated control systems is included.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. Required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component, subsystem and integrated system tests (to the extent practical) to demonstrate the following, with regard to both the turbine and its auxiliaries:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability, including the turbine supervisory instrumentation;
- Proper operation of system pumps and valves in all design operating modes;
- Proper system flow paths, flow rates, temperatures and pressures (particularly with regard to the lube oil and gland sealing steam systems);
- Proper operation of valve auxiliaries such as hydraulic fluid systems, including pumps and accumulators, and power supplies;
- Verification that automatic starting of motor driven lube oil pumps, the alarm functions of lube oil level and the pressure drop of lube oil filters;
- Proper operation of interlocks and equipment protective devices in various turbine, pump, and valve controls;
- Proper operation of the turbine turning gear including proper turning gear engagement and disengagement functions; and
- Proper operation of the turbine overspeed protection system to provide Primary and Emergency electrical overspeed trips 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.)

#### 14.2.8.1.60 Main Generator and Auxiliary Systems Preoperational Test

***Purpose***

The objective of this test is to verify that the operation of the main generator and its auxiliary systems, including the generator hydrogen system and its associated seal oil and cooling systems, those subsystems and components that provide cooling to the generator exciter, stator, circuit breakers and isophase bus duct, and the generator protection system, is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. Appropriate power sources that supply power to the control circuits and instrumentation are available to support testing. The generator manufacturer's instruction manual shall be reviewed in detail in order that precautions relative to generator operation are followed. Required interfacing systems shall be available, as needed, to support the specified testing and the corresponding system configurations.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component, subsystem and integrated system tests (to the extent practical) to demonstrate the following, with regard to both the generator and its auxiliaries:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system pumps, valves, fans, and piping or ducting in all design operating modes;
- Proper system flow paths, flow rates and pressures (particularly with regard to the generator hydrogen system and its associated seal oil and cooling systems);
- Proper operation of the generator purge system;
- Proper operation of interlocks and equipment protective devices in the various generator and auxiliary system controls; and
- Proper operation of the field excitation.

#### 14.2.8.1.61 Seismic Monitoring System Preoperational Test

***Purpose***

The objective of this test is to verify that the Seismic Monitoring System operates as designed in response to a seismic event.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The required electrical power shall be available and system-recording devices should have sufficient storage medium available. Instrument calibration and instrument loop checks have been completed.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of tests, as recommended by the manufacturer, to demonstrate the following:

- Proper calibration and response of seismic instrumentation, including verification of alarm and initiation setpoints;
- Proper operation of internal calibration or test features; and
- Proper operation of recording and playback devices.

**14.2.8.1.62 Liquid and Solid Radwaste Systems Preoperational Tests**

***Purpose***

The objective of this test is to verify the proper operation of the various equipment and processes, which make up the liquid and solid radwaste systems.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure(s) and approved the initiation of testing. There shall be access to appropriate laboratory facilities and an acceptable effluent discharge path shall be established. Additionally, an adequate supply of demineralized water, the electrical power, and other required interfacing systems shall be available, as needed, to support the specified testing.

***General Test Methods and Acceptance Criteria***

The testing described below includes that of equipment and processes for the handling, treating, storing, and preparation for the disposal or discharge of liquid and solid radwaste.

The liquid and solid radwaste systems performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate to the extent practical for the following:

- Proper operation of equipment controls and logic, including prohibit and permissive interlocks;
- Proper operation of equipment protective features and automatic isolation functions, including those for ventilation systems and liquid effluent pathways;
- Proper functioning of instrumentation and alarms used to monitor system operation and status;
- Acceptable system and component flow paths and flow rates, including pump capacities and tank volumes;
- Proper operation of system pumps, valves, and motors under expected operating conditions;
- Proper operation of phase separators;
- Proper operation of concentrating and packaging functions, including verification of the absence of free liquids in packaged waste;

- Proper operation of mechanical and activated carbon filters, reverse osmosis water treatment units, demineralizer units and their associated support facilities; and
- Proper functioning of drains and sumps, including those dedicated for handling of specific agents such as detergents.

#### 14.2.8.1.63 Isolation Condenser System Preoperational Test

***Purpose***

The objective of this test is to verify that the operation of the Isolation Condenser System (ICS) loops, including valves, logic and instrumentation is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. High-pressure nitrogen must be available to operate the spring-loaded condensate return valves, and nitrogen operated pneumatic rotary motor isolation valves. Electrical power is also required to operate valves and controls.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper calibration of instrumentation;
- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing;
- Verification that the steam flow paths from the IC/PCCS pools to the atmosphere are unobstructed;
- Verification that isolation condenser steam and condensate-return piping flow passages are unobstructed;
- Proper operation of IC/PCCS pool level control;
- Verification that the isolation condenser pool subcompartment valves are locked open;
- Proper isolation of isolation condenser containment isolation valves upon receipt of simulated isolation signals; and
- Acceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.

#### 14.2.8.1.64 Passive Containment Cooling System Preoperational Test

The Passive Containment Cooling System (PCCS) is a unique ESBWR design for passive containment cooling in post accident conditions. The system consists of multiple loops or trains for redundancy. 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 with this section.

***Purpose***

The objective of this test is to verify the operation of PCCS is as specified.

***Prerequisites***

The construction tests have been successfully completed and the integrated containment leak rate test has been completed successfully. Makeup Water System is available to support the proper level control of IC/PCCS pool. The SCG has reviewed the test procedure and approved this visual inspection.

***General Test Methods and Acceptance Criteria*** Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Verification that PCCS steam supply, drain and vent piping are unobstructed;
- Verification that PCCS condenser air flow versus differential pressure is within acceptable test limits;
- Verification that PCCS pool subcompartment valves are locked open;
- Proper operation of IC/PCCS pool level control;
- Verification of the system interface with Fuel and Auxiliary Pools Cooling System (FAPCS) for IC/PCCS pool cooling;
- Verification that the PCCS Vent fans operate as required from the Main Control Room from normal power and from alternative power; and
- Verification that the PCCS fans will meet the specified flow requirements.

#### 14.2.8.1.65 Gravity-Driven Cooling System Preoperational Test

The Gravity-Driven Cooling System (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 with this section.

***Purpose***

The objective of this test is to verify that the operation of the four trains of the GDCS, including valves, logic and instrumentation, is as specified.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The reactor vessel shall be ready to accept GDCS flow. The required electrical power shall be available for squib-type valve power supply. Instrument calibration and instrument checks have been completed. To prevent actuation of single-use squib valves during the logic portion of this testing process, the valve(s) may be

isolated. This process of isolation, verification of the firing signal during the test, and reconnection must be controlled within the test document.

***General Test Method and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper calibration of instrumentation;
- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing;
- Verification that the flow passages from GDCS and Suppression Pool to reactor vessel are unobstructed;
- Verification that the flow passages to upper drywell are unobstructed;
- Adequacy to provide required design flow rate; and
- Acceptability of instrument channel response times, as measured from each applicable process variable input signal to the applicable process actuator confirmation signal.

**14.2.8.1.66 Deleted**

**14.2.8.1.67 Ancillary Diesel Generator & AC Power System Preoperational Test**

***Purpose***

The objective of this test is to demonstrate the capability of the ancillary diesel generators (ADG) to provide electrical power to plant nonsafety-related loads on the ancillary buses when the normal offsite and SDG power sources are unavailable. The ability of the ADG to supply power to the 120-volt Safety-Related Uninterruptible AC buses will be confirmed.

***Prerequisites***

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. The ADG auxiliary systems (for example, diesel fuel oil transfer and lube oil) are operable to support continuous diesel operation. Appropriate electrical power sources, diesel generator room HVAC and equipment required to support system operation shall be available, as needed, for the specified testing configuration. Additionally, sufficient diesel fuel shall be available onsite to perform the scheduled tests.

***General Test Methods and Acceptance Criteria***

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper automatic startup of the ADGs on the loss of PIP AC power to their buses;

- Proper automatic startup of the ADGs upon detection of a low temperature in the room where the diesel generator is located;
- Proper operation of the ADGs when manually connected to their ancillary electrical bus. The testing will include verification that voltage and frequency are maintained within design limits when connection to the bus is made or interrupted and that overspeed limits are not exceeded when the diesel generator is unloaded;
- The ADGs are tested at full load and rated power factor for a period of 24 hours. This ensures diesel cooling and room HVAC systems perform their design functions;
- The rate of fuel consumption determined in the load testing at full load, is used to confirm that fuel capacity of the associated day tank meets the design operational requirement;
- The rate of fuel consumption determined in the load testing with the proper operation of the fuel oil transfer pumps, meets the requirement for 7-day minimum storage inventory without refueling for each ancillary diesel generator;
- Testing includes verification of the setting of the low-level alarm in the day tanks and proper operation of the fuel oil transfer pumps are consistent with the design requirements;
- The proper function of the ADG protective devices;
- That permissive and prohibit interlocks, controls, and alarms operate in accordance with design specifications;
- Proper operation of auxiliary systems such as those used for starting, cooling, heating, ventilating, lubricating, and fueling the ADGs; and
- Capability of the system to allow use of the ADGs to supply power to the safety-related 120-volt Uninterruptible buses through the Isolation Power Center buses.

### *14.2.8.2 General Discussion of Startup Tests*

Those tests proposed and expected to comprise the startup test phase are discussed in this subsection. For each test, a general test synopsis is provided that includes the purpose, prerequisites, description and acceptance criteria, where applicable.

Because additions, deletions, and changes to these discussions are expected to occur as the test program is developed and implemented, the descriptions remain general in scope. In describing a test, however, an attempt is made to identify those operating and safety-oriented characteristics of the plant which are to be explored and evaluated.

The ESBWR, because it is a natural circulation reactor, has unique characteristics during startups and especially during the initial startup. The CRD cooling flow provides a steady supply of cold water to the bottom of the RPV and core heat warms the upper part of the RPV (that is, there is a designed-in tendency for temperature stratification until natural circulation is established). This can be overcome with the RWCU/SDC system (See Subsection 14.2.8.2.17).

Where applicable, the relevant acceptance criteria for the test are discussed. Some of the criteria relate to the value of process variables assigned in the design or analysis of the plant, component

systems, and associated equipment. Other criteria may be associated with expectations relating to the performance of systems. The Startup Administrative Manual shall describe the various categories of acceptance criteria and shall designate how differentiation between them is accomplished in the test procedures. Specific actions for dealing with criteria failures and other testing exceptions or anomalies are also described in the Startup Administrative Manual.

The specifics of the startup tests relating to test methodology, plant prerequisites, initial conditions, acceptance criteria, analysis techniques, and the like, are incorporated into the detailed test procedures to be utilized, based on the scoping documents to be supplied by the appropriate design and engineering organizations in the form of plant, system and component performance and testing specifications. The power ascension test phase procedures are made available to the NRC 60 days prior to the scheduled date for fuel loading. Furthermore, to ensure that the tests are conducted in accordance with established methods and appropriate acceptance criteria, the associated plant testing specifications are made available to the NRC.

#### 14.2.8.2.1 Chemical and Radiochemical Measurements Test

***Purpose***

The objective of this test is to secure information on the chemistry and radiochemistry of the reactor coolant and gaseous process streams while verifying that sampling equipment, procedures and analytical techniques are adequate to supply the data required to demonstrate the chemistry of all parts of the reactor system meet specifications and process requirements.

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with prerequisite testing completed. Instrumentation has been checked or calibrated as appropriate.

***Description***

Specific objectives of the test program include evaluation of fuel performance, evaluations of demineralizer operations by direct and indirect methods, measurements of filter performance, confirmation of condenser integrity, demonstration of proper steam separator-dryer operation, and evaluation and calibration of certain process instrumentation (including that used to monitor reactor water conductivity). Data for these purposes is secured from a variety of sources such as plant operating records, regular routine coolant analysis, radiochemical measurements of specific nuclides, and special chemical tests.

Prior to fuel loading, a complete set of chemical and radiochemical samples is taken to ensure that sample stations are functioning properly, if not demonstrated during the preoperational testing, and to determine initial concentrations. Subsequent to fuel loading, during reactor heatup, and at each major power level change, samples are taken and measurements made to determine the chemical and radiochemical quality of reactor water and incoming feedwater, amount of radiolytic gas in the steam, gaseous activities leaving the air ejectors, decay times in the offgas lines, and performance of filters and demineralizers in both the Condensate Purification System (CPS) and RWCU system.

Calibrations are made of monitors in effluent release paths, waste handling systems, and process lines. Proper functioning of such monitors is verified, as appropriate, including via comparison with independent laboratory or other analyses. In particular, the proper operation of failed fuel detection functions of the main steamline and offgas pretreatment process radiation monitors is verified. In this regard, sufficient data is taken to assure proper setting of, or to make needed adjustments to, the alarm and trip settings of the applicable instrumentation.

***Criteria***

Chemical factors defined in the Fuel Warranty Operating Limits must be maintained within the limits specified.

The activity of gaseous and liquid effluents must conform to license conditions and NRC effluent concentration limits in 10 CFR 20 Appendix B Table 2.

Water quality must be known at all times and shall remain within the guidelines of the water quality specifications and the requirements of the Fuel Warranty document.

#### 14.2.8.2.2 Radiation Measurements Test

***Purpose***

The objectives of this test are to:

- Determine the background radiation levels in the plant environs prior to operation for base data on activity buildup, and
- Monitor radiation at selected power levels to assure the protection of personnel during plant operation.

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Instrumentation has been checked or calibrated as appropriate.

***Description***

A survey of natural background radiation throughout the plant site is made prior to fuel loading, and repeated periodically during startup testing, subsequent to fuel loading, during reactor heatup, and at several power levels up to and including rated power. Gamma dose rate measurements and, where appropriate, neutron dose rate measurements are made at specific locations throughout the plant. All potentially high and very high radiation areas are surveyed, including:

- Containment penetrations;
- All accessible areas where intermittent activities have the potential to produce transient high radiation conditions before, during, and after such operations; and
- All accessible floor areas within the plant prior to fuel loading, at intermediate powers, and at full power.

***Criteria***

The radiation doses of plant origin and the occupancy times of personnel in radiation zones shall be controlled consistent with the guidelines outlined in 10 CFR 20, "Standards for Protection Against Radiation."

#### 14.2.8.2.3 Fuel Loading Test

***Purpose***

The objective of this test is to load fuel safely and efficiently to the full core size.

***Prerequisites***

The plant has received the proper authorization from the NRC to proceed with fuel loading and plant management has reviewed the applicable procedures and the overall plant readiness, and approved the initiation of loading.

Additionally, the following requirements are met prior to commencing fuel loading to assure that this operation is performed in a safe manner:

- The status of all systems required for fuel loading is specified and the systems are in the required status;
- Fuel and control rod inspections are complete. Control rods are fully inserted and functionally tested;
- For the initial core, neutron sources are installed;
- The required number of SRNM channels are operable and calibrated with high flux scram and rod block trips being set conservatively low in the non-coincident mode;
- Nuclear instruments are source checked with a neutron source prior to loading;
- Reactor vessel status is specified relative to internal component placement and this placement established to make the vessel ready to receive fuel;
- Reactor vessel water level is established above the minimum level prescribed; and
- Other required systems shall be operable as defined by the plant Technical Specifications and as demonstrated by the applicable surveillance tests.

***Description***

Fuel loading commences and proceeds according to written procedures in a predetermined sequence that assure a safe and efficient loading, with each fuel assembly by serial number in its specified location. The neutron count rates shall be monitored as the core loading progresses to ensure continuous subcriticality, and shutdown margin demonstrations are performed at specified loading intervals. Criteria for and actions required to address any deviations from expected results will be delineated in the fuel loading procedures as described in Subsection 14.2.2.

***Criteria***

The partially loaded core, at the applicable intervals, must be subcritical by at least the specified amount, in terms of reactivity, with the analytically determined highest worth rod pair fully withdrawn (a rod pair is defined as having a shared accumulator).

#### 14.2.8.2.4 Full Core Shutdown Margin Demonstration Test

***Purpose***

The objective of this test is to demonstrate that the reactor is subcritical throughout the first fuel cycle with the highest worth control rod pair (two CRDs with a shared accumulator) fully withdrawn and all other control rods fully inserted.

***Prerequisites***

The plant management has reviewed the test procedure and approved the initiation of the testing. The following prerequisites are satisfied prior to performing the full core shutdown margin tests:

- The predicted rod position for the criticality has been determined;
- The Standby Liquid Control (SLC) System is operable;
- Nuclear instrumentation is operable with the minimum neutron count rate and signal-to-noise ratio as specified by the Technical Specifications; and
- High-flux scram trips are set conservatively low on SRNMs.

***Description***

This test is performed in the fully loaded core in the xenon-free condition. This test is performed by withdrawing the control rods from the all-rods-in configuration in the specified withdrawal sequence until criticality is reached. The difference between the measured $K_{eff}$ and the calculated $K_{eff}$ for the in-sequence critical is applied to the calculated value to obtain the true shutdown margin.

***Criteria***

The shutdown margin of the fully loaded, cold (20°C/68°F), xenon-free core occurring at the most reactive time during the cycle must be at least that amount required by Technical Specifications, with the analytically strongest rod pair (or the reactivity equivalent) fully withdrawn. If the core reactivity is calculated to increase during the fuel cycle, compliance with the above criterion is shown by demonstrating that the shutdown margin is the specified amount plus an exposure-dependent increment, which adjusts for the difference in core reactivity between the most reactive exposure and the time at which the shutdown margin is demonstrated. Additionally, criticality shall occur within the specified tolerance of the predicted Estimated Critical Position.

#### 14.2.8.2.5 Control Rod Drive System Performance Test

***Purpose***

The objective of this test is to demonstrate that the control rods operate properly over the full range of primary coolant temperatures and pressures from ambient to operating conditions, in both the scram and fine motion control modes, in conjunction with the Rod Control and Information System (RC&IS).

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant

shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated as appropriate. In addition, a special test fixture containing a small pump and associated hydraulic control shall be available for performing driveline friction testing.

***Description***

The CRD testing performed during the heatup and power ascension phases of the startup test program is designed as an extension of the testing performed during the preoperational phase. The continuous-insert friction test is performed after completion of fuel loading for each drive with the reactor at cold, atmospheric pressure condition. The underside of each FMCRD hollow piston will be pressurized using a portable friction test cart connected to the hydraulic control unit. The pressure acting on the bottom surface of the FMCRD hollow piston is measured by the friction test device as the control rod drive moves toward insertion. The variation in water pressure under the hollow piston is then compared against the acceptable limit for indication of abnormal driveline resistance that would adversely affect drive operation.

After it is verified that all CRDs operate properly when installed, tests are performed periodically during heatup to assure that there is no significant binding caused by thermal expansion of the core components and no significant effect on performance due to increased pressure, power or flow. Additionally, software functions such as those associated with the RC&IS are tested to the extent that they could not be checked during preoperational testing.

Coupling tests will be performed by withdrawing each drive from full-out to overtravel-out position (that is, uncoupling check position) using Coupling Check Test Mode. The coupling test is performed to:

- Demonstrate actuation of the separation switches;
- Confirm synchro position indication as the drive is withdrawn to the overtravel-out position; and
- Confirm the integrity of the coupling between the control blade and the hollow piston.

Gang rod operation in response to commands from the RC&IS and the PAS during automatic rod movement will be demonstrated during reactor heatup and at reactor rated temperature and pressure conditions. This test will also verify that a rod withdrawal block is activated as a result of rod gang misalignment during normal gang rod movement.

The scram performance tests will be demonstrated at atmospheric and rated reactor pressure conditions by using Scram Test Switches on the test panel. The accumulator charging line valve in the associated Hydraulic Control Unit (HCU) shall be closed so that the CRDs do not ride the CRD pump head during the paired (two-CRD per HCU) and unpaired (one-CRD per HCU) CRD scram performance test. Four CRDs will be selected based on slow normal accumulator pressure scram times as determined from preoperational or atmospheric scram performance testing, or unusual operating characteristics. During reactor heatup with reactor pressure at 4.14±0.34 MPaG (600±50 psig) and 5.51±0.34 MPaG (800±50 psig), scram performance tests of these four selected CRDs with the CRD accumulators normally charged will be conducted for continuous monitoring purposes.

Additionally, the full core scram tests will be performed in conjunction with the various planned scram tests. The scram insertion time of each fully withdrawn rod will be measured during each scram test. The scram follow function will be confirmed to actuate automatically and go to completion. The intermediate position reed switches will be verified to actuate momentarily at the end of scram. The separation switches will be verified to actuate at the start of scram and return to their normal state at the completion of the scram follow function.

***Criteria***

Each CRD shall have a measured scram time that is less than or equal to the Technical Specifications requirements and consistent with safety analysis assumptions during both individual rod pair and full-core scrams, as applicable. Each CRD shall have a measured insert/withdrawal speed consistent with specified design requirements, including those associated with group or gang movement. The CRDs shall meet friction test requirements. For each control rod, the scram-follow function shall actuate automatically to insert the scrammed control rod(s) to the full-in position within the time limit specified as per design. The separation switches for each control rod shall operate normally from scram occurrence to scram-follow completion during both paired/unpaired rod and full-core scram performance tests.

#### 14.2.8.2.6 Neutron Monitoring System Performance Test

***Purpose***

The objective of this test is to verify response, calibration and operation of Startup Range Neutron Monitors (SRNMs), Local Power Range Monitors (LPRMs), Average Power Range Monitors (APRMs), and other hardware and software of the NMS during fuel loading, control rod withdrawal, heatup and power ascension.

***Prerequisites***

The applicable preoperational phase testing is complete and the plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled test iteration the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated, as appropriate.

***Description***

Testing of the NMS commences prior to fuel loading and continues at intervals up to and including rated power. The SRNMs and operational sources are tested during fuel loading and during rod withdrawal on the approach to criticality and heatup to rated temperature and pressure and low power operation. The LPRMs and APRMs are tested as soon as sufficient flux levels exist and at specified intervals during the ascension to rated power. Testing includes response checks, calibrations and verification of system software calculations using actual core flux levels and other plant inputs.

***Criteria***

The SRNMs, in conjunction with the installed neutron sources, shall have count rates that meet Technical Specifications and Design Control Document (DCD) Subsection 7.2.2 design requirements, as applicable. The respective range functions of the SRNMs and APRMs shall provide for overlapping neutron flux indication as required by plant Technical Specifications and the applicable DCD Subsection 7.2.2 design requirements. The APRMs shall be calibrated

against core thermal power by means of a heat balance. The accuracy of this calibration shall be consistent with the Technical Specifications. The LPRMs shall be calibrated based upon calibration factors provided by the Automated Fixed In-Core Probe (AFIP) (gamma thermometer) subsystem. The accuracy of this calibration shall be consistent with the Gamma Thermometer Licensing Topical Report, NEDE-33197P-A, Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring. Additionally, system hardware and software shall function properly in response to actual core flux levels.

#### 14.2.8.2.7 Core Performance Test

***Purpose***

The objective of this test is to demonstrate that the various core and reactor performance characteristics such as power and flow, core power distributions, and those parameters used to demonstrate compliance with core thermal limits and plant license conditions are in accordance with design limits and expectations.

***Prerequisites***

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Applicable instrumentation shall have been checked and calibrated, as appropriate.

***Description***

This test collects data sufficient to demonstrate that reactor and core performance characteristics remain within design limits and expectations for the operational conditions the plant is normally expected to encounter. Beginning with rod withdrawal and continuing through initial criticality, plant heatup, and the ascension to rated power, pertinent data is collected at various rod patterns and powers sufficient to determine the axial and radial core power distributions, compliance with core thermal limits, and the level of consistency with predicted core reactivity and core flow versus core power. Core flow is calculated from a heat and mass-flow balance on the downcomer. Core power is calculated from a heat and mass-flow balance on the nuclear boiler.

[*A First Of A Kind (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 partitions may experience flow-regime-transition-induced flow oscillation. The test will begin at 20% thermal power and the first time the reactor achieves a new 5% 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 monitored LPRM signals are filtered to remove noise components with frequencies above the range of stability-related power oscillation. This data will be collected at sufficient instances to capture the development of instability patterns (if any) that may occur during in the ascent to rated power*.]*

***Criteria***

Technical Specification and license condition requirements involving core thermal limits, maximum power level, and any observed reactivity anomalies or core instabilities shall be met.

*Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

**14.2.8.2.8 Nuclear Boiler Process Monitoring Test**

***Purpose***

The objectives of this test are to:

- Verify proper operation of various nuclear boiler process instrumentation;
- Collect pertinent data from such instrumentation at various plant operating conditions; and
- Verify the test instruments to measure the flow-induced vibration of reactor internals have been installed and calibrated in order to validate design assumptions and identify any operational limitations that may exist.

***Prerequisites***

The applicable preoperational testing has been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Additionally, system and test instrumentation shall have been installed and calibrated. The internals, test instrumentation and instrumentation lead wires for measurement of flow-induced vibration of reactor internals are installed in the reactor vessel head and it is water leaktight. The proper operation and calibration of the test instrumentation and recording equipment is verified during the leak testing of the RPV.

***Description***

After all in-vessel work has been completed and the RPV head has been secured, a hydrostatic pressure test is required before nuclear heatup. The RPV must be heated to a minimum temperature before it can be hydrotested; refer to the Pressure Temperature Limit Report (PTLR) discussed in Subsection 5.6.4 of Chapter 16.. The feedwater system in conjunction with the RWCU/SDC System shall be used to meet this temperature requirement and demonstrate their capability.

During plant heatup and power ascension, pertinent parameters such as reactor coolant temperature, vessel bottom head temperature, vessel dome pressure, vessel water level, and water-level reference column temperature distribution are monitored at selected intervals and plant conditions. This data is used to verify proper instrument response to changing plant conditions and to document the relationships among these parameters and with other important parameters such as reactor power, feedwater flow and steam flow. The data are also used to validate design assumptions such as those used in the calibration of vessel level indication and to identify potential operational condition limitations such as excessive coolant temperature stratification in the vessel bottom head region.

***Criteria***

The various nuclear boiler process instrumentations shall operate as designed in response to changes in plant conditions. The observed process characteristics shall be conservative relative to applicable safety analysis assumptions and shall be consistent with design expectations.

#### 14.2.8.2.9 System Expansion Test

***Purpose***

The purpose of the thermal expansion test is to confirm that the pipe suspension system is working as designed, the piping is free of obstructions during power changes, the measured and observed pipe expansion is in accordance with design, and the piping returns to its approximate cold condition after cooldown.

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedures and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

The thermal expansion tests consist of measuring displacements and temperatures of piping during various operating modes. The power levels used to heat and hold the system at a constant temperature shall be as low as practicable. The PAS can be used to control the rate of heatup and hold the temperature constant. Thermal movement and temperature measurements shall be recorded for at least the following test points (following a suitable hold period to assure steady-state temperatures):

- During reactor pressure vessel heatup at least one intermediate temperature (between 121°C/250°F and 177°C/350°F) prior to reaching normal operating temperature, including an inspection of the piping and its suspension for obstructions or inoperable supports;
- Following RPV heatup to normal operating temperature;
- Following heatup of other piping systems to normal operating temperature (those systems whose heatup cycles differ from the RPV); and
- Subsequent heatup/cooldown cycles, as specified, at the applicable operating and shutdown temperatures, to measure possible shakedown effects.

Thermal expansion testing includes the following:

- Main Steam Piping: Steamlines between the RPV nozzles and the outboard main steam isolation valves (MSIVs), and steamlines downstream of the outboard MSIVs shall be tested;
- Relief Valve Discharge Piping: The piping attached to the MSL and bounded by the SRV discharge flange and the quencher in the wetwell shall be tested;
- Feedwater Piping: The feedwater discharge piping downstream of the butt welds, located nominally one meter of piping outside of the RB boundary up to the RPV feedwater nozzles, shall be tested;
- Isolation Condenser Piping: The steam supply and condensate return piping shall be tested;
- RWCU/SDC Piping: The RWCU pumps suction and discharge piping is tested;

- RPV Head Vent Piping: RPV Head Vent piping shall be tested; and
- Piping Inside Drywell: Major piping systems inside the drywell including the GDCS and SLC discharge piping are tested and subject to inspection.

A test procedure and acceptance criteria will be developed on the basis of the test experience gained from the previous tests performed on the existing BWR units. The test procedure will meet the applicable systems design specifications and thermal modes.

The system expansion test consists of measuring displacements and temperatures of piping systems using installed instruments or local measurements during various system and plant operating modes. A visual examination for evidence of obstruction or interference will be performed on the above mentioned system piping inside containment at appropriate hold points during reactor heatup to rated temperature and pressure conditions and after three heatup and cooldown cycles. In addition, visual observation will also be made by a system walkdown at accessible locations to determine acceptability of the system outside containment under the conditions existing during each specified system test.

Thermal movement and temperature measurements shall be recorded inside the drywell and wetwell on the following piping: MS, selected SRV discharge lines, ICS steam and condensate piping, feedwater lines, and RWCU/SDC, at least at the following points during the power ascension phase of startup testing:

- Ambient temperature (for baseline data);
- 1.05 MPaG (150 psig) reactor pressure;
- 4.14 MPaG (600 psig) reactor pressure;
- Approximately 7.07 MpaG (1025 psig); and
- 20-25%, 50%, 75% and 100% of rated thermal power.

Thermal movements of feedwater and RWCU/SDC system piping will also be recorded at appropriate temperature increments, up to the required test temperature, when each system is placed in service during normal plant operation.

For applicable Balance of Plant (BOP) system piping, cold baseline data will be initially recorded. During initial reactor heatup, measurement data will be obtained at specified temperature plateaus. Heatup will be stopped if any excessive movement is encountered. On completion of cooldown to ambient temperature, measurement data will again be collected.

Additionally, a special test procedure and acceptance criteria will be developed for the feedwater thermal stratification mode. Tests will be performed to monitor the conditions and effects of temperature stratification that may exist in the feedwater discharge piping inside and outside of containment. This special test will be conducted during heatup, hot standby, post-scram, during ICS operation, and during reactor shutdown. During the performance of this test, thermal displacements, strains, and temperature measurements will be taken on at least one of the main feedwater headers inside and outside the containment, at selected feedwater riser piping, and at selected feedwater RPV nozzles to measure thermal cycling.

***Criteria***

The thermal expansion acceptance criteria are based upon the actual movements being within a prescribed tolerance of the movements predicted by analysis. Measured movements are not expected to precisely correspond with those mathematically predicted. Therefore, a tolerance is specified for differences between measured and predicted movement. The tolerances are based on consideration of measurement accuracy, suspension free play, and piping temperature distributions. If the measured movement does not vary from the predictions by more than the specified tolerance, the piping is expanding in a manner consistent with predictions and is therefore acceptable. Tolerances shall be the same for all operating test conditions. The locations to be monitored and the predicted displacements for the monitored locations in each plant are provided by the applicable testing specification.

#### 14.2.8.2.10 System Vibration Test

***Purpose***

The objective of this test is to verify that the vibration of critical plant system components and piping is within acceptable limits during normal steady-state power operation and during an expected Anticipated Operational Occurrence (AOO).

***Prerequisites***

The applicable preoperational phase testing is complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. Applicable systems have been walked through and verified complete to the extent required to conduct this test. Temporary hangers have been removed and replaced with permanently installed hangers for the systems involved, prior to starting the test on the particular system. For each scheduled test iteration the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. The required remote monitoring instrumentation shall be calibrated and operational.

Test procedures and acceptance criteria for ESBWR piping and components will be developed on the basis of the test experience gained from previous tests performed for earlier BWRs. Specific piping systems may be added to the vibration test program based on the results of the preoperational walkdown.

***Description***

Vibration testing during the power ascension phase is limited to those systems that could not be adequately tested during the preoperational phase. Systems within the scope of this testing are therefore the same as mentioned in Subsection 14.2.8.1.42. However, the systems that remain to be tested are primarily of those exposed to and affected by steam flow and high rates of core flow. Because of the potentially high levels of radiation present during power operation, the testing is performed using remote monitoring instrumentation. Displacement, acceleration, and strain data is collected at various critical steady-state operating conditions and during a significant AOO such as turbine or generator trip, main steamline isolation, and SRV actuation.

***Criteria***

Criteria are calculated for those points monitored for vibration for both steady-state and AOO cases. Two levels of criteria are generated, one level for predicted vibration and one level based on acceptable values of displacement and acceleration and the associated stress to assure that

there are no failures from fatigue over the life of the plant. Failure to remain within the predicted levels of vibration shall be investigated but do not necessarily preclude the continuation of further testing. However, failure to meet the criteria based on stress limits requires prompt investigation and resolution while the plant or affected system is placed in a safe condition.

#### 14.2.8.2.11 Reactor Internals Vibration Test (Initial Startup Flow-Induced Vibration Testing)

***Purpose***

The objective of this test is to collect information needed to verify the adequacy of the design, manufacture, and assembly of reactor vessel internals with respect to the potential affects of flow-induced vibration. Instrumentation of major components and the flow tests and remote inspections provide assurance that excessive vibration amplitudes, if they exist, are detected at the earliest possible time. The data collected also helps establish the margin to safety associated with steady-state and AOO conditions and helps confirm the pretest analytical vibration calculations. This testing fulfills the initial startup test requirements of Regulatory Guide 1.20 for a vibration measurement and inspection program for prototype reactor internals. A complete description of the reactor internals vibration test program is provided in Subsection 3.9.2.4.

***Prerequisites***

The applicable preoperational phase testing is complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. The initial vibration analysis computations and specifications of acceptance criteria shall be complete. These results shall be utilized to define final inspection and measurement programs. Reactor vessel components and structures shall be installed and secured as designed in expectation of being subjected to rated volumetric core flow. This includes the steam separator and dryer assembly and reactor vessel head. The assembly and disassembly of vessel internals shall be choreographed such that structures and components requiring remote inspections are accessible at the proper times. The required sensors shall be installed and calibrated prior to the flow testing. All other systems, components and structures shall be available, as required, to support the reactor internals vibration assessment program. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified testing complete.

***Description***

The reactor internals vibration testing subsequent to fuel loading is performed during the power ascension phase and includes intermediate and high power and flow conditions during steady-state operation. AOOs that are expected to result in limiting or significant levels of reactor internals vibration are also included.

The reactor internals vibration assessment program consists of two parts: a vibration analysis program, and an inspection and measurement program. The vibration analysis portion is performed on the final design, prior to the initial startup test, and the results are used to develop the measurement and inspection portions of the program. The initial startup test therefore consists of an instrumented flow test and pre- and post-test inspections as described in the following paragraphs:

Pre-flow Vessel Inspection — The pre-flow inspection is performed primarily to establish and document the status of vessel internal structures and components. Some of the inspection requirements may be met by normal visual fabrication inspections. The majority of the

inspection requirements are met by visual and remote observations of the installed reactor internals in a flushed and drained vessel. The following types of structures and components shall be included in the vessel internals inspection program:

- Major load bearing elements, including lateral, vertical and torsional supports;
- Locking and bolting components whose failure could adversely affect structural integrity;
- Known or potential contact surfaces;
- Critical locations as identified by the vibration analysis program; and
- Interior surfaces for evidence of loose parts or foreign material.

Flow Testing — The initial startup flow test are performed at low, mid and high core powers leading to rated volumetric core flow with the vessel internals completely assembled, including the fuel bundles, the control blades and the steam dryer assembly. The internals vibration is measured during individual component or system startup testing where operation may result in significant vibrational excitation of reactor internals, such as ICS testing. The duration of the startup testing at the various flow configurations shall ensure that each critical component vibration is within design limitations.

Post-Flow Vessel Inspection — The post-flow inspection shall be performed after the resultant vibration from the startup flow testing described above. This is done at the first refueling outage unless there are compelling reasons (based on the data obtained during testing) to investigate earlier. The structures and components inspected shall be the same as specified for the pre-flow inspection. Remote observations are performed after the vessel has been depressurized and the head removed. The schedule for this step is determined by analysis of the measured data obtained during flow testing.

***Criteria***

The acceptance criteria are generated as part of the analytical portion of the program in terms of maximum vibrational response levels of overall structures and components and translated to specific sensor locations.

Reactor vessel internals vibration is considered acceptable when results of the measurement program correlate and compare favorably with those of the analysis program, and when the results of inspections show no signs of defects, loose parts, extraneous material, or excessive wear due to flow testing.

#### 14.2.8.2.12 Feedwater Control Test

***Purpose***

The objective of this test is to demonstrate that the stability and response characteristics of the FWCS are in accordance with design requirements for applicable system configurations and operational conditions.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the

appropriate operational configuration with specified prerequisite testing complete. This includes preliminary adjustments and optimization of control system components, as appropriate.

***Description***

Startup phase testing of the FWCS is intended to demonstrate that the overall response and stability of the system meets design requirements subsequent to controller optimization. Testing begins during plant heatup for any special configurations designed for very low feedwater or condensate flow rates and continues up through the normal full power lineup. Testing shall include all modes of control and encompass all expected plant power levels and operational conditions. Testing is accomplished by manual manipulation of controllers or by direct input of demand changes at various levels of control. System response shall also be evaluated under AOO conditions such as an unexpected loss of a feedwater pump or a rapid reduction in core power level and after plant trips such as turbine trip or main steamline isolation. Proper setup of control system components or features designed to handle the nonlinearities or dissimilarities in system response at various conditions shall also be demonstrated. The above testing also serves to demonstrate overall core stability to subcooling changes.

***Criteria***

The Feedwater Control System 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.

**14.2.8.2.13 Pressure Control Test**

***Purpose***

The objective of this test is to demonstrate that the stability and response characteristics of the pressure regulation system are in accordance with the design requirements for all modes of control under expected operating conditions.

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Additionally, applicable instrumentation shall have been checked or calibrated as appropriate. This includes preliminary adjustment and optimization of control system components, as appropriate.

***Description***

Startup phase testing of the Pressure Control System is intended to demonstrate that the overall response and stability of the system meets design requirements, subsequent to control system optimization. Performance shall be evaluated across the spectrum of anticipated steam flows for both the pressure regulation and load-following modes of control, as applicable. Testing shall demonstrate acceptable response with either the turbine control valves or bypass control valves in control and for the transition between the two. Testing is accomplished by manual manipulation of controllers or direct input of demand changes at various levels of control. It shall also be demonstrated that other affected parameters remain within acceptable limits during

such pressure regulator-induced maneuvers. Overall system response is evaluated during other plant AOOs as well. Additionally, proper setup of components or features designed to deal with the nonlinearities or dissimilarities in system response that may exist under various conditions shall be demonstrated.

***Criteria***

System performance shall be stable such that any type of divergent response is avoided. The response shall be sufficiently fast but with any oscillatory modes of response well damped, usually with decay ratios less than 0.25.

#### 14.2.8.2.14 Plant Automation and Control Test

***Purpose***

The objectives of this test are to:

- Verify proper plant performance in automatic modes of control such as during automatic plant startup or automatic load following under the direction of the PAS; and
- Verify the ability of the PAS to collect, process, and display plant data, execute plant performance calculations, support MCR display functions, and interface with various plant control systems during actual plant operating conditions.

***Prerequisites***

The applicable preoperational tests have been completed and plant management has reviewed the testing procedure and approved the initiation of testing. Affected systems and equipment, including lower level control systems such as RC&IS, feedwater control and turbine control, as well as monitoring and predicting functions of the PAS or automation computer, shall have been adequately tested under actual operating conditions.

***Description***

A comprehensive series of tests is performed in order to demonstrate proper functioning of the various plant automation and control features. This testing shall include or bound all expected plant operating conditions under all permissible modes of control and shall also verify, to the extent practical, avoidance of prohibited or undesirable conditions or control modes. Auto load following capabilities are demonstrated under control of the PAS for control rod movements, including anticipated transition regions. Such testing includes demonstration(s) that the dynamic response of the plant (including BOP signals) to design load swings for the facility, including limiting step and ramp changes as appropriate, is in accordance with design. The ability of the PAS to properly orchestrate automated plant startup, shutdown and power maneuvering is shown. Also to be tested are system components or interfaces that perform monitoring, prediction, processing, validation, alarm, protection or control functions.

***Criteria***

The PAS and other features and functions of plant automation and control shall perform in accordance with the applicable design and testing specifications. Automatic maneuvering characteristics of plant and systems shall meet the appropriate response and stability requirements. Safety and protection features shall perform consistent with safety analysis assumptions and predictions.

#### 14.2.8.2.15 Feedwater System Performance Test

***Purpose***

The objective of this test is to verify that the overall feedwater system performance characteristics are in accordance with the design requirements.

***Prerequisites***

The preoperational testing is complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Applicable instrumentation has been checked or calibrated, as appropriate.

***Description***

Pertinent parameters are monitored throughout the feedwater system, and condensate system if appropriate, across the spectrum of system flow and plant operating conditions in order to demonstrate that system operation is in accordance with design. Parameters to be monitored may include temperatures, pressures, flow rates, pressure drops, pump speeds, developed heads, and general equipment status. Of special interest is data that serves to verify design assumptions used in plant AOO performance and safety analysis calculations (for example, maximum feedwater runout capabilities and feedwater temperature versus power level relationships). Steady-state and AOO testing are conducted, as necessary, to assure that adequate margins exist between system variables and setpoints of instruments monitoring these variables to prevent spurious actuations or loss of system pumps and motor-operated valves.

***Criteria***

When applicable, measured parameters shall compare conservatively with safety analysis design assumptions. Additionally, test data shall demonstrate that system steady state and AOO performance meets design requirements.

#### 14.2.8.2.16 Main Steam System Performance Test

***Purpose***

The objective of this test is to verify that MS system related performance characteristics are in accordance with design requirements.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate.

***Description***

Pertinent system parameters, such as temperatures, pressures, and flows, are monitored at various steam flow rates in order to demonstrate that system operation is in accordance with design. The steam flow measuring devices that provide input to feedwater control and leak detection logic shall be crosschecked to verify the accuracy of design calibration assumptions. If appropriate, the pressure drop developed across critical components shall be compared with design values.

The quality of the steam leaving the reactor shall also be determined to be within design requirements.

***Criteria***

When applicable, measured parameters shall compare conservatively with safety analysis design assumptions. Additionally, test data shall demonstrate that system steady state and AOO performance meets design requirements.

**14.2.8.2.17 Reactor Water Cleanup/Shutdown Cooling System Performance Test**

***Purpose***

The objective of this test is to verify that RWCU/SDC System performance, in all designed modes of operation, is in accordance with design requirements at rated reactor temperature and pressure conditions.

***Prerequisites***

The preoperational testing is complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Instrumentation has been checked or calibrated as appropriate.

***Description***

To prevent thermal stratification in the RPV during RPV heatup for reactor startup and hot standby conditions, both trains of the RWCU/SDC System shall be aligned to take suction from only the bottom drain lines to preclude vessel thermal stratification. The normal shutdown cooling suction line shall be shut during this mode of operation.

Startup phase testing of the RWCU/SDC System is an extension of the preoperational tests for rated temperature and pressure conditions. System parameters are monitored in the various modes of operation at critical temperature, pressure and flow conditions. Acceptable NPSH for the pumps must be demonstrated.

The performance of system heat exchangers and demineralizer units are evaluated at hot operating conditions. The ability of the system to reject excess vessel inventory during plant heatup is verified. Other system features shall be demonstrated as appropriate.

***Criteria***

The RWCU/SDC System shall maintain the temperature difference between the reactor steam dome and the bottom head drain to less than 80.6°C (145°F) during reactor startup and hot standby conditions. System performance shall meet other specified design requirements in required operating modes.

**14.2.8.2.18 Plant Service Water System Performance Test**

***Purpose***

The objective of this test is to verify performance of the PSWS, including the Reactor Component Cooling Water System (RCCWS), and the TCCWS under expected reactor power operation load conditions.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate

***Description***

Power ascension phase testing of plant cooling water systems is necessary only to the extent that fully loaded conditions could not be approached during the preoperational phase. Pertinent parameters shall be monitored in order to provide a verification of proper system flow balancing and heat exchanger performance under near design or special conditions, as appropriate. This includes extrapolation of results obtained under normal or test conditions as needed to demonstrate required performance at limiting or accident conditions.

***Criteria***

System performance shall be consistent with design requirements.

#### 14.2.8.2.19 Heating, Ventilation and Air Conditioning System Performance Test

***Purpose***

The objective of this test is to verify the ability of various HVAC systems to maintain area temperatures and humidity within the specified limits during reactor power operation.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

Power ascension phase testing of plant HVAC systems is necessary only to the extent that fully loaded conditions could not be approached during the preoperational phase. Pertinent parameters are to be monitored in order to provide a final verification of proper system flow balancing and cooler performance under near design or special situation conditions, as appropriate.

***Criteria***

System performance shall be consistent with design requirements. For systems that are taken credit for in the plant safety analysis, performance shall meet the minimum requirements assumed in such analysis.

#### 14.2.8.2.20 Turbine Valve Performance Test

***Purpose***

The objective of this test is to demonstrate proper functioning of the turbine valves during reactor power operation.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

Early in the startup test phase with the reactor at a moderate power level and with the turbine generator on-line, the operability of the control, stop, bypass, non-return, intermediate stop and intercept valves are demonstrated. This testing is similar to the individual valve testing required by the TS surveillances for the bypass valves or the augmented valve testing for the control, stop, non-return, intermediate stop and intercept valves. In addition to valve operability, the overall control system and plant response is observed. Because turbine valve testing is required routinely during power operation, the maximum power level at which such tests can safely be performed is determined by observing plant response during such tests at successively higher power levels.

***Criteria***

Turbine valves shall operate properly and in accordance with applicable requirements. Valve performance, control system response and plant response shall be consistent with design requirements. During high power testing, adequate scram avoidance margins shall be maintained.

**14.2.8.2.21 Nuclear Boiler System Isolation Test**

***Purpose***

The objectives of this test are to demonstrate proper operation of and to verify closure times for MSIVs, FW isolation valves, including steamline drain branch isolation valves, during power operation.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

Beginning at rated temperature and pressure, and then again at intermediate power levels, each MSIV is individually stroked in the fast closure mode. Valve operability and closure time are verified and overall plant response observed. Closure times are evaluated consistent with TS and safety analysis requirements. If appropriate, the maximum power level at which such tests can safely be performed is determined by observing plant response during such tests at successively higher power levels. In addition, at rated temperature and pressure, proper functioning and stroke timing of steamline drain isolation valves (for example, on the common drain line) are demonstrated.

Beginning at rated temperature and pressure, and then again at intermediate power levels, each FW isolation valve is individually stroked in the fast closure mode. Valve operability and closure time are verified and overall plant response observed. Closure times are evaluated consistent with TS and safety analysis requirements. FW isolation valve closure will not be demonstrated at high power levels to avoid the potential for a full loss of feedwater.

***Criteria***

MSIV and FW isolation valve closure times shall be within the limits required by plant Technical Specifications and those assumed in the plant safety analysis. Overall valve performance shall be in accordance with design requirements. During higher power level tests, adequate scram avoidance margins shall be maintained.

#### 14.2.8.2.22 Safety Relief Valve Performance Test

***Purpose***

The objective of this test is to demonstrate that each ADS safety/relief valve (SRV) can be manually opened and closed properly during reactor power operation.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

A functional test of each SRV is to be performed during plant heatup and at the 50% power plateau by manually opening and closing each valve. Opening and closing of each valve, as well as evidence of steam flow, are verified by response of SRV discharge tailpipe temperature sensors and by observed changes in turbine bypass valve positions or generator load. Tailpipe temperature indication is also used to confirm valve closure and no significant leakage. Downstream indications of SRV operation could be changes in such parameters as turbine valve positions or generator output. Such changes are also evaluated for anomalies that may indicate a restriction or blockage in a particular SRV tailpipe by making valve-to-valve comparisons.

***Criteria***

There shall be a positive indication of steam discharge during each manual valve opening. SRV open and close indications, and tailpipe temperature sensor, shall function as designed. For manual openings, the apparent steam flow through each SRV shall not vary significantly from the average for all valves. Each SRV shall be properly reseated after testing.

#### 14.2.8.2.23 Loss of Feedwater Heating Test

***Purpose***

The objectives of this test are to:

- Demonstrate proper integrated plant response to a loss of feedwater heating event; and

- Verify the adequacy of the modeling and associated assumptions used for this AOO in the plant licensing analysis.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

The credible single failure or operator error that has been identified as resulting in the largest feedwater temperature reduction is initiated at a significantly high power level, while considering the event analyzed and the predicted results. The ESBWR design provides automatic SCRRI and SRI when a loss of feedwater heating is greater than or equal to 16.7°C (30°F). This feature is checked and verified in this test. Core performance and overall plant response are observed in order to demonstrate proper integrated response and to compare actual results with those predicted. This comparison takes into account the differences between actual initial conditions and observed results and the assumptions used for the analytical predictions.

***Criteria***

Resultant Minimum Critical Power Ratio (MCPR) shall remain greater than the MCPR safety limit, and measured results shall compare conservatively with design assumptions and predictions. The overall plant response shall be according to design and test specifications. Proper SCRRI operation shall be verified.

#### 14.2.8.2.24 Feedwater Pump Trip Test

***Purpose***

The objective of this test is to demonstrate the ability of the plant to respond and continue power operation following the loss of an operating feedwater pump from near rated power conditions.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate.

***Description***

From an initial reactor power level near rated, one of the normally operating feedwater pumps is tripped to demonstrate that the overall plant response is such that a reactor scram is avoided. Specifically, it shall be verified that the FWCS is sufficiently responsive, in conjunction with specified mitigating features, to prevent a reactor scram due to the reactor water level change. Separate tests may be required to demonstrate auto start of a standby pump.

***Criteria***

From normal operating conditions, the reactor shall avoid low water level scram with adequate margin to the low water level trip setpoint.

#### 14.2.8.2.25 Shutdown From Outside the Main Control Room Test

***Purpose***

The objective of this test is to demonstrate that the reactor can be shut down from normal power operation to the point where a controlled cool down has been established, via decay heat rejection to the environment, with vessel pressure and water level under control, all using means entirely outside the MCR.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. The applicable instrumentation shall be checked or calibrated, as appropriate. An adequate number of qualified personnel shall be on site to perform the specified testing as well as their normal plant operational duties.

***Description***

This test shall be performed from a low initial power level but from one that is sufficiently high that a majority of plant systems are in their normal configurations for power operation. This test is as much a test of normal and emergency plant procedures and the ability of plant personnel to carry them out, as it is a test of plant systems and equipment. Therefore, the test shall be performed using the minimum shift crew that would be available during an actual event. Additional qualified personnel are available in the control room to monitor the progress of the test and to re-establish control of the plant should an unsafe condition develop. The personnel also perform predefined nonsafety-related activities to protect plant equipment, where such activities would not be required during an actual emergency situation. The test is initiated by simulating a control room evacuation and then tripping and isolating the reactor by means outside of the main control room. Achievement and maintenance of the hot standby condition and subsequent reactor cool down is then demonstrated through control of vessel pressure and water level from the remote shutdown panel. The cold shutdown capability does not necessarily have to be demonstrated immediately following the shutdown and hot standby demonstration as long as the total integrated capability is adequately demonstrated. Also, additional personnel, over and above the minimum shift crew may be utilized for the cold shutdown portion of the test consistent with plant procedure and management's ability to assemble extra help at the plant site in emergency situations.

***Criteria***

The remote shutdown test shall, as a minimum, demonstrate the capability of plant personnel, equipment, and procedures to initiate a reactor trip, to achieve and maintain hot standby conditions for at least 30 minutes, and to initiate decay heat removal such that coolant temperature is reduced by at least 28°C (50°F) at a rate within TS limit, all from outside the MCR. Additionally, system and plant performance shall be consistent with design and testing specification requirements.

#### 14.2.8.2.26 Loss of Turbine Generator and Offsite Power Test

***Purpose***

The objective of this test is to verify proper electrical equipment response and reactor system transient performance during and subsequent to a turbine generator trip with coincident loss of all offsite power sources.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate. A sufficient number of qualified personnel shall be available to handle the needs of this test, as well as those associated with normal plant operation.

***Description***

This test is performed at a relatively low power level early in the power ascension phase, but with the generator on-line at greater than 10% load. The test is initiated in a way such that the turbine generator is tripped and the plant is completely disconnected from all offsite power sources. The plant is maintained isolated from offsite power for a minimum of 30 minutes. During this time, appropriate parameters are monitored in order to verify the proper response of plant systems and equipment, including the proper switching of electrical equipment and the proper starting and sequencing of onsite power sources and their respective loads.

***Criteria***

Reactor protection system actions shall prevent violation of fuel thermal limits. The ICS and associated plant systems shall function properly without manual assistance to maintain reactor level above the initiation level of ADS and GDCS. The SDGs will start automatically following the loss of both Normal Preferred Power and Alternate Preferred Power and supply power to the 6.9 kV PIP buses. Other systems and equipment shall perform consistent with applicable design and testing specifications.

#### 14.2.8.2.27 Turbine Trip and Generator Load Rejection Test

***Purpose***

The objective of this test is to verify that the dynamic response of the reactor and applicable systems and equipment is in accordance with design for protective trips of the turbine and generator during power operation.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate, including steamline expansion/vibration sensors.

***Description***

In the ESBWR design, there is no direct scram because of turbine trip or generator load rejection. From an initial power level of 100%, the main generator is tripped (generator output breaker is

opened 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. This method for initiating the trip is chosen to create a complete loss of electrical load so the turbine is subjected to maximum overspeed potential. Reactor parameters such as vessel dome pressure and simulated fuel surface heat flux are monitored and compared with predictions so that the adequacy and conservatism of the analytical models and assumptions used to license the plant can be verified. Proper response of systems and equipment such as the turbine stop, control, and bypass valves, steamline vibration, the RPS, reduction in reactor power by SCRRI and staggered SRI group insertions, and the feedwater system are also demonstrated. The ability of the feedwater system to control vessel level after a 100% load rejection shall also be verified. Overspeed response of the main turbine shall also be evaluated because the generator is unloaded prior to complete shutoff of steam to the turbine.

For a turbine trip, the generator initially remains synchronized and there is no overspeed. However, the dynamic response of the reactor may be different if the steam shutoff rate is different. If there is expected to be a significant difference, it may be necessary to perform a separate demonstration and evaluation (similar to that discussed above), but initiated by a direct trip of the main turbine.

A turbine or generator trip is also to be performed at a lower power level. Reactor dynamic response is not as important for this AOO, compared to the full power demonstration, except for the ability to remain operating as designed. More important is the demonstration of proper integrated plant and system performance.

***Criteria***

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. Feedwater control shall prevent flooding of the steamline following generator or turbine trip. After generator load rejection, turbine speed shall not exceed design limits. The positive change in reactor dome pressure and fuel surface heat flux shall not exceed limits assumed in the transient analysis. Plant systems and equipment, including the turbine overspeed protection system and associated components, shall perform in accordance with the appropriate design and testing specifications.

#### 14.2.8.2.28 Reactor Full Isolation Test

***Purpose***

The objective of this test is to verify that the dynamic response of the reactor and applicable systems and equipment is in accordance with design for a simultaneous full closure of all MSIVs from near rated reactor power.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated, as appropriate.

***Description***

A simultaneous full closure of all MSIVs is initiated from near rated power in order to verify proper reactor and integrated plant response. Reactor dynamic response, as determined by such parameters as vessel dome pressure and simulated fuel surface heat flux, is compared with analytical predictions in order to verify the adequacy and conservatism of the models and assumptions used in the plant safety and licensing analysis. Proper response of systems and equipment such as the MSIVs, ICS, the RPS, and the Feedwater System is also demonstrated.

***Criteria***

The reactor must scram to limit the severity of the neutron flux and simulated fuel surface heat flux transients. Feedwater system settings must prevent flooding of the mainsteam line following the full reactor isolation transient event. The recorded MSIV full closure times must meet the limits specified in the Technical Specifications. The positive change in vessel dome pressure and simulated fuel surface heat flux shall not exceed the limits assumed in transient analysis. Initiation of timing of ICS and system performance shall be within specification.

**14.2.8.2.29 Offgas System Test**

***Purpose***

The objective of this test is to verify proper operation of the various components of the Offgas System over the expected operating range of the system.

***Prerequisites***

The preoperational tests have been completed and plant management has reviewed the test procedure and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with the specified prerequisite testing complete. Applicable instrumentation shall be checked or calibrated as is appropriate.

***Description***

Proper operation of the Offgas System is demonstrated by monitoring pertinent parameters such as temperature, pressure, flow rate, humidity, hydrogen content, and effluent radioactivity. Data shall be collected at selected operating points such that each critical component of the system is evaluated over its particular expected operating range. Performance shall be demonstrated for specific components such as catalytic recombiners, and activated carbon adsorbers, as well as the various heaters, coolers, dryers and filters. Also to be evaluated are the piping, valving, I&C that comprise the overall system.

***Criteria***

Hydrogen concentration within the system shall not exceed license conditions. Radioactivity effluents shall not exceed license conditions nor NRC concentration limits in 10 CFR 20 Appendix B Table 2. Steam supply to the non-condensing stage of steam jet air ejector must be maintained above the required flow. Applicable system and component parameters shall be consistent with design and testing specification requirements.

#### 14.2.8.2.30 Deleted

#### 14.2.8.2.31 Concrete Penetration Temperature Surveys Test

***Purpose***

The objective of this test is to demonstrate the acceptability of concrete wall temperatures in the vicinity of selected high temperature penetrations under normal plant operational conditions.

***Prerequisites***

The plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. Applicable instrumentation shall be installed and checked or calibrated as is appropriate.

***Description***

Concrete temperature data is collected, around selected high temperature penetrations, at various power levels and system configurations in order to verify acceptable performance under expected plant operational conditions. Penetrations and measurement locations selected for monitoring, as well as the test conditions at which data is to be collected, shall be sufficiently comprehensive so as to include the expected limiting thermal loading conditions on critical concrete walls and structures within the plant.

***Criteria***

The temperature(s) of the concrete at the monitored locations shall be consistent with design predictions and shall not exceed design basis requirements or assumptions critical to associated design basis analyses.

#### 14.2.8.2.32 Liquid Radwaste System Performance Test

***Purpose***

The objective of this test is to demonstrate acceptable performance of liquid radioactive waste processing, storage and release systems under normal plant operational conditions.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated. Appropriate precautions shall be taken relative to activities conducted in the vicinity of radioactive material or potential radiation areas.

***Description***

Radwaste System operation is monitored, and appropriate data collected, during the power ascension test phase to demonstrate that system operation is in accordance with design requirements. Operation of liquid radwaste systems is discussed in detail in section 11.2. Performance shall be demonstrated periodically throughout the startup test program to evaluate acceptable operation of piping, valving, and I&C that comprise the overall system.

***Criteria***

The liquid radwaste system shall be capable of collecting, processing, and controlling the liquid radwaste as designed. Handling and release of radioactive wastes shall be in conformance with applicable regulations including effluent concentration limits in 10 CFR 20 Appendix B Table 2.

**14.2.8.2.33 Steam and Power Conversion System Performance Test**

***Purpose***

The objective of this test is to demonstrate acceptable performance of the power conversion systems under expected operational conditions, particularly those equipments that could not be fully tested during the preoperational phase due to inadequate steam flow conditions.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated.

***Description***

Operation of the main turbine-generator power conversion system with related auxiliaries is monitored, and appropriate data collected, during the power ascension test phase to demonstrate that system operation is in accordance with design requirements. Systems to be monitored include the main turbine and generator and their auxiliaries, the feedwater heaters and moisture separator, the main condenser and condenser air removal system, and the main circulating water system. At each major power level change, data is taken to determine reactor power, core flow and generator output. Operation and testing of power conversion systems are discussed in detail in Chapter 10. The main turbine generator and related auxiliaries are discussed in Section 10.2 and other power conversion equipment and systems are discussed in Section 10.4. Testing specific to turbine valves is described in Subsection 14.2.8.2.20 and plant AOO testing involving the main turbine generator is also described in Subsection 14.2.8.2.27.

***Criteria***

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.

**14.2.8.2.34 Isolation Condenser Performance Test**

***Purpose***

The objective of this test is to demonstrate acceptable performance of the four isolation condensers when supplied with reactor steam at rated pressure.

***Prerequisites***

The preoperational tests are complete and plant management has reviewed the test procedure and approved the initiation of testing. The plant shall be in the appropriate operational configuration for the scheduled testing. The necessary instrumentation shall be checked or calibrated. Any

required expansion/vibration, and temporary flow and temperature measurement instrumentation for the ICS piping must be in place.

***Description***

With the plant operating at approximately 20% steady state power initiate operation of one ICS by opening the condensate return valve and condensate return bypass valve. Determine acceptable heat removal capability by measuring ICS steady state flows, temperatures, Isolation Condenser/Passive Containment Cooling System (IC/PCCS) pool level changes and temperature, and other parameters as needed. A First of a Kind (FOAK) capacity test (Subsection 14.2.8.2.35.2 ICS Heatup and Steady State Operation) is performed on one of the four trains of ICS. The heat removal capability of the three remaining ICS trains is tested using acceptance criteria derived from the FOAK testing. See Surveillance Requirement SR 3.5.4.6 in Chapter 16.

***Criteria***

Performance characteristics of the ICS shall be in accordance with the design and test specifications.

#### 14.2.8.2.35 [*ESBWR First of a Kind Tests*

*The ESBWR is an evolutionary design in the BWR family. As such, it has some systems or applications that are new or are increased in size such that these systems or applications are subjected to "First of a Kind" testing to confirm proper operation of the new design or to confirm that testing of prior smaller application is valid. The tests in the following subsections are created for testing the first ESBWR to be commissioned and are only required on the first ESBWR.*

#### 14.2.8.2.35.1 *Reactor Pre Critical Heatup With RWCU/SDC*

***Purpose***

*The objective of this test is to demonstrate an effective method of ESBWR non-nuclear heatup exists and can be used when decay heat levels are low. The test measures and records the vertical profile of the reactor metal temperature during non-nuclear heat up prior to beginning control rod withdrawal for the purpose of achieving criticality. The primary purpose of the test is to:*

- *Confirm the uniform heatup of the reactor vessel metal temperature; and*
- *Determine the time to achieve the minimum temperatures necessary to begin control rod withdrawal in accordance with the Technical Specification surveillance requirement 3.4.4.2 and the Pressure and Temperature Limits Report (PTLR) DCD Tier 2 Chapter 16 Subsection 5.6.4.*

***Prerequisites***

*The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated, as appropriate. Temporary*

*instrumentation is installed on the exterior of the RPV to measure the vertical temperature profile during this test. This instrumentation consists of at least eight vertical strings, spaced at 45-degree increments around the vessel. Each of these strings consists of a defined number of temperature elements located from near the flange down to the bottom head. The temperature elements are mounted directly on the RPV under the vessel insulation and the signals are brought outside the primary containment and recorded during the testing. The temperature elements are abandoned in place at the conclusion of the startup program.*

***Description***

*The ESBWR non-nuclear heatup is accomplished by operating the RWCU system in a manner to remove water from the lower region of the vessel and reject to the main condenser while the vessel is fed from a heated feedwater source. Data collection is conducted during the non-nuclear heatup of the reactor coolant and metal. This data will be used to verify achievement of the desired temperature to begin control rod withdrawal. Data collection is continued during rod withdrawal and after criticality as reactor heat up is continued to the point of boiling and establishment of natural core circulation due to boiling and convection.*

***Criteria***

*The criteria for this test are met when sufficient data is collected to demonstrate the following:*

- *An effective procedural method for vessel heatup without decay heat is provided;*
- *Plant heat up is established using feedwater heated with non-nuclear steam in conjunction with operation of the RWCU system;*
- *The heatup method and hardware provides uniform heating around the vessel; and*
- *A heat up can be established to meet the minimum Pressure/Temperature requirements to begin control rod withdrawal for criticality in a timely manner.*

#### 14.2.8.2.35.2 *Isolation Condenser System Heatup and Steady State Operation*

***Purpose***

*The objective of this test is to confirm proper startup, operation and shutdown of one ICS train. Proper operation is determined by:*

- *Measurement of vibration, displacement and strain on the ICS heat exchanger (Isolation Condenser) piping and tubing;*
- *Measurement of steam inlet and condensate flow return to the reactor;*
- *Change in bulk pool temperature and temperature profiles within the pool; and*
- *Level changes in the IC/PCCS system pools.*

*The measurement of all parameters is made and recorded as the ICS train transitions from standby into normal operation and then back into standby. The testing for this subsection is to be performed during the 14.2.8.2.34 Isolation Condenser Performance Test.*

***Prerequisites***

*The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated, as appropriate. One of the four trains of ICS and the associated IC/PCCS pool has temporary instrumentation installed for this test. This instrumentation consists of:*

- *Displacement transducers attached to predefined locations on the Isolation Condenser tubes and locations on the steam supply and condensate return piping;*
- *Strain gages attached to predefined locations on the Isolation Condenser tubes and locations on the steam supply and condensate return piping;*
- *Temperature elements to measure the vertical temperature profile of the water in at least two locations in the selected pool; and*
- *Supplemental flow instrumentation mounted as low as possible on the condensate return piping to monitor and record the value and stability of the flow rate of condensate returning to the reactor.*

***Description***

*Data collection is accomplished during the ICS Performance Test. A single train of the ICS is placed into service and operated until steady state operation is achieved. After a period of steady state operation and data collection, the operating ICS train is secured and returned to standby.*

*During the return to standby, the time for the condensate return piping to re-fill with condensate to the top of the piping is measured. This point determines when the system has fully returned to the standby state or condition.*

***Criteria***

*The criteria for this test are met when sufficient data is collected to demonstrate the following:*

- *The displacement and strain produced in the rapid startup of the Isolation Condenser remains within design limits;*
- *The temperature profile changes as the pool is heated by the Isolation Condenser is consistent with engineering design calculations;*
- *IC/PCCS pool level control is per design;*
- *Isolation Condenser startup and shutdown transients are smooth, as indicated by flow, displacement and vibration measurements that do not indicate evidence of water hammer or steam collapse;*
- *Variations in steam and condensate return flow measurements observed and recorded during the startup and shutdown transients which do not challenge set points for leak detection isolation; and*

- *Determine acceptable heat removal capability by measuring ICS steady state flows, temperatures, IC/PCCS pool level changes and temperatures, and other parameters as needed.*

**14.2.8.2.35.3** ***Power Maneuvering In the FW Temperature Operating Domain***

***Purpose***

*The objective of this test is to maneuver reactor power at high power using plant-operating procedures to demonstrate effective and stable reactor power control is achieved by varying temperature of final feedwater fed into the reactor.*

***Prerequisites***

*The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated. Data necessary to limit operation within the bounds of the permissible operating domain have been inserted into the ATLM system. All initial startup tests for the low and mid power plateaus are satisfactorily completed. The startup-testing program has been authorized to proceed into testing in the high power region.*

***Description***

*In the ESBWR, one method used to change reactor power is achieved by controlling final feedwater temperature. This is accomplished by adjustment of steam flow to the shell of the seventh stage feedwater heater or by adjusting the amount of feedwater bypassing high pressure feedwater heaters as discussed in DCD Tier 2 in Subsections 7.7.3 and 10.4.7.2.2.3. This test collects data sufficient to demonstrate that reactor and core performance characteristics remain within design limits and expectations for the operational conditions the plant is expected to encounter. The testing maneuvers the plant through the acceptable regions of the Power-Feedwater Temperature Operating Domain (Figure 4.4-1). Data is taken at a number of specifically identified points on this map to ensure complete coverage of the operational area. The data is sufficient to determine:*

- *The axial and radial core power distributions;*
- *Compliance with core thermal limits;*
- *Consistency with predicted core reactivity; and*
- *Stability and core flow versus core power.*

***Criteria***

*The criteria for this test are met when sufficient data is collected to demonstrate the following:*

- *Power maneuvering via adjustment of feedwater temperature is an effective method for power control;*
- *Power maneuvering procedures are fully functional; and*

- *Operation of the reactor within the envelope of the Power-Feedwater Temperature Operating Domain is shown to be acceptable for core thermal limits and stability.*

**14.2.8.2.35.4** ***Load Maneuvering Capability***

*Automatic load maneuvering testing is included in the First-of-a-Kind tests to demonstrate automatic maneuvering characteristics of the first plant commissioned meets the ESBWR design basis. Any future testing of this feature is to be conducted by utilities that plan on using this mode of operation. Therefore this testing is not considered a fixed requirement for the follow-on plants.*

***Purpose***

*The objectives of this test are to verify the power plant can execute automated load maneuvering to a pre-programmed profile (or trajectory) without operator intervention. During this demonstration of automatic maneuvering, all plant parameters remain within the plant's design and administrative limits.*

***Prerequisites***

*The applicable preoperational and startup tests have been completed and plant management has reviewed the testing procedure and approved the initiation of testing. Affected systems and equipment, including lower level control systems such as RC&IS, feedwater level and temperature control, turbine control, as well as monitoring and predicting functions of the PAS, PGCS, Automatic Power Regulator (APR) and/or N-DCIS, have been adequately tested under actual operating conditions during the startup test program. A pre-programmed power profile is loaded into the plant's PAS to operate under full automatic mode for the purpose of this testing. The power profile is created to test the plant's ability to achieve, but not exceed, the power rate-of-change contained in the unit's design specification. This profile is consistent with the ESBWR load maneuvering capability described in Subsection 10.2.1.3.3.*

***Description***

*This test consists of a single period of plant operation when the power operation follows a specific generator electric output profile. The test profile includes a power reduction from 100% to 50% in two hours, a hold at 50% of at least 2 - 10 hours (see subsection 10.2.1.3.3) followed by a two-hour return to full power. The balance of the 24-hour period will be fixed 100% operation. This testing includes power reduction and increase rates based on the ESBWR design requirements for load following. During the entire period, enhanced monitoring of the plant systems and the reactor core is conducted to ensure the proper plant operation is being maintained.*

***Criteria***

*Throughout the planned automatic load following test interval, PAS and other features and functions of plant automation and control perform in accordance with the applicable design and operational specifications. Core thermal power and generator electrical output are within the allowable limits of the programmed profile. Automatic maneuvering characteristics of plant and systems meet the appropriate response and stability requirements. Safety and protection features perform at all times consistent with safety analysis assumptions and predictions. Plant*

*parameters do not reach or exceed plant technical or administrative limits, nor require operator action to avoid exceeding them.*

#### 14.2.8.2.35.5 *Defense-In-Depth Stability Solution Evaluation Test*

***Purpose***

*The objective of this test is to evaluate and confirm the proper operation and setpoints of the defense-in-depth stability solution. As initially installed this subsystem will function to provide alarm functions only. Specifically the portion of the subsystem allowing the Oscillation Power Range Monitor (OPRM) channel to signal the associated RPS channel to generate a reactor scram request is not enabled. This test will be conducted during the entire first cycle of plant operation. A secondary objective of this testing is to allow an opportunity to adjust trip and alarm setpoint if test evaluations determine the setpoints are too conservative or too near the operating values and nuisance alarms/trips are being observed.*

***Prerequisites***

*The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. During the preoperational testing confirmation has been made that simulation of an OPRM channel trip does not cause the associated RPS channel to trip, however all alarm functions of the OPRM are functional.*

***Description***

*Data collection during the defense-in-depth stability solution test consists of monitoring OPRM performance during all modes where the defense-in-depth stability solution subsystem is armed (>25% thermal power). This data is to be sufficient to evaluate the performance of the three algorithms: Period Based Detection Algorithm (PBDA), Amplitude Based Algorithm (ABA), and Growth Rate Algorithm (GRA) used in the subsystem. The data collections include the margin to trip of the monitored signals to the subsystem setpoints. Collection is made during both steady-state operation and transient events created in the startup test program.*

***Criteria***

*Data collected in the performance of the entire startup test program period show the defense-in-depth stability solution subsystem to provide effective protection against power oscillations without creation of unnecessary alarms or scram requests*.]*

*Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

### 14.2.9 Site-Specific Preoperational and Start up Tests

The preceding discussion of preoperational and startup tests was limited to those systems and components within, or directly related to, the ESBWR. Other testing, with respect to site-specific aspects of the plant, is necessary.

The COL Applicant will define any required site specific preoperational and startup testing. See Subsection 14.2.10 for COL Information item 14.2-5-A. Testing of such systems and components should be adequate to demonstrate conformance to such requirements as defined throughout the specific chapters of the Standard Safety Analysis Report (SSAR). Below are systems that may require such testing:

- Electrical switchyard and equipment;
- Station Water System;
- Personnel monitors and radiation survey instruments; and
- The automatic dispatcher control system (if applicable).

If site-specific preoperational or startup tests are identified as necessary, the appropriate procedures will be prepared by the same method and to the same standard as discussed in Subsection 14.2.2.2. The COL Applicant will provide milestones for making available to the NRC approved test procedures satisfying the requirements for the ITP (COL 14.2-6-A).

#### *14.2.9.1 Site-Specific Preoperational Tests*

System tests as appropriate.

#### *14.2.9.2 Site Specific Startup Tests*

System tests as appropriate.

### 14.2.10 COL Information

#### *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 (Subsection 14.2.2.1).

#### *14.2-2-A Startup Administrative Manual*

The COL Applicant will provide a milestone for completing the Startup Administrative Manual and making it available for NRC inspection (Subsection 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 satisfying the requirements for the ITP (Subsection 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 making it available to the NRC (Subsection 14.2.7).

#### *14.2-5-A Site Specific Tests*

The COL Applicant will define any required site specific preoperational and startup testing (Subsection 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 satisfying the requirements for the ITP (Subsection 14.2.9).

### 14.2.11 References

See Subsection 14.2.3 for a list of applicable Regulatory Guides.

14.2-1 American Society of Mechanical Engineers OM-S/G-1990, Standards and Guides for Operation and Maintenance of Nuclear Power Plants.

14.2-2 GE Hitachi Nuclear Energy, "Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring," NEDE-33197P-A, Revision 3, Class III (Proprietary), October 2010, and NEDO-33197-A, Revision 3, Class I (Non-Proprietary), October 2010.

## Table 14.2-1

## Power Ascension Test Matrix

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **Chemical and Radiochemical Measurements** | | | | | | |
| Sampling System Functioning | X | X | X | X | X | Includes verification of water quality |
| Process Rad Monitoring Functioning | X | X | X | X | X | |
| Liquid and Gaseous Effluent Activities Steady-state Performance Measurements | X | X | X | X | X | Includes verification of water quality |
| Condensate Polisher Performance | | X | X | X | X | |
| RWCU Filter/Demin Performance (No Cleanup Test) | | | | X | X | |
| Steam Separator-Dryer Performance | | X | X | X | X | |
| **Radiation Measurements** | | | | | | |
| Steady-state Measurements | X | X | X | X | X | Background survey before fuel loading and initial criticality |
| Shielding Adequacy Assessment | | X | X | X | X | |
| **Fuel Loading** | | | | | | |
| Partial Core Shutdown Margin | X | | | | | |
| Full Core Verification | X | | | | | |
| Full Core Shutdown Margin Demonstration | X | | | | | |

**Table 14.2-1**

**Power Ascension Test Matrix**

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **Control Rod Control System Performance** | | | | | | |
| CRD Functional Testing | X | X | | | | Step, notch and continuous drive mode |
| Gang Motion Verification | | X | | | | |
| Friction Testing | X | X | | | | After fuel has been loaded in the cell |
| Rod Pair Scram Testing | X | X | | | | Open vessel and rated pressure |
| Full Core Scram | | | Y | Y | Y | With planned scrams |
| SCRRI Functioning | | | | | Y | During generator load rejection and loss of feedwater heating tests |
| Alternate Rod Run-in Functioning | | | Y | Y | Y | Post scram verification following planned trips |
| **Neutron Monitoring System Performance** | | | | | | |
| SRNM Calibration/Response | X | X | | | | |
| LPRM Calibration/Response | | X | X | X | X | Calibrate to local power density using AFIP |
| APRM Calibration/Response | | X | X | X | X | Calibrate to total core power by heat balance |
| **Core Performance** | | X | X | X | X | |
| **Nuclear Boiler Process Monitoring** | | | | | | |
| Reactor Coolant Temperature Measurement | | X | | X | X | At MP & HP during steady-state |
| Reactor Water Level Measurement | X | X | X | X | X | |

**Table 14.2-1**

**Power Ascension Test Matrix**

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **System Expansion** | | | | | | |
| Support Inspection/Interference Check | | X | Y | Y | Y | Only as needed upon return to cold setting conditions after planned shutdowns subsequent to HU |
| Displacement Measurements | | X | X | X | X | |
| **System Vibration** | | | | | | |
| Steady-state Measurements | | X | X | X | X | |
| AOO (Transient) Response | | | X | X | X | |
| **Reactor Internals Vibration** | | X | X | X | X | |
| **Feedwater Control** | | | | | | |
| Control System Adjustment/Confirmation | | X | X | X | X | |
| **Pressure Control** | | | | | | |
| Control System Adjustment/Confirmation | | X | X | X | X | |
| **Plant Automation and Control** | | | | | | |
| NSSS**/BOP Monitoring Program | | X | X | X | X | |
| Plant Startup/ Shutdown | | X | X | X | X | |
| Load Following | | | | | X | |

**Table 14.2-1**

**Power Ascension Test Matrix**

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **Feedwater System Performance** | | | | | | |
| Steady-state Performance | | X | X | X | X | |
| - Maximum Runout Flow Determination | | | | | X | |
| **Main Steam System Performance** | | | | | | |
| Steady-state Performance | | X | X | X | X | |
| **Reactor Water Cleanup/Shutdown Cooling System Performance** | | | | | | |
| Steady-state Performance | | X | | | X | |
| Inventory Rejection Mode | | X | | | | |
| **Plant Service Water System Performance** | | | | | | |
| Steady-state Power Operations | | X | X | X | X | |
| Off-Normal Operations | | Y | Y | | Y | |
| **HVAC System Performance** | | | | | | |
| Steady-state Power Operations | | X | X | X | X | |
| Off-Normal Operations | | Y | Y | Y | Y | In individual spaces as conditions allow (i.e. as pertinent equipment is operated) |
| **Turbine Valve Performance** | | X | X | X | X | Only bypass valves need be tested at HU |

**Table 14.2-1**

**Power Ascension Test Matrix**

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **MSIV Performance** | | | | | | |
| Individual MSIV Closure/ Timing | | X | X | X | | Fast closure not required at High Power |
| Branch Line Closure/ Timing | | X | X | | | |
| **SRV Performance** | | | | | | |
| Individual Valve Functioning | | X | | X | | |
| **Loss of Feedwater Heating** | | | | | X | At 80-90% Core Thermal Power |
| **Feedwater Pump Trip** | | | | | X | |
| **Shutdown from Outside the Control Room** | | | X | | | At >10% Generator Load |
| **Loss of Turbine Generator and Offsite Power** | | | X | | | At 10-20% rated power |
| **Turbine Trip and Generator Load Rejection** | | | | | | |
| Load Rejection within Bypass Capacity | | | X | | | |
| Turbine Trip | | | | X | | |
| Full Power Load Rejection | | | | | X | |
| **Reactor Full Isolation** | | | | | X | |
| **Offgas System Performance** | | X | X | X | X | |
| **Power Conversion Equipment Performance** | | X | X | X | X | |
| **Liquid Radwaste Systems Performance** | | X | X | X | X | |
| **Concrete Penetration Temperatures** | | X | | | X | |

## Table 14.2-1

## Power Ascension Test Matrix

| Power Ascension Test | Testing Plateau * | | | | | Notes |
|---|---|---|---|---|---|---|
| | OV | HU | LP | MP | HP | |
| **Isolation Condenser Performance** | | | X | | | |
| **ESBWR First of a Kind Tests** | | | | | | |
| Reactor Pre Critical Heatup with RWCU/SDC | X | | | | | |
| ICS Heatup and Steady State Operation | | | X | | | |
| Power Maneuvering with FW Temperature Control | | | | | X | |
| Load Maneuvering | | | | | X | |
| Stability Solution Evaluation Testing | | | X | X | X | |

* OV = Open Vessel; HU = Nuclear Heatup; LP = Low Power; MP = Mid Power; HP = High Power

** NSSS =Nuclear Steam Supply System

X = Testing required in plateau; alternative test conditions or exceptions identified in detailed testing specification.

Y = Testing not specifically required in indicated plateau, but to be done in conjunction with other testing, or at specific testing conditions, generally within indicated plateau; see Notes column for explanation.

## 14.3 INSPECTIONS, TESTS, ANALYSES AND ACCEPTANCE CRITERIA

This section provides the selection criteria and processes used to develop the Tier 1 information and inspections, tests, analyses and acceptance criteria (ITAAC). The Tier 1 information provides the principal design bases and design characteristics that are certified by the 10 CFR Part 52 rulemaking process and included in the formal ESBWR design certification rule.

This top-level design information in Tier 1 is extracted from the more detailed ESBWR design information presented in Tier 2. Limiting the Tier 1 contents to top-level information reflects the tiered approach to design certification consistent with NRC guidance in NUREG-0800 and in Regulatory Guide (RG) 1.206. Specifically, RG 1.206, Section C.II.1, "Inspections, Tests, Analyses, and Acceptance Criteria," states:

> The type of information and the level of detail included in the ITAAC for each structure and system are based on a graded approach that is commensurate with the safety-significance of the facility's SSCs.

The theme is also noted in NUREG-0800, "Standard Review Plan," Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria," which states:

> The types of information and the level of detail in Tier 1 are based on a graded approach commensurate with the safety significance of the structures, systems, and components (SSCs) for the design.

The objective of this section is to describe the bases and methods that were used to develop Tier 1. This section contains no new technical information regarding the ESBWR design.

Tier 1 consists of the following:

- Preamble material which includes a Table of Contents, a List of Tables, and a List of Illustrations.
- An introduction section (described in Subsection 14.3.1).
- Design Descriptions and ITAAC (described in Subsection 14.3.2). This section includes:
  - Systems that are fully within the scope of the ESBWR design certification; and
  - The in-scope portion of those systems that are only partially within the scope of the ESBWR design certification.
- Non-System Based Material (described in Subsection 14.3.3).
- Interface Material (described in Subsection 14.3.4).
- Site Parameters (described in Subsection 14.3.5).

The sections below describe the criteria and methods by which specific technical entries for Tier 1 were selected. The structure of the description is based on the Tier 1 report structure. The criteria and methods that are discussed in the following sections are guidelines only. For some matters, the contents of Tier 1 may not directly correspond to these guidelines, because special considerations related to the matters may have warranted a different approach. For such matters, a case-by-case determination was made regarding how or whether the matters should be

addressed in Tier 1. These determinations were based upon the principles inherent in 10 CFR Part 52 and its underlying purposes, as well as NRC guidance regarding the content of Tier 1 and ITAAC. Tier 1 does not contain information that the NRC may designate as "Tier 2*", which is information in Tier 2 that, if considered to be changed by a combined license applicant or licensee, requires NRC approval prior to the changes. NRC guidance in NUREG-0800, Section 14.3, states that "Tier 2* is generally information that is not appropriate for treatment in Tier 1 because it is subject to change."

### 14.3.1 Tier 1, Section 1 - Introduction

The introduction section defines terms used in Tier 1, as well as lists general provisions, which are applicable to Tier 1 entries. The intent of these entries is to avoid ambiguities and misinterpretations by providing front-end guidance to users of Tier 1.

This section includes:

1.1 Definitions and General Provisions

Definitions are included for terms used in Tier 1 that could be subject to various interpretations. The intent is to be consistent with Tier 2 information, and to reflect NRC guidance regarding various terms. Should questions on terminology arise, the definitions would aid in understanding the intent of the information in Tier 1.

General provisions are included for treatment of individual items, implementation of ITAAC (including ITAAC format), discussion of matters related to operations, interpretation of figures, and rated reactor core thermal power.

The legend for figures provided in this section explains the symbols used in the Tier 1. The purpose is solely to aid in understanding the figures. The symbols used are consistent with general industry use.

**Selection Methodology** — Entries in the Definitions section were selected largely on the basis of a self-evident need for a term to be defined. These terms were accumulated during the preparation and review of Tier 1. Entries in the General Provisions section also were arrived at as part of Tier 1 development and review process. Each entry has a unique background, but the overall intent is to clearly state the broad guidelines and interpretations that guided Tier 1 preparation for the ESBWR and should be understood by Tier 1 users. Symbols in the legend were selected because they may be subject to interpretation and explanation of the symbols may aid in understanding.

### 14.3.2 Tier 1, Section 2 - Design Descriptions and ITAACs

This section contains the design description and ITAAC material for individual ESBWR systems, and includes an entry for every system that is either fully or partially within the scope of the ESBWR design certification. Consequently, there is a Tier 1, Section 2 entry for each ESBWR system identified in Tier 2, Section 1.2. The intent of this comprehensive listing of ESBWR systems is to better define at the Tier 1 level the full scope of the certified design. As discussed further below, the Tier 1 entry for many systems with no safety significance is limited to the system name only and does not include any design description or ITAAC material. The preparation of system design descriptions and the associated ITAAC are discussed separately in the next two subsections.

The intent of the Tier 1 Design Descriptions is to delineate the principal design bases and principal design characteristics that are referenced in the design certification rule. Consequently, the design descriptions focus on the ITAAC content. The design descriptions are accompanied by the ITAAC required by 10 CFR Part 52 to be part of the design certification application. The ITAAC define verification activities that are to be performed for a facility with the objective of confirming that the plant is built, and can operate, in accordance with the design certification. Successful completion of the certified design ITAAC, together with the site-specific ITAAC for the site-specific portions of the plant, are the basis for the NRC finding under 10 CFR 52.103(g).

### *14.3.2.1 Design Descriptions*

The Tier 1 Design Descriptions for each ESBWR system address the top-level design features and performance standards that pertain to the safety of the plant and include descriptive text and supporting figures. The intent of Tier 1 Design Descriptions is to define the ESBWR design characteristics which are referenced in the design certification rule as a result of the certification provisions of 10 CFR Part 52.

**Selection Criteria** — The following criteria were considered in determining which information warranted inclusion in the certified design descriptions.

(1) The information in the Tier 1 Design Descriptions is to be selected from the technical information presented in Tier 2 and should not contain information that is not in Tier 2. This reflects the approach that Tier 1 contains top-level design information and is based on the Commission directive in the Statement of Considerations for Part 52 that there "be less detail in a certification than in an application for certification." In this context, the certification is Tier 1 and the application for certification includes Tier 2.

(2) Tier 2 contains a wide spectrum of information on various aspects of the ESBWR design, and not all of this information warrants inclusion in the Tier 1 design descriptions. The Tier 1 Design Descriptions should only contain information from Tier 2 that is most significant to safety and which focuses on the ITAAC. This selection criterion reflects the Commission directive in the Statement of Considerations for Part 52 that the certified design should "encompass roughly the same design features that Section 50.59 prohibits changing without prior NRC approval." This is consistent with NRC guidance in RG 1.206, section C.II.1, and NUREG-0800, Section 14.3, which states the following:

> The design descriptions address the most safety-significant aspects of each of the systems of the design, and were derived from the detailed design information contained in Tier 2. The applicant should put the top-level design features and performance characteristics that were the most significant to safety in the Tier 1 design descriptions. The level of detail in 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 design descriptions serve as binding requirements for the lifetime of a facility to assure that the plant does not deviate from the certified design. For example, safety-related SSCs should be described in Tier 1 with a relatively greater amount of information. Other SSCs should also be included based on their importance to safety, such as containment isolation aspects of non-safety systems. Some non-safety aspects of SSCs need not be discussed in Tier 1. This graded approach

recognizes that although many aspects of the design are important to safety, the level of design detail in Tier 1 and verification of the key design features and performance characteristics should be commensurate with the significance of the safety functions to be performed.

In determining what Tier 2 information is most significant to safety, several factors were considered, including the following:

a. Whether the feature or function in question is necessary to satisfy NRC regulations in 10 CFR Parts 20, 50, 52, 73 and 100.

b. Whether the feature or function in question pertains to a structure, system or component classified as safety-related.

c. Whether the feature or function in question is specified in the NRC Standard Review Plan (NUREG-0800) as being necessary to perform a safety-significant function.

d. Whether the feature or function in question represents an important assumption or insight from the probabilistic risk assessment.

e. Whether the feature or function in question is important in preventing or mitigating severe accidents or protection against hazards.

f. Whether the feature or function in question could have a significant effect on the safety or operation of the nuclear power plant.

g. Whether the feature or function in question is typically the subject of a provision in the Technical Specifications.

The absence or existence of any of one of these factors was not conclusive in determining which information is significant to safety. Instead, these factors, together with the other factors listed in this section, were taken into account in making this determination.

(3) Mostly safety-related features and functions of SSCs are discussed in the Tier 1 design descriptions. Some nonsafety-related SSCs are discussed in the Tier 1 Design Descriptions only to the extent that they perform safety-significant functions or have features to prevent a significant adverse effect upon the safety-related functions of other SSCs. This criterion follows from the principle that only features and functions that are safety-significant warrant treatment in Tier 1. Nonsafety features and functions of safety-related SSCs are not generally discussed in the Tier 1 design descriptions.

(4) The Tier 1 Design Descriptions for SSCs are limited to a discussion of design features and functions, focusing largely on what will be the content for ITAAC. The design bases of SSCs, and explanations of their importance to safety, are provided in Tier 2 and are not included in the Tier 1 design descriptions. The purpose of the Tier 1 Design Descriptions is to define the certified design and to provide a description that will be used in the ITAAC Design Commitment column. Justification that the design meets regulatory requirements is presented in Tier 2 and that is not the intent of Tier 1 design descriptions.

(5) The Tier 1 Design Descriptions focus on the physical characteristics of the facility that will be verified through the associated ITAAC. Neither the Tier 1 Design Descriptions nor ITAAC contain programmatic requirements related to operating conditions or to operations, maintenance, or other programs because these matters are controlled by other

means such as the Technical Specifications. For example, the design descriptions do not describe operator actions needed to control systems.

(6) The design descriptions in Tier 1, Section 2, discuss the configuration and performance characteristics that the SSCs should have after construction is completed. In general, the Tier 1 Design Descriptions do not discuss the processes that are used for designing and constructing a plant that references the ESBWR design certification. This is acceptable because the safety-function of a SSC is dependent upon its final as-built condition and not the processes used to achieve that condition. Exceptions to this criterion include the information in Section 3 of Tier 1.

(7) The Tier 1 Design Descriptions address fixed design features expected to be in place for the lifetime of the facility. This is acceptable because portable equipment and replaceable items are controlled through operational-related programs. Because Tier 1 pertains to the design, it is not appropriate for it to include a discussion of these items.

(8) The Tier 1 Design Descriptions do not usually discuss component types (e.g., valve and instrument types), component internals, or component manufacturers. This approach is based on the premise that the safety function of a particular design element can be performed by a variety of component types and internals from different manufacturers. Consequently, a Tier 1 entry that defines particular component type/manufacturer would have no safety-related benefit and would unnecessarily restrict the procurement options of future applicants and licensees. Tier 1 does contain exceptions to this general criterion, and these exceptions occur when the type of component is of safety significance. For example, if Tier 1 specifies that the safety valves are of the direct-acting type, then this precludes the use of reverse-acting valves controlled by pilot valves as safety valves. Therefore, ITAAC were developed to avoid this type of restriction on equipment types to the degree practical while still addressing enough design detail to specify the appropriate means of verification that the as-built plant conforms with the design. Where appropriate, ITAAC include specific types of components.

(9) The Tier 1 Design Descriptions do not contain any proprietary information, because of the need to comply with requirements associated with publication of rules. However, Tier 1 does contain information (largely related to figures) that may be withheld from public disclosure on the basis of it being sensitive unclassified nuclear security information.

(10) In order to allow an applicant or licensee of a plant that references the ESBWR design certification to take advantage of improvements in technology, Tier 1 Design Descriptions in general do not prescribe design features that are the subject of rapidly evolving technology. Examples include design of the main control room and instrumentation and control systems. This issue is discussed further in Subsection 14.3.3.

(11) Tier 1 Design Descriptions are intended to be self-contained and generally do not make direct reference to Tier 2, industrial standards, regulatory requirements or other documents. (There are some exceptions involving industry standards, such as the ASME Code and the Code of Federal Regulations. Specific versions of code editions are identified in Tier 2 rather than Tier 1. This provides for specific requirements that are acceptable, yet allows the code to be updated via the change process in the design certification rule. However, due to the provisions of 10 CFR 52.63 and the rule certifying the design, updates to codes

and standards in 10 CFR 50.55a would not necessarily be requirements for the certified design.) If various sources contain technical information of sufficient safety significance to warrant Tier 1 treatment, the information has been extracted from the source and included directly in the appropriate system design description. This approach is appropriate because it is unambiguous and it avoids potential questions regarding how much of a referenced document is encompassed in, and becomes part of, the Tier 1 material.

(12) Selection of the technical terminology to be used in Tier 1 was guided by the principle that the terminology should be as consistent as possible with that used in Tier 2 and the body of regulatory requirements and industrial standards applicable to the nuclear industry. This approach is intended to minimize problems in interpreting the intent of Tier 1 commitments.

**Selection Methodology** — Using the criteria listed above, Tier 1 description material was developed for each system by reviewing Tier 2 material relating to that system. Tier 1 utilizes a system-by-system report structure that is different than the structure of Tier 2. Consequently, developing the Tier 1 design description entry for any one system was based on review of the multiple Tier 2 chapters having technical information related to that system.

Because the safety significance of the ESBWR systems varies, application of the criteria listed above results in a graded treatment of the systems. This leads to considerable variations in the scope of the design description entries. Table 14.3-1 lists the types of ESBWR systems, and is a summary of the overall consequences of this graded treatment. Table 14.3-1a lists the ESBWR systems and denotes which ones have ITAAC in Tier 1. In addition, Tables 14.3-1b and 1c provide a list of key design features for the ESBWR that were considered in developing the content of Tier 1, including the information that supports the related ITAAC.

For safety-related systems, application of the above criteria resulted in design description entries that include the following information (as applicable) described briefly, focusing the content on ITAAC, and relying on figures where appropriate:

- System name and scope;
- System purpose;
- System safety-related modes of operation;
- System classification (i.e., safety-related, seismic category, and ASME Code Class);
- System location;
- Functional arrangement of the portions of the system that are safety significant, including any components located in that portion of the system (usually shown by means of a figure);
- Type of electrical power provided for the system;
- Electrical independence and physical separation of divisions within the system;
- System instruments, controls, and alarms to the extent located in the Main Control Room or Remote Shutdown System;
- Valves within the system that have active safety-related functions; and

- Any other features or functions significant to safety or important for meeting certain NRC regulations, such as 10 CFR Part 20.

The Tier 1 Design Descriptions for nonsafety-related systems also include the information listed above but only to the extent that the information is relevant to the system and is significant to safety. Because much of this information is not relevant to safety-related systems, the Tier 1 Design Descriptions for nonsafety-related systems are generally substantially less extensive than the descriptions for safety-related systems. As discussed above, there are many systems for which no design description entries (and therefore no ITAAC) are included in Tier 1 and the entry is limited to the system title and a statement that "No ITAAC are required for this system." This is consistent with NRC guidance in RG 1.206, Section C.II.1.

### *14.3.2.2 Inspections, Tests, Analyses and Acceptance Criteria (ITAAC)*

As needed, a table of ITAAC entries is provided for each system that has design description entries. The intent of these ITAAC is to define activities that are undertaken to verify the as-built system conforms to the design features and characteristics defined in the design description for that system. ITAAC are provided in tables with the following three-column format.

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| | | |

Each design commitment in the left-hand column of the ITAAC tables has an associated inspections, tests or analyses (ITA) requirement specified in the middle column, and the acceptance criteria for the ITA are defined in the right-hand column.

**Selection Criteria:** — The following were considered when determining which information warranted inclusion in the Tier 1 ITAAC entries:

(1) The scope and content of the ITAAC correspond to the scope and content of the Tier 1 design descriptions. The design commitment is extracted directly from the design descriptions and differences in text are minimized, unless intentional, but the text is essentially the same in all cases. This approach ensures that there are no ITAAC for aspects of the design not addressed in the design description. This is appropriate because the objective of the ITAAC design certification entries is to verify that the as-built facility has the design features and performance characteristics defined in the Tier 1 design descriptions.

Each system that has a design description, which addresses some design aspect required for plant safety, has an ITAAC table.

(2) An inspection, test, or analysis, or a combination thereof, may verify one or more provisions in the Tier 1 design description, as defined by the ITAAC.

(3) The inspections, tests, and analyses are to be completed (and the acceptance criteria satisfied) prior to fuel loading. Therefore, the ITAAC do not include any inspections, tests, or analyses that are dependent upon conditions that only exist after fuel load.

(4) Because the Tier 1 Design Descriptions are limited to fixed design features expected to be in place for the lifetime of the facility, the ITAAC also are limited to a verification of fixtures in the plant.

(5) In general, the ITAAC verify the as-built configuration and performance characteristics of SSCs as identified in the Tier 1 design descriptions. With limited exceptions, (e.g., welding), the ITAAC do not address typical construction processes for the reasons discussed in item (6) of Subsection 14.3.2.1.

**Selection Methodology** — Using the criteria listed above, ITAAC table entries were developed for each system. This was achieved by evaluating the design features and performance characteristics defined in the Tier 1 Design Descriptions and preparing an ITAAC table entry for each design description entry that satisfied the above selection criteria. As a result of this process there is a close correlation between the left-hand column ("Design Commitment") of the ITAAC table and the corresponding design description entry.

Having established the design features for which ITAAC are appropriate, the ITAAC table was completed by selecting the method to be used for verification (either a test, an inspection, or an analysis, or a combination of these) and the acceptance criteria against which the as-built features or performance are measured. The proposed verification activity is identified in the middle column of the ITAAC table.

The emphasis when selecting an ITAAC verification method was to utilize onsite testing of the as-built facility wherever possible. However, the selection of these items was dependent upon the plant feature to be verified but was guided by the ITA approach presented in Table 14.3-2. Thus, in some cases, a "type test" is specified to mean a manufacturer's test or other tests that are not necessarily intended to be in the final as-installed condition.

Where testing is specified, appropriate conditions for the test will be established in accordance with the Initial Test Program (ITP) described in Tier 1, DCD Tier 2 Section 14.2, and Regulatory Guide 1.68. Conversion or extrapolation of test results from the test conditions to design condition may be necessary to satisfy certain ITAAC. To the extent practical, the ITAAC verification methods will be either tests or inspections, which are objective.[1]

Selection of acceptance criteria is dependent upon the specific design characteristic being verified by the ITAAC table entry. In most cases the appropriate acceptance criteria are self-evident and are based upon the Tier 1 design descriptions. For many of the ESBWR ITAAC, the acceptance criterion is a statement that the as-built facility has the design feature or performance characteristic identified in the design description. A central guiding principle for acceptance criteria preparation is the recognition that the criteria should be objective and unambiguous.

[1] Such objective ITAAC which are verified through tests and inspections are generally not subject to adjudication (*see* NRC Letter, J. Lyons (NRC) to R. Simard (NEI), "Resolution of Combined License Topic 5 (COL-5), the 10 CFR 52.103 Hearing Process," Nov. 20, 2003, Encl. at 4: "NEI also states that the Commission may consider, in deciding whether to grant a request for a hearing, 'whether the contention is exempt from adjudication under the Administrative Procedures Act.' NEI Paper at 27; *see* Administrative Procedure Act (APA) 5 U.S.C. § 554(a)(3). The NRC staff agrees"). ML032760053. In amending 10 CFR Part 52 in 2007, the NRC specifically acknowledged in the discussion of the rule change that this provision could be invoked for ITAAC. See 72 Fed. Reg. at 42428 (Aug. 28, 2007).

The use of objective and unambiguous terms for the acceptance criteria minimizes opportunities for multiple, subjective (and potentially conflicting) interpretations as to whether an acceptance criterion has, or has not, been met. In most cases, the ITAAC acceptance criteria contain numerical parameters from Tier 2 that are not specifically identified in the Tier 1 design description or the Design Commitment column of the ITAAC table. This is acceptable because the design description defines the important design feature/performance that merits Tier 1 treatment, whereas the acceptance criterion defines a measurement standard for determining if the as-built facility is in compliance with the Tier 1 design description commitment. NRC guidance in NUREG-0800, Section 14.3, states the following regarding acceptance criteria:

> In general, the acceptance criteria should be objective and unambiguous. In some cases, the acceptance criteria may be more general because the detailed supporting information in Tier 2 does not lend itself to concise verification. For example, the acceptance criteria for the design integrity of piping and structures may be that a report “exists” that concludes the design commitments are met. In these cases, Tier 2 provides the detailed supporting information on multiple interdependent parameters that should be provided in order to demonstrate that a satisfactory report exists.
>
> Numeric performance values for SSCs are specified as ITAAC acceptance criteria when values consistent with the design commitments are possible, or when failure to meet the stated acceptance criterion would clearly indicate a failure to properly implement the design or meet the safety analysis.

Where appropriate, Tier 2 has identified detailed criteria applicable to the same design feature or function that is the subject of more general acceptance criteria in the ITAAC table.

For numerical acceptance criteria, ranges or tolerances are generally included. This is necessary and acceptable because:

- Specification of a single-value acceptance criterion is impractical because minute/trivial deviations would represent noncompliance;
- Tolerances recognize that legitimate site variations can occur in complex construction projects; and
- Minor variations in plant parameters within the tolerance bounds have no effect on plant safety.

The Acceptance Criteria column specifies that a report documents the successful completion of the ITAAC verification. This is generally intended to represent the front material (e.g., a form) that would be included in an ITAAC closure package to summarize completion of the ITAAC. All supporting information would be referenced in such a report and be included in the closure package or the location specified in the report. The “report” may be a simple form that consolidates all of the necessary information related to the verification package for supporting successful completion of the ITAAC.

### 14.3.3 Tier 1, Section 3 - Non-System Based Material

Tier 1 Design Descriptions and their associated ITAAC for design and construction activities that are applicable to more than one system are included in this section. Design related processes have been included in Tier 1 for:

- Aspects of the ESBWR design are likely to undergo rapid, beneficial technological developments during the lifetime of the design certification. Certifying the design processes associated with these areas of the design rather than specific design details permits future license applicants referencing the ESBWR design certification to take advantage of the best technology available at the time of a site-specific application and facility construction. Examples include design of programmable, microprocessor-based instrumentation and control systems.
- Aspects of the design that depend upon characteristics of as-procured, as-installed systems, structures and components. These characteristics are not available at the time of certification and, therefore, cannot be used to develop and certify design details. Examples include design of piping systems that depend upon detailed routing and equipment information and equipment qualification.

Thus, the material in Section 3 may be included because, in selected areas of the design, Tier 2 may not contain sufficient design detail. These ITAAC may represent what is commonly referred to as Design Acceptance Criteria. For these Design Acceptance Criteria, the Tier 1 ITAAC, combined with design information and appropriate design methodologies, codes, and standards provided in Tier 2, provide sufficient detail to provide an adequate basis for the NRC to make a final safety determination regarding the design, subject only to satisfactory design implementation and verification of the Design Acceptance Criteria ITAAC. Design Acceptance Criteria also have confirmation ITAAC which ensure that the as-built plant conforms to the design Design Acceptance Criteria ITAAC.

Entries in this section of Tier 1 have the same structure as the system material discussed in Subsection 14.3.2; i.e., design description text and figures and a table of ITAAC entries. The objective of this Tier 1 material is to address selected design and construction activities, which are applicable to more than one system and cannot conveniently be covered in the system-by-system information presented in Tier 1, Section 2. Where appropriate, Tier 1 specifies that these non-system based ITAAC may be closed on a system-by-system basis for purposes of system turnover. However, the final ITAAC closure package must include verification that all of the systems were completed for that particular ITAAC.

The following summarizes the scope and bases for the Tier 1, Section 3 entries. For each, the design description text defines the applicability of the entry.

### *14.3.3.1 Design of Piping Systems and Components*

The piping design section of Tier 1 defines the processes by which ESBWR piping is designed and evaluated. The material applies to piping systems that are classified as safety-related. In general, these piping systems are designated as Seismic Category I and are further classified as ASME Code Class 1, 2 or 3. The section also addresses the consequential effects of pipe rupture such as jet impingement, potential missile generation, and pressure/temperature effects. Similarly, ASME components are designed and procured to ASME Codes and Standards that require ASME Code design reports. ITAAC are included to ensure that piping systems and ASME component design reports and ASME Code design certifications are in order and verify that the ASME Code requirements are met. Each of these is reconciled to ensure that the as-

installed piping systems or ASME components are in conformance with the design reports and design certifications.

Certification of plant safety-related piping systems via design processes rather than via certification of specific design features is necessitated and justified by the following:

- Piping design is based on detailed piping arrangement information as well as the geometry and dynamic characteristics of the as-procured equipment that forms part of the piping system. This detailed plant-specific information is unavailable at the time of design certification and cannot therefore be used to develop detailed design information. This precludes certification of specific piping designs.
- An extensive definition of design methodologies is contained in Tier 2, Chapter 3. These methodologies are not considered to be part of Tier 1 but are one of several methods for executing the design process steps defined in the piping design. In addition, sample design calculations have been performed with these methods to provide confidence that they are complete and yield acceptable design information.
- Piping design for nuclear plants is a well-understood process based on straightforward engineering principles. This, together with Tier 2 methodology definition and sample calculations, provides confidence that future design work by individual applicants/licensees results in acceptable designs that properly implement the applicable requirements.

The technical material in the piping design Tier 1 entry was selected using the criteria and methodology as discussed above for Tier 1, Section 2 system entries.

#### *14.3.3.2 (Deleted)*

#### *14.3.3.3 Human Factors Engineering*

The human factors engineering (HFE) entry defines the processes by which the details of the human-system interface (HSI) are developed, designed and evaluated. The processes defined in this entry require the use of analyses based on human factors principles and apply to the main control room (MCR), including areas which provide the displays, controls and alarms required for normal, abnormal and emergency plant conditions. They also apply to the Remote Shutdown System (RSS), Technical Support Center (TSC), Emergency Operations Facility (EOF), and Local Control Stations (LCSs) with safety-related functions or as defined by HFE task analysis. For detailed HSI design implementation, the certification of processes (rather than specific design features) is necessitated and justified by the following:

- The technology of equipment associated with HSI implementation is rapidly evolving (and improving) and certification of implementation processes permits future licensees to take advantage of beneficial technological advances available at the time of application. An example is the rapid advances that have taken (and are taking) place in flat panel display technology.
- Detailed implementation of the HSI is dependent upon the details of the as-procured, as-installed equipment. For example, different manufacturers use different techniques to monitor equipment performance. Because this equipment is not available at the time of

design certification, it is not possible to develop HSI implementation details. This can only be accomplished by a licensee when specific equipment characteristics are known.

- The fundamental design work for the ESBWR HSI has been completed and is described in Tier 2, Chapter 18. This includes commitments to a set of standard design features necessary for the operators to implement the emergency operating procedures, severe accident management procedures, and to carry out those human actions shown to be important by the plant Probabilistic Risk Assessment (PRA). In addition, the minimum inventory of fixed alarms, displays and controls necessary for the operators to implement the emergency operating procedures and to carry out those human actions shown to be important by the plant Probabilistic Risk Assessment (PRA) is defined. This design information, coupled with the comprehensive commitments to HSI implementation processes based on currently accepted HFE practices, provides confidence that the execution of these processes result in acceptable MCR and RSS detail designs that implement the applicable requirements.

Selection of specific technical material for the HFE Design Descriptions and ITAAC entries in the Tier 1 utilized the same selection criteria and methodology as described above for Tier 1, Section 2 system entries.

#### *14.3.3.4 Radiation Protection*

The Tier 2 radiation protection chapter (Chapter 12) defines the design confirming that radiation protection features maintain exposures for both plant personnel and the general public below allowable limits. The material applies to the radiological shielding and ventilation design of buildings within the scope of the ESBWR certified design. ITAAC confirm that the building radiation zones are in accordance with site-specific radiation shielding calculations.

#### *14.3.3.5 Initial Test Program*

The Initial Test Program (ITP) defines testing activities that are conducted following completion of construction and construction-related inspections and tests. The ITP extends through to the start of commercial operation of the facility. This program is discussed within Section 14.2 and centers heavily on testing of the safety-related systems.

A summary of the ITP has been included in Tier 1, Section 3.5. This summary includes an overview of the ITP structure together with commitments related to test documentation and administrative controls. This information has been included in Tier 1 because of the importance of the ITP in defining comprehensive pre-fuel load and post-fuel load testing for the as-built facility to demonstrate compliance with the design certification. Key pre-fuel load ITP testing for individual systems is defined in the system ITAAC in Tier 1, Sections 2 and 3.

No ITAAC entries have been included in Tier 1 for the ITP. This is acceptable because:

- Many of the ITP activities involve testing with the reactor at various power levels and thus cannot be completed prior to fuel load (Part 52 requires ITAAC to be completed prior to fuel load).
- Testing activities specified as part of the ITAAC in Tier 1, Sections 2 and 3, must be performed prior to fuel load. Because these ITAAC testing activities address the design features and characteristics of key safety significance, additional ITAAC for the ITP as

defined in Tier 1, Section 3.5, are not necessary to assure that the as-built plant conforms with the ESBWR certified design.

#### *14.3.3.6 Design Reliability Assurance Program*

The Tier 1 scope of the Design Reliability Assurance Program (D-RAP) design description and ITAAC includes risk-significant SSCs, both safety-related and nonsafety-related, that provide defense-in-depth or result in significant improvement in the Probabilistic Risk Assessment (PRA) evaluations. The D-RAP ITAAC will provide reasonable assurance that the design of risk-significant SSCs is consistent with their risk analysis assumptions.

#### *14.3.3.7 Post-Accident Monitoring Instrumentation*

The Tier 1 post-accident monitoring instrumentation design description and ITAAC provide information required to monitor variables and systems over their anticipated ranges for post-accident conditions as appropriate to ensure adequate safety. The design description and ITAAC include from what systems the post-accident monitoring instrumentation receives information.

#### *14.3.3.8 Environmental Qualification of Mechanical and Electrical Equipment*

The environmental qualification design description and ITAAC address safety-related electrical equipment located in harsh environment(s), mechanical equipment located in harsh environment(s), and digital I&C equipment located in mild environment(s), to ensure that safety-related functions can be performed.

### 14.3.4 Tier 1, Section 4 - Interface Material

Interface requirements are included as defined by 10 CFR 52.47. Interface requirements are those that must be met by the site-specific portions of the complete nuclear power plant that are not within the scope of the certified design. These requirements define characteristics of the site-specific features that must be provided in order for the certified design to comply with certification commitments. Interface requirements are defined for: (a) systems entirely outside the scope of the design certification, and (b) the out-of-scope portions of those systems that are only partially within the scope of the design certification. Site-specific ITAAC design features implement the interface requirements; therefore, Tier 1 does not include ITAAC for interface requirements.

This section of Tier 1 provides interface requirements for those systems of a complete power-generating facility that are either totally or partially not within the scope of the ESBWR design as defined in the certification application (Tier 2). Generally structures, systems and components that are part of, or within, the Reactor Building, Fuel Storage Building, Service Building, Control Building, Turbine Building and Radwaste Building are in the ESBWR scope. Those portions of the plant outside of these buildings are not generally in the DCD scope. This scope split occurs because design of the plant features located outside the main buildings is dependent upon site-specific characteristics that are unknown at the time of certification (e.g., the long-term source of water for the PCCS pools).

The basis for this interface requirements entry in Tier 1 is the discussion in 10 CFR Part 52.47. An applicant for a license that references the ESBWR design certification must provide site-specific systems with design features/characteristics that comply with the interface requirements.

For systems that are partially within the scope of the ESBWR, interface requirements are listed in either Tier 1, Section 4 or in a separate sub-part of the Tier 1, Section 2 entry that addresses the in-scope portion of the system. In all cases, the Tier 1 entries for these systems are limited to defining interface requirements. Conceptual designs for the out-of-scope interfacing systems are presented in Tier 2 but are not addressed in Tier 1. This is appropriate because the applicant provides site-specific designs that meet the interface requirement; these site-specific designs may not correspond to the conceptual designs described in Tier 2.

Tier 1 does not define any ITAAC associated with the interface requirements. This is acceptable because the individual site-specific applicants who reference the ESBWR design certification provide ITAAC for the plant SSCs outside the scope of the ESBWR design certification on a site-specific, design-specific basis. (Part of the review process at the time of the license application is to assess compliance of the site-specific designs with the interface requirements.)

Design certification applications should contain justification that the requirements are verifiable through inspection, testing or analysis and that the method to be used for verification be included as part of the ITAAC. Interface requirements are similar in nature to the design commitments in Tier 1, Section 2 for which ITAAC have been developed. This represents justification that a site-specific applicant is able to develop ITAAC to verify compliance with the design features or characteristics that implement the interface requirements. The methods to be used for these verifications are specified in the site-specific ITAAC and are similar to the methods in the Tier 1, Section 2 ITAAC for comparable/similar design characteristics.

**Selection Criteria** — The selection criteria listed in Tier 2, Subsection 14.3.2.1 were used to guide selection of interface requirements defined in Tier 1, Section 4 (or in the Section 2.0 entries referenced from Tier 1, Section 4). The intent is that the interface requirements in Tier 1 define key, safety-significant design attributes and performance characteristics of the site-specific, out-of-scope portion of the plant which must be provided in order for the certified portions of the ESBWR to comply with the design commitments in Tier 1. It is an objective of this section that it address interfaces between in-scope and out-of-scope portions of the plant that are unique to the ESBWR design; it is not intended that it be a comprehensive listing of all design requirements applicable to the out-of-scope portions of the plant. The latter is provided along with a site-specific Final Safety Analysis Report that includes a discussion of the site-specific design features.

**Selection Methodology** — The interface requirements included in the Tier 1 were selected from the interface requirements listed in Tier 2 for fully or partially out-of-scope systems, which are not already addressed elsewhere in Tier 1.

### 14.3.5 Tier 1, Section 5 - Site Parameters

Site Parameters used as the basis for ESBWR design presented in Tier 2 are included in Tier 1. These parameters represent a bounding envelope of site conditions for any license application referencing the ESBWR design certification. No ITAAC are necessary for the site parameter entries, because compliance with site parameters are verified as part of issuance of a license for a plant that references the ESBWR design certification.

This section of Tier 1 defines the site parameters that were used as a basis for the design defined in the ESBWR certification application. These entries respond to the 10 CFR 52.47

requirements that the design certification documentation include site parameter information. The plant must be designed and built using the parameters in Tier 1, Section 5. That is, it is intended that applicants referencing the ESBWR design certification demonstrate that these parameters for the selected site are within the certification envelope.

Site-specific external threats that relate to the acceptability of the design (and not to the acceptability of the site) are not considered site parameters and are addressed as interface requirements in the appropriate system entry in Tier 1, Section 4. For example, the Technical Support Center (TSC) HVAC System requires that toxic gas monitors be located in the outside air intake if the site is adjacent to toxic gas sources with the potential for releases of significance to plant operating personnel in the TSC.

Section 5 of Tier 1 does not include any ITAAC, and is limited to defining the ESBWR site parameters. This is an appropriate approach because a license applicant prior to issuance of the license must demonstrate compliance of the site with these parameters.

**Selection Criteria** — Tier 2, Section 2 provides the envelope of site design parameters used for the ESBWR design. The corresponding Tier 1, Section 5 is based on using information from Tier 2 Section 2. Tier 1, Section 5 is limited to tabular entries, and no supporting text material is required.

### 14.3.6 Tier 1 Generation Summary

A central element of the design certification processes deriving from 10 CFR Part 52 centers on selection and documentation of the technical information to be included in the rule as the ESBWR certified design. The certified design description is a subset of the comprehensive set of design information presented in Tier 2. It includes:

- The key, safety-significant aspects of the overall design described in the certification application (Tier 2);
- The ITAAC that are used to verify the as-built facility conforms with the ESBWR certified design;
- Interface requirements; and
- Site parameters.

The information presented in Tier 1 is prepared using the selection criteria and methodology described herein, and is intended to satisfy the above Part 52 requirements for Rule content. In particular, the ITAAC entries in Tier 1, Sections 2 and 3, confirm that key design performance characteristics and design features are in place, and that the as-built facility operates in accordance with the design certification.

### 14.3.7 Evaluation Process For Updating Design Descriptions and ITAAC

The following guidance is based on NRC guidance in NUREG-0800, Section 14.3, and RG 1.206, Section C.II.1, and 10 CFR 52.97(b)(1), with respect to the ESBWR design. This guidance is to be used for determining the content of system design description and ITAAC updates, changes and additions in Section 2 of Tier 1, and may be used for determining site-specific ITAAC.

To ensure the appropriate level of detail for Tier 1 changes, the following Tier 1 content determination process for systems uses a graded approach with sets of Tier 1 design description and ITAAC selection criteria.

### *14.3.7.1 Generic Guidance*

The DCD Tier 2 safety analyses are based largely on system-level safety functions (assumed and analyzed) being performed and the key parameters of each safety-related function (e.g., water injection in "x" seconds with a flow rate of "y" gallons per minute), rather than addressing all aspects of each individual component in a system. Therefore, component-level details that are already covered by a verifiable Design Characteristic, Feature or Function (DCFF) of a safety-related function or a system-level detail should be described in Tier 2, if appropriate, and need not be included in the Tier 1 design descriptions. The ITAAC, however, should be written with objective criteria that can, to the extent practical, be verified through inspection or testing, and should include values that verify that a structure, system or component (SSC) performs as assumed in the safety analyses (as applicable) or as required by NRC regulation.

Tier 1 should address the equipment performance values modeled in the Tier 2 safety analyses and other performance values directly related to ensuring nuclear safety and ensuring compliance with NRC regulations.

To ensure the safety of the as-built plant, the ITAAC should confirm the DCFFs assumed or modeled in the Tier 2 safety analyses.

10 CFR 52.97(b)(1) states "*The Commission shall identify within the combined license the inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that, if met, are necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the license, the provisions of the Atomic Energy Act, and the Commission's rules and regulations.*" Therefore, Tier 1 should include the design descriptions and ITAAC needed to ensure that the design-related regulations (e.g., the 10 CFR 50, App. A, *General Design Criteria*) will be verified.

It is understood that not all safety-related SSCs are safety/risk-significant, and that all nonsafety-related are not safety/risk-significant. For a passive plant like the ESBWR, the safety-significant nonsafety-related SSCs are determined by applying the Regulatory Treatment of Non-safety Systems (RTNSS) criteria. Plus, there are nonsafety-related functions modeled/assumed in the plant safety analyses with respect to mitigating the effects of anticipated operational occurrences (AOOs) and special events (e.g., station blackout and ATWS). To ensure conservatism, all safety-related SSCs should be assumed to be safety-significant. Therefore, for completeness, it is assumed that all SSCs that perform safety-related, AOO mitigation, special event mitigation and RTNSS mitigation functions have some degree of safety significance. By exclusion, all other SSC functions are not safety-significant, and need not be addressed in Tier 1, except to address any design aspects directly required to ensure compliance with a regulation.

### *14.3.7.2 NRC Guidance*

Much of the information within RG 1.206 and NUREG-0800, Section 14.3, addresses active or evolutionary plants, and thus, may not be directly applicable to a passive plant like the ESBWR.

However, those portions that apply to both evolutionary and passive plants can be applied to the ESBWR.

### *14.3.7.3 Criteria and Application Process*

Each system addressed in Tier 2 shall be addressed in Tier 1 to the appropriate level of detail. The graded three-level approach described in the items below, is used to determine the general level of detail in each Tier 1 system description.

(1) General Tier 1 Content Determination:

a. Systems with system-level or component-level safety-related, RTNSS, Infrequent Event or Special Event (e.g., ATWS, Station Blackout and Safe Shutdown Fire in Tier 2, Chapter 15) mitigation functions or that have a DCFF required for meeting a regulation shall have Tier 1 inputs that include design description and ITAAC.

b. For nonsafety-related systems with design functions or features that:

(i) Prevent or mitigate AOOs analyzed in Tier 2;

(ii) Perform fuel protection or cooling (inside or outside the reactor vessel) functions; or

(iii) Are included in the plant to actively/automatically control offsite doses below 10 CFR 20 limits.

For these nonsafety-related systems, Tier 1 shall include design descriptions, but ITAAC are not required. However, some ITAAC are included for functions/values specifically modeled in the AOO safety analyses, specific fuel protection and cooling functional criteria, or active/automatic offsite release prevention functions. The ITAAC may simply verify that the equipment is provided and "exists" in the plant. According to NRC guidance in NUREG-0800, Section 14.3, the term "exists," when used in the Acceptance Criteria for ITAAC, means that the item is present and meets the design description. Detailed supporting information on what should be present to conclude that an item "exists" and meets the design description is contained in the appropriate sections of the DCD. The approach stated herein also is consistent with the graded approach for Tier 1 content and ITAAC described in the NRC guidance.

The Tier 1 content of those systems that do not qualify under Items (1)a or (1)b above generally need not include design descriptions or ITAAC. (These systems generally will be included in Tier 1 only by subject [i.e., title], and include a "no entry" statement.)

(2) Design Description Content Determination:

For each Item (1)a system, the following DCFFs may be included in the Tier 1 Design Descriptions and are useful for consideration when determining appropriate ITAAC. However, the main focus of the Tier 1 Design Descriptions is to specifically identify the information needed for the ITAAC Design Commitments. Thus, these DCFFs also relate directly to the ITAAC.

a. Purpose and functions;

b. Classifications (i.e., safety-related, seismic category, and ASME Code Classes);

c. Safety-related functions (i.e., modes of operation) and requirements;

d. Application of 10 CFR 50, Appendix A single failure criterion (e.g., separate trains, loops and divisions) to provide each safety-related function;

e. Features or functions used to mitigate the special events evaluated in the Tier 2 safety analyses;

f. Safety-related electrical trip signals and initiations modeled in the Tier 2 safety analyses;

g. The functional arrangement of a safety-related system's safety-significant components (usually provided by means of a figure or table), generally showing which equipment must be qualified for a harsh environment (i.e., within the containment);

h. Use of safety-related electrical power;

i. Safety-related electric power independence, capacity, capability, electrical protection and controls;

j. The safety-related instruments and manual controls located in the Main Control Room;

k. Safety-related logic, interlocks, bypasses and system inputs;

l. Safety-related electrical channel integrity and channel independence;

m. Safety to non-safety interfaces and isolation devices (if any);

n. Alarms (if any);

o. In a separate Tier 1 subsection, Remote Shutdown System instruments and controls for performing safety-related functions;

p. Equipment initiations and system performance parameters used in the Tier 2 accident analyses (e.g., key containment design parameters validated by the plant safety analyses);

q. Non-system level, safety-related functions in nonsafety-related systems (e.g., containment isolation);

r. Features or functions determined by the Tier 2 RTNSS evaluation;

s. Any additional safety-significant details from NUREG-0800, Section 14.3, Appendix D, or Regulatory Guide 1.206, Section C.II.2, or its appendices; and

t. Nonsafety-significant DCFFs, needed to verify the design-related NRC regulations.

For each Item (1)b system, the following DCFFs may be included in the Tier 1 Design Descriptions and are useful for consideration when determining appropriate ITAAC. However, the main focus of the Tier 1 Design Descriptions is to specifically identify the information needed for the ITAAC Design Commitments. Thus, these DCFFs also relate directly to the ITAAC.

a. Those that are specifically provided to prevent or mitigate Anticipated Operational Occurrences analyzed in Tier 2, Chapter 15;

b. Those that are specifically provided to perform nonsafety-related fuel protection or cooling (inside or outside the reactor vessel) functions;

c. Those that actively or automatically control offsite doses below 10 CFR 20 limits; and

d. Nonsafety-significant DCFFs, needed to verify the design-related NRC regulations or to comply with NRC regulations.

(3) ITAAC Table Line Item Topics Determination:

The DCFFs determined in Item (2), are reviewed against the functions and features assumed in the safety analyses. The level of detail of each ITAAC line item should be such that it is not expected to change, and DCD Tier 2 should be used for the additional details needed to verify the ITAAC. The following criteria describe the ITAAC table line item topics for each system.

a. Determine those as-built configuration and performance characteristics of the DCFF, that can be confirmed prior to fuel load;

b. Line item topics should encompass those configurations and performance characteristics that are:

i. Assumed or modeled in a safety analysis or required for a RTNSS function; or

ii. Required to meet a design related NRC regulation or to comply with NRC regulation.

c. Any DCFF, already covered by the verification of higher-level ITAAC table line item(s) (e.g., system/function vs. component), should not be included.

d. Do not combine DCFFs if it would be easier to confirm them through separate line items, particularly if there are objective criteria for each of these items.

### 14.3.8 Overall ITAAC Content For Combined License Applications

10 CFR 52.80(a) specifies that the contents of a COL application must include:

(1) The proposed inspections, tests, and analyses that the licensee shall perform, and

(2) The acceptance criteria that provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, provisions of the Atomic Energy Act, and NRC rules and regulations.

This subsection provides the methodology used in developing the ITAAC, in accordance with 10 CFR 52.80(a). The ITAAC are provided in tabular form, consistent with the format shown in RG 1.206 Table C.II.1-1.

The entire set of ITAAC for each facility (COL-ITAAC) consists of the following four parts:

(1) Design Certification ITAAC, i.e., Tier 1 ITAAC;

(2) Emergency Planning ITAAC;

(3) Physical Security Hardware ITAAC; and

(4) Site-specific ITAAC , if any is/are needed.

COL-ITAAC = (Design Certification + Emergency Planning +
Physical Security Hardware + Site Specific) ITAAC

RG 1.206, Section C.II.1, Appendix C discusses generic Physical Security Hardware ITAAC developed by the Nuclear Energy Institute's Plant Security Task Force (see Reference 14.3-1). The result of this effort is a generic set of Physical Security Hardware ITAAC for security design features that can be included in a certified design or on a site-specific basis without change. The design Physical Security Hardware ITAAC are included within Tier 1.

The COL Applicant shall provide Emergency Planning ITAAC, based on industry guidance (COL 14.3-1-A).

### 14.3.9 Site-Specific ITAAC

RG 1.206 Section C.III.7.2 states that the COL Applicant is required "to develop ITAAC for the site-specific design portions of the facility (Site-Specific ITAAC) that are not included in the certified design." Therefore, if there are design functions or features for ensuring plant safety, which are not addressed in Tier 1, then the Tier 1 ITAAC must be supplemented with Site-Specific ITAAC. If Tier 1 addresses all functions and features that ensure plant safety, then a Site-Specific ITAAC is not required. The COL Applicant shall provide Site-Specific ITAAC for systems not evaluated in the DCD (COL 14.3-2-A).

Based upon Subsection 14.3.7 and RG 1.206 Sections C.II.1 and C.III.7.2, the extent to which each site-specific system requires ITAAC is dependent upon the safety significance of the functions performed by the system. In particular, a system with a safety-significant function (e.g., safety-related function) should have at least one entry in an ITAAC table for that function. If a site-specific system is described in the Final Safety Analysis Report (FSAR) and does not meet an ITAAC selection criterion, just the system title and the statement "No entry for this system" are provided within the ITAAC portion of the COL application. If a site-specific system is not described in the FSAR, then the system is not addressed within the ITAAC.

Site-Specific ITAAC do not address ancillary buildings and structures on the site, such as administrative buildings, parking lots, warehouses, training and facilities.

### 14.3.10 COL Information

#### *14.3-1-A Emergency Planning ITAAC*

The COL Applicant shall provide Emergency Planning ITAAC, based on industry guidance (Subsection 14.3.8).

#### *14.3-2-A Site-Specific ITAAC*

The COL Applicant shall provide Site-Specific ITAAC for systems not evaluated in the DCD (Subsection 14.3.9).

### 14.3.11 References

14.3-1 USNRC, Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants," June 2006.

14.3-2 USNRC, NUREG-0800, "Standard Review Plan."

14.3-3 Nuclear Energy Institute, "New Plant Security Task Force Work Product," August 2007.

## Table 14.3-1

## Types of Systems and Summary of Their Graded Treatment

| System Type | Scope of Design Description and ITAAC Design Commitment |
|---|---|
| Safety-related systems that contribute to plant performance during design basis events (e.g., emergency core cooling systems). | Major safety-related features and performance characteristics. |
| Nonsafety-related systems that have safety-related components (e.g., containment isolation valves). | Brief discussion of design features and performance characteristics of the safety-related components. |
| Nonsafety-related systems used to mitigate AOOs (e.g., turbine bypass). | Brief discussion of design features and performance characteristics affecting the analyzed response(s) to the event(s). |
| Nonsafety-related systems involved in special events (e.g., station blackout). | Brief discussion of design features and performance characteristics affecting the safety of the plant's response to the event(s). |
| Nonsafety-related systems potentially affecting safety (e.g. potential missiles from the main turbine). | Brief discussion of design features which prevent or mitigate the potential safety concern. |
| Nonsafety-related systems, which affect overall plant design (e.g., Drywell Cooling System). | Case-by-case evaluation. A brief discussion of the system if warranted by overall standardization goals. |
| Nonsafety-related systems with no relationship to safety and no substantial influence on overall plant design (e.g., Potable Water and Sanitary Waste System). | No discussion except identification of the system title. |
| System for which the Tier 1 entry has been included in another system (e.g., the Unit Auxiliary Transformer is addressed in the electrical power distribution system). | No additional discussion except identification of the system title. |

**Table 14.3-1a**
**ITAAC Screening Summary**

| Structure/System/Equipment Description | ITAAC Table |
|---|---|
| Reactor Pressure Vessel and Internals | 2.1.1-3 |
| Nuclear Boiler System | 2.1.2-3 |
| Rod Control and Information System | 2.2.1-6 |
| Control Rod Drive System | 2.2.2-7 |
| Feedwater Control System | 2.2.3-4 |
| Standby Liquid Control System | 2.2.4-6 Note 2 |
| Neutron Monitoring System | 2.2.5-4 Note 2 |
| Remote Shutdown System | 2.2.6-3 |
| Reactor Protection System | 2.2.7-4 |
| Plant Automation System (nonsafety-related) | Note 4 |
| Steam Bypass and Pressure Control System | 2.2.9-3 |
| Distributed Control and Information System (safety-related) | Note 1 |
| Distributed Control and Information System (nonsafety-related) | Note 1 |
| Leak Detection and Isolation System | 2.2.12-5 |
| Safety System Logic and Control System | 2.2.13-4 Note 2 |
| Diverse Instrumentation and Controls | 2.2.14-4 |
| Instrumentation & Control Compliance With IEEE Std. 603 | 2.2.15-2 |
| HP CRD Isolation Bypass Function Independent Control Platform | 2.2.16-4 Note 2 |
| Process Radiation Monitoring System | 2.3.1-2 |
| Area Radiation Monitoring System | 2.3.2-2 |
| Isolation Condenser System | 2.4.1-3 |
| Emergency Core Cooling System — Gravity-Driven Cooling System | 2.4.2-3 |
| Fuel Service Equipment | Note 4 |
| Miscellaneous Service Equipment | Note 4 |
| Reactor Pressure Vessel Servicing Equipment | Note 4 |

**Table 14.3-1a**
**ITAAC Screening Summary**

| Structure/System/Equipment Description | ITAAC Table |
|---|---|
| RPV Internals Servicing Equipment | Note 4 |
| Refueling Equipment | 2.5.5-1 |
| Fuel Storage Facility | 2.5.6-1 |
| Under-Vessel Servicing Equipment | Note 4 |
| FMCRD Maintenance Area | Note 4 |
| Fuel Cask Cleaning | Note 4 |
| Fuel Transfer System | 2.5.10-1 |
| Reactor Water Cleanup/Shutdown Cooling System | 2.6.1-2 |
| Fuel and Auxiliary Pools Cooling System | 2.6.2-2 |
| Liquid Waste Management System | 2.10.1-2 |
| Solid Waste Management System | 2.10.2-2 |
| Gaseous Waste Management System | 2.10.3-1 |
| Turbine Main Steam System | 2.11.1-1 |
| Condensate and Feedwater System | 2.11.2-1 |
| Condensate Purification System | Note 4 |
| Main Turbine | 2.11.4-1 |
| Turbine Gland Seal System | 2.11.5-1 |
| Turbine Bypass System | 2.11.6-1 |
| Main Condenser | 2.11.7-1 |
| Circulating Water System | Note 4 |
| Power Cycle Auxiliary Systems | Note 4 |
| Makeup Water System | Note 3 |
| Condensate Storage and Transfer System | Note 4 |
| Reactor Component Cooling Water System | 2.12.3-1 |
| Turbine Component Cooling Water System | Note 4 |

**Table 14.3-1a**
**ITAAC Screening Summary**

| Structure/System/Equipment Description | ITAAC Table |
|---|---|
| Chilled Water System | 2.12.5-1 |
| Oxygen Injection System | Note 4 |
| Plant Service Water System | 2.12.7-1 |
| Service Air System | Note 3 |
| Instrument Air System | Note 4 |
| High Pressure Nitrogen Supply System | Note 3 |
| Auxiliary Boiler System | Note 4 |
| Potable Water and Sanitary Waste System | Note 4 |
| Hydrogen Water Chemistry System | Note 4 |
| Process Sampling System | Note 4 |
| Zinc Injection System | Note 4 |
| Freeze Protection | Note 4 |
| Station Water System | Note 4 |
| Electrical Power Distribution System | 2.13.1-2 |
| Direct Current Power Supply | 2.13.3-3 |
| Standby Onsite AC Power Supply | 2.13.4-2 |
| Uninterruptible AC Power Supply | 2.13.5-2 |
| Communication System | Note 4 |
| Lighting Power Supply | 2.13.8-1 |
| Grounding and Lighting Protection System | 2.13.9-1 |
| Power Transmission | Note 4 |
| Containment System | 2.15.1-2 |
| Containment Vessel | Note 4 |
| Containment Internal Structures | 2.15.3-2 |
| Passive Containment Cooling System | 2.15.4-2 |
| Containment Inerting System | 2.15.5-2 |

**Table 14.3-1a**
**ITAAC Screening Summary**

| Structure/System/Equipment Description | ITAAC Table |
|---|---|
| Drywell Cooling System | Note 4 |
| Containment Monitoring System | 2.15.7-2 |
| Passive Autocatalytic Recombiner | 2.15.8-1 |
| Cranes, Hoists and Elevators | 2.16.1-1 |
| Reactor Building HVAC | 2.16.2-2 |
| Control Building HVAC System | 2.16.2-4 |
| Emergency Filter Units | 2.16.2-6 |
| Turbine Building HVAC System | 2.16.2-7 |
| Fuel Building HVAC System | 2.16.2-9 |
| Radwaste Building HVAC System | Note 4 |
| Electrical Building HVAC System | 2.16.2-10 |
| Other Building HVAC Systems | Note 4 |
| Fire Protection System | 2.16.3-2 |
| Fire Barriers | 2.16.3.1-1 |
| Equipment and Floor Drain System | 2.16.4-1 |
| Reactor Building | 2.16.5-2 |
| Control Building | 2.16.6-2 |
| Fuel Building | 2.16.7-2 |
| Turbine Building | 2.16.8-1 |
| Radwaste Building | 2.16.9-1 |
| Service Building | 2.16.10-1 |
| Ancillary Diesel Building | 2.16.11-1 |
| Fire Water Service Complex | 2.16.12-1 |
| Electrical Building | 2.16.13-1 |
| Service Water Building | 2.16.14-1 |
| Intake and Discharge Structure | Note 4 |

**Table 14.3-1a**
**ITAAC Screening Summary**

| Structure/System/Equipment Description | ITAAC Table |
|---|---|
| Oil Storage and Transfer Systems | Note 4 |
| Site Security | Note 4 |
| Plant Security | 2.19-1 |
| Plant Service Water System | Interface Material |
| Offsite Electrical Power | Interface Material |

Tier 1 contains non-system based ITAAC for the following:

- Design of Piping Systems and Components — Table 3.1-1
- Software Development — Table 3.2-1
- Human Factors Engineering — Table 3.3-2
- Radiation Protection — Table 3.4-1
- Design Reliability Assurance Program — Table 3.6-1
- Post-Accident Monitoring Instrumentation — Table 3.7-1
- Environmental and Seismic Qualification of Mechanical and Electrical Equipment — Table 3.8-1

Notes:
(1) The ITAAC information for these software projects are provided in Table 3.2-1.
(2) Conformance with IEEE Std. 603 requirements by the safety-related control system structures, systems, and components defined in Tier 1 Tables 2.2.10-1 and addressed in Subsection 2.2.15.
(3) For these systems, the only ITAAC relate to containment isolation valves. Refer to Table 2.15-1.
(4) ITAAC not required for these systems.

## Table 14.3-1b

## Design Basis Accident Analysis Critical Parameters

| References | | Design Feature |
|---|---|---|
| Tier 2 | Tier 1 | |
| **Reactor Power** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | APRM High Flux Scram |
| Table 15.2-1 | Table 2.2.15-2[(1)] | APRM High Simulated Thermal Power Scram |
| Table 15.2-1 | Subection 1.1.2.5[(2)] | Thermal Power Level |
| **Reactor Water Level** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | Low Level Scram (L3) |
| Table 15.2-1 | Table 2.2.15-2[(1)] | High Level Scram (L8) |
| Table 15.2-1 | Table 2.2.15-2[(1)] | Water Level Trips (L2, L1, L0.5) |
| **Reactor Pressure** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | High Pressure Scram |
| **MSIV Closure** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | MSIV Closure Scram (Position of 2 or more MSIVs) |
| Table 15.2-1 | Table 2.1.2-3 | MSIV Closure Time<br>Minimum/Maximum |
| **Suppression Pool Temperature** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | High SP Temperature Scram |
| Table 15.2-1 | Table 2.6.2-2 | Initiate FAPCS |
| **TSV Closure** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | TSV Closure Scram, (Position of 2 or more TSVs) |
| **TCV Closure** | | |
| Table 15.2-1 | Table 2.2.15-2[(1)] | TCV Fast Closure Scram Trip |
| **Control Rod Drive Scram Time** | | |
| Table 15.2-2 | Table 2.2.2-7 and Table 2.2.2-2 | Maximum Scram Time of all rods for Vessel Bottom Pressures below 7.481 MPaG |
| Table 15.2-3 | N/A[(3)] | Scram Times for Vessel Bottom Pressures between 7.481 and 8.618 MPaG |

## Table 14.3-1b

## Design Basis Accident Analysis Critical Parameters

| References | | Design Feature |
|---|---|---|
| Tier 2 | Tier 1 | |
| **Overpressure Protection and Depressurization** | | |
| Table 5.2-2 | Table 2.1.2-3 | Ten SRVs and eight Safety Valves (SVs) are included in the ESBWR design. |
| Table 5.2-2 | Table 2.1.2-3 | Analytical Limit Setpoint:<br>8.618 MPaG (SRV)<br>8.756 MPaG (SV) |
| Table5.2-2 | Table 2.1.2-3 | SRV Capacity |
| Table 5.2-2 | Table 2.1.2-3 | SV Capacity |
| Table 5.2-2 and Table 5.4-4 | Table 2.1.2-3 | DPV Capacity |
| **Isolation Condenser** | | |
| Subsection 5.4.6 | Table 2.4.1-3 | Initiation Signals:<br>MSIV Closure (2 of 4)<br>High RPV Dome Pressure<br>Low RPV Water Level<br>Loss of Feedwater |
| Table 15.2-1 | Table 2.4.1-3 | Minimum capacity (each) 4 IC, MW / % NBR |
| Table 15.2-1 | N/A[4] | Minimum Initial Temperature |
| Table 15.2-1 | Table 2.4.1-3 | Injection valve stroke |
| Table 6.3-1 | Table 2.4.1-3 | Minimum drainable liquid volume |
| **Main Steam** | | |
| Table 15.2-1 | Table 2.11.1-1 | Total Steamline Volume (vessel to TSVs/TBVs) |
| Table 15.2-1 | Table 2.11.6-1 | Turbine Bypass Capacity |
| Table 15.2-1 | Table 2.11.6-1 | Delay Response Time from TSV or TCV to 80% of Total Bypass Valve Capacity |
| Table 15.2-1 | Table 2.11.6-1 and Table 2.11.7-1 | TBV Sustained Operation on loss of preferred power |

**Table 14.3-1b**

**Design Basis Accident Analysis Critical Parameters**

| References | | Design Feature |
|---|---|---|
| **Tier 2** | **Tier 1** | |
| Subsection 15.2.2 | Table 2.11.6-1 | On TSV closure or TCV fast closure, to prevent an increase in system pressure, sufficient bypass capacity is provided to pass steam flow diverted from the turbine. |
| Table 15.2-1 | Table 2.11.4-1 | TSV closing stroke time |
| Table 15.2-1 | Table 2.11.4-1 | TCV closing stroke time (fast) |
| Table 15.2-1 | Table 2.11.4-1 | TCV closure stroke time (minimum servo) |
| Table 15.2-1 | Table 2.11.4-1 | % rated through 3 TCVs |
| Table 5.2-6 | Table 2.1.2-3 | MSIV Isolation Signals:<br>L2 Water Level + Time Delay<br>L1 Water Level<br>Low Turbine Inlet Pressure<br>Low Condenser Vacuum |
| **Core Flow** | | |
| Reference 4.4-12 | N/A[5] | Core Flow measurement accuracy |
| **Feedwater** | | |
| Subsection 7.7.3 | Table 2.2.15-2[1] | L 0.5 Equalization Line Trip |
| Table 15.2-1 | Table 2.11.2-1 | Runout Capacity (3 pumps) |
| Table 15.2-1 | Table 2.11.2-1 | Runout Capacity (1 pump) |
| Table 15.2-1 | Table 2.11.2-1 | Feedwater Temperature (rated) |
| Table 15.2-1 | Table 2.11.2-1 | Feedwater heater temperature loss (Δ) |
| Table 15.2-1 | Table 2.2.1-6 | Loss of feedwater heating setpoint (Δ) (SCCRRI/SRI Initiation) |
| Ref. 4.4-12 | Table 2.2.3-4 | Feedwater flow measurement (1 σ) |
| **Anticipated Transient Without Scram** | | |
| Subsection 7.7.3 | Table 2.2.3-4 | Feedwater runback on ATWS signal |

**Table 14.3-1b**

**Design Basis Accident Analysis Critical Parameters**

| References | | Design Feature |
|---|---|---|
| **Tier 2** | **Tier 1** | |
| **Standby Liquid Control** | | |
| Subsection 15.5.4 | Table 2.2.4-6 | System Initiation Signals:<br>High RPV Press + SRNM not downscale for 3 min<br>L2 + SRNM not downscale for 3 min<br>SRNM not downscale for 3 min with manual ARI / FMCRD run-in |
| Subsection 9.3.5 | Table 2.2.4-6 | Boron concentration |
| Subsection 9.3.5 | Table 2.2.4-6 | Total Volume |
| Subsection 9.3.5; Table 15.5-2 | Table 2.2.4-6 | Average flowrate:<br>first half of volume<br>second half of volume |
| **Containment** | | |
| Table 6.2-1 | Table 2.15.1-2 | Design Pressure |
| Table 6.2-1 | Table 2.15.1-2 | Design Temperature |
| Table 6.2-1 | Table 2.15.1-2 | Maximum Differential Pressure |
| Table 6.2-1 | Table 2.15.1-2 | Maximum DP (DW>WW) |
| Table 6.2-1 | Table 2.15.1-2 | Leakage Rate |
| Table 6.2-1; Table 6.2-8 | Table 2.15.1-2 | Vacuum Breakers:<br>(DW>WW) – 3 each<br>Opening DP (WW - DW)<br>Closing DP (WW - DW)<br>Loss Coefficient (K/A2) |
| Table 6.2-3 | Table 2.15.1-2 | Containment Volume:<br>Upper DW free gas volume<br>Lower DW free gas volume<br>Wetwell free gas space volume<br>Suppression Pool volume |

## Table 14.3-1b

## Design Basis Accident Analysis Critical Parameters

| References | | Design Feature |
|---|---|---|
| Tier 2 | Tier 1 | |
| Table 6.2-3 | Table 2.15.1-2 | Suppression Pool:<br>Pool surface only<br>Vertical vents<br>SP depth (High level)<br>SP depth (Nominal level)<br>SP Depth (Low level) |
| Table 6.2-4 | Table 2.15.1-2 | Vertical Vents:<br>Total Number<br>Inside diameter |
| Table 6.2-4 | Table 2.15.1-2 | Horizontal Vents:<br>Vents (per vertical vent)<br>Total number<br>Inside Diameter<br>Submergence<br>Top Row (Centerline)<br>Middle Row (Centerline)<br>Bottom Row (Centerline) |
| **PCCS** | | |
| Table 6.2-10 | Table 2.15.4-2 | Number of PCCS Condensers |
| Table 6.2-10 | Table 2.15.4-2 | Heat Removal Capacity per Condenser |
| Table 6.2-10 | Table 2.15.4-2 | Design Pressure |
| Table 6.2-10 | Table 2.15.4-2 | Design Temperature |
| **Emergency Core Cooling System** | | |
| Table 6.3-1 | Table 2.2.15-2[(1)] | RPV Water Level 1 Signal |
| Table 6.3-1 | Table 2.2.15-2[(1)] | Alternate ADS/GDCS Initiation Signal |
| Table 6.3-1 | Table 2.4.2-3 | GDCS line loss coefficient |
| Table 6.3-2 | Table 2.4.2-3 | GDCS Divisions |
| Table 6.3-2 | Table 2.4.2-3 | Injection Lines / Division |
| Table 6.3-2 | Table 2.4.2-3 | Injection line RPV Nozzles (per Division) |

## Table 14.3-1b

## Design Basis Accident Analysis Critical Parameters

| References | | Design Feature |
|---|---|---|
| Tier 2 | Tier 1 | |
| Table 6.3-2 | Table 2.4.2-3 | Equalizing line RPV Nozzles (per Division) |
| Table 6.3-2 | Table 2.4.2-3 | Minimum drainable inventory |
| Table 6.3-2 | Table 2.4.2-3 | Min. Elevation of GDCS pool above RPV nozzles |
| Table 6.3-2 | Table 2.4.2-3 | Minimum flow through deluge lines |
| Table 6.3-2 | Table 2.4.2-3 | Minimum GDCS equalizing line head |

Notes:

(1) System limits that are based on process analytical limits are verified in Tier 1 by system functionality requirements in combination with the requirements for a control system setpoint control program as required by Table 2.2.15-2, Item 21.

(2) Rated reactor power is included in Tier 1 content, but is not verified through an ITAAC.

(3) Control Rod Scram times vary with reactor pressure; therefore, this key parameter cannot be verified prior to fuel load and is not addressed by an ITAAC.

(4) The minimum initial IC temperature is a conservatively assumed value that is equivalent to the minimum reactor building ambient temperature (Tier 2, Table 9.4-8) even though the lines are physically located inside the drywell and the Isolation Condenser Inadvertent Initiation event is assumed to occur at normal power operating conditions. This is an operational parameter limit that cannot be verified by ITAAC prior to fuel load.

(5) The total core flow is calculated by the heat balance core flow methodology. This is a critical parameter that cannot be verified prior to fuel load, thus there is no ITAAC requirement associated with this parameter. This parameter is met provided the input values for the heat balance (e.g. reactor pressure, feedwater flow and temperature) are within their required accuracy ranges.

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| FAPCS, internal and external, injection capability provide adequate core cooling for transients given successful DPV or ADS valve operation, even if containment pressure is at the ultimate containment pressure. | Subsection 9.1.3.2 | 2.6.2<br><br>Table 2.6.2-2 Item 7b |
| The Diverse Protection System (DPS) cabinet is assumed to be located in a separate fire area in the control building. A preliminary fire PRA analysis model with DPS cabinet located inside room 3301 shows that the fire risk in fire area F3301 would be the dominant contributor to all fire risks due to the high failure probability of common cause failure of software for the safety –related system, the failure of DPS, and multiple nonsafety-related systems impacted by a fire in room 3301. With a separate fire area for the proposed DPS cabinet in the detailed design, the fire risk can be significantly reduced. | Figure 1.2-4 | 2.2.14<br><br>Table 2.2.14-4 Item 11 |
| The exposure of the distributed control and information system (Q-DCIS and N-DCIS) equipment to heat and smoke caused by a fire in a single fire area does not cause spurious actuations that could adversely affect safe shutdown. | Subsection 9.5.1.12 | 2.16.3.1<br><br>Table 2.16.3-1 Item 5 |
| The communication links between the main control room (MCR) and the Q-DCIS and N-DCIS rooms do not include any copper or other wire conductors that could potentially cause fire-induced spurious actuations that could adversely affect safe shutdown. | Subsection 9.5.1.10 | 2.2.15<br>Table 2.2.15-2 Items 10a and 10b |
| Doors that connect the Control and Reactor Buildings with the Electrical Building galleries are watertight, for flooding of the galleries up to the ground level elevation. | Subsection 3.4.1.4.3 | 2.16.5, 2.16.6<br><br>Table 2.16.5-2, Item 13<br>Table 2.16.6-2, Item 7 |

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| The Drywell Floor Drain Sump channels, which allow leakage on the lower drywell floor to flow into the sump, will prevent any molten debris, which reaches the inlet, from entering the sump. | Subsection 6.2.1.1.10.2 | 2.15.3<br><br>Table 2.15.3-2, Item 9 |
| Closure of both the equipment hatch and the personnel hatch can be performed from outside the lower drywell/containment. | Figure 1.2-2 | 2.15.1<br><br>Table 2.15.1-2, Item 9 (iv) |
| The IC/PCCS Pool valves that provide make-up water from the equipment storage pool have DPS controls and are powered from a reliable source of power, which is capable of long-term support. | Subsection 5.4.6.2.2 | 2.4.1<br><br>Table 2.4.1-3, Item 1 and Item 24 |
| Control logic cabinets for each of the containment vacuum breaker isolation valves must be located in separate fire zones. | Subsection 6.2.1.1.2 | 2.15.1<br><br>Table 2.2.14-4, Item 8(iv) |
| Because of the high consequence of a RWCU/SDC line break outside containment this system is designed with an additional diverse, nonsafety-related valve that is used for line isolation. This valve is controlled by the nonsafety-related DCIS system and closes on the same signals that provide the safety-related isolation. | Subsection 5.4.8.1.2 | 2.6.1<br><br>Table 2.6.1-2, Item 1<br><br>Table 2.2.12-5 |

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| Power operated equipment and valves on lines attached to the RPV that require maintenance have maintenance valves installed such that freeze seals will not be required. | Subsection 5.2.3.1.1<br>Cryogenic Conditions | 2.2.2 CRD<br>Item 16<br>2.2.4 SLCS<br>Item 24<br>2.4.1 ICS<br>Item 29<br>2.4.2 GDCS, Item 28<br>2.6.1 RWCU<br>Item 10<br>2.6.2 FAPCS<br>Item 13<br>2.11.1 TMSS<br>Item 11<br>2.11.2 CFW<br>Item 9 |
| A pneumatic accumulator and check valve are required to support the remote-manual and ADS-activated functions of the SRV valve. The accumulator and check valve ensure that the SRV valve opens via the pneumatic operator following a failure of the pneumatic pressure source. | Subsection 5.2.2.2.2 | Table 2.1.2-3, Item 23 |
| The lower drywell water level is monitored to indicate any increases in water level that may occur in the lower drywell following a LOCA condition. | Subsection 7.5.2.1 | 2.15.7<br><br>Table 2.15.7-2, Item 1 |
| Basemat Internal Melt Arrest Coolability (BiMAC) temperature indication: Temperature sensors in the BiMAC device provide the actuation signal to open the squib valves from the GDCS pool deluge headers. | Subsections 19.3.2.5 and 19.3.2.6 | 2.4.2<br><br>Table 2.4.2-3, Item 25<br>Table 2.4.2-3, Item 26 |

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| **RTNSS Functions** | | |
| DPS – ARI Actuation | Subsection 19A.8.4.1 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – FWRB Actuation | Subsection 19A.8.4.1 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – ADS Inhibit | Subsection 19A.8.4.1 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – GDCS Injection | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – ADS Actuation | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – Open IC/PCCS Pool Cross-Connect Valves | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – Isolation RWCU/SDC Valves | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4 Item 8 |
| DPS – Scram | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – MSIV Closure | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – SRV Actuation | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| DPS- FMCRD Actuation | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – ICS Actuation | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| DPS – SLC Actuation LOCA | Subsection 19A.8.4.3 | 2.2.14<br>Table 2.2.14-4, Item 8 |
| Fire Protection System (FPS) Diesel Driven Pump | Subsection 19A.8.4.2 | 2.16.3<br>Table 2.16.3-2, Item 1 and<br>Item 7a |
| FPS Motor Driven Pump | Subsection 19A.8.4.2 | 2.16.3<br>Table 2.16.3-2, Item 1<br>and Item 5 |
| FPS to FAPCS Connection Piping | Subsection 19A.8.4.2 | 2.16.3<br>Table 2.16.3-2, Item 1 and<br>Item 7 |
| Passive Autocatalytic Recombiners | Subsection 19A.8.4.10 | 2.15.8<br>Table 2.15.8-1 |
| PCCS Vent Fans | Subsection 19A.8.4.10 | 2.15.4<br>Table 2.15.4-2 Item 11 |
| Emergency Lighting – Post 72 Hour | Subsection 19A.8.4.4 | 2.13.8<br>Table 2.13.8-1, Item 4<br>Table 2.13.8-1, Item 7 |

## Table 14.3-1c

## PRA and Severe Accident Insights

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| FAPCS (Low Pressure Coolant Injection, Suppression Pool Cooling Modes) | Subsection 19A.8.4.7 | 2.6.2<br>Table 2.6.2-2, Item 7 |
| BiMAC Device | Subsection 19.3.2.5<br>19.3.2.6<br>19A.8.4.5 | 2.4.2<br>Table 2.4.2-3, Item 29 |
| GDCS Deluge Valves | Subsection 19A.8.4.5 | 2.4.2<br>Table 2.4.2-3, Item 1 |
| Reactor Building HVAC Purge Exhaust Filters | Subsection 19A.8.4.11 | 2.16.2<br>Table 2.16.2-2, Item 11 |
| FPS Water Tank | Subsection 19A.8.4.2 | 2.16.3<br>Table 2.16.3-2, Item 4 |
| FPS Diesel Fuel Oil Tank | Subsection 19A.8.4.2 | 2.16.3<br>Table 2.16.3-2, Item 7b |
| Ancillary Diesel Generators | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 5 |
| Ancillary AC Power Buses | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 5 |
| Ancillary DG Fuel Oil Tank | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 5 |
| Ancillary DG Fuel Oil Transfer Pump | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 5 |
| N-DCIS | Subsection 19A.8.4.6 | 2.2.11<br>Table 2.2.11-1 |

## Table 14.3-1c

## PRA and Severe Accident Insights

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| 6.9 kV PIP Buses | Subsection 19A.8.4.8 | 2.13.1<br>Table 2.13.1-2, Item 6 |
| Standby Diesel Generators | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 2 |
| Standby DG Auxiliaries | Subsection 19A.8.4.8 | 2.13.4<br>Table 2.13.4-2, Item 2 |
| RCCWS | Subsection 19A.8.4.9 | 2.12.3<br>Table 2.12.3-1, Item 2 |
| Nuclear Island Chilled Water | Subsection 19A.8.4.9 | 2.12.5<br>Table 2.12.5-1, Item 2 |
| PSWS | Subsection 19A.8.4.9 | 2.12.7<br>Table 2.12.7-1, Item 2 |
| Electrical Building HVAC Area Cooling | Subsection 19A.8.4.9 | 2.16.2.7<br>Table 2.16.2-10, Item 2 |
| Fuel Building HVAC Local Cooling | Subsection 19A.8.4.9 | 2.16.2.5<br>Table 2.16.2-9, Item 5 |
| Reactor Building HVAC Local Cooling | Subsection 19A.8.4.9 | 2.16.2.1<br>Table 2.16.2-2, Item 7 |
| Turbine Building HVAC Local Cooling | Subsection 19A.8.4.9 | 2.16.2.4<br>Table 2.16.2-7, Item 2 |
| CRHAVS Air Handling Units | Subsection 19A.8.4.4 | 2.16.2.2<br>Table 2.16.2-6, Item 12 |

**Table 14.3-1c**

**PRA and Severe Accident Insights**

| Design Feature | DCD Tier 2 Reference | DCD Tier 1 Reference |
|---|---|---|
| CRHAVS Air Handling Unit auxiliary heaters and coolers | Subsection 19A.8.4.4 | 2.16.2.2<br>Table 2.16.2-4, Item 10 |
| **RTNSS Structures** | | |
| Fire Pump Enclosure | Subsection 19A.8.3 | 2.16.3<br>T2.16.3-2, Item 1 |
| Ancillary DG Building | Subsection 19A.8.3 | 2.16.11<br>Table 2.16.11-1 |
| Reactor Building | Subsection 19A.8.3 | 2.16.2.1<br>Table 2.16.5-2 |
| Control Building | Subsection 19A.8.3 | 2.16.6<br>Table 2.16.6-2 |
| Electrical Building | Subsection 19A.8.3 | 2.16.13<br>Table 2.16.13-1 |
| Turbine Building | Subsection 19A.8.3 | 2.16.8<br>Table 2.18.8-1 |
| Fuel Building | Subsection 19A.8.3 | 2.16.7<br>Table 2.16.7-2 |
| Service Water Structure | Subsection 19A.8.3 | 2.16.14<br>Table 2.16.14-1 |

## Table 14.3-2

## Test, Inspection or Analysis Approach & Application Process

| ITA Approach | Application |
|---|---|
| Inspection | To be used when verification can be accomplished by visual observations, physical examinations, review of records based on visual observations or physical examinations that compare the as-built structure, system or component condition to one or more Tier 1 design description commitments. |
| Test | To be used when verification can be accomplished by the actuation or operation, or establishment of specified conditions, to evaluate the performance or integrity of the as-built structures, system or components. The type of tests identified in the ITAAC tables are not limited to in-situ testing of the completed facility but also include (as appropriate) other activities such as factory testing, special test facility programs, and laboratory testing. |
| Analysis | To be used when verification can be accomplished by calculation, mathematical computation or engineering or technical evaluations of the as-built structures, systems or components. (In this case, engineering or technical evaluations could include, but are not limited to, comparisons with operating experience or design of similar structures, systems or components.) |

# 14.3A DESIGN ACCEPTANCE CRITERIA ITAAC CLOSURE PROCESS

The general ITAAC closure process is set forth in NRC regulations. Specifically, 10 CFR 52.99 establishes the regulatory process for ensuring that ITAAC are performed. 10 CFR 52.99 (a) requires a licensee to submit an initial schedule for completing ITAAC, and to then submit periodic updates throughout construction. The licensee must submit the initial schedule within one year of issuance of the COL, or at the start of construction, whichever is later.

Schedule updates are to be submitted every 6 months thereafter up to one year prior to the scheduled fuel loading date when the licensee then submits the updates every 30 days. These updates continue until the final notification is submitted to the NRC and all ITAAC are thus completed. 10 CFR 52.99 (b) clarifies that an applicant for a COL may perform design and procurement activities subject to ITAAC at its own risk, even though the NRC may not have found that the associated acceptance criteria for those ITAAC are met. 10 CFR 52.99 (c) specifies the notification requirements for completion of ITAAC. The most current regulations will apply when implementing the ITAAC closure process.

Design Acceptance Criteria are a special type of ITAAC and consist of a set of prescribed limits, parameters, procedures, and attributes upon which the NRC may rely in making a final safety determination to support a design certification (reference SECY 92-053). The ESBWR includes Design Acceptance Criteria in the areas of piping, digital instrumentation and controls (I&C), and human factors engineering (HFE). The Design Acceptance Criteria are identified in Tier 1 as Design Acceptance Criteria ITAAC (the designation used is {{Design Acceptance Criteria}}), which are established to demonstrate that the design is completed to the level that would have been necessary if it had been completed for certification (see 10 CFR 52.47). Following completion of the Design Acceptance Criteria ITAAC, the aspects of the related structure, system, or component will be verified through an as-built ITAAC, which will be performed to demonstrate that the as-built facility conforms to the design as completed through the Design Acceptance Criteria ITAAC.

NRC provides regulatory guidance regarding Design Acceptance Criteria ITAAC in RG 1.206, Section C.III.5. The guidance provides an outline of the level of design detail that may be necessary to comply with the Design Acceptance Criteria ITAAC process and that should be available for NRC review and inspection as the information becomes available. RG 1.206, Section C.III.5, should be used for guidance regarding NRC expectations on the level of detail and design elements for Design Acceptance Criteria ITAAC closure, as these expectations are not repeated in detail herein. However, this appendix provides a high-level description of the Design Acceptance Criteria ITAAC closure process based on NRC guidance as one acceptable means of implementing the regulations associated with the ITAAC process. Where references are made to actions to be taken by the COL Licensee, this is in accordance with NRC guidance and reflects that a COL Licensee may implement this process. However, because this is based on NRC guidance, a COL Licensee may elect to establish a different process and present it to the NRC as an acceptable means of closing Design Acceptance Criteria ITAAC.

## 14.3A.1 DESIGN ACCEPTANCE CRITERIA ITAAC CLOSURE OPTIONS

There are typically three options to close Design Acceptance Criteria ITAAC, all of which involve essentially the same level of design detail. The design information necessary to close Design Acceptance Criteria ITAAC should be that level which would have been provided during design certification review if Design Acceptance Criteria ITAAC had not been used. The three options for Design Acceptance Criteria ITAAC closure, as they might apply to the ESBWR, are as follows:

- *Resolution through amendment of a design certification rule.*
- *Resolution through the COL application review process.*
- *Resolution through Design Acceptance Criteria ITAAC after COL issuance.*

The third option is discussed below as it would be implemented for the first standard ESBWR plant and initially reviewed, inspected, or audited by the NRC for Design Acceptance Criteria ITAAC closure. Treatment in subsequent standard ESBWR plants may be based on the initial closure of Design Acceptance Criteria ITAAC under the concept of "one issue, one review, one position" in NRC guidance (see RG 1.206, C.III.5). GEH may submit Licensing Topical Reports (LTR) for NRC review of the material supporting Design Acceptance Criteria ITAAC closure and request that the NRC issue a Safety Evaluation in conjunction with a closure letter or Inspection Report conclusion that the acceptance criteria of the Design Acceptance Criteria ITAAC have been met. Subsequent licensees could reference the LTRs and NRC closure documents for Design Acceptance Criteria ITAAC closure unless the design certification rule has been amended to reflect the design information. Each COL Applicant will provide a Design Acceptance Criteria ITAAC closure schedule in the COL application and identify whether the standard approach will be used (COL 14.3A-1-1). This schedule may simply be an indication that the Design Acceptance Criteria ITAAC completion for the first standard plant will be used.

Regarding the initial Design Acceptance Criteria ITAAC closure, depending upon the area of Design Acceptance Criteria ITAAC, the closure process may vary. In the area of piping Design Acceptance Criteria ITAAC, for example, the completion steps are basically as prescribed by the ASME Code. The more complex areas of digital I&C and HFE involve phases of work and a series of Design Acceptance Criteria ITAAC, leading to a final design, as described in RG 1.206, Section C.III.5. Each of the three ESBWR Design Acceptance Criteria ITAAC areas is discussed below.

## 14.3A.2 DESIGN ACCEPTANCE CRITERIA ITAAC FOR PIPING DESIGN

[*The ESBWR piping Design Acceptance Criteria ITAAC consists of both the piping/piping component analysis and the pipe break analysis for safety-related ASME Code components. These are identified in separate Design Acceptance Criteria ITAAC in Tier 1. The piping design may be completed on a system-by-system basis for applicable systems and, in order to support closure of the Design Acceptance Criteria ITAAC, information will be made available for NRC review, inspection, and audit on a system basis. Information will be made available to the NRC to facilitate reviews, inspections, and audits throughout the process and, if appropriate, the NRC may inform the licensee of any concerns as they are identified so that adjustments may be made in a timely manner.* ]*

The ASME Code prescribes certain procedures and requirements that are to be followed for completing the piping design. The piping Design Acceptance Criteria ITAAC includes a verification of the ASME Code design report to ensure that the appropriate code design requirements for each system's safety class have been implemented. The design information (including ASME design reports) will be available to the NRC for review, inspection, and audit as the information becomes available, in order to ensure that the closure of the Design Acceptance Criteria ITAAC can be completed in a timely manner after the Design Acceptance Criteria ITAAC closure notification letter is submitted.

A reconciliation of the applicable safety-related as-built piping systems is covered in an as-built ITAAC to demonstrate that the as-built piping reflects the design, as reconciled. The reconciliation report will be made available for NRC inspection or audit when it is has been completed.

[*For completing the pipe break analysis Design Acceptance Criteria ITAAC, the analyses will document that structures, systems, and components (SSCs) which are required to be functional during and following a safe shutdown earthquake have adequate high-energy and moderate-energy pipe break mitigation features. The pipe break analysis report verifies that the criteria used to postulate pipe breaks, the analytical methods used to analyze pipe breaks, and the method to confirm the adequacy of the results of the pipe break analyses are appropriate. The pipe break analysis report provides assurance that the high-energy and moderate-energy line break analyses have been completed. The content of the report is discussed in Subsection 3.6.2.5 of the ESBWR Tier 2 DCD.*]*

Following NRC review of the report and the supporting analyses, the NRC may review plans for the protection features that are determined necessary to mitigate the consequences of a pipe break. Information will be made available to the NRC so that, if appropriate, issues that may be identified by the NRC may be resolved prior to the final as-built installation of the protective features. Upon completion of the installation of the protective features, the as-built verification ITAAC will be performed. The Pipe Break Analysis Report shall conclude that, for each postulated piping failure, the reactor can be shut down safely and maintained in a safe shutdown condition (Stable Shutdown Mode) without offsite power.

The piping design completed for the first standard ESBWR plant will be available to subsequent standard ESBWR plants under the "one issue, one review, one position" approach for closure. The as-built ITAAC for reconciliation and as-built verification will be performed following completion of the Design Acceptance Criteria ITAAC and installation of the piping system component and mitigation features for pipe break.

*Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

## 14.3A.3 DIGITAL INSTRUMENTATION AND CONTROL DESIGN ACCEPTANCE CRITERIA ITAAC CLOSURE

[*NRC guidance in RG 1.206, Section C.III.5, describes a phased Design Acceptance Criteria ITAAC process for digital I&C. The set of ESBWR digital I&C Design Acceptance Criteria ITAAC establishes a phased Design Acceptance Criteria ITAAC closure process for the digital I&C design. The set of digital I&C Design Acceptance Criteria ITAAC identifies the process*

*and requirements necessary to develop the design information and acceptance criteria for the various stages of design and subsequent construction and testing. By following the set of digital I&C Design Acceptance Criteria ITAAC, the COL Licensee should have sufficient information to determine which elements of the design are necessary for each phase of the digital I&C Design Acceptance Criteria ITAAC closure.*

*According to NRC guidance, based on the Design Acceptance Criteria ITAAC, the COL Licensee should develop procedures and test programs necessary to demonstrate that the Design Acceptance Criteria ITAAC requirements are met at each phase. The COL Licensee should certify to the NRC that the design through each phase is in compliance with the certified design. It is expected that information will be made available (e.g., Topical Report) for the NRC to review, audit, and inspect the work to confirm that the COL Licensee has adequately implemented commitments of the Design Acceptance Criteria ITAAC at the various phases. The "phased" digital I&C Design Acceptance Criteria ITAAC process consists of a set of sequential steps or phases that require successful completion, as described in NRC guidance in RG 1.206, C.III.5.*

*According to NRC guidance, a COL Licensee is not required to certify that each phase is completed sequentially. However, if the NRC determines that a phase of the digital I&C Design Acceptance Criteria ITAAC was not successfully completed, the design process may need to be repeated to meet the Design Acceptance Criteria ITAAC acceptance criteria. It is expected that information will be made available (e.g., Topical Report) for the NRC to conduct reviews, inspections, and audits throughout the process in order to identify any concerns with the various phases of design completion in a timely manner so that adjustments may be made as the process proceeds. With early NRC interactions, the licensee should be able to avoid or limit unnecessary rework.*

*The first of any standard ESBWR may complete the digital I&C Design Acceptance Criteria ITAAC actions. Each subsequent standard ESBWR using the standard approach may use the summary reports or design completion elements that are developed to complete the first of a standard ESBWR digital I&C Design Acceptance Criteria ITAAC under the "one issue, one review, one position" approach. In this manner, a group of standard ESBWR plants may be based on the same set of results summary reports and design elements for digital I&C.*

*Notwithstanding the standard bases established by the first standard ESBWR, the fleet may identify through operating experience changes that may be made in accordance with the appropriate change process. As with any other elements of the standard ESBWR design certification, a generic change to the digital I&C design process may also be the subject of a design certification amendment. In that case, the amendment would address whether the digital I&C Design Acceptance Criteria ITAAC are to be amended and whether any of the results summary reports or design elements would need to be modified.*

*Following completion of the Design Acceptance Criteria ITAAC, other ITAAC that address implementation of the design will be performed to verify that the systems have been constructed and installed consistent with the design*.]*

*Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

## 14.3A.4 HUMAN FACTORS ENGINEERING DESIGN ACCEPTANCE CRITERIA ITAAC CLOSURE

[*NRC guidance in RG 1.206, Section C.III.5, describes a phased Design Acceptance Criteria ITAAC process for HFE. The Tier 1 Design Descriptions and Design Acceptance Criteria ITAAC delineate the process and requirements to develop the design information required in each area of HFE, as described in NRC guidance document NUREG-0711, "Human Factors Engineering Program Review Model." The Design Commitments specify certain actions that are taken in accordance with an associated ESBWR HFE implementation plan. These HFE implementation plans are reviewed as part of the design certification review and are designated as Tier 2* information.*

*Each element of the phased process established by the HFE Design Acceptance Criteria ITAAC results in a summary report of the specific activity. Acceptance Criteria are specified in Tier 1 for the development process at various stages of detailed design, with an ITAAC for verifying the final as-built condition through subsequent construction and testing. Acceptance Criteria for HFE Design Acceptance Criteria ITAAC consist of a series of results summary reports that are developed and which verify that the specific associated Design Commitment is met.*

*As the Design Acceptance Criteria closure process proceeds, procedures and test programs are developed as necessary to demonstrate that the Design Acceptance Criteria requirements are met at each stage. These procedures and test programs will be available for NRC review and inspection as they become available.*

*The Design Acceptance Criteria ITAAC closure process for HFE is a "phased" process because it consists of a set of sequential steps or phases that require successful completion. As each phase of the HFE Design Acceptance Criteria ITAAC process is completed, the supporting documentation will be available for the NRC to review and inspect to ensure that the design through that phase is in compliance with the certified design information that describes the HFE elements. The information will be made available throughout the phased process so that the NRC may review, audit, and inspect the work to confirm that the Design Acceptance Criteria ITAAC commitments have been adequately implemented for the various phases. NRC guidance discusses that it is not necessary that each phase be completed sequentially. However, if the NRC identifies a concern that a Design Acceptance Criteria ITAAC, or an element thereof, was not successfully met, the design process may need to be repeated to meet the Design Acceptance Criteria ITAAC before final as-built activities are completed.*

*The first of any standard ESBWR will complete the HFE Design Acceptance Criteria ITAAC actions. Each subsequent standard ESBWR may use the summary reports that are developed to complete the first of a standard ESBWR HFE Design Acceptance Criteria ITAAC. In this manner, a group of standard ESBWR plants may be based on the same set of results summary reports for HFE.*

*Notwithstanding the standard bases established by the first standard ESBWR, the fleet may identify through operating experience changes that may be made in accordance with the appropriate change process. As with any other elements of the standard ESBWR design certification, a generic change to the HFE process may also be the subject of a design certification amendment. In that case, the amendment would address whether the HFE Design*

*Acceptance Criteria ITAAC are to be amended and whether any of the results summary reports would need to be modified.*

*Following completion of the Design Acceptance Criteria ITAAC, other ITAAC that address implementation of the design will be performed to verify that the systems have been constructed and installed consistent with the design*.]*

*Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

## 14.3A.5 COL INFORMATION

### *14.3A-1-1 Establish a Schedule for Design Acceptance Criteria ITAAC Closure*

Each COL Applicant will provide a Design Acceptance Criteria ITAAC closure schedule in the COL application and identify whether the standard approach will be used (Subsection 14.3A.1).

## 14.3A.6 REFERENCES

None.