Table of Contents

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List of Tables

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14.0 Initial Tests and Operation

A comprehensive initial testing and operating program was conducted at the Oconee Nuclear Station. The purpose of this program was (1) to assure that the equipment and systems perform in accordance with design criteria, (2) to effect initial fuel loading in a safe efficient manner, (3) to determine the nuclear parameters, and (4) to bring the unit to rated capacity.

The test program began as installation of individual components and systems was completed. The individual components and systems were tested and evaluated according to written test procedures. An analysis of the test results verified that each component and system performed satisfactorily.

The written procedures for the initial tests and operation included the purpose, conditions, precautions, limitations, prerequisites, and the acceptance criteria.

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14.1 Organization of Test Program

14.1.1 General Organization

The organization for development and execution of the test program had major participants from the Oconee Nuclear Station operating personnel, the Nuclear Production Department General Office staff, and Babcock & Wilcox (B&W) Site Operations. Additional participants were from the Duke Engineering Department; Construction Department; and Electrical, Maintenance, and Construction Department. Bechtel Corporation participated in the tests associated with the Reactor Building.

The Oconee Nuclear Station organization for the test program consisted of the Superintendent, Assistant Superintendent, Station Review Committee (SRC), and a station test coordinator assigned for each test.

The Nuclear Production Department General Office staff organization for the test program consisted of a Nuclear Production General Office test coordinator assigned for each test.

The B&W Site Operations organization for the test program consisted of the Site Operations Manager, Site Operations Engineer, and Site Service Engineers who worked in the specific areas of test procedures, testing, startup, operations, maintenance, fueling, field analysis, and reports. The test program had technical support from B&W Nuclear Power Generation Division engineers. This support included technical analysis of the test results of certain tests with the result analyses transmitted to the Nuclear Production Department through normal channels of communication for checking and final analyses prior to test completed approval. Special rapid channels of communication were utilized where results were needed as soon as possible for other operations to proceed. The qualifications for the B&W Site Operations organization are listed below:

1. The minimum qualification for the B&W Site Operations Manager are:
   a. Graduate in engineering, or related physical science, or equivalent experience. (2 years experience for one year of college).
   b. Four years of responsible power plant experience or two years of responsible nuclear reactor experience.
   c. One year engineering or test program preparation experience for this or similar nuclear plant.
2. The minimum qualifications for the B&W Site Operations Engineer are:
   a. Graduate in engineering, or related physical science or equivalent experience. (2 years experience for one year of college).
   b. Two years of responsible power plant experience or one year of responsible nuclear reactor experience.
   c. One year engineering or test program preparation experience for this or similar nuclear plant.

Various individuals from the Mechanical, Electrical, and Civil sections of the Duke Engineering Department furnished technical support as needed in specific areas. Similarly, individuals in the Duke Construction Department, Duke Electrical, Maintenance, and Construction Department; and Bechtel Corporation furnished technical support as needed. This support principally applied to the review of test procedures prior to approval, analysis of test results, and the development and installation of modifications to the equipment and systems as required and identified during the test program. Qualifications for Duke personnel are contained in Chapter 13.

During the initial criticality (including fuel loading) and post-criticality phases of the test program, the nuclear physics and thermal hydraulics aspects of the reactor operation were under the technical responsibility of the Nuclear Production Department Nuclear Engineer and the Oconee Technical Support Engineer with assistance from B&W Site Operations, B&W Nuclear Power Generation Division, and Duke Engineering Department nuclear engineers as needed. A very close coordination between these groups existed with the appropriate support available when needed.

14.1.2 Responsibilities

14.1.2.1 Superintendent

The Superintendent or his authorized representative has final responsibility for the overall test program which included the approval of the test procedures, modification of test procedures, scheduling, completion of the tests, and approval of the test results. Approval of test procedures, modifications of test procedures, and approval of test results was not be made without giving proper consideration to recommendations of Babcock and Bechtel in their areas of interest.

14.1.2.2 Test Working Group

A Test Working Group (TWG) coordinated the activities of B&W, Duke Construction, and Nuclear Production Department during the preoperational test program. Representatives were from Oconee Nuclear Station and B&W (Site Operations Engineer). Duke Engineering; Construction; Steam Production General Office; and Electrical, Maintenance, and Construction Departments had representatives participate as required. The Oconee representative was chairman of the TWG. The TWG met at regular intervals; approximately every week during the most active phases of the program.

14.1.2.3 Station Test Coordinator

A station test coordinator was designated for each test. His responsibility was to develop the test procedure, coordinate the performance of the test, analyze results, identify discrepancies in test and acceptance criteria, initiate action to correct discrepancies, obtain approval of other parties when test had been completed satisfactorily, and file results in the master final documentation file.

14.1.2.4 Nuclear Test Engineer

A general office nuclear test engineer was designated for the testing program. His responsibility was to furnish technical guidance for the test program; to assist in the development of the approved procedures; and to assist the station personnel in conducting and evaluating the tests. Other members of the general office staff assisted in the test program as necessary.

14.1.2.5 Nuclear Safety Review Committee

An audit of safety related tests and their results was performed by the Nuclear Safety Review Committee.

14.1.3 Resolution of Discrepancies

Any discrepancies in systems or equipment found during the Test Program was promptly reported by the station test coordinator to the Superintendent. A corrective action request was made to the appropriate departments by the Superintendent to initiate any revision or repair deemed necessary. After the corrective action had been completed the Superintendent or his authorized representative was notified. Retests were performed on systems and components as necessary to verify the adequacy of the corrective action.

Prior to any revisions relating to the health and safety of the public or plant personnel, structural integrity of plant components and systems, and items covered by codes and nuclear standards, review and approval was necessary by the Duke Power Design Engineering Department with assistance from vendors or consultants as necessary.

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14.2 Tests Prior to Reactor Fuel Loading

The tests prior to reactor fuel loading assure that systems are complete and operate in accordance with design. The test program was divided into two phases: Preheatup Test Phase and Hot Functional Test Phase. In many instances systems were tested during both the Preheatup Test Phase and the Hot Functional Test Phase. A list of the tests performed prior to fuel loading is provided in Table 14-1. This section summarizes the initial test program prior to fuel loading for Oconee I, 2, and 3. The startup reports and supplements, References 1 through 14, provide the results of the startup test program for each unit.

The types of tests are classified as hydro/leak, operational, electrical, and functional with the following definitions for each classification:

Hydro/Leak Test	– Structural integrity leak test of the various systems and components at the appropriate pressure.
Operational Test	– Operation of systems and equipment under operating conditions.
Electrical Test	– Consists of: grounding, megger, continuity, and phasing checks; circuit breaker operation and control checks; potential measurement and energizing of buses and equipment to ensure continuity, circuit integrity, and proper functioning of electrical apparatus.
Functional Test	– Tests to verify that systems and equipment will function as intended.

Instruments and controls of each system or component were also subjected to a preoperational instrumentation and controls calibration prior to the initial operation of that system or component to assure proper operation.

An Engineered Safeguard Actuation System test was performed to assure actuation and proper operation of the Engineered Safeguards System and to evaluate the test method and frequency for future testing.

A one-time emergency power ES functional test which involves the three Oconee units during shutdown conditions has been evaluated. The scope of the test was described in NRC Safety Evaluation related to Amendment No. 220 to Facility Operating License DPR-38, Amendment No. 220 to Facility Operating License DPR-47, and Amendment No. 217 to Facility Operating License DPR-55 issued January 2, 1997, Duke letters to the NRC dated November 21, 1996, and December 11, 1996 (as supplemented by letters dated December 17, 19, and 26, 1996). This test verified certain design features of the emergency power system in an integrated fashion. Oconee Unit 3 was defueled and Oconee Units 1 and 2 were at cold shutdown with fuel in the reactor core during the performance of the test.

A one time Keowee Emergency Power - Engineering Safeguards Functional Test which involves Oconee Unit 3 during 3EOC17 has been evaluated. This test verifies certain design features of the emergency power and engineering safeguards systems in an integrated fashion. The scope of the test supports Nuclear Station Modification (NSM) ON-53014. This integrated test will emergency start the Keowee Unit aligned to the underground power path from shutdown condition and accept loads from the shutdown Oconee Unit through the standby bus.

14.2.1 Preheatup Test Phase

The objective of the Preheatup Test Phase was to assure that the equipment and systems perform as required for hot functional testing. This phase of the testing included certain preoperational calibration, hydro/leak, operational, electrical, and functional tests as required. The Reactor Building Containment System has undergone a structural integrity and integrated leakage rate test to verify the building design and to ensure that leakage is within the design limit.

14.2.2 Hot Functional Test Phase

The Hot Functional Test Phase was a period of hot operation of the Reactor Coolant System and the associated auxiliary systems prior to the initial fueling of the reactor. The Reactor Coolant System was heated up to no-load operating pressure and temperature.

The Hot Functional Test Phase continued the preparation toward the initial fuel loading. The objectives of this phase of the test program were:

1. Operational test of systems, components, and non-nuclear instrumentation and controls at no load operating pressure and temperature.
2. Operator training.
3. Verification of normal operating procedures.
4. Verification of emergency operating procedures.

Following the hot functional test, the reactor vessel intervals were removed and inspected for signs of distress, e.g., loose parts, cracking, or fretting.

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14.3 Initial Criticality Test Program

The Initial Criticality Test Program consists of the initial fuel loading followed by initial criticality.

14.3.1 Initial Fuel Loading

Fuel was loaded into the reactor in accordance with a step-by-step written procedure. This procedure contains a number of safety precautions and operating limitations.

The fuel loading procedure includes:

1. A sequence of loading temporary detectors, sources, control rods, and fuel assemblies in order to maintain shutdown margin requirements.
2. The conditions under which fuel loading may continue after any step.
3. An identification of responsibility and authority.
4. During any reactivity changes, a minimum of two detectors will be operating and indicating neutron level after the source has been inserted. At all other times, at least one detector shall be indicating neutron level.
5. Two completely independent plots of reciprocal neutron multiplications as a function of the parameter causing reactivity change are maintained.
6. Reactivity effects for each fuel assembly addition are checked prior to the release of the fuel assembly by the fuel handling grapple.
7. An estimate of the reactivity effect for the next fuel addition is made prior to insertion of the next fuel assembly.
8. The boron concentration in the reactor vessel, spent fuel pool, and Reactor Coolant System is maintained at a value to assure the required subcritical margin at all times.
9. The valve alignment of the auxiliary systems connected to the Reactor Coolant System is checked periodically to prevent dilution of the reactor coolant boron concentration.
10. Chemical analysis and water level monitoring is used to assure that inadvertent dilution of the reactor coolant boron concentration has not occurred.
11. Communication between control room and fuel handling areas is maintained.
12. The Plant Radiation Monitoring Systems are in operation.
13. Radiation Protection and chemistry monitoring and services are provided.

14.3.2 Preparation for Initial Criticality

Upon completion of the initial fuel loading, prestartup checks were completed prior to the approach to initial criticalty. The prestartup checks included:

1. Control rod trip test
2. Reactor coolant flow test
3. Reactor coolant flow coastdown test

A reactor coolant flow test and a reactor coolant flow coastdown test were conducted under cold reactor conditions to assure that the flow characteristics of the Reactor Coolant System had not materially changed as a result of the reactor core installation.

14.3.3 Initial Criticality

A written procedure was followed during the approach to initial criticality. This procedure specified in detail the sequence to be followed, the limitations and precautions, the required plant status, and the prerequisite system conditions. (This procedure also specified the alignment of fluid systems to assure controlled boron dilution and core conditions under which the approach to criticality proceeded.)

Permissible rod group withdrawal and deboration are based on calculated reactivity effects. Two independent plots of inverse multiplication characteristics are maintained during rod group withdrawal and deboration. A predicted rod group position or boron concentration for criticality is determined before the next rod group withdrawal or deboration is started.

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14.4 Postcriticality Test Program

The Postcriticality Test Program was performed to provide assurance that the plant is operating in a safe and efficient manner. Systems and components which cannot be operationally tested prior to initial criticality were tested during the Postcriticality Test Program to verify reactor parameters and to obtain information required for plant operation. A list of the postcriticality tests is provided in Table 14-2. This section summarizes the test program after each unit achieved initial criticality. The startup reports and supplements, References 1 through 14, provide the results of the startup test program for each unit.

14.4.1 Zero Power Physics Tests

Following initial criticality, a program of reactor physics measurements was undertaken to verify the physics parameters. Measurements were made under zero power condition at sufficient temperature plateaus to verify calculated worths of individual control rods and control rod groups, moderator temperature coefficient, boron worth, and excess reactivity of the core. In addition, the response of the source and intermediate range nuclear instrumentation were verified.

Detailed written procedures specifying the sequence of tests, parameters to be measured, and conditions under which each test is to be performed were followed. These tests involve a series of prescribed control rod configurations and boron concentrations with intervening measurements of control rod and/or boron worth during boron dilution or boron injection.

14.4.2 Power Escalation Test Program

Following determination of the operating characteristics and physics parameters of the reactor at zero power, a detailed power escalation test program was conducted. This program consists of specified incremental increases in power levels up to full power with appropriate testing conducted at each power level. An analysis of the significant parameters at each step was made prior to initiating an additional power escalation.

At selected power levels, the following tests were performed:

1. Unit heat balance test
2. Power coefficient measurement
3. Core power distribution measurement
4. Unit load steady state test
5. Unit transient test.

Other Power Escalation Tests were performed at one or more power levels in the test sequence.

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14.5 Startup Physics Test Program

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14.6 Operating Restrictions

During initial operations and associated testing, the normal plant safety procedures and technical specifications are in effect. In addition, special safety precautions and limitations are included in the test procedures and more restrictive operating limitations than those in the technical specifications are imposed, where required, from initial criticality through the power escalation program. The Reactor Protective System power level trip point was initially set at a low value and raised as the power escalation program progresses.

14.6.1 References

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3. Thies, A. C. (DPC), Letter to Giambusso, A. (NRC), May 15, 1974, Oconee I Startup Report - Supplement 2.
4. Thies, A. C. (DPC), Letter to Giambusso, A. (NRC), August 12, 1974, Oconee I Startup Report - Supplement 3.
5. Thies, A. C. (DPC), Letter to Giambusso, A. (NRC), November 11, 1974, Oconee I Startup Report - Supplement 4.
6. Thies, A. C. (DPC), Letter to Moseley, N. C. (NRC), February 7, 1975, Oconee 1 Startup Report - Supplement 5.
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9. Thies, A. C. (DPC), Letter to Giambusso, A. (NRC), November 7, 1974, Oconee 2 Startup Report - Supplement 1.
10. Thies, A. C. (DPC), Letter to Moseley, N. C. (NRC), February 5, 1975, Oconee 2 Startup Report - Supplement 2.
11. Thies, A. C. (DPC), Letter to Moseley, N. C. (NRC), May 6, 1975, Oconee 2 Startup Report - Supplement 3.
12. Thies, A. C. (DPC), Letter to Moseley, N. C. (NRC), March 14, 1975 Oconee 3 Startup Report.
13. Thies, A. C. (DPC), Letter to Moseley, N. C. (NRC), June 12, 1975, Oconee 3 Startup Report - Supplement 1.
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15. Parker, W. O. Jr. (DPC), Letter to Denton, H. R. (NRC), August 15, 1980.
16. Parker, W. O. Jr. (DPC), Letter to Denton, H. R. (NRC), August 15, 1980.
17. Stolz, J. F. (NRC), Letter to Parker, W. O. Jr (DPC), March 23, 1981.

18. Thies, A. C. (DPC), Letter to Denton, H. R. (NRC), May 29, 1981.

19. Wagner, P. C. (NRC), Letter to Parker, W. O. Jr. (DPC), November 30, 1981.

20. Tucker, H. B. (DPC), Letter to Denton, H. R. (NRC), September 2, 1986.

21. Stolz, J. F. (NRC), Letter to Tucker, H. B. (DPC), October 7, 1986.

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