NRC INSPECTION MANUAL

INSPECTION PROCEDURE 72304

AP1000 STARTUP TEST INSPECTIONS

PROGRAM APPLICABILITY: IMC 2514

72304-01 INSPECTION OBJECTIVES

01.01 Determine whether the startup test procedures are consistent with the licensee's technical and administrative criteria, Combined Operating License (COL) commitments, Design Control Document (DCD), Final Safety Analysis Report (FSAR), Regulatory Requirements, and Technical Specifications (TS).

01.02 Witness AP1000 startup tests and determine whether they are being performed in accordance with the COL, DCD, FSAR, and test procedures.

01.03 Determine whether the startup test results are being evaluated to ensure that test acceptance criteria are met.

72304-02 INSPECTION REQUIREMENTS

02.01 Review of Startup Test Procedures: Select a minimum of four tests from Attachment 24, Table 1, "AP1000 Startup Tests." Review the startup test procedures for the following and the additional requirements in the respective Attachments 1 through 23.

a. Management approval is indicated. All test procedures shall include licensee operations management review, regardless of who prepares the procedures.

b. Safety review committee approval is indicated. The FSAR and TS will identify those tests that require special committee review and will define the committee composition.

c. Format is consistent with ANSI N18.7 and the guidance in Regulatory Guide (RG) 1.68, Revision 2, (August, 1968), "Initial Test Programs for Water-Cooled Nuclear Power Plants," Appendix C, "Preparation of Procedures."

d. Test objectives are clearly stated, along with all DCD and FSAR commitments.

e. Pertinent prerequisites are identified, as applicable:

   1. Required plant systems are specified.
   2. Proper facility procedures are specified.
   3. Calibration checks are completed, limit switch setting protective device setting included, where applicable.
   4. Special supplies and test equipment are specified.

f. Special environmental conditions are identified.

g. Acceptance criteria are clearly identified. The test shall require a comparison of the test results with the acceptance criteria.

h. The sources of the acceptance criteria and critical steps in the test procedure are identified; for example, the DCD, FSAR, TS. Sources of acceptance criteria are only necessary for critical variables.

i. Initial test conditions are specified, such as the following:

   1. valve lineups
   2. electrical power and control requirements
   3. temporary installations (instrumentation, electrical, and piping)
   4. temperatures, pressures, flows
   5. water chemistry
   6. other

j. All references are listed; that is, FSAR, drawings, codes, and other requirements.

k. Step-by-step instructions are provided to ensure that test objectives are met. Use of plant operating procedures by reference is permissible, provided the operating procedures have been approved for use as stated in the FSAR and TS.

l. Items, including prerequisites, can be initialed to indicate their completion. Signoffs of individual steps should include the date and time, if the actual time is pertinent to the test. Initials and check marks or stamps may be used if they are traceable to an individual.

m. Provisions and instructions are provided for recording details of test performance; that is, deficiencies, their resolution, and retest.

n. Steps are provided to restore temporary connections, disconnections, or jumpers to their normal state or to control them.

o. Test records identify the personnel conducting the testing and evaluating the test data.

p. Quality assurance verification is provided for critical steps or parameters. Modifications of the tests from how they are described in the FSAR, in any manner, shall require special review, evaluation, and approval pursuant to Appendix D, Section VIII, of the AP1000 Design Certification Rule, Title 10 of the *Code of Federal Regulations* (10 CFR) 52.63(b)(2), and 10 CFR 52.97(a)(2).

q. Each test procedure is consistent with the respective test description in the FSAR.

r. Special precautions for personnel and equipment safety are specified. Guidance appears in Appendix C, Section 1.c, “Preoperational Test Procedures—Special Precautions,” of RG 1.68, Revision 2.

s. Instructions for testing a system or component over the full operating range or load change are provided. Guidance appears in RG 1.68, Revision 2, Appendix A, Section 1, “Preoperational Testing.”

t. Provisions are made for the data taker to indicate the acceptability of the data. Guidance appears in RG 1.68, Revision 2, Appendix C, Section 1.i, “Preoperational Test Procedures—Documentation of Test Results.”

u. Expected performance of automatic controls; for example, automatic actuation of process components and safety systems, is specified. Guidance appears in RG 1.68, Revision 2, Appendix A, “Initial Test Program,” Section 1, “Preoperational Testing.”

v. Provisions are made for using the plant simulator as a training means for startup testing and for updating the simulator with data taken during the startup testing.

w. The tests shall meet the intent and operability requirements of the TS.

02.02 Witnessing Startup Tests: The inspector shall witness the tests selected in Section 02.01. Before witnessing a test, the inspector shall have completed a review of the test procedure in accordance with Section 02.01 of this inspection procedure (IP). The inspector must be familiar with the test procedure to adequately witness the testing described in this IP. Communication must be maintained between the inspector and the licensee so that the licensee’s test dates are known far enough in advance for the inspector to be ready to witness the selected tests. Licensees are not expected, nor are they to be asked, to delay conduct of a test pending the inspector's arrival. The Inspector shall verify the following:

a. Overall Crew Performance.

1. The current test procedure must be available and in use by all crew members involved in the test.

2. Minimum crew requirements are met for both licensed and nonlicensed operators.

3. All crew members attend the pre-job brief for the test.

4. Verify procedural prerequisites and initial conditions have been met by reviewing the required records; for example, valve lineup list, instrumentation calibration procedure, system checklist, or signoff item in the listed test procedure, or by direct observation; for example, monitoring instrumentation indications, valve positions, equipment start position switches, or personnel actions. Additionally, if the test involves the use of a TS special test exception limiting condition for operation (LCO), ensure that the LCO is adhered to and the applicable surveillance requirements are performed.

5. Test equipment must be calibrated and ready for use. Verify that the equipment is not outside its calibration period.

6. Verify that crew actions are correct, timely, and coordinated. The individual directing the test activities must have knowledge of the activities of each crew member and of the time sequence of activities, when necessary. The test sequence may need to be interrupted or modified. These interruptions or changes must be communicated to crew members, and any changes must be handled in accordance with existing procedures. On a sampling basis, verify adherence to the procedural limitations and precautions and the individual test steps.

7. Summary analysis shall be made to assure a proper plant response to the test. The test procedure must state the acceptance criteria.

8. Verify all data are collected for the final analysis by the proper personnel. All necessary raw data must be gathered in a timely manner following the test. The person in charge must ensure that these data are collected, assembled, and transferred to the person(s) performing the final analysis.

b. Test Results: The inspector shall observe or evaluate the most important events or data-gathering activities and shall verify the following:

1. All test acceptance criteria have been met.

2. The licensee's preliminary test evaluation is consistent with inspector observations.

3. The test adheres to the requirements of any TS LCO affected during the test.

02.03 Evaluation of Test Results: For the tests selected for inspection from Table 1 of this inspection procedure and following the licensee's evaluation and acceptance of the test results, inspect the licensee's completed test data, as applicable below:

a. Review all changes, including deletions, to the test program for conformance to the requirements established in the FSAR and guidance in RG 1.68. If a change results in the failure to satisfy FSAR commitments, or eliminates testing identified in RG 1.68, the change should have been reviewed and approved pursuant to 10 CFR 50.59, "Changes, Tests, and Experiments." In addition,

1. Verify that each change was approved in accordance with the pertinent administrative procedures and that the basis for the change is documented.

2. Verify that the test procedure is annotated to identify test changes.

3. Verify that the test change has been completed if it entails specific actions.

4. Verify that nothing changed the basic objectives of the test.

b. Review all test deficiencies. In some cases, the test data will not be within the written predicted acceptance criteria. If this occurs, determine whether further licensee actions will be or have been taken. These actions may require (1) plant design changes, (2) evaluation by a manufacturer of the error between the design and predicted plant performance, or (3) restriction of plant operations because of the difference in plant performance and predicted acceptance criteria. The inspector must determine that, for each of the above actions, licensee follow-up corrective actions have been correctly performed (i.e., 10 CFR 50.59 review, licensing approval if required, and subsequent testing for each design change) and must do the following:

1. Verify that each test deficiency has been resolved, that the resolution has been accepted by appropriate management, and that retest requirements have been completed.

2. Verify that any system or process changes necessitated by a test deficiency have been properly documented and reviewed.

3. Verify that deficiencies that constitute a reportable occurrence as defined by the TS have been properly reported (inspectors follow up on reportable deficiencies).

c. Review test exceptions that are inconsequential errors in the test procedure (e.g., typographical errors), which the licensee believes will not invalidate the test or create a test deficiency, by doing the following:

1. Verify that they were documented during the test.

2. Verify that they were subsequently approved after the test was completed.

3. Confirm that the licensee has administrative and procedural controls in place to address such errors.

d. Review the Test Procedure: Make an independent technical analysis and use technical judgment to assure that the licensee's analysis has been performed correctly. Confirm that all test results have been compared with acceptance criteria and do the following:

1. Verify that data sheets have been completed.

2. Verify that all data are recorded where required and are within acceptance tolerances.

3. Verify that all test changes, deficiencies, and exceptions are noted.

4. Verify that individual test steps and data sheets have been properly initialed and dated.

e. Review the Test Summary and Evaluation: Review the test data packages assembled by the licensee to ensure that the package is complete (as defined in licensee procedures). Ascertain that the licensee has verified that the acceptance criteria of the test procedure have been met. The inspector should use the appropriate means available (e.g., computer software) to ensure that test data support the conclusion that test acceptance criteria have been met. The inspector should also do the following:

1. Verify that the cognizant engineering function has evaluated the test results and has signified that the testing demonstrated that the system or component met design requirements.

2. Verify that the licensee specifically compared test results with established acceptance criteria.

3. Verify that those personnel responsible for the review and acceptance of test results have documented their review and acceptance of the data package and the evaluation.

4. If the offsite review committee or equivalent has audited the test package, verify that the records reflect this audit and that its comments are included and corrective action has been taken.

5. Verify the Quality Assurance/Safety Group or another independent organization's review of test results, as prescribed in the FSAR or other commitments.

f. Verify that the test results have been approved. Verify that those personnel charged with responsibility for review and acceptance of test results have documented their review and acceptance of the data package and the evaluation.

Normally, the test results are reviewed through the startup organization, culminating in review by a committee comprised of the plant superintendent, the nuclear steam system supplier site manager, the architect/engineer site manager, or their designees. FSAR or other commitments frequently require review by Quality Assurance, Safety Review, or another independent organization.

Frequently, test review committees will also have examined the results in accordance with TS requirements.

72304-03 INSPECTION GUIDANCE

General Guidance

Refer to the attachments for test-specific inspection requirements and guidance that are based on the startup test program in Chapter 14, "Initial Test Program," of the AP1000 DCD. Some of these attachments have general guidance that is labeled and located at the end of each of those attachments. The inspector should be fully aware that the test requirements in Chapter 14 of the DCD for a particular test are subject to change. The primary purpose of the inspection requirements and guidance in the attachments is to focus the attention of the inspectors and to provide insight into the specific aspects of each startup test. The inspection requirements are not regulatory requirements and are provided to assist the inspector's complete review of AP1000 startup tests. The inspector is to use the attachments for test procedure review, witnessing, and results evaluation.

Specific Guidance

03.01 Review of Startup Test Procedures

None

03.02 Witnessing Startup Tests. The inspector should determine the proper procedure revision by examining the licensee's master index or the current procedure file. Assure by examination and discussions that crew members are using the test procedure with the proper revision number and are familiar with the procedural requirements, especially the limitations and precautions.

Crew coordination is an important part of any test since many of the steps involve coordinated activities between two or more crew members. The individual directing the test activities must have knowledge of the activities of each crew member and of the time sequence of activities, when necessary. The test sequence may need to be interrupted or modified. These interruptions or changes must be communicated to crew members and any changes must be handled in accordance with existing procedures. On a sampling basis, verify adherence to the procedural limitations and precautions and the individual test steps.

A summary analysis is made to assure proper plant response to the test. The test procedure should state the acceptance criteria. Crew members should be knowledgeable of the expected events at their stations; that is, control rod position, boron concentration, thermal power level, core axial and radial power distribution, departure from nucleate boiling ratio (DNBR), peak linear heat rates, system flow rates, pressures, and temperatures. This type of information should be available to the person in charge in a timely manner so that an evaluation may be made soon after performing the test. Events or data that are individually within expectations may collectively indicate unexpected results.

All data are collected for final analysis by the proper personnel. All necessary raw data must be gathered in a timely manner following the test. The person in charge must ensure that these data are collected, assembled, and transferred to the person(s) performing the final analysis.

Independent of the licensee evaluation, the inspector should observe and evaluate certain events or data gathering during and following the tests. These events or data gathering activities should be selected during the inspector's review of the test procedure. The inspector should be knowledgeable of the expected measurements for important test parameters; for example, (1) the flow rate drops to 1/10 of the initial value for x seconds and returns to some other value within 2 minutes, (2) a specific reactivity change occurs during a specified time interval, or (3) computer printout values are read to be within the acceptance criteria.

03.03 Evaluation of Test Results

None

72304-04 RESOURCE ESTIMATE

This IP supports review of the startup testing for this design. The resource estimate for this IP with the completion of a minimum of four tests selected from Table 1 in Attachment 24 is approximately 320–480 hours per unit, of direct inspection effort. This inspection uses 80 hours of direct inspection effort as an estimate needed to satisfactorily complete the inspection requirement associated with each startup test.

72304-05 PROCEDURE COMPLETION

Completion of a minimum of four startup tests per unit which are selected from Attachment 24, Table 1, and reported in the Reactor Program System (RPS) would be considered completion of this procedure.

Tables 2 and 3 of Attachment 24 provide other startup tests that can be inspected by the region. Regional management approval should be obtained before selecting tests from Tables 2 or 3 for inspection.

72304-06 REFERENCES

AP1000 Design Control Document, Chapter 14, "Initial Test Program" (Agencywide Documents Access and Management System Accession No. ML11171A500)

RG 1.68, Revision 2, "Initial Test Programs for Water-Cooled Nuclear Power Plants," August 1978

IMC 2514, "AP1000 Reactor Inspection Program—Startup Testing Phase"

IMC 2515, "Light-Water Reactor Inspection Program—Operations Phase"

72304-07 LIST OF ACRONYMS

AP1000	Westinghouse Advanced Pressurized Water Reactor
BOL	Beginning of Life
COL	Combined Operating License
DCD	Design Control Document
DNBR	Departure from Nucleate Boiling Ratio
EOL	End of Life
FSAR	Final Safety Analysis Report
FW	Feedwater
IIS	Incore Instrumentation System
IR	Intermediate Range
IRWST	In-containment Refueling Water Storage Tank
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
LCO	Limiting Conditions for Operation
MCR	Main Control Room
NOP	Normal Operating Pressure
NOT	Normal Operating Temperature
NSIR	Nuclear Security and Incident Response
NSSS	Nuclear Steam System Supplier
PRHRHX	Passive Residual Heat Removal Heat Exchanger
PXS	Passive Core Cooling System
PZR	Pressurizer
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RNS	Normal Residual Heat Removal System
RPCS	Reactor Power Control System
RPIS	Rod Position Indication System
RPRS	Rapid Power Reduction System
RPS	Reactor Protection System
RTD	Resistance Temperature Detector
RWS	Remote Shutdown Work Station
SDG	Standby Diesel Generator
SRO	Senior Reactor Operator

SR	Source Range
SRM	Source Range Meter
S/G	Steam Generator
S/U	Startup
Tave	Average Temperature of RCS Coolant.
T/C	Thermocouple
T/G	Turbine Generator
TS	Technical Specifications
3D	Three Dimensional

Attachments:

01. Axial Flux Difference Instrumentation Calibration (Flux Asymmetry)
02. Bank Worth Measurement (Rod Worth)
03. Boron Endpoint Determination (Boron Reactivity Worth Measurements)
04. Determination of Physics Testing Range
05. Fuel Loading Prerequisites and Periodic Checks
06. Incore Instrumentation System (Core Performance)
07. Initial Criticality
08. Initial Fuel Loading
09. Isothermal Temperature Coefficient Measurement (Moderator Temperature Coefficient)
10. Load Follow Demonstration Test
11. Loss of Offsite Power
12. Natural Circulation
13. Passive Residual Heat Removal Heat Exchanger
14. Plant Trip from 100-Percent Power
15. Rapid Power Reduction System
16. Reactor Coolant System Flow Measurement
17. Reactor Power Control System
18. Remote Shutdown Work Station
19. Resistance Temperature Detectors—Incore Thermocouple Cross Calibration
20. Rod Cluster Control Assembly Out of Bank Measurements
21. Rod Drop Measurements
22. Rod Position Indicator System
23. 100-Percent Load Rejection
24. AP1000 Startup Tests

Attachment 01—Axial Flux Difference Instrumentation Calibration (Flux Asymmetry)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Axial flux difference signals from the nuclear instrumentation power range (excore) detectors are within the specified limits in the plant-specific DCD. The primary function of the incore instrumentation system (IIS) is to generate a three-dimensional (3D) flux map so as to calibrate the excore power range detectors. The operator can check the peaking factor. The axial flux difference is displayed in the main control room (MCR), and the operators can get hard copies of the 3D flux maps.
   2. The signals from the excore detectors indicate the actual incore power distribution.
   3. The MCR panel displays the axial flux difference signals.

b. Assure these precautions are identified and met during the test: The control room operators can check the 3D flux maps of the IIS to determine whether the outputs of the excore system appear correct and can monitor the reactor overpower and overtemperature trips. The reactor thermal power calculated by a heat balance calculation can also be used in this verification.

   1. Critical peaking factors, DNBR, and peak linear heatup rate shall not be exceeded.
   2. Safe-shutdown margin is maintained.
   3. Reactivity changes only with specified approval.
   4. Reactor coolant system (RCS) temperature and pressure are maintained.
   5. Control rod drive control system meets TS and administrative requirements.
   6. Reactor protection circuits are functional.
   7. Overtemperature and overpower trips should not initiate.
   8. Excore instrumentation power range high neutron trip (high setpoint) and high positive flux rate do not initiate.

c. Confirm these initial conditions are identified and are met during the test:

   1. Reactor power level is in the range of power ascension testing.
   2. IIS is available.
   3. Axial flux difference instrumentation is available.
   4. Overtemperature and overpower trips are functional.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Sufficient data points are selected to ensure accurate calibration of the nuclear instrumentation power range channels.

2. Data points are for reactor thermal power and outputs of incore and nuclear (power range) instrumentation.
3. Axial power distribution is varied to obtain sufficient data points.
4. Agreement is verified between reactor thermal power and output of IIS in regard to reactor power level before proceeding.
5. Calibration of excore instrumentation is based on data for reactor thermal power and output of IIS for various axial power distributions.
6. Allowed tolerance for flux difference signals is stated.

<u>Attachment 02—Bank Worth Measurement (Rod Worth)</u>

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

    1. Measured value of bank worth is consistent with the DCD.
    2. Sum of all bank worths meet shutdown margin requirements.

    The bank worths have been stated in the DCD, but this is a check to determine whether actual values are within the tolerance range of the expected values. This test is important in verifying that the required shutdown margin can be maintained for various reactor power levels.

b. Assure these precautions are identified and are met during the test:

    1. The requirements of shutdown margin shall not be violated.
    2. Critical peaking factor and DNBR shall not be exceeded.
    3. No more than two banks should be simultaneously withdrawn. Permissives only allow two banks to be withdrawn but requirement exists even if they are bypassed.
    4. Boron sampling rates are such that boron sampling and dilution maintain boron concentration.
    5. Required ranges of nuclear instrumentation are operable, including their trip points.
    6. Startup rate limits are met, if required.

c. Confirm these initial conditions are identified and are met during the test:

    1. Identify the plant power level and basis.
    2. RCS temperature and pressure should be constant to better determine the change in reactivity caused by insertion of the rods.
    3. Neutron flux level and RCS boron concentrations status should be constant to better determine change in reactivity caused by the insertion of rods.
    4. Instrumentation and equipment to measure or compute reactivity are installed and operational.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. All rod control banks are withdrawn.
    2. A rod control bank is inserted and its reactivity is measured.
    3. The worths of remaining rod control banks are measured as in d.2 or determined by using the worth of a reference bank at various points.

GENERAL GUIDANCE:

There will be an indication of banks being withdrawn and being inserted in a prescribed manner, and it is possible to check the licensee's method and accuracy of records. There should not be any alarms as a result of this test and, if there are, the licensee should investigate the cause. This test should plainly indicate the reactivity worth of each rod control bank and whether that agrees with expected values and how any deviations are to be handled and their impact on the performance of the plant. The inspector should verify that, for each rod bank, only its reactivity is measured and recorded.

Attachment 03—Boron Endpoint Determination (Boron Reactivity Worth Measurements)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring that the boron endpoint is consistent with design values in TS, and that they are met.

b. Assure these precautions are identified and are met during the test:

   1. Startup rate limits
   2. Boron dilution rate limits
   3. Boron sampling frequency
   4. Nuclear instrumentation trip limits
   5. Power level limits and startup rates before attaining measurable thermal power
   6. Incore instrumentation to be used as a backup to nuclear instrumentation
   7. Controls for reactor operation in the event of significant delay or interruption during testing
   8. Temperature limits for criticality

c. Confirm these initial conditions are identified and met during the test:

   1. Precritical tests after fuel loading are complete and evaluated.
   2. Manual scram is tested. Verify the capability for operator intervention as ensured by manual scram capability.
   3. Reactor critical and neutron flux level are within range for low-power physics testing. These variables should be stable so that there is an easier computation of a change in reactivity caused by boron concentration.
   4. RCS temperature, pressure, and boron concentration are stable. RCS temperature will change slightly during the test.
   5. Test equipment for measuring reactivity is installed and operational.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Confirm rod banks positions in the reactor and supporting basis.
   2. Data and measurements are to be taken: boron concentration, change in reactivity caused by rod repositioning.
   3. State any conversions of data to obtain equivalent change in boron concentration.
   4. Any uncertainties are stated and justified.
   5. A reference is made for supporting the method for determining the boron endpoint.

GENERAL GUIDANCE:

The licensee should address the test methodology that will be used and the appropriate uncertainties that will be incorporated into the data analysis. The test procedure should provide the justification to support the test as conducted. The rods are being adjusted with no boron adjustment; thus, the change in reactivity induced by the movement of the rods and the change in coolant temperature is computed and added to just critical boron concentration to determine boron concentration at end of life (EOL). There will be changes in rod positions in accordance with expected values at EOL and changes in RCS temperatures that can be observed. The inspector can determine whether the computations involved are in agreement with the basis for calculating boron at EOL in this manner.

Attachment 04—Determination of Physics Testing Range

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of ensuring that the zero power testing range and corresponding neutron flux are determined and that they are met.

b. Assure these precautions are identified and are met during the test:

  1. Source range and intermediate range trips
  2. Shutdown margin

c. Confirm these initial conditions are identified and are met during the test:

  1. RCS temperature, pressure, boron concentration, and neutron flux level ranges
  2. Means to measure neutron flux level
  3. Rod banks' positions in reactor
  4. Reactor power level
  5. Power level and the basis

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

  1. Ascertain how the point of nuclear heating is determined.
  2. Determine the neutron flux level at the point of nuclear heating.
  3. Require calculations to obtain the maximum flux level for zero power testing range.
  4. Refer to the support test method.

GENERAL GUIDANCE:

The licensee's method should be supported by an acceptable standard. For this test, the inspector should focus on the following:

- The licensee's expected changes in the reactor as the result of the test
- The factors that determine the minimum and maximum values of the physics testing range and the purpose of knowing the boundaries of the physics testing range
- The factors that determine when nuclear heating occurs
- The purpose of knowing the point of nuclear heating and how that is used in the future operation of the reactor

The inspector should determine the safety concerns associated with the physics testing range and point of nuclear heating and whether those safety concerns are being properly addressed.

Attachment 05—Fuel Loading Prerequisites and Periodic Checks

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify that conditions for fuel loading are met and those conditions are documented. The test acceptance criteria should specifically delineate the requirements for loading fuel and how the licensee assures that the actual loading of fuel will be in accordance with the FSAR and TS. Verify that the test procedure indicates the required checks to determine that the required operational programs dictated by the license or regulations are established.

b. Assure these precautions are identified and are met during the test:

   1. Security measures. The licensee should provide the required security resources to ensure that fuel loading is not compromised in any way. NSIR and regional personnel should identify prior to this inspection the measures that should be in place before fuel loading is initiated.
   2. Source and intermediate range trips.
   3. Radiation monitoring.

c. Confirm these initial conditions are identified and are met during the test:

   1. Preoperational testing is complete with open items addressed.

      The FSAR requires that preoperational testing be complete before fuel loading, which can be accomplished by the following:

      - Confirm that the Commission has found that all inspections, tests, analyses, and acceptance criteria (ITAAC) have been met in accordance with 10 CFR 52.103(g)
      - For important systems and components with no ITAAC but risk significance, review the licensee's lists of systems and components for which preoperational testing has been completed and confirm that the systems and components in question are on that list.

   2. Identify plant conditions for fuel loading in accordance with the TS.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Method for determining that conditions for loading fuel are met
   2. Means to verify if those conditions are maintained during fuel loading

Attachment 06—Incore Instrumentation System (IIS) (Core Performance)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

    1. The requirements, basis, and purpose for recording incore thermocouple (T/C) and flux data should be stated, along with an indication that the flux maps are in agreement with TS Section 3.2.
    2. Core power distributions and peaking factors are consistent with the design basis. Determine how these factors are measured and identify the criteria used to state that they have been met.
    3. Criteria for fuel loading errors should establish how fuel loading errors are determined and justified.

b. Assure these precautions are identified and are met during the test:

    1. DNBR
    2. Linear heat rates and heatup rates
    3. Axial flux difference
    4. Status of plant condition

c. Confirm these initial conditions are identified and are met during the test:

    1. IIS is available and calibrated.
    2. Intermediate and power range trips are available.
    3. Power range instrumentation is preliminarily calibrated.
    4. Reactor and plant are safe to operate up to full-power level.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Identify steady-state operations.
    2. Determine the method of increasing the power level. As discussed in RG 1.68, Revision 2, paragraph C.8, power hold points (power test conditions) are approximate. The licensee may choose to select its power hold points at 5 to 10 percent from the 10-, 25-, 50-, 75-, and 100-percent power levels. The IIS's two purposes are generating a 3D flux map of the core and determining the core exit temperatures. These variables will be available in the MCR and hard copies of the flux maps can be obtained. The expected values of these variables and others covered by this test should agree with design predictions. The inspector should observe the indications in the MCR or elsewhere of the 3D flux and core exit temperatures and also of the core peaking factors. The test should indicate the process for determining fuel loading errors, and the inspector should understand how the licensee justifies the present loading of the reactor core and evaluate whether that is correct or not.

3. Record data at various power levels to produce incore T/C and flux maps.
4. Compare data obtained for core power distribution with design predictions.
5. Determine any fuel loading errors.

Attachment 07—Initial Criticality

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Reactor achieved criticality.
   2. Boron concentration was predicted at criticality. Parametric treatment is required to account for variations in temperature from the point of calculation.

b. Assure these precautions are identified and are met during the test: Signoffs for control are in place. Nuclear instrumentation is calibrated in accordance with the TS. If more than 3 months after fuel loading, the Source Range Meters (SRMs) should be checked before initial criticality for any indication of neutron activity.

   1. Nuclear instrumentation calibration meets surveillance requirements.
   2. A manual scram test is conducted not more than 24 hours before initiation of boron dilution.
   3. Acceptable signal-to-noise ratios and the minimum acceptable count rate are specified for special startup and source range (SR) channels.
   4. Reactor coolant system temperature and pressure are within TS limits for reactor startup.
   5. A list of reactor protection system (RPS) trips required to be in service is available, including reduced trip points, if applicable.

c. Confirm these initial conditions are identified and are met during the test:

   1. RCS temperature and pressure requirements
   2. Rod banks' positions in the reactor
   3. RCS boron concentration level requirements

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Identify the control rod pattern before and during boron dilution. Specify rod positions for all rods including for the part length rods.
   2. Require maintenance of inverse multiplication plots during dilution until criticality is achieved. Inverse multiplication plots are required if the licensee has committed to RG 1.68.
   3. Establish an acceptable startup rate limit for increasing power following criticality. Startup rate limits are typically defined as a 60-second period but rates of 1 decade per minute are acceptable.
   4. Determine the frequency of boron concentration and limits on boron dilution rates. Analyze samples at least once/hour and draw them at about 15-minute intervals. Use of continuous monitors would justify reduced sampling once response and accuracy have been confirmed.

5. Verify overlap of SR and intermediate range (IR) nuclear instrumentation. One decade of overlap will be adequate to prove operability of the IR instrumentation.
6. Determine the manner and order in which control rods are to be withdrawn.
7. Establish the means for monitoring the approach to criticality and the plant operating procedures to be followed.
8. As criticality is approached, state the required dilution of boron concentration.

<u>Attachment 08—Initial Fuel Loading</u>

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Fuel assemblies are installed consistent with the designated configuration of the reactor core. Fuel loading should be a slow, orderly process with sufficient licensee oversight. The licensee should have a detailed record of the fuel loading steps, in case any changes in the positions of the fuel assemblies are required.

b. Assure these precautions are identified and are met during the test:

   1. Controls for fuel loading are established and maintained.
   2. Initial fuel loading is supervised by a senior reactor operator, whose oversight is required so that fuel loading proceeds in a controlled manner and so that any incidents are properly addressed.
   3. Security measures and the capability to monitor radiation levels are addressed. The NRC considers security of utmost importance, and the licensee should take the necessary precautions.

c. Confirm these initial conditions are identified and are met during the test:

   1. ITAAC are met based on the Commission's finding for 10 CFR 52.103(g).
   2. Boron concentration meets TS requirements.
   3. Status of RCS water sources is determined.
   4. Conditions for loading fuel are met and are being monitored and maintained.
   5. Source range channels are operable for monitoring core reactivity.
   6. Preoperational testing is completed with open items addressed. The startup test for "Fuel Loading Prerequisites and Periodic Checks" should have been completed.
   7. The reactor water is at the required level in accordance with the TS.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Fuel assemblies are loaded one at a time in accordance with the prescribed loading sequence. Loading must be conducted exactly as described in the established and approved sequence.
   2. Changes in source range indication are to be verified as expected or not. The goal is to maintain the reactor subcritical during the loading sequence.
   3. Make multiple checks of fuel assemblies' serial numbers and types. Attention to detail is needed to ensure fuel assemblies are in the correct location.
   4. Ensure criteria are met to stop loading operations for a loading step in regard to the count rate on SRMs and a decrease in boron concentration, in accordance with NRC guidelines. Guidelines must be established to ensure unwanted criticality does not occur.

Attachment 09—Isothermal Temperature Coefficient Measurement (Moderator Temperature Coefficient)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring that the measured value of the moderator temperature coefficient conservatively exceeds the TS limit, and that they are met.

b. Assure these precautions are identified and are met during the test:

   1. Source and intermediate range instrumentation should be calibrated and operable.
   2. Boron sampling verifies no variation in the RCS boron concentration.
   3. Limits on startup rate and power level are met before obtaining test initial conditions.
   4. The reactor should not go subcritical.

c. Confirm these initial conditions are identified and are met during the test:

   1. Reactor power and neutron flux levels
   2. RCS temperature, pressure, and boron concentration
   3. required instrumentation installed and operable
   4. status of rod banks

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Vary the RCS temperature using reactor coolant pumps (RCPs) or a similar means. RG 1.68, Revision 2, Appendix A, paragraph 4.a, provides guidance. Because of a soluble absorber in the RCS coolant, the temperature coefficient may be positive at low temperatures, so an alternative method is required to heatup the RCS. Typically, that is achieved by operating the RCPs until the RCS is at normal operating temperature. The inspector should verify that an alternative means is also used to obtain normal operating pressure.
   2. Plot a curve indicating increase or decrease of reactivity versus RCS temperature. As RCS temperature is varied, the change in reactivity will vary directly but negatively with increasing temperature. At least three data points are needed to obtain a good graph of a line. More data points would provide more affirmation that the true slope of the line is obtained. Be aware of how changes in RCS temperature cause resulting changes in reactivity. Pressure in RCS should not change once a bubble is drawn in the pressurizer (PZR). The temperature coefficient with boron in the RCS is not as negative at high temperatures as it would be without boron.
   3. Determine that the isothermal temperature coefficient is the slope of curve plotted. The licensee should have a basis that supports computing the isothermal temperature coefficient in accordance with the test procedure. The licensee

should state the tolerance of the calculation and whether the effects of induced errors have been considered.

4. Determine that the moderator temperature coefficient at the beginning of life is the isothermal temperature coefficient minus the Doppler temperature coefficient. This equation should be supported by some industry standard or contractor manual. The inspector should review the data for determining the Doppler temperature coefficient at each data point.

GENERAL GUIDANCE:

Refer to IP 61708, “Isothermal and Moderator Temperature Coefficient Determinations,” for additional guidance.

Attachment 10—Load Follow Demonstration Test

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. The reactor can load follow for slow or fast changes in turbine loading without changes to the reactor boron concentration. The reactor is in load follow, meaning the reactor will respond to main generator loading, which is normally how the plant will operate. As turbine load increases, the average temperature of RCS coolant (Tave) will decrease. The reactor power control system (RPCS), sensing a change in Tave, tries to maintain it by withdrawing control rod banks. This test simulates both slow and fast changes in turbine loading.
   2. Core power limits should not be exceeded.

b. Assure these precautions are identified and are met during the test:

   1. Load decreases should not be so rapid as to initiate a turbine trip. A turbine trip should be avoided, since this test only verifies the operation of the plant for normal occurrences, not for tripping the turbine and then possibly the reactor.
   2. Cooldown and heatup rates should not be exceeded.

c. Confirm these initial conditions are identified and are met during the test:

   1. Identify the reactor power level and xenon status.
   2. Incore and nuclear (power range) instrumentation is calibrated and available.
   3. Reactor and turbine protection circuits are operational based on prior testing.
   4. Calibrated test equipment is set up to record data.
   5. Identify the MCR operator and roving operator following this test.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Determine references for thermal power and incore power distribution maps. To determine that core power limits are not exceeded, the licensee should develop power and flux distributions for full rated power.
   2. Slow reduction in turbine load to achieve a significantly lower reactor thermal power. The turbine will experience small load fluctuations to simulate daily load changes and determine whether the reactor output will follow turbine load. Again, this is under the control of the RPCS.
   3. Slow the increase in the turbine load to achieve a significantly higher reactor thermal power. This simulates loading of the turbine during normal operations.
   4. Monitor outputs of incore and excore instrumentation to track plant performance during the reduction and increase in power level. This is further verification that the reactor is responding to turbine load changes. These records can be permanent records used as a baseline during future plant operations. The

licensee should state the purpose of the records and whether regulatory and license commitments are being met.

5. Fast changes in turbine loading simulate abrupt grid frequency perturbations. The licensee is determining whether the reactor and turbine respond properly to fast load changes that simulate frequency changes in the offsite power grid.

Attachment 11—Loss of Offsite Power

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Verify that the reactor trips.
   2. Standby diesel generators (SDGs) start and supply the safety buses.
   3. Battery continues to supply DC loads.
   4. RCS temperature and pressure remain within prescribed limits.
   5. Turbine bypass system operates to maintain secondary system pressure.
   6. Steam generator (S/G) level remains within prescribed limits. The plant should align itself for operation using the SDGs. Reactor protection circuits should activate to initiate an reactor trip when RCS variables or reactor power exceeds prescribed limits caused by a turbine trip. In this case, because the RCPs would trip on loss of offsite power, the reactor would probably trip because of low RCS flow. Primary and secondary plants should initially stabilize at or near normal operating temperatures and pressure. The plant trip steam dump controller should activate to open the steam dump valves to remove decay heat.
   7. The PZR and S/G safety valves should not lift. The pressure in the primary and secondary systems should not rise to the thresholds where the safety valves in the primary and secondary systems activate.

b. Assure this precaution is identified and is met during the test:

   1. DNBR is not exceeded.

c. Confirm these initial conditions are identified and are met during the test:

   1. Turbine is only supplying in-house loads.
   2. Reactor protection circuits and permissives are operable.

d. Assess whether the test procedure has steps for tripping the turbine generator, resulting in the opening of the generator output breaker. The generator should have been disconnected from the grid so that a large load rejection is avoided. The test procedure should reference a licensee procedure that states the events that will occur following a loss of offsite power with the reactor and turbine generator tripping.

Attachment 12—Natural Circulation

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring that the average vessel temperature drop for natural circulation is equal to or less than limiting design predictions, and that they are met. The reactor should not trip, and no permissive or protection circuits should activate. The temperature variation across the reactor vessel, the low primary-side hydraulic resistance of the S/Gs, and the large surface area of the S/Gs are the factors that allow natural circulation to be achieved without using the RCPs.

b. Assure that a precaution is identified so that the DNBR does not decrease below the design-base limit at any time and that it is met. The licensee should monitor temperatures in the reactor to determine, by some means, whether the temperatures of the fuel bundles are exceeding their design limitations because of low or no coolant flow around them.

c. Confirm these initial conditions are identified and are met during the test:

    1. status of reactor power level and neutron flux level
    2. RCS boron concentration and temperature
    3. plant equipment operating
    4. instrumentation available to measure neutron flux and reactor temperature drop

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Obtaining a prescribed low power level.
    2. Recording neutron flux level and RCS loop temperatures during forced flow condition.
    3. Tripping of RCPs.
    4. Means to verify natural circulation established.
    5. Recording neutron flux level and RCS temperatures for natural circulation.
    6. Determining flow rate achieved during natural circulation. The licensee should have a calculation or analysis stating the required minimum flow rate under natural circulation for the reactor core to be sufficiently cooled.

GENERAL GUIDANCE:

For this test, a low power level is achieved by pulling the rods. The RCPs are initially running with the RCS flow through the reactor being verified along with neutron flux levels and RCS temperatures. The RCPs are subsequently tripped with the plant still operating at the same power level. The RCS low-flow reactor trip should not be operable at this low power level. There will be a comparison of critical plant parameters with forced and natural circulation. A determination should be made when natural circulation is achieved and whether the flow rate agrees with expected value. The plant should be able to remove decay heat from the RCS using the S/Gs to the main condenser. The passive residual heat removal heat exchanger (PRHRHX) should not activate because the S/Gs are still available and the plant is operating at a low power level. The PRHRHX typically operates when there is either an increase or decrease in the heat removal capability of the secondary system or when required with the activation of the passive core cooling system.

Attachment 13—Passive Residual Heat Removal Heat Exchanger (PRHRHX)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify that the procedure contains acceptance criteria, with the intent of ensuring that the heat removal rate of the PRHRHX is equal to or greater than predicted in the safety analysis, and that they are met. The heat removal capability of the PRHRHX will be higher than what was measured during the preoperational test because more heat is being put into the RCS system, with the core operating at a low power level, than during the preoperational test when the plant was heated up using the RCPs.

b. Assure these precautions are identified and are met during the test:

    1. DNBR does not decrease below design base limit at any time. During any increases in core power, the possibility exists that hot spots could impair the integrity of some fuel bundles.
    2. The average water temperature of the in-containment refueling water storage tank (IRWST) should not reach 150 degrees Fahrenheit. The PRHRHX is located inside the IRWST, and it heats up the water inside the IRWST. The temperature limit is to prevent the water from boiling in the IRWST so that its vents do not open up and disperse hot steam into the containment.
    3. PZR safety valves do not actuate. The PRHRHX should be able to cool the primary systems without operation of the PZR safety valves.

c. Confirm these initial conditions are identified and are met during the test:

    1. Reactor power in physics testing range
    2. RCS boron concentration and temperature
    3. equipment operating and its purpose
    4. instrumentation available to measure neutron flux and RCS temperatures
    5. the startup test, “Natural Circulation,” just completed
    6. PRHRHX’s inlet and outlet temperature instrumentation available
    7. status of PRHRHX’s inlet and outlet isolation valves

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Obtain a certain reactor power and neutron flux levels.
    2. Manually establish flow through the PRHRHX.
    3. S/G steam dump should reduce heat removal by S/Gs.
    4. Record PRHRHX’s flow and inlet/outlet temperatures.
    5. Calculate PRHRHX’s heat removal rate.
    6. Record RCS temperatures and pressure.
    7. On termination of flow through PRHRHX, the S/Gs heat removal should increase to maintain Tave.
    8. Restart the RCPs once the reactor has been shut down by inserting control rods.

GENERAL GUIDANCE:

The calculated heat removal rate of the PRHRHX should be compared to the safety analysis to confirm that it is sufficient to allow the PRHRHX to meet its assignments for Chapter 15 accidents and events. The inspector should also determine whether the S/G steam dump changes the heat removal rate of the S/Gs, based on the participation of the PRHRHX in removing heat from the reactor.

Attachment 14—Plant Trip from 100-Percent Power

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Primary and secondary systems should stabilize. The turbine will trip on overspeed because there is no load on it and that should be evident by alarms for turbine overspeed, the plant operating on SDGs, and no steam being drawn by the turbine. The rapid power reduction system (RPRS) will activate to reduce reactor power by inserting rods unless the reactor trips. The turbine bypass (steam dump) system will activate to dump excess steam.

   2. PZR and S/G safety valves do not open. The activation of these safety valves should not be necessary since the systems stated in a.1 above should stabilize the primary and secondary systems.

   3. Hot-leg temperature responses are less than or equal to those in the safety analysis. Section 15.2 of the DCD contains the hot-leg temperatures.

b. Assure that a precaution is identified that DNBR is not exceeded and that it is met.

c. Confirm these initial conditions are identified and are met during the test:

   1. Reactor power level
   2. Primary and secondary safety valves operable
   3. Startup feedwater available
   4. Steam dump control system available
   5. PRHRHX available

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Open the main generator output breaker.
   2. Monitor and record such items as the RCS temperatures and pressure, PZR and S/G levels, and plant power level.
   3. Adjust primary and secondary controls, if necessary.
   4. Determine resistance temperature detector (RTD) time responses for RCS.

GENERAL GUIDANCE:

Opening the generator output breaker will trip the turbine on overspeed since it will be unloaded. There is not a direct link between a turbine trip and an reactor trip in accordance with the Chapter 15 analysis, but the reactor may trip as a result of high PZR pressure or level, overtemperature delta T, low RCP speed, and low steam generator water level. Following a turbine trip, offsite power is assumed to be lost shortly thereafter, which causes a coastdown of the RCPs. The Chapter 15 analysis of a turbine trip does not consider the operation of either the RPRS or the steam dump system. However, with the operation of those two systems, the severity of a turbine trip will be mitigated, and the protective functions that could cause an reactor trip may not reach their necessary thresholds. The inspector should observe the responses of the primary and secondary systems to a turbine trip to see if they compare favorably to the Chapter 15 analysis. The licensee will be collecting these data to be used in its operating procedures so that operators can respond predictably to this event in the future.

Attachment 15—Rapid Power Reduction System (RPRS)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

    1. The RPRS performs in accordance with design requirements.
    2. For simulated loss of load, power to preselected control rods is interrupted.

    The test is with the reactor shut down so only the RPRS is verified, along with the opening of the prescribed reactor trip breakers for the preselected control rods.

b. Assure these precautions are identified and are met during the test:

    1. Shutdown margin is not reduced below required value.
    2. Reactor is not allowed to go critical.

c. Confirm these initial conditions are identified and are met during the test:

    1. Reactor is shut down.
    2. Designated rod position and boron concentration allow shutdown margin to be maintained.
    3. Rod positions are specified along with basis.
    4. Rod control and indication systems are available.
    5. RPS and related reactor trips are functional.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Simulated reactor power signals input to reactor control and protections system.
    2. Closing of the reactor trip breakers.
    3. Simulated input signal for rapid loss in power input to the RPRS.
    4. The verification of the RPRS response.

GENERAL GUIDANCE:

The closing of the reactor trip breakers and inputs to the RPRS should be indicated, followed by an output signal that will trip the reactor trip breakers just closed. The purpose of the RPRS is to quickly reduce reactor power to a level capable of being handled by the steam dump system for a large load rejection. When activated, the RPRS causes the release of a specified number of control rods. This causes reactor power to drop to approximately 50 percent of rated power if the reactor were operating at a higher power level initially. The inspector can verify that only the preselected control rods drop into the reactor.

Attachment 16—Reactor Coolant System Flow Measurement

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring that RCS flow equals or exceeds 90 percent of the minimum value in TS, and that they are met.

b. Assure that a precaution is identified (that DNBR is not exceeded) and that it is met.

c. Confirm these initial conditions are identified and are met during the test:

    1. status of RCS temperature and pressure
    2. instrumentation to measure reactor flow installed
    3. Reactor at a specific high power level

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Determine RCS flow rates by measuring core thermal power and hot- and cold-leg temperatures at various power levels. Calculate the flow rates using a prescribed equation. The indications of core thermal power, the hot- and cold-leg temperatures, and the RCS flow should be readily available in the MCR. The calculation should be supported by a widely accepted industry standard. The inspector could check the licensee’s results by using the data and doing his or her own hand calculation.

Attachment 17—Reactor Power Control System (RPCS)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring the RPCS returns RCS Tave to a temperature reference setpoint within specified limits, and that they are met without manual intervention. The RPCS comprises two subsystems: Power Control and Axial Offset Control. The power control subsystem actually controls Tave, which is described in DCD Section 7.7.1.1.1. The power control system receives temperature signals from protection channels and an additional input comprised of the difference of reactor power and turbine load. The latter input modifies the determination of Tave by enhancing response time and reducing transient peaks.

b. Assure these precautions are identified and are met during the test:

    1. DNBR does not decrease below the design base limit at any time.
    2. Shutdown margin is maintained.

c. Confirm these initial conditions are identified and are met during the test:

    1. Reactor status and power level are identified.
    2. Equipment required for the test is operable.
    3. The required control room and auxiliary operators are on duty.
    4. The required systems in accordance with the TS are operable.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Tave is varied by some method (i.e., loading the turbine generator).
    2. The performance of the RPCS is determined.

GENERAL GUIDANCE:

Tave is displayed on the MCR and the response of it to various changes in the reactor power level can be readily witnessed. Tave is controlled by regulating certain control bank positions. The rod-position displays for those control rod banks will indicate movement and in a specific direction. Temperature in the cold leg should vary first with the temperature in the hot leg changing as rods are moved. If the temperature in the cold leg drops with increased turbine load, then the specified rods will move out to increase the temperature in the hot leg to maintain Tave.

Attachment 18—Remote Shutdown Work Station (RWS)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria, with the intent of ensuring that the operators can shut down the reactor, maintain hot standby, and transition to a point approaching cold shutdown conditions, and that they are met. These types of operations are available to the operators from the remote shutdown work station (RWS) outside of the MCR.

b. Assure these precautions are identified and are met during the test:

    1. Sufficient operators are available in case of an emergency.
    2. Prescribed cooldown limits are not exceeded.

c. Confirm these initial conditions are identified and are met during the test:

    1. Operators using required normal and emergency operating procedures
    2. Communication requirements
    3. Reactor power level, status, and basis
    4. Shutdown margin maintained

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Evacuate the MCR. Transfer control of plant from the MCR to means outside of the MCR.
    2. After transferring control, operators will trip and isolate the reactor per plant procedures. There should be a defined method of transferring control from the MCR to means outside the MCR.
    3. Operators take the plant to hot standby.
    4. The plant is brought to hot standby and then will approach, but not obtain, cold shutdown. The operators will cool the plant sufficiently to initiate the shutdown cooling mode of the normal residual heat removal (RHR) system.

GENERAL GUIDANCE:

Systems controlled for this test should be readily available on the RWS. The operator's actions can be observed and there should be an indication of what systems are operating and how reactor power and other plant parameters are responding to the operator's actions. The operators should be following the test procedure and also applicable plant procedures for this test, which the inspectors can determine by observing the operators and questioning them on particular steps.

Attachment 19—Resistance Temperature Detectors (TRD)—Incore Thermocouple (T/C) Cross Calibration

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Determine that the temperature values derived by using the calibration data with each RTD resistance compare within reasonable tolerance to the different temperature values at which data were recorded during the test.
   2. Determine that the temperature values derived by using the calibration data with each T/C output compare within reasonable tolerance to the different temperature values at which data were recorded during the test.

b. Assure these precautions are identified and are met during the test:

   1. Factors that could induce significant errors in this test and subsequent calculations are identified. The licensee should identify the factors that could cause appreciable errors and the basis.
   2. Reactor is not taken critical.

c. Confirm these initial conditions are identified and are met during the test:

   1. Status of reactor and power level
   2. RCS RTDs all operational with initial alignment completed
   3. Incore instrumentation system operational and calibrated
   4. Availability of calibration data obtained during preoperational testing for the RTDs and the T/Cs.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Measurement and recording of the resistance of each RTD and output of each incore T/C at different temperatures as RCS temperature is increased to the normal operating temperature
   2. Determination of best temperature value for each data point
   3. Sufficient iterations to validate the correct temperature values
   4. Determination of calibration data for RTDs and T/Cs
   5. Licensee to identify the basis for performing the test in this manner with supporting evidence of vendor and industry standards

GENERAL GUIDANCE:

The calibration data determined in this test of the RTDs in the RCS and the T/Cs for the IIS are being verified against the calibration data obtained for those same components during preoperational testing. The final calibration data are based on the results of both preoperational and startup testing and are very important because the data for the

RTDs are used in the overtemperature trip for the reactor and the data for the T/Cs are used in determining core exit temperatures for the reactor core. The final calibration data are also verified by using them in calculations employing the RTDs' resistance and the T/C outputs independently to determine whether the temperature values obtained in that manner compare favorably with the temperatures at which data were recorded during this test. The inspector can check the values obtain from preoperational testing with those obtained during this startup test and also in the appropriate equations using the licensee's data.

Attachment 20—Rod Cluster Control Assembly Out of Bank Measurements

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

    1. Power distributions and power peaking factors are within TS.
    2. The sensitivity of incore and excore instrumentation is verified.

b. Assure these precautions are identified and are met during the test:

    1. Do not exceed minimum DNBR.
    2. Critical peaking factors should not be exceeded.

c. Confirm these initial conditions are identified and are met during the test:

    1. The reactor power level is identified.
    2. The RCS boron concentration and temperature status are verified.
    3. The positioning of rod assemblies is determined.
    4. Control room operators review required operating procedures.
    5. Systems required by TS are operable.

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

    1. Insert and withdraw to the limits of misalignment specified in FSAR Chapter 15. Compensate for reactivity changes.
    2. Record incore and excore instrumentation signals at the various misalignments of the rod control assemblies.
    3. Compare the outputs of incore and excore instrumentation to determine whether power distributions and peaking factors meet TS.
    4. Determine the sensitivity of incore and excore instrumentation to control rod assembly misalignment.
    5. Capture these data for future use by the licensee.

GENERAL GUIDANCE:

The incore and excore instrumentation systems are being used to determine whether they are sensitive to control rod assembly misalignments. The licensee should state the expected sensitivities so a comparison can be made with the actual values. The test is also looking at the effect of the misalignments on power distributions and peaking factors. The inspector should ask if this information will somehow be maintained for future use under similar plant conditions.

Attachment 21—Rod Drop Measurements

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Rod drop times are consistent with the design basis and TS.
   2. Rod decelerating devices properly operate.

b. Assure these precautions are identified and are met during the test:

   1. Shutdown margin should be maintained.
   2. Control rods should not incur any damage.

c. Confirm these initial conditions are identified and are met during the test:

   1. Reactor status and power level
   2. RCS temperature and pressure
   3. Source Range instrumentation available
   4. status of control rods
   5. equipment required to be operating
   6. Rod position indication system available

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Withdraw each rod cluster control assembly one at a time.
   2. Drop the control assembly into the core.
   3. Measure and record rod drop times for the following conditions:
      (a) no flow cold
      (b) full flow cold
      (c) no flow, hot zero power
      (d) full flow, hot zero power
   4. Compare the results with the expected rod drop times for the assemblies.
   5. Perform additional drops for those assemblies that do not meet design requirements.

GENERAL GUIDANCE:

The inspector should verify the rod drop times against TS and verify that the rod drop times are satisfactory under all test conditions. The test procedure should state the additional number of times that a rod should be dropped if it fails to meet the design requirements, and the allowed tolerances for rod drop times. The licensee should have defined remedial steps that must be taken for any rod that does not meet the expected drop time requirements after repeated tests.

Attachment 22—Rod Position Indicator System (RPIS)

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. The rod position indicator system (RPIS) performs as intended for indication and alarm functions.
   2. Rods can freely travel over the entire operating range.

b. Assure these precautions are identified and are met during the test:

   1. The reactor should not go critical.

c. Confirm these initial conditions are identified and are met during the test:

   1. reactor status and power level
   2. RCS temperature and pressure
   3. Source Range instrumentation available
   4. status of control rods
   5. equipment required to be operating

d. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Withdraw each rod bank one at a time.
   2. Reinsert the rod bank.
   3. Record the rod position on readouts and step counters in the MCR.
   4. Determine whether each rod is able to be tracked over entire range and whether appropriate alarms activate.

GENERAL GUIDANCE:

The RPIS must have the capability to track each rod bank from fully inserted to fully withdrawn with any errors in the RPIS displays taken into account. Being able to know the accurate position of each rod bank enables the licensee to determine when criticality will be obtained, the positions of the rod banks for a designated plant power, when all rods are fully inserted, and when a rod bank is misaligned. The licensee will keep track of rod positions during power ascension testing and record those rod positions so that the reactor operator can know approximately which rod positions elicit a specific plant response.

Attachment 23 – 100-Percent Load Rejection

INSPECTION REQUIREMENTS AND GUIDANCE

Perform the following review:

a. Verify the test procedure has acceptance criteria with the intent of the following and that they are met:

   1. Plant can accept 100-percent load rejection without an reactor trip or the operations of PZR safety valves or S/G relief and safety valves.
   2. Turbine remains operable and supplies in-house loads.

b. Confirm these initial conditions are identified and are met during the test:

   1. Reactor is stable at 100-percent load.
   2. Reactor and turbine control and protection circuits are available.
   3. Incore instrumentation is available.
   4. Turbine bypass system is functional.
   5. PZR and S/G safety valves are functional.

c. Assess whether the test procedure has similar steps to the following and whether the test is conducted in accordance with them:

   1. Trip the main step-up transformer.
   2. Record key plant parameters (i.e., temperature, pressure, flow rates in primary and secondary systems).

GENERAL GUIDANCE:

The AP1000 plant is designed to accept a 100-percent load rejection from full power to in-house loads without a reactor trip or operation of the PZR or S/G safety valves. The RPRS rapidly reduces power to about 50 percent by sending a signal that causes preselected control rods to be inserted. The large power reduction also activates the steam dump system, which prevents a large increase in RCS temperatures. Insertion of the rods continues until power is reduced to about 15 percent rated with the steam dump system operating to remove excess steam. The turbine continues to operate in a stable manner and eventually supplies only in-house loads that require only 5-percent power.

Attachment 24, Table 1—*AP1000 Startup Tests

No.	Test Title	PRA Risk Category**	RG 1.68, Revision 2, Appendix A, "Initial Test Program"
1.	Initial Criticality (DCD 14.2.10.2.2) (Attachment 7)	-	Section 3, "Initial Criticality"
2.	Load Follow Demonstration Test (DCD 14.2.10.4.22)—prototype only (Attachment 10)	-	Section 5, "Power-Ascension Tests, (5.h.h)"
3.	Loss of Offsite Power (DCD 14.2.10.4.26) (Attachment 11)	Y/VL	Section 5, "Power-Ascension Tests, (5.j.j)"
4.	Natural Circulation—prototype only (DCD 14.2.10.3.6) (Attachment 12)	Y/VH	Section 4, "Low-Power Testing, (4.t)"
5.	Passive Residual Heat Removal Heat Exchanger—prototype only (DCD 14.2.10.3.7) (Attachment 13)	Y/VH	Section 4, "Low-Power Testing, (4.q)"
6.	Plant Trip from 100% Power (Generator Trip) (DCD 14.2.10.4.24) (Attachment 14)	-	Section 5, "Power-Ascension Tests, (5.l.l)"
7.	Rapid Power Reduction System (Protective Trip Circuit and Manual Scram) (DCD 14.2.10.1.15) (Attachment 15)	Y/VH	Section 2, "Initial Fuel Loading and Precritical Tests (2.c)"
8.	Reactor Power Control System (DCD 14.2.10.4.19) (Attachment 17)	Y/VL	Section 5, "Power-Ascension Tests, (5.s)"
9.	Remote Shutdown Work Station (DCD 14.2.10.4.28) (Attachment 18)	-	Section 5, "Power-Ascension Tests, (5.d.d)"
10.	100-Percent Load Rejection (DCD 14.2.10.4.20) (Attachment 23)	-	Section 5, "Power-Ascension Tests, (5.n.n)"

*Inspect a minimum of four startup tests from Table 1 for this IP completion

**The probabilistic risk assessment (PRA) column identifies tests that are linked to SSCs and events modeled in the PRA. This PRA category is based on the risk-significant SSCs table for AP1000 on page App A-10 of IMC 2519 and used the risk significance that matched the test to mark each test with one of three keys ["– "(meaning the PRA did not specifically model the component), "Y/VL" (meaning it is modeled and it has low risk significance), and "Y/VH" (meaning it is modeled and it has high risk significance)]. The risk-significant SSC table from IMC 2519 was used to inform this activity because it was developed in conjunction with the industry. In addition, the table has been successfully used for other activities with no industry objection.

Attachment 24, Table 2—Optional* AP1000 Startup Tests

No.	Test Title	RG 1.68, Revision 2, Appendix A, "Initial Test Program"
1.	Axial Flux Difference Instrumentation Calibration (Flux Asymmetry) (DCD 14.2.10.4.7) (Attachment 01)	Section 5, "Power-Ascension Tests, (5.x)"
2.	Bank Worth Measurement (Rod Worth) (DCD 14.2.10.3.5) (Attachment 02)	Section 4, "Low-Power Testing, (4.b)"
3.	Boron Endpoint Determination (Boron Reactivity Worth Measurements) (DCD 14.2.10.3.3) (Attachment 03)	Section 4, "Low-Power Testing, (4.a)"
4.	Determination of Physics Testing Range (Power Reactivity Coefficient) (DCD 14.2.10.3.2) (Attachment 04)	Section 4, "Low-Power Testing"
5.	Fuel Loading Prerequisites and Periodic Checks (DCD 14.2.10.1.1) (Attachment 05)	Section 2, "Initial Fuel Loading and Precritical Tests (2.c)"
6.	Incore Instrumentation System (Core Performance) (DCD 14.2.10.4.2) (Attachment 06)	Section 5, "Power-Ascension Tests, (5.i)"
7.	Initial Fuel Loading (DCD 14.2.10.1.5) (Attachment 08)	Section 2, "Initial Fuel Loading and Precritical Tests"
8.	Isothermal Temperature Coefficient Measurement (Moderator Temperature Coefficient) (DCD 14.2.10.3.4) (Attachment 09)	Section 4, "Low-Power Testing, (4.a)"
9.	Reactor Coolant System Flow Measurement (DCD 14.2.10.1.17) (Attachment 16)	Section 5, "Power-Ascension Tests, (5.m)"
10.	Resistance Temperature Detector—Incore Thermocouple Cross Calibration (DCD 14.2.10.1.8) (Attachment 19)	Section 2, "Initial Fuel Loading and Precritical Tests"
11.	Rod Cluster Control Assembly Out-of-Bank Measurements (Pseudo Rod Ejection—prototype only) (DCD 14.2.10.4.6) (Attachment 20)	Section 5, "Power-Ascension Tests, (5.y)"
12.	Rod Drop Measurements (DCD 14.2.10.1.14) (Attachment 21)	Section 2, "Initial Fuel Loading and Precritical Tests (2.b)"
13.	Rod Position Indication System (DCD 14.2.10.1.12) (Attachment 22)	Section 2, "Initial Fuel Loading and Precritical Tests (2.b)"

*Table 2 provides optional startup tests that can be inspected by the region. Regional management approval should be obtained before selecting tests from this table for inspection.

Attachment 24, Table 3—Additional* AP1000 Startup Tests

No.	DCD Test No	Test Title
1.	14.2.10.1.3	Fuel Loading Instrumentation and Neutron Source Requirements
2.	14.2.10.2.1	Initial Criticality Test Sequence
3.	14.2.10.1.7	Incore Instrumentation System Precritical Verification
4.	14.2.10.1.4	Inverse Count Rate Ratio Monitoring for Fuel Loading
5.	14.2.10.4.3	Nuclear Instrumentation System
6.	14.2.10.1.9	Nuclear Instrumentation System Precritical Verifications
7.	14.2.10.2.3	Nuclear Instrumentation System Verification During Initial Criticality
8.	14.2.10.4.20	Load Swing Test
9.	14.2.10.3.1	Low-Power Test Sequence
10.	14.2.10.1.6	Post-Fuel Loading Precritical Sequence
11.	14.2.10.1.19	Pressurizer Spray Capability and Continuous Spray Flow Verification (Pressurizer Effectiveness)
12.	14.2.10.1.16	Process Instrumentation Alignment
13.	14.2.10.4.10	Process Instrumentation Alignment at Power Conditions
14.	14.2.10.4.9	Process Measurement Accuracy Verification
15.	14.2.10.4.8	Primary and Secondary Chemistry
16.	14.2.10.4.11	Reactor Calibration Coolant System Flow Measurement at Power Conditions
17.	14.2.10.1.18	Reactor Coolant System Flow Coastdown
18.	14.2.10.1.10	Setpoint Precritical Verification
19.	14.2.10.4.12	Steam Dump Control System (Turbine Trip)
20.	14.2.10.4.5	Startup Adjustments of Reactor Coolant System
21.	14.2.10.4.13	Steam Generator Level Control System
22.	14.2.10.4.17	Thermal Power Measurement and Statepoint Data Collection

*Table 3 provides additional startup tests that can be inspected by the region. Regional management approval should be obtained before selecting tests from this table for inspection.

Attachment 25

Revision History for IP 72304

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
N/A	ML053620357 09/05/06 CN 06-021	IP 72304 has been issued for Construction Inspection Program	N/A	ML061100395
N/A	ML18233A370 02/28/19 CN 19-009	IP 72304 revised in accordance with IMC 0040, IMC 2514A and added PRA perspective on startup tests	N/A	ML18263A015