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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: AP600 INITIAL TEST PROGRAM DRAFT MATERIAL

Dear Mr. Quay:

Enclosed with this letter is a draft revision to portions of the AP600 Initial Test Program (SSAR Chapter 14). Table 1 provides a revised table of contents for the Initial Test Program and identifies those portions included in the enclosure. This information is provided to support an April 18, 1996 meeting with NRC staff to discuss the general approach to SSAR Chapter 14, how NRC staff comments are being addressed and discussions on specific test abstracts. The staff feedback obtained during this meeting will be used to finalize the remaining portions of Chapter 14.

Please contact John C. Butler on (412) 374-5268 if you have any questions concerning this transmittal.

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/nja

Enclosure

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Chapter 14

INITIAL TEST PROGRAM

14.1 Specific Information to be Included in Preliminary/Final Safety Analysis Reports

Not applicable to the AP600.

14.2 Specific Information to be Included in Standard Safety Analysis Reports

14.2.1 Summary of Test Program and Objectives

The purpose of this section is to describe the test program that is performed during initial startup of the AP600 plant.

The overall objective of the test program is to demonstrate that the plant has been constructed as designed, that the systems perform as required by the plant design, and that activities culminating in operation at full licensed power including initial fuel load, initial criticality, and power ascension; are performed in a controlled and safe manner.

As required by 10 CFR 52.47 (a)(1)(vi), the inspections, tests, analyses and acceptance criteria relating to the AP600 design are found in the AP600 Inspections, Tests, Analyses and Acceptance Criteria (ITAAC) Document.

The initial plant test program consists of a series of tests categorized as construction and installation, preoperational, and startup tests. They are to be performed by the Combined Operating License (COL) applicant.

• Construction and installation tests are performed to determine that plant

structures, components, and systems have been constructed or installed correctly and are operational. Some of these tests may be part of the ITAAC program.

- Preoperational tests are performed after construction and installation tests, but prior to initial fuel loading to demonstrate the capability of plant systems to meet performance requirements. Some of these tests may be part of the ITAAC program.

- Startup tests, which begin with initial fuel loading, are performed to demonstrate the capability of individual systems, as well as the integrated plant, to meet performance requirements.

The following are the specific objectives of the initial plant test program:

- Demonstrate that the plant construction is complete and that components and systems are correctly installed and operational.

- Demonstrate the capability of structures, components and systems to meet performance requirements.

- Confirm selected design and analysis assumptions for the standard AP600 design.

- Achieve initial fuel loading, initial criticality, and power ascension in a controlled and safe manner.

- Bring the plant to rated capacity for sustained power operation.

- Provide, to the extent practical, in-plant training for plant operating personnel.

Preoperational or startup testing or both are performed on those systems that:

- Are relied upon for safe shutdown and cooldown of the reactor plant under normal plant conditions and for maintaining the reactor in a safe condition for an extended shutdown period;

- Are relied upon for safe shutdown and cooldown of the reactor under transient and postulated accident conditions and for maintaining the reactor in a safe condition for an extended shutdown period following such conditions;

- Are relied upon for establishing conformance with safety limits or limiting conditions for operation;

- Are classified as engineered safety features actuation systems (ESFAS) or are relied upon to support operation of engineered safety features actuation systems within design limits;

- Are assumed to function during an accident or for which credit is taken in the accident analysis;

- Perform safety-related, defense-in-depth, or RTNSS-important functions as described in the appropriate sections in the Standard Safety Analysis Report or the Probabilistic Risk Assessment; and

- Are used to process, store, control, or limit the release of radioactive material.

14.2.1.1 Construction and Installation Test Program Objectives

The adequacy of construction, installation, and preliminary operation of

components and systems is verified by a construction and installation test program.

In this program, various electrical and mechanical tests are performed including the following:

- Cleaning and flushing
- Hydrostatic testing
- Checks of electrical wiring
- Valve testing
- Energization and operation of equipment
- Calibration of instrumentation

On a system basis, completion of this program demonstrates that the system is ready for preoperational testing.

Abstracts for tests constituting the construction and installation test program are not provided in support of Design Certification. Construction and installation tests are the responsibility of the COL applicant. Development of the construction and installation tests is based on the engineering information for the equipment and systems installed.

14.2.1.2 Preoperational Test Program Objectives

Following construction and installation testing, preoperational tests are performed to demonstrate that equipment and systems perform in accordance with design criteria so that initial fuel loading, initial criticality, and subsequent power operation can be safely undertaken.

The general objectives of the preoperational test program are the following:

- Demonstrate that essential plant components and systems, including alarms and indications, meet appropriate criteria based on the design.

- Provide documentation of the performance and condition of equipment and systems.

- Provide baseline test and operating data on equipment and systems for future use and reference.

- Operate equipment for a sufficient period to demonstrate performance.

- Demonstrate that plant systems operate on an integrated basis.

Abstracts for the preoperational tests for portions of systems/components that perform safety-related functions, defense-in-depth (DID) functions, or which have been evaluated to have importance based on RTNSS (Regulatory Treatment of Non-Safety Systems) evaluations are provided in this section. Abstracts for tests of nonsafety-related systems / components listed in Regulatory Guide 1.68, Revision 2, which have no DID or RTNSS importance are not provided.

Plant operating, emergency, and surveillance procedures are developed, tested, and revised if necessary, prior to fuel loading. These procedures are incorporated into the initial test program procedures or otherwise verified through use, to the extent practicable, during the preoperational test program.

Plant equipment used in the performance of preoperational tests operates in accordance with appropriate operating procedures, thereby giving the plant operating staff an opportunity to gain experience in using these procedures and demonstrating their adequacy prior to plant initial criticality.

14.2.1.3 Startup Test Program Objectives

The startup test program begins with initial fuel loading after the preoperational testing has been successfully completed.

Startup tests can be grouped into four broad categories:

- Tests related to initial fuel loading
- Tests performed after initial fuel loading but prior to initial criticality
- Tests related to initial criticality and those performed at low power (less than 5 percent)
- Tests performed at power levels greater than 5 percent

During performance of the startup test program, the plant operating staff has the opportunity to obtain practical experience in the use of normal and abnormal operating procedures while the plant progresses through heatup, criticality, and power operations.

The general objectives of the startup test program are:

- Install the nuclear fuel in the reactor vessel in a controlled and safe manner.

- Verify that the reactor core and components, equipment, and systems required for control and shutdown have been assembled according to design and meet specified performance requirements.

- Achieve initial criticality and operation at power in a controlled and safe manner.

- Verify that the operating characteristics of the reactor core and associated control and protection equipment are consistent with design requirements and accident analysis assumptions.

- Obtain the required data and calibrate equipment used to control and protect the plant.

- Verify that the plant is operating within the limits imposed by the technical specifications.

Abstracts of the startup tests are provided in this section.

14.2.2 Organization, Staffing, and Responsibilities

The COL is responsible for the establishment of management with overall responsibility for defining the responsibilities, requirements, and interfaces necessary to safely and efficiently test, operate, and maintain the AP600 plant.

The COL is responsible for developing the specific plant organization and staffing level appropriate for the operation of the AP600 plant.

14.2.3 Test Procedures

Preoperational and startup tests are performed under the auspices of the COL applicant and holder using test procedures. For each test, the test procedure specifies the following:

- Objectives for performing the test
- Prerequisites that must be completed before the test can be performed
- Initial conditions under which the test is started
- Special precautions required for the safety of personnel or equipment
- Instructions delineating how the test is to be performed
- Identification of the required data to be obtained and the methods for documentation

• Data reduction analysis methods as appropriate

• Criteria for test results evaluation

Available information on operating and testing experiences of operating reactors are factored into the test procedures as appropriate.

Copies of the test procedures for the startup tests are provided to NRC inspection personnel not less than 60 days prior to the scheduled fuel loading date.

Copies of the test procedures are available to NRC inspection personnel approximately 60 days prior to the scheduled performance of the following preoperational tests:

• Tests of systems/components that perform safety related functions
• Tests of systems/components that are non-safety related but perform defense-in-depth (DID) functions.
• Tests of systems/components which have importance based on the regulatory treatment of non-safety systems (RTNSS) evaluations.

Submittal to the NRC of procedures for the preoperational tests of the plant systems / components which perform no safety or DID functions and have no RTNSS importance is not required. Preparation of the test procedures which incorporate the test method and criteria for these systems / components are the responsibility of the COL applicant.

Tests of safety related functions are performed with the quality assurance requirements as specified by COL applicant Quality Assurance program for operations (SSAR Section 17.4).

14.2.3.1 Conduct of Test Program

The initial test program conduct is the responsibility of the COL applicant / holder. Administrative procedures and requirements that govern the activities of the conduct of the initial test program includes the following:

- Format and content of test procedures
- Process for both initial issue and subsequent revisions of test procedures
- Review process for test results
- Process for resolution of failures to meet performance criteria and of other operational problems or design deficiencies
- Various phases of the initial test program and the requirements for progressing from one phase to the next as well as requirements for moving beyond selected hold points or milestones within a given phase
- Controls to monitor the as-tested status of each system and modifications including retest requirements deemed necessary for systems undergoing or already having completed testing
- Qualifications and responsibilities of the positions within the startup group

The startup administrative procedures supplement normal plant administrative procedures by addressing those administrative issues that are unique to the startup program.

14.2.3.2 Review of Test Results

Final review of the individual tests is the responsibility of COL management which is also responsible for final review of overall test results and for review of selected milestones or hold points within the test phases.

14.2.3.3 Test Records

Initial test program results are compiled and maintained according to the startup manual, and plant administrative procedures.

Test records demonstrating the adequacy of safety-related components, systems, and structures are retained for the life of the plant.

Retention periods for other test results are based on considerations of their usefulness in documenting initial plant performance characteristics.

14.2.4 Compliance of Test Program with Regulatory Guides

Subsection 1.9.1 and Table 1.9-1 discuss compliance with the applicable NRC regulatory guides.

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

The AP600 design team experience in the design, startup, and operation of pressurized water reactor plants is utilized in the development of the initial preoperational and startup test program for the plant. Other sources of experience reported and described in documents such as NRC reports including Inspection and Enforcement bulletins and Institute of Nuclear Power Operations

(INPO) reports including Significant Operating Event Reports (SOER) are also utilized in the AP600 initial preoperational and startup test program.

Special tests to establish a unique performance parameter of AP600 design features that will not change from plant to plant, are performed for the first plant only. Because of the standardization of the AP600 design, these special tests (designated as first plant only tests) are not required on follow plants. These first plant only tests are identified in the individual test descriptions. (See Subsection 14.2.9.)

14.2.6 Use of Plant Operating and Emergency Procedures

As appropriate and to the extent practicable, plant normal, abnormal, and emergency operating procedures are used when performing preoperational startup tests.

The use of these procedures is intended:

- To demonstrate the adequacy of the specific procedure or identify changes that may be required
- To increase the level of knowledge of plant personnel on the systems being tested

A test procedure using a normal, abnormal, or emergency operating procedure references the procedure directly or extracts a series of steps from the procedure in the way that accomplishes the operator training goals while safely and efficiently performing the specified testing.

As specified in section 14.2.10.34, a first plant only test is performed at low

power to demonstrate that core decay heat can be removed by the steam generators under the conditions of natural circulation (no reactor coolant pumps operating). In addition to providing experience and training for the operating staff as specified in NUREG-0737 action item I.G.1, the test data are used to confirm models for natural circulation.

14.2.7 Initial Fuel Loading and Initial Criticality

Initial fuel loading and subsequent initial criticality and power ascension to full licensed power are performed during the startup test program.

These operations are performed in a controlled and safe manner by using test procedures that specify:

- Required prerequisite testing
- Operational status of required systems
- Step-by-step instructions
- Precautions which must be observed
- Actions to be taken in the event of unanticipated or abnormal response

Following successful completion of preoperational testing, the systems are in an operable status consistent with the plant requirements for surveillance testing.

14.2.7.1 Initial Fuel Loading

The minimum conditions for initial core loading include:

- The composition, duties, and emergency procedure responsibilities of the fuel handling crew are established.

- Radiation monitors, nuclear instrumentation, manual initiation controls, and other devices to actuate alarms and ventilation controls are tested and verified to be operable.

- The status of systems required for fuel loading is established and verified.

- The status of protection systems, interlocks, mode switch, alarms, and radiation protection equipment is established and verified for fuel loading.

- Inspections of fuel and control rods have been made.

- Containment integrity has been established to the extent required by the Technical Specifications.

- The reactor vessel status has been established for fuel loading. Components are verified to be in place or out of the vessel as required for fuel loading.

- Required fuel handling tools are available, operational, and calibrated to include indexing of the manipulator crane with a dummy fuel element. The fuel handling tools have been successfully tested.

- Reactor coolant water quality requirements are established and the reactor coolant water quality is verified.

- The reactor vessel is filled with water to a level approximately equal to the center of the vessel outlet nozzles. The reactor coolant water is circulating at a rate which provides reasonable assurance of uniform mixing.

- The boron concentration in the reactor coolant is verified to be equal to or greater than required by the plant Technical Specifications for refueling and is being maintained under a surveillance program.

- Sources of unborated water to the reactor coolant system have been isolated and are under a surveillance program.

- The status of the core makeup tanks is verified as available.

- At least two neutron detectors are calibrated, operable, and located in such a way that changes in core reactivity can be detected and recorded. One detector is connected to an audible count rate indicator and a containment alarm.

- A response check of nuclear instruments to a neutron source is required within eight hours prior to loading (or resumption of loading if delayed for eight hours or more).

Fuel assemblies together with inserted components (control rods, burnable poison assemblies, primary and secondary neutron sources) are placed in the reactor vessel, according to an established and approved sequence.

During and following the insertion of each fuel assembly, until the last fuel assembly has been loaded, the response of the neutron detectors is observed and compared with previous fuel loading data or calculations to verify that the observed changes in core reactivity are as expected. Specific instructions are

provided if unexpected changes in reactivity are observed.

Because of the unique conditions that exist during initial fuel loading, temporary neutron detectors may be used in the reactor vessel to provide additional reactivity monitoring. Credit for the use of temporary detectors may be taken in meeting Technical Specifications' requirements on the number of operable source range channels.

14.2.7.2 Initial Criticality

Following initial fuel loading, the reactor upper internals and the pressure vessel head are installed. Additional mechanical and electrical tests are performed in preparation for critical and power operations. The following conditions exist prior to initial criticality:

- The reactor coolant system is filled and vented.

- Tests are completed on the control rod drive system that demonstrate that the control rods have been latched, that the control and position indication systems are functioning properly, and that the rod drop time under hot full flow conditions is less than the Technical Specifications' limit.

- Tests are completed that demonstrate that plant control and protection systems are operable and that the reactor trip breakers respond as designed to appropriate trip signals.

- The reactor coolant system is at hot no-load temperature and pressure. The reactor coolant boron concentration is such that the shutdown margin requirements of the Technical Specifications are satisfied for the hot shutdown condition.

Initial criticality is achieved in an orderly, controlled fashion by the combination of shutdown and control bank withdrawal and reactor coolant system boron concentration reduction.

During the approach to initial criticality, the response of the source range nuclear instruments is used as an indication of the rate of reactivity addition and the proximity to a critical condition so that criticality is achieved in a controlled, predictable fashion.

Rates for rod withdrawal and boron reduction are specified in such a way that the startup rate is less than one decade per minute.

Following criticality and prior to operation at power levels greater than five percent of rated power, physics tests are performed to verify that the operating characteristics of the reactor core are consistent with design predictions. During these tests, values are obtained for the reactivity worth of control and shutdown rod banks, isothermal temperature coefficient, and critical boron concentration for selected rod bank configurations.

Other tests at low power include verification of the response of the nuclear instrumentation system and radiation surveys.

14.2.7.3 Power Ascension

After the operating characteristics of the reactor have been verified by low-power testing, a power level ascension program brings the unit to its full rated power level in successive stages. At each successive stage, hold points are provided to evaluate and approve test results prior to proceeding to the next stage. The minimum test requirements for each successive stage of power ascension are specified in the applicable startup test procedures.

During the power ascension program, tests are performed at various power levels as follows:

- Statepoint data, to include secondary system heat balance measurements, are obtained at various power levels to include full licensed power. This information is used to project plant performance during power escalation, provide calibration data for the various plant control and protection systems, and provide the bases for plant trip setpoints.

- At prescribed power levels, the dynamic response characteristics of the primary and secondary systems are evaluated. System response characteristics are measured for design step load changes, rapid load reductions, and plant trips.

- Adequacy of the radiation shielding is verified by gamma and neutron radiation surveys. Periodic sampling is performed to verify the chemical and radiochemical analysis of the reactor coolant.

- Using the incore instrumentation as appropriate, the power distribution of the reactor core is measured to verify consistency with design predictions and technical specifications limits on peaking factors.

14.2.8 Test Program Schedule

The schedule for the initial fuel load and for each major phase of the initial test program is the responsibility of the COL management.

This schedule includes the timetable for generation, review, and approval of procedures as well as the actual testing and analysis of results.

During the preoperational phase, testing is performed as availability allows. However, the interdependence of systems are also considered so that common support systems (such as electrical power distribution, service and instrument air, and the various makeup water and cooling systems) are tested as early as possible.

Sequencing of tests during the startup depends on construction progress, specified power and flow conditions and intersystem prerequisites.

The schedule establishes that, prior to core load, the test requirements are met for those plant structures, systems, and components that are relied upon to prevent, limit, or mitigate the consequences of postulated accidents.

Testing is sequenced so that the safety of the plant is not dependent on untested systems, components, or features.

14.2.9 Individual Test Descriptions

Test abstracts are provided for the preoperational testing of systems / components that perform safety related functions; for systems / components that are non-safety related but perform defense-in-depth functions or which are important based on RTNSS (Regulatory Treatment of Non-Safety Systems) evaluations; and for the startup testing of the plant. A limited number of these testing abstracts confirm design or analysis assumptions used in the standard AP600 design. Because the AP600 design is standardized, testing to confirm design and analysis predictions and assumptions need only be performed on the first AP600 plant. These testing abstracts are clearly identified.

Abstracts for pre-operational testing of the plant components / systems which perform no safety functions and have no direct impact on plant safety are not provided in support of Design Certification.

14.2.9.1 Preoperational Tests of Safety-Related Functions

14.2.9.1.1 Reactor Coolant System Preoperational Test

Purpose

The purpose of the safety-related reactor coolant system testing is to verify that the as-installed reactor coolant system properly performs the following safety-related functions:

- Provide reactor coolant system pressure boundary integrity as specified in section 5.2

- Provide core cooling and boration in conjunction with the passive core

cooling system as described in sections 5.1 and 6.3.

- Measure process parameters required for safety-related actuations as specified in sections 7.2, 7.3 and 7.4.

- Measure process parameters required for post-accident monitoring as specified in section 7.5

Prerequisites

The construction tests are successfully completed and prerequisite testing of required interfacing systems is completed to support the specified testing. The reactor coolant system is filled and vented and then pressurized above the minimum pressure required for reactor coolant pump operation as specified in the appropriate design specifications. Component cooling water to the reactor coolant pumps is initiated prior to pump startup.

A hydrostatic test pump is available for the reactor coolant system pressure boundary integrity testing. The reactor vessel lower and upper internals and the closure head are installed. The closure head studs are tensioned to the design value for the hydrostatic test pressure. Temporary temperature instrumentation is installed to measure the temperature of the steam generator tube sheets, the bottom of the pressurizer, and the closure flange of the reactor vessel. The pressurizer safety valves and instrumentation within the test boundary are either removed, recalibrated or verified to be able to withstand the hydrostatic test pressure. Welds within the test boundaries are verified as ready for hydrostatic testing.

General Test Method and Acceptance Criteria

Reactor coolant system performance is observed and recorded during a series of individual component and system tests. The following testing demonstrates that the reactor coolant system can perform its safety-related functions as described above:

a) The integrity and leaktightness of the reactor coolant system and the high-pressure portions of associated systems is verified by performing a cold hydrostatic pressure test in conformance with Section III of the American Society of Mechanical Engineers (ASME) Code. The reactor coolant system is pressurized by operation of the temporary hydrostatic test pump, to test pressure in stages, monitoring system welds, piping, and components for leaks at each stage. The hydrostatic test verifies that there are no leaks at welds or piping within the test boundaries during the final inspection. Leaks at valves, flanges, or mechanical fittings are acceptable during the hydrostatic test. They are repaired prior to the final inspection, or the leak may be isolated, repaired, and retested at a later date.

b) Proper operation of the safety-related reactor coolant system and reactor coolant pressure boundary valves is verified by the performance of baseline inservice tests as specified in section 3.9.

c) The operability of the pressurizer safety valves is demonstrated by a bench test at temperature and pressure with steam as the pressurizing fluid or with a suitable in-situ test. This testing verifies that each pressurizer safety valve actuates at the pressure as specified in section 5.4, with a tolerance as specified in the Technical Specifications. The safety valve rated capacity as recorded on the valve vendor code plates

is greater than or equal to that specified in section 5.4.

d) During hot functional testing, reactor coolant system leakage is verified to be within the limits specified in the Technical Specifications. The pressurizer water level is set to a no-load level, the chemical and volume control system makeup pumps and letdown line do not operate, and no primary system samples are taken. During this test, the identified and unidentified reactor coolant system leakage rates are determined by monitoring the reactor coolant system water inventory over a specified period of time.

e) The leakage across individual valves between high pressure and low pressure systems, as specified in the Technical Specifications, is verified to be less than design requirements.

f) The as-installed safety valve discharge chamber rupture disks are inspected to verify the manufacturer's stamped set pressure is within the limits specified in the appropriate design specifications.

g) Proper calibration and operation of safety-related instrumentation, controls, actuation signals and interlocks is verified. This testing includes the following:

- hot leg and cold leg resistance temperature detectors
- cold leg flow instrumentation
- reactor coolant system wide range pressure transmitters
- hot leg level instruments
- pressurizer level instruments
- reactor coolant pump bearing water temperature detectors
- reactor coolant pump speed sensor instruments

- reactor vessel head vent valve controls

This testing includes selected demonstration of proper actuation of safety-related functions from the main control room.

h) Automatic opening of the reactor coolant pump breakers following appropriate safety-related actuation signals is demonstrated.

Tests associated with the automatic depressurization functions of reactor coolant system components are described in section 14.2.9.1.3.

Section 14.2.9.1.2 will be provided later.

14.2.9.1.3 Passive Core Cooling System Testing

Purpose

The purpose of the passive core cooling system testing is to verify that the as-installed components and their associated piping and valves properly perform the following safety functions, described in section 6.3:

- Emergency core decay heat removal
- Reactor coolant system emergency makeup and boration
- Safety injection
- Containment pH control

Prerequisites

The construction testing of the passive core cooling system is successfully completed. The preoperational testing of the reactor coolant system, normal residual heat removal system, chemical and volume control system, the Class 1E dc and uninterruptable power supply, the ac electrical power and distribution systems, and other interfacing systems required for operation of the above systems and data collection is completed as needed to support the specified testing and system configurations. A source of water, of a quality acceptable for filling the passive core cooling system components and the reactor coolant system, is available.

General Test Method and Acceptance Criteria

The performance of the passive core cooling system is observed and recorded during a series of individual component testing and testing with the reactor coolant system that characterizes the passive core cooling system modes of

operation. The following testing demonstrates that the passive core cooling system operates as specified in Section 6.3 and as specified in appropriate design specifications.

a) Proper operation of safety-related valves is verified by the performance of baseline inservice tests as specified in section 3.9.6.

b) Proper calibration and operation of safety-related instrumentation, controls, actuation signals, and interlocks is verified. This testing includes the following:

- Passive residual heat removal heat exchanger flow
- Core makeup tank level
- In-containment refueling water storage tank level
- Containment floodup level
- Core makeup tank inlet/outlet valve controls
- Passive residual heat removal heat exchanger inlet/outlet valve controls
- In-containment refueling water storage tank outlet valve controls
- Containment recirculation valve controls
- Automatic depressurization valve controls

This testing includes demonstration of proper actuation of safety-related functions from the main control room. This testing does not include actuation of the passive core cooling system squib valves. Testing of the squib valves is described in item (t) below.

The passive core cooling system emergency core decay heat removal function is verified by the following testing of the passive residual heat removal heat exchanger.

c) During hot functional testing of the reactor coolant system, the heat exchanger supply and return line steady state piping water temperatures are verified. This testing is performed with the chemical and volume control system purification loop in service.

d) The heat transfer capability of the passive residual heat removal heat exchanger with natural circulation flow is verified. This testing is performed during reactor coolant system hot functional tests and the reactor coolant pumps are not running.

e) The proper operation of the passive residual heat removal heat exchanger and its heat transfer capability with forced flow is verified by operating the heat exchanger with all four reactor coolant pumps running. This testing is performed during reactor coolant system hot functional testing at conditions consistent with the heat exchanger inservice testing specified in Section 3.9.6.

f) The heatup characteristics of the IRWST water is verified by measuring the vertical water temperature gradient that occurs in the IRWST water at the PRHR HX tube bundle and at several distances from the HX tube bundle, during testing in Item (d), above. **Note that this verification is required only for the first plant.**

The passive core cooling system emergency makeup and boration function is verified by the following testing of the core makeup tanks.

g) The resistance of the core makeup tank cold leg balance lines is determined by filling the core makeup tanks with flow from the cold legs. This testing is performed with the reactor coolant system cold and filled with a constant, measured makeup flow from the normal residual heat removal pumps. The reactor coolant system is maintained at a constant level above the top of the cold leg balance line(s). The core makeup tanks are vented during this test. The normal residual heat removal system flow rate and the pressure differential across the cold leg balance line are used to determine the resistance of the line.

h) During hot functional testing of the reactor coolant system, the tank cold leg balance line steady state piping water temperature gradient is verified.

i) Proper operation of the core makeup tanks to perform their reactor water makeup and boration function is verified by initiating recirculation flow through the tanks during reactor coolant system hot functional testing. This testing is initiated by simulating a safety signal which opens the tank discharge isolation valves, and stops reactor coolant pumps after the appropriate time delay. The proper tank recirculation flow after the pumps have coasted down is verified. Based on the cold leg temperature and temporary flow instrumentation, the net mass injection rate into the reactor is verified. **Note that this verification is required only for the first plant.**

The passive core cooling system safety injection function is verified by the following testing of the core makeup tanks, accumulators, in-containment refueling water storage tank, containment sump, automatic depressurization, and their associated piping and valves.

j) Proper flow resistance from each of the core makeup tanks is verified by gravity draining each tank, filled with cold water, into the empty RCS. Air enters the top of the draining tank from the reactor coolant system cold leg via the cold leg balance line. If necessary, the flow orifice in the core makeup tank discharge line is to be resized, and the CMT retested to obtain the required injection flowrate.

k) The proper resistance of the accumulator discharge lines is verified by performing a blowdown from a partially pressurized accumulator into the empty reactor. If necessary, the flow orifice in the accumulator discharge line is to be resized and the accumulator retested to obtain the required discharge line resistance.

l) The proper flow resistance of each in-containment refueling water storage tank discharge line and valves is verified by gravity draining into the empty reactor with the tank level initially at 4 feet of water. If necessary, the flow orifice in the in-containment refueling water storage tank discharge line is to be resized and retested, until the required injection flowrate is achieved. A spool piece with prototypical resistance may be used to simulate the squib valves in the flow paths tested.

m) The flow resistance of the piping and valves from the in-containment refueling water storage tank to each containment sump and from each containment sump to the reactor is verified by gravity draining from the

incontainment water storage tank filled to the 4 ft. level into the empty reactor. This testing is performed using a temporary piping connection from one incontainment refueling water storage tank to sump flowpath to the other sump to reactor piping, while the incontainment refueling water storage tank discharge nozzle associated with this sump is plugged. A spool piece with prototypical resistance may be used to simulate the squib valves in the flow paths tested.

n) The resistance of each automatic depressurization stage 1, 2, and 3 flowpath and flowpath combinations is verified by pumping cold water from the in-containment refueling water storage tank into the cold, depressurized reactor coolant system; and back to the in-containment refueling water storage tank using the normal residual heat removal pump(s). Temporary instrumentation may be used to measure the pressure drop across the flow paths tested.

o) The resistance of each automatic depressurization stage 4 flowpath and all their flowpath combinations is verified by pumping cold water from the in-containment refueling water storage tank into the cold, depressurized reactor coolant system; and back to the in-containment refueling water storage tank using the normal residual heat removal pump(s). Temporary instrumentation may be used to measure the pressure drop across the flow paths tested. The automatic depressurization stage 4 squib valves may not be included in this test.

p) The operability of the vacuum breakers in the automatic depressurization discharge lines following discharges into the in-containment refueling water storage tank is demonstrated following the completion of a automatic depressurization stage one partial blowdown from the heated and pressurized reactor coolant system.

q) During hot functional testing of the reactor coolant system, proper operation of automatic depressurization is demonstrated by blowing down the reactor coolant system. This testing verifies proper operation of the stage 1, 2, and 3 components including the ability of the spargers to limit loads imposed on the in-containment refueling water storage tank by the blowdown. Proper operation of the in-containment refueling water storage tank overflows and proper operation of the stage 1, 2 and 3 valves is demonstrated during blowdown conditions. **Note that this verification is required only for the first plant.**

r) The proper initiation of draindown of a core makeup tank and operation of their level instrumentation is verified when the tanks are filled with cold water and steam replaces the water drained from the tanks. This testing is performed with the reactor coolant system at elevated temperature and pressure. The reactor coolant system is drained to the hot leg level, and the pressure in the RCS is reduced to create steam. Testing is initiated by opening the core makeup tank discharge isolation valves, and demonstrates the proper operation of the tank steam distributor before draindown initiates. **Note that this verification is required only for the first plant.**

s) The proper operation of at least one of each squib valve size and type including a containment recirculation, in-containment refueling water storage tank injection, and a stage 4 automatic depressurization squib valve are demonstrated. The squib valve performance and the flow resistance of the actuated squib valves is compared to the squib valve qualification testing results. These tests may be performed prior to reactor coolant system cold preoperational tests.

The passive core cooling system containment pH control function is verified by inspections.

14.2.9.2 Preoperational Testing of Defense-In-Depth and RTNSS-Important Functions

14.2.9.2.1 Reactor Coolant System

Purpose

The purpose of this testing is to verify that the as-installed reactor coolant system properly performs the following defense-in-depth or RTNSS-important functions:

- verify reactor coolant pump operation to circulate reactor coolant,
- verify proper pressurizer pressure and level control operations including alarms, actuations and setpoints.
- verify proper operation of the control circuitry and operation of reactor coolant system valves.

Prerequisites

The construction tests are successfully completed, and the component testing and instrument calibration of the reactor coolant system components and instruments, or specific portion to be tested are specifically completed. Prerequisites of all required interfacing systems, as needed, is completed to the extent sufficient to support the specified testing and the appropriate system configuration. The reactor coolant system is filled and vented and then

pressurized above the minimum pressure required for reactor coolant pump operation as specified in the appropriate design specifications. Component cooling water to the reactor coolant pumps is initiated prior to startup.

General Test Methods and Acceptance Criteria

Reactor coolant system performance is observed and recorded during a series of individual component and integrated system testing that includes all modes of reactor coolant system operation. The following testing demonstrates that the reactor coolant system operates as specified in Chapter 5 and as specified in the applicable design specifications.

a) Reactor coolant pump performance and operating characteristics are verified with the reactor coolant system at cold conditions. All four reactor coolant pumps are operated in all combinations. Pump operating characteristics are measured and recorded to verify the reactor coolant pumps are operating within the limits as specified in the appropriate design specifications.

b) Following completion of the cold preoperational tests, the plant is heated up from cold shutdown conditions to hot standby by operating the reactor coolant pumps and the pressurizer heaters. The reactor coolant system is operated at full flow conditions for a minimum of 240 hours prior to core loading. The reactor coolant temperature must be at or above 515°F for at least one-half of this operating time. In addition to facilitating reactor coolant system tests required to be performed hot and pressurized, hot functional tests allow the plant operators to control the plant using the plant operation procedures for the reactor coolant system, auxiliary systems, and principal secondary systems prior to nuclear operation.

Other preoperational tests that require these hot and / or dynamic conditions are conducted during hot functional testing as coordinated by the test procedure for this test.

c) During hot functional testing, pump operating characteristics are measured and recorded at various temperature plateaus to verify the reactor coolant pumps are operating within appropriate design limits. With the reactor coolant system at normal operating temperature and pressure and with all four pumps operating, measurements are made of the reactor coolant flow in each cold leg to estimate the reactor coolant system flow rate. The reactor coolant flow rate is consistent with design expectations for the hot functional test configuration, with adequate allowance for measurement uncertainty.

d) Tests are performed to demonstrate the stability and response of the pressurizer pressure control logic, including the verification of alarm and control functions. Pressurizer pressure control is verified by a series of individual component and system testing that includes all modes of pressurizer pressure control as specified in section 7.7.

e) Tests are performed to demonstrate the response of the pressurizer level control logic, including the verification of alarm and control functions. Pressurizer level control is verified by a series of individual component and system testing that includes all modes of pressurizer level control as specified in section 7.7.

NOTE: Sections 14.2.9.2.2 through 14.2.9.2.4 to be provided later

14.2.9.2.5 Normal Residual Heat Removal System Testing

Purpose

The purpose of the normal residual heat removal system testing is to verify that the as-installed components and associated piping, valves, and instrumentation properly perform the following defense-in-depth or RTNSS important functions:

- Remove reactor core decay heat and cool the reactor coolant system during shutdown operations at low pressure and temperature.
- Remove reactor core decay heat from the reactor coolant system during reduced reactor coolant inventory operations in Modes 5 and 6.
- Following actuation of the automatic depressurization valves, provide makeup to the reactor coolant system at low pressure and circulate coolant from the containment after draindown of the in-containment refueling water storage tank.
- Provide low temperature overpressure protection for the reactor coolant system.

Prerequisites

The construction testing of the normal residual heat removal system is successfully completed. The required preoperational testing of the in-containment refueling water storage tank, reactor coolant system, passive core cooling system, component cooling water system, service water system, central

chilled water system, ac electrical power and distribution systems, and other interfacing systems required for operation of the above systems and data collection is available as needed to support the specified testing and system configurations. Additionally, the reactor coolant system and the in-containment refueling water storage tank is filled with appropriate quality water.

General Test Acceptance Criteria and Methods

Normal residual heat removal system performance is observed and recorded during a series of individual component and system testing, that characterizes system operation. This testing demonstrates that the normal residual heat removal system operates as specified in subsection 5.4.7, and as specified in applicable design specifications:

a) Proper operation of valves to open, to close, or to control flow as required to perform the defense-in-depth functions is verified.

b) Proper operation of system controls, alarms, instrumentation, and interlocks associated with performing the defense-in-depth functions is verified.

c) The capability of the normal residual heat removal system pumps to perform their defense-in-depth functions is verified. This testing includes verification of the pump flow rate corresponding to the expected system alignment, pump miniflow operation, and verification that adequate NPSH is available for the configurations tested. The following configurations shall be tested with each pump operating individually:

- Recirculation from and to the reactor coolant system with the

reactor coolant system at mid-loop hot leg water level and atmospheric pressure;

- Makeup to the reactor from the in-containment refueling water storage tank with the minimum in-containment refueling water storage tank water level

d) Demonstrate the capability of the normal residual heat removal heat exchangers to provide the minimum heat removal rates from the reactor coolant by testing performed with flow from and to the heated RCS, with each RNS pump / heat exchanger operating individually.

e) Proper operation of the normal residual heat removal system relief valve which provides low temperature overpressure protection for the reactor coolant system is verified by the performance of baseline inservice testing , as specified in Section 3.9.6.

f) Proper operation of the normal residual heat removal system containment isolation valves is verified as described in Section 14.2.9.1.10.