



# UFSAR Revision 29.0

 An <b>AEP</b> Company	<b>INDIANA MICHIGAN POWER</b> <b>D. C. COOK NUCLEAR PLANT</b> <b>UPDATED FINAL SAFETY ANALYSIS REPORT</b>	Revised: 17.0 Chapter 13 Page i of i
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## **13.0 [HISTORICAL] INITIAL TESTS AND OPERATIONS**

### **13.1 [HISTORICAL] TESTS PRIOR TO INITIAL REACTOR FUELING**

The comprehensive testing program ensured that the equipment and system performed in accordance with design criteria prior to fuel loading. As the installation of individual components and systems was completed, they were tested and evaluated according to predetermined and approved written testing techniques, procedures, or check-off list. Field and engineering analyses of test results were made to verify that systems and components were performing satisfactorily and correction action was taken, when necessary.

The program included tests, adjustments, calibrations, and systems operations ensuring that initial fuel loading, initial criticality and subsequent power operation was completed in a safe manner. In general, testing was classified as hydrostatic, functional, electrical and operational. Functional tests verified that the system or equipment was capable of performing the function for which it is designed. Operational tests involved actual operation of the system and equipment under design or simulated design conditions.

Whenever possible, these tests were performed under the same conditions as experienced under station operations. During system tests for which unit parameters were not available and could not be simulated, the systems were operationally tested as far as possible without these parameters. The remainder of the tests were performed when the parameters became available. Abnormal unit conditions did not endanger personnel or equipment, or contaminate clean systems.


The tests described in Table 13.1-1 were performed prior to initial reactor fueling.

#### **[Historical] Preoperational Piping Vibrational and Dynamic Effects Test Program**

Paragraph 101.5.4 of the USAS B31.1-1967 Code for Pressure Piping states: "Piping shall be arranged and supported with consideration of vibration".

All piping systems listed below have been designed and supported in accordance with the B31.1 Code requirement for "consideration of vibration". This is accomplished by means of variable spring hangers, rigid supports, constant support hanger, pipe anchors, guides and snubbers. Although a vibrational and dynamics effects test program is not required by B31.1, we did, during the course of the normal preoperational test program, visually check all piping systems for excessive vibration. Each given system was monitored during its check-out phase under the

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transient conditions imposed by routine starting and stopping of pumps and opening and closing of valves.

In addition, specific attention was directed at evaluating possible vibration problems during the performance of the following preoperational transient test:

### **Preoperational Test**

1. Reactor Coolant System Heatup

2. Reactor Coolant System at Temperature

3. Reactor Coolant System Cooldown

4. Emergency Core Cooling Flow Test

5. Chemical and Volume Control System

### **Specific Transient**

- A. Operational test of Centrifugal Charging Pump (Step Changes)
- B. Reactor Coolant Pump Start
- C. Operation of Pressurizer Power Operated Relief Valves
- D. Operation of Pressurizer Spray Valves
- E. Operation of Letdown Isolation Valves

- A. Operation of Pressurizer Power Operated Relief Valves
- B. Reactor Coolant Pumps(Stopping and Starting)


- A. Initiation of Residual Heat Removal

- Initiation and Termination of the following:
- A. Safety Injection (SI Pumps)
  - B. Boron Injection (Centrifugal Charging Pumps with Primary Water)
  - C. Safety Injection (RHR Pumps)

- A. Operational tests of Positive Displacement Charging Pump (Stop and Start)

Except for the piping associated with the above systems subjected to the listed transients, no special transients, deliberate system abnormalities, pump trips or valve closures were implemented during the normal preoperational tests for the remainder of the plant systems. Nor will a separate piping vibrational and dynamics effects test program be performed on the remainder of the plant systems.

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The acceptance of an observed vibration was based on operator and cognizant engineer experience with consideration of the factors listed below to determine if practically no movement or movement of up to several inches would be allowed. Acceptability of a piping system vibrational or dynamic effect considered such items as:

1. pipe size and schedule,
2. length of run between supports,
3. type of support,
4. overall system configuration,
5. observed vibration frequency,
6. location of vibration or dynamic effect relative to stress concentration points such as nozzles or branch connections,
7. occurrence period (i.e., startup only or continuous during normal operation), and
8. for those systems subject to the transient listed above the amplitude of vibration that will theoretically cause the pipe to reach its elastic limit. Charts or nomographs were available during preoperational testing, to define these amplitudes as a function of pipe span and schedule, as an aid for the operator and cognizant engineer.

In addition, critical plant systems and components were physically examined (visually) for the following types of deficiencies which are indicative of possible vibration problems or associated dynamic effects:


1. Cracks in the grouting of equipment foundations.
2. Leaking gaskets in piping systems and pump seals.
3. Leaks from flanged connections in piping systems.
4. Metal to metal contact indications on piping system restraints.
5. Water hammer "noises" during transient operations.

When the above types of indications were evident, further investigation was performed to establish and correct adverse conditions.

### **13.2 [HISTORICAL] FINAL STATION PREPARATION**

Fuel loading began after all prerequisite system tests and operations were satisfactorily completed and the facility operating license was obtained. Upon the completion of fuel loading, the reactor upper internals and pressure vessel head were installed and additional mechanical and electrical tests were performed. The purpose of this phase of activities was to prepare the system

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for nuclear operation and to establish that all design requirements necessary for operation were achieved. The core loading and post loading tests are described below.

During initial fuel loading and related physics testing additional technical support was provided. The major considerations in this planning came from the recommendations of the reactor vendor and the accumulated experience of the Applicant's technical personnel. Part of this experience was the Westinghouse nuclear engineering training program which was undertaken by two of the Applicant's engineers. This consisted of a three month formal lecture series in Pittsburgh followed by active participation in a major Westinghouse PWR start-up similar to the Cook units. This program progressed through the fuel loading and the actual start-up. Using the results of this training program during the preparation and review of the detailed test procedures for Cook Plant, each start-up test and operation was evaluated for its manpower requirements in all aspects; reactor operation, instrumentation, data taking, data reduction and analysis. Augmentation of the standard plant operating crews was made on a case by case basis. The sources of additional manpower was gathered from the Plant staff, the American Electric Power Service Corporation engineering staff, Nuclear Start-Up Services personnel and Westinghouse personnel. As indicated in Section 12.1 of the FSAR, Westinghouse provided certain technical assistance during core loading, initial start-up and pre-commercial operation.


Westinghouse provided technical assistance to AEP during installation, start-up, testing and operation of Westinghouse-Nuclear Steam Supply System (W-NSSS) equipment. Through this technical assistance, Westinghouse assured itself that the W-NSSS was installed, started, tested and operated in conformance with design intent. The Westinghouse personnel that provided this technical assistance interpreted Westinghouse requirements and acted as the technical liaison with Westinghouse headquarters to resolve problems with W-NSSS equipment.

The Westinghouse manning requirements during the initial tests and start-up program was established by the Westinghouse Site Manager. Requests were made by him for technical assistance from Westinghouse specialists.

Westinghouse provided on-site technical assistance required through the completion of the acceptance tests.

American Electric Power Service Corporation (AEPSC) was responsible through its cognizant engineers for the successful completion of the initial start-up and power escalation program by providing technical assistance and support to the Plant operating staff. The cognizant engineer drew upon the AEPSC, specifically calling on the members of the Nuclear Division for technical assistance and support in following tests as they were performed, for recording and analyzing data, and preparing detailed test reports.

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Other cognizant engineers in the various disciplines similarly exercised coordination and interface responsibilities during the test program. They either spent time at the site or closely communicated with site personnel.

### **13.2.1 [Historical] Initial Core Loading**

The overall responsibility and direction for initial core loading was exercised by the Plant Manager. The overall process of initial core loading was, in general, directed from the operating deck of the containment structure. Standard procedures for the control of personnel and the maintenance of containment security were established prior to fuel loading. Westinghouse provided technical advisors to assist during the initial core loading operation.


The as-loaded core configuration was specified as part of the core design studies conducted well in advance of station start-up and as such, was not subject to change at start-up. In the event that mechanical damage was sustained during core loading operations by a fuel assembly of a type for which no spare was available on site, an alternate core loading scheme whose characteristics closely approximate those of the initially prescribed pattern would have been determined.

The core with control rods was assembled in the reactor vessel, submerged in water containing enough dissolved boric acid to maintain a calculated core effective multiplication constant of 0.90 or lower. The refueling cavity was dry during initial core loading. Core moderator chemistry conditions (particularly boron concentration) were prescribed in the core loading procedure document and was verified periodically by chemical analysis of moderator samples taken prior to and during core loading operations.

Core loading instrumentation consisted of two permanently installed source range (pulse type) nuclear channels and three temporary incore source range channels. The permanent channels were monitored in the Control Room; the temporary channels were installed in the containment structure and were monitored locally. At least one permanent and one temporary channel was equipped with an audible count rate indicator. Both permanent channels had the capability of displaying the neutron flux level on a strip chart recorder. The temporary channels were indicated on rate meters with one channel recorded on a strip chart recorder. Minimum count rates attributable to core neutrons were required on at least two of the five (i.e., three temporary and two permanent source range detectors) available nuclear source channels at all times following installation of the initial eight fuel assemblies.

At least two artificial neutron sources were introduced into the core at appropriately specified points in the core loading program to ensure an adequate neutron population.

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Fuel assemblies together with inserted components (control rod assemblies, burnable poison inserts, source spider, or thimble plugging devices) were placed in the reactor vessel one at a time according to a previously established and approved sequence that was developed to provide reliable core monitoring with minimum possibility of core mechanical damage. The core loading procedure documents included a detailed tabular check sheet that prescribed and verified the successive movements of each fuel assembly and its specified inserts from their initial position in the storage racks to their final position in the core. Checks were made of component serial numbers and types to guard against possible inadvertent exchanges or substitutions of components, and two fuel assembly status boards were maintained throughout the core loading operation.

An initial nucleus of eight fuel assemblies, the first of which contained an activated neutron source, was the minimum source-fuel nucleus permitting subsequent meaningful inverse count rate monitoring. This initial nucleus was determined by calculation and previous experience to be markedly subcritical under the required conditions of loading.

Each subsequent fuel assembly addition required detailed neutron count rate monitoring to determine that the just loaded fuel assembly did not excessively increase the count rate and that the extrapolated inverse count rate ratio did not decrease for unexplained reasons. The results of each loading step were evaluated by plant personnel and technical advisors before the next prescribed step was started.


Criteria for safe loading required that loading operations would stop immediately when:

- a. An unanticipated increase in the neutron count rate by a factor of two occurred in all the operating channels during any single loading step after the initial nucleus of eight fuel assemblies was loaded (excluding anticipated change due to detector and/or source movement).
- b. The neutron count rate on any individual nuclear channel increased by a factor of five during any single loading step after the initial nucleus of eight fuel assemblies was loaded (excluding anticipated changes due to detector and/or source movements).

An audible alarm in the containment building and control room would sound when the source range channels reached a predetermined count rate. This alarm would automatically alert the loading operators of an indication of an increasing count rate.

Core loading procedures specified: (a) the alignment of fluid systems to prevent inadvertent dilution of the reactor coolant, (b) restrictions on the movement of fuel to preclude the possibility

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of mechanical damage, (c) prescribed conditions under which loading would proceed, and (d) continuous and complete fuel and core component accountability.

### **13.2.2 [Historical] Post Loading Tests**

Upon completion of initial core loading, the reactor upper internals and the pressure vessel head were installed and additional mechanical and electrical tests were performed prior to initial criticality. The final pressure tests were conducted after filling and venting were completed.

Mechanical and electrical tests were performed on the control rod drive mechanisms. These tests included a complete operational checkout of the control rod drive mechanisms. Checks were made to ensure that the control rod assembly position indicator coil stacks were connected to their position indicators. Similar checks were made on control rod drive mechanism coils.

Tests were performed on the reactor trip circuits to test manual trip operation and actual control rod assembly drop times were measured for each control rod assembly. The reactor control and protection system trip functions were tested to ensure the system functioned properly.

At all times while the control rod drive mechanisms were being tested the boron concentration in the coolant (moderator) was high enough such that criticality could not be achieved, even with all control rod assemblies out.

A complete functional electrical and mechanical check was made of the incore nuclear flux mapping system at system operating temperature and pressure.


The tests described in Table 13.2-1 were performed prior to initial criticality.

### **13.3 [HISTORICAL] INITIAL TESTING OF THE OPERATING REACTOR**

Following satisfactory completion of fuel loading and final precritical tests, nuclear operation of the reactor began. The final phase of startup and testing included Initial Criticality, Low Power Testing and Power Level Escalation. The purpose of these tests was to establish the operational characteristics of the unit and core, to acquire data for the proper calibration of set points, and to ensure that operation was within license requirements. A brief description of the testing is presented in the following sections. Table 13.3-1 summarizes the tests which were performed from initial core loading to rated power.



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## **13.3.1 [Historical] Initial Criticality**

Initial criticality was established by sequentially withdrawing the shutdown and control groups of control rod assemblies from the core, leaving the last withdrawn control group inserted far enough in the core to provide effective control when criticality was achieved, and then continuously diluting the heavily borated reactor coolant until the chain reaction was self-sustaining.

Initial start-up procedures required continuous monitoring by both plant source range nuclear instrumentation channels; these procedures, which included RCC Assembly group withdrawal, were not commenced nor continued unless both channels were responding, i.e., that both channels had a minimum count rate attributable to core neutrons.

Successive stages of control banks of rod assembly group withdrawal and of boron concentration reduction were monitored by observing changes in neutron count rate as indicated by the source range nuclear instrumentation.

Primary safety reliance was based on inverse count rate ratio monitoring as an indication of the nearness to criticality of the core during control rod withdrawal and during reactor coolant boron dilution. Written procedures specified: alignment of fluid systems to allow controlled start and stop of boron dilution to control the rate at which criticality was approached; indicated values of core conditions under which criticality was expected.


## **13.3.2 [Historical] Low Power Testing**

A prescribed program of reactor physics measurements was undertaken to verify that the basic static and kinetic characteristics of the core were acceptable and that the values of the kinetic coefficients assumed in the safeguards analysis were indeed conservative.

The measurements were made at low power and primarily at or near operating temperature and pressure. Measurements included verification of: calculated values of control rod assembly group reactivity worths, isothermal temperature coefficient under various core conditions, differential boron concentration reactivity worth, and critical boron concentrations as functions of control rod assembly group configuration. In addition, measurements of the relative power distributions were made.

Detailed procedures were prepared to specify the sequence of tests and measurements to be conducted and the conditions under which each was to be performed to ensure both safety of operation and the relevancy and consistency of the results obtained.

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### **13.3.3 [Historical] Power Level Escalation**

When the operating characteristics of the reactor and unit were verified by the low power testing, a program of power level escalation in successive stages brought the unit to its full rated power level. Both reactor and unit operational characteristics were closely examined at each stage and the relevance of the safeguards analysis were verified before escalation to the next programmed level.

Measurements were made to determine the relative power distribution in the core as functions of power level.

Secondary system heat balances ensured that the various indications of power level were consistent and provided bases for calibration of the power range nuclear instrumentation channels. The Reactor Control System was verified to respond correctly to signals from primary and secondary instrumentation under a variety of conditions encountered in normal operations. At prescribed power levels the dynamic response characteristics of the reactor coolant and steam systems was evaluated. The response of system components was measured for 10% reduction of load and recovery, 50% reduction of load and recovery and turbine trip.


Adequacy of radiation shielding was verified by gamma and neutron radiation surveys inside the containment and throughout the station site. The sequence of tests, measurements and intervening operations was prescribed in the power escalation procedures together with specific details relating to the conduct of the tests and measurements.

### **13.3.4 [Historical] Post Startup Surveillance and Testing Requirements**

Post startup surveillance and testing requirements were designed to provide assurance that essential systems, which include equipment components and instrument channels, are always capable of functioning in accordance with their original design criteria. These requirements can be separated into two categories:

- a. The system must be capable of performing its functions, i.e., pumps deliver at design flow and head, and instrument channels respond to initiating signals within design calibration and time responses.
- b. Reliability is maintained at levels comparable to those established in the design criteria.

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The testing requirements described in the Technical Specifications establish this reliability and provide the means by which this reliability is continually reconfirmed. Verification of operation of complete systems is checked at refueling intervals. Individual checks of components and instrumentation are made at more frequent intervals as outlined in the Technical Specifications.

The techniques used for the testing of instrument channels include a preoperational calibration which confirmed values obtained during factory test programs. These reconfirmed calibration values became the reference for recalibration maintenance at refueling intervals during plant life. Periodic testing, as defined in the Technical Specifications, includes the insertion of a predetermined signal that trips the channel bistable. Indication of the operation is confirmed and recorded.

Testing of components such as pumps, is initiated through manual actuation. If response times are important, they are measured and recorded. The capability to delivery design output is checked by instrumentation and compared against design data. Allowable discrepancies are established in the Technical Specifications. The component is operated sufficiently long to allow equalization of operating temperatures in bearings, seals, and motors. Checks are made on these parameters as required. The component is surveyed for excessive vibration. Readings are recorded.


The Applicant believes that testing in accordance with the above described program provides a realistic basis for determining maintenance requirements and, as such, ensures continued system capabilities including reliability equal to that established in the original criteria.

### **13.4 [HISTORICAL] OPERATING RESTRICTIONS**

#### **13.4.1 [Historical] Safety Precautions**

The measurements and test operations during low power and power escalation were similar to normal station operations at power, and normal safety precautions were observed. Those tests which require special operating conditions were accomplished using test procedures which prescribe necessary limitations and precautions.

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### **13.4.2 [Historical] Initial Operation Responsibilities**

The Plant Manager had the overall responsibility for supervising and directing all phases of testing. All system operations in the testing program were performed by station operators in accordance with approved written procedures. Those procedures included such items as delineation of administrative and test responsibilities, equipment clearance, test purpose, conditions, precautions, limitations, and sequence of operation. Procedural changes were made only in accordance with an approved standard procedure requiring review and approval of the change(s) by experienced supervisory personnel.

Test procedures stating the test purpose, conditions, precautions, and limitations were prepared for each test. All such procedures were reviewed and approved by D.C. Cook personnel in accordance with approved standard procedures prior to implementation. Also refer to Section 13.3 for additional information.



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SYSTEM TESTS		TEST OBJECTIVE
1.	Electrical System	Ensured continuity, circuit integrity, and the correct and reliable functioning of electrical apparatus required for core loading. Special attention is directed to the following tests:  (a) Station loss of voltage auto-transfer test. (b) Normal to preferred offsite auxiliary power transfer test.
2.	Voice Communication System	Verified proper communication between all local stations, for interconnection to commercial phone service, and balanced and adjusted amplifiers and speakers. Verified that all temporary communication stations located at the fuel loading status boardsites were functioning.
3.	Essential Service Water System	Verified that service water was available for all component cooling required during core loading.
4.	Fire Protection System	Verified proper operation of the System by ensuring the design intent was met for the fire pumps, and verified that the automatic start functions operated as designed, and verified that the pressure controls met acceptance specifications.
5	Compressed Air System	Verified leak tightness of the system proper operation of all compressors, the, manual and automatic operation of controls at design setpoints, design air-dryer cycle time and moisture content of discharge air, and proper air pressure to each controller served by the system.
6.	Reactor Coolant System Cleaning	Flushed and cleaned the reactor coolant and related primary systems, obtained the degree of cleanliness required for the intended service. Provisions were made to maintain cleanliness and protection from contaminated sources after system cleaning and acceptance was completed. Coolant was analyzed for chloride content, solids, pH, and conductivity. Oxygen content is analyzed and brought to specifications prior to exceeding 250 °F.




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SYSTEM TESTS		TEST OBJECTIVE
7.	Ventilation Systems	Verified the proper operability of fans, controls, and other components of the Containment Ventilation System and Auxiliary Building Ventilation System.
8.	Residual Heat Removal and Component Cooling Water Systems	Verified adequate component cooling flow to the Residual Heat Removal System, and verified proper operation of instrumentation, controllers, and alarms related to the Residual Heat Removal System
9.	Chemical and Volume Control System	<p>Verified prior to critical operation, that the Chemical and Volume Control System functioned as specified in the system description and appropriate manufacturers' technical manuals. More specifically that:</p> <ul style="list-style-type: none"> <li>(a) All manual and remotely operated valves were operable manually and/or remotely.</li> <li>(b) All pumps performed to specification.</li> <li>(c) All temperature, flow, level, and pressure controllers functioned to control at the required set-point when supplied with appropriate signal(s).</li> <li>(d) All temperature, flow, level, and pressure alarms provided alarms at the required locations when the alarm setpoint was reached and cleared when the reset point was reached.</li> <li>(e) The reactor makeup control regulated blending, dilution and boration as designed.</li> <li>(f) The design seal water flow rates were attainable at each reactor coolant pump.</li> <li>(g) Chemical Addition Subsystem functioned as specified.</li> </ul>

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**[HISTORICAL] OBJECTIVES OF SYSTEM TESTS PRIOR TO INITIAL REACTOR FUELING**

SYSTEM TESTS	TEST OBJECTIVE
10. Fuel Handling Systems <sup>1</sup>	<p>Showed that the system design is capable of providing a safe and effective means of transporting and handling fuel from the time it reaches the station until it is stored in the spent fuel pool. In particular, the tests verified that:</p> <ul style="list-style-type: none"> <li>(a) The major structures required for refueling, such as the reactor cavity, refueling canal, new fuel and spent fuel storage, and decontamination facilities, were in accordance with the design intent.</li> <li>(b) The major equipment required for refueling such as the manipulator crane, fuel handling tools, and spent fuel transfer system operated in accordance with the design specifications.</li> <li>(c) All auxiliary equipment and instrumentation functioned properly.</li> </ul>
11. Radiation Monitoring Systems	Verified the calibration, operability and alarm setpoints of all radiation monitors, air particulate monitors, gas monitors and liquid monitors which are located in the Containment Building, Auxiliary Building, Spent Fuel Area and Control Room.

<sup>1</sup> Tests are conducted with a dummy fuel element.


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SYSTEM TESTS		TEST OBJECTIVE
12.	Nuclear Instrumentation System	<p>To insure that the instrumentation system is capable of monitoring the reactor leakage neutron flux for the source range. In particular, the tests verified that:</p> <ul style="list-style-type: none"> <li>(a) All source range equipment, cabling, and interconnections were properly installed.</li> <li>(b) The source range detector and associated instrumentation respond to neutron level changes and that the source range protection (high flux reactor trip) as well as alarm features, audible count rate, and strip chart recorders operated properly.</li> <li>(c) All auxiliary equipment connected to the source range and temporary core loading detectors operated properly.</li> <li>(d) Source range and temporary core loading detectors were properly calibrated and the associated setpoints and alarms were properly adjusted.</li> </ul>
13.	Reactor Plant Sampling System	<p>Verified that a quantity of representative fluid could be obtained safely from each sampling point. In particular, the tests verified that:</p> <ul style="list-style-type: none"> <li>(a) All system piping and components were properly installed.</li> <li>(b) All remotely and manually operated valving operated in accordance with the design specifications.</li> <li>(c) All sample containers and quick-disconnect couplings function properly.</li> </ul>



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**[HISTORICAL] OBJECTIVES OF SYSTEM TESTS PRIOR TO INITIAL REACTOR FUELING**


SYSTEM TESTS	TEST OBJECTIVE
14    Emergency Power System	<p>Demonstrated that the system is capable of providing power for operation of vital equipment under power failure conditions. In particular, the tests verified that:</p> <ul style="list-style-type: none"> <li>(a) All system components were properly installed</li> <li>(b) Each emergency diesel functioned according to the design intent under emergency conditions.</li> <li>(c) The emergency units were capable of supplying the power to vital equipment as required under emergency conditions.</li> <li>(d) All redundant features of the system functioned according to the design intent.</li> </ul>
15.    Cold Hydrostatic Tests	<p>Verified the integrity and leak tightness of fluid systems such as the Reactor Coolant System, CVCS, Sampling System, Waste Disposal System and the ECCS by performance of a hydrostatic test at the specified test pressure.</p>

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**[HISTORICAL] OBJECTIVES OF SYSTEM TESTS PRIOR TO INITIAL REACTOR FUELING**

SYSTEM TESTS		TEST OBJECTIVE
16.	Hot Functional Tests	<p>Using pump heat, the Reactor Coolant System is tested to check heatup and cooldown procedures to demonstrate satisfactory performance of components that were exposed to the reactor coolant temperature; verified proper operation of instrumentation, controllers and alarms, and provided design operating conditions for checkout of auxiliary systems.</p> <p>The Chemical and Volume Control System was tested to determine that water could be charged at rated flow against normal Reactor Coolant System pressure; to verify letdown flow against design rate for each pressure reduction station; determined the response of the system to changes in pressurizer level; checked procedures and components used in boric acid batching and transfer operations; checked operation of the reactor makeup control; checked operation of the excess letdown and seal water flowpath; and verified proper operation of instrumentation controls and alarms.</p> <p>The Sampling System was tested to determine that a specified quantity of representative fluid could be obtained safely and at design conditions from each sampling point.</p> <p>The Component Cooling Water System was tested to evaluate its ability to remove heat from systems containing radioactive fluid and other special equipment; verified component cooling flow to all components; and verified proper operation of instrumentation controllers and alarms.</p>
17.	Primary System Safety Valve Tests	Tested and set all primary system safety valves ensuring each valve lifted at the specified set pressure.

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### OBJECTIVES OF SYSTEMS TESTS PRIOR TO INITIAL CRITICALITY

SYSTEM TESTS		TEST OBJECTIVE
1.	Electrical System	<p>Ensured continuity, circuit integrity and the correct and reliable functioning of electrical apparatus. Electrical tests were performed on transformers, switchgear, motors, cables, control circuits, excitation switchgear, d-c systems, annunciator systems, lighting distribution switchboards, communication systems and miscellaneous equipment. Special attention was directed to the following tests:</p> <ul style="list-style-type: none"> <li>(a) High voltage switchgear breaker interlock test</li> <li>(b) Station loss of voltage auto-transfer test</li> <li>(c) Normal to preferred offsite auxiliary power transfer test</li> <li>(d) Tests of protective devices</li> <li>(e) Equipment automatic start tests</li> <li>(f) Exciter check for proper voltage build up</li> <li>(g) Insulation tests</li> </ul>
2.	Essential Service Water System	<p>Verified the design head-capacity characteristics of the service water system, i.e., that the system supplied design flow rate through all heat exchangers, and met the specified requirements when operated in the safeguards mode.</p>
3.	Nitrogen Storage System	<p>Verified system integrity, valve operability, regulating and reducing station performance, and the ability to supply nitrogen to interconnecting systems as required.</p>
4.	Condensate and Feedwater System	<p>Verified valve and control operability and setpoints, and inspected for completeness and integrity. Functional testing was performed when the main steam system was available. Flushing and hydrostatic tests were performed where applicable.</p>

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### OBJECTIVES OF SYSTEMS TESTS PRIOR TO INITIAL CRITICALITY

5.	Residual Heat Removal and Component Cooling Water Systems	<p>Verified component cooling flow to all components, and verified the proper operation of instrumentation, controllers, and alarms. Specifically, each of the two systems, i.e., component cooling system and residual heat removal system, was tested ensuring:</p> <ul style="list-style-type: none"> <li>(a) All manual and remotely operated valves were operable.</li> <li>(b) All pumps performed their design functions satisfactorily.</li> <li>(c) All temperature, flow, level and pressure controllers functioned properly at the required set-points when supplied with appropriate signals.</li> <li>(d) All temperature, flow, level and pressure alarms provided alarms at the required locations when the alarm set-point was reached and cleared when the reset point was reached.</li> </ul>
6.	Boron Recovery System (CVCS)	<p>Verified valve and control operability and set-points, flushing and hydrostatic testing as applicable, inspection for completeness and integrity. Functional testing was performed when a steam supply was available.</p>
7.	Safety Injection System (ECCS)	<p>Verified correct response to control signals and sequencing of the pumps, valves, and controllers of this system as specified in the system description and the manufacturer's technical manuals. More specifically that:</p> <ul style="list-style-type: none"> <li>(a) All manual and remotely operated valves were operable.</li> <li>(b) Each pair of valves installed for redundant flow paths operated as designed.</li> <li>(c) All pumps performed their design functions satisfactorily.</li> <li>(d) The proper sequencing of valves and pumps occurred on initiation of a safety injection signal.</li> <li>(e) The failed position on a loss of power for each remotely operated valve was as specified.</li> <li>(f) All level and pressure instruments were set at the specified points, alarmed and reset as required.</li> </ul>

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### OBJECTIVES OF SYSTEMS TESTS PRIOR TO INITIAL CRITICALITY

8.	Containment Spray System	Verified responses to control signals and sequencing of the pumps, valves and controllers as specified in the system description and the manufacturer's technical manuals; checked that the time required to actuate the system after a containment high-high pressure signal is received was appropriate.
9.	Reactor Control and Protection System	Verified calibration, operability and alarm settings of the reactor control and protection system; tested its operability in conjunction with other systems; e.g., the nuclear instrumentation system as detailed below.
10.	Nuclear Instrumentation System	<p>Ensured that the instrumentation system was capable of monitoring the reactor leakage neutron flux from source range through 120 percent of full power and that protective functions were operating properly. In particular, the tests were designed to verify that:</p> <ul style="list-style-type: none"> <li>(a) All system equipment, cabling and interconnections are properly installed.</li> <li>(b) The source range detector and associated instrumentation responded to neutron level changes, and that the source range protection (high flux level reactor trip) as well as alarm features and audible count rate operated properly.</li> <li>(c) The intermediate range instrumentation operated properly, the reactor protective and control features such as high level reactor trip and high level rod stop signals operated properly, and the permissive for blocking source range trip and source range high voltage-off operated properly.</li> </ul>
11.	Pressurizer Level Control System	Ensured that the system was capable of monitoring the full range of pressurizer level alarms and setpoints and that the system, in conjunction with the chemical and volume control system, controls pressurizer level.
12.	Rod Position Indication System	Checked the systems response to test signals verified correct indicating functions. After fuel loading and after the position indication coils were installed, a calibration and complete operational check was performed by operating the individual control rod drive mechanisms.

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### OBJECTIVES OF SYSTEMS TESTS PRIOR TO INITIAL CRITICALITY

13.	Reactor Thermocouple/ RTD Instrumentation	Checked and calibrated the system and compared thermocouple readings with RTD readings up to the maximum allowable temperature at isothermal conditions.
14.	Turbine Auxiliary Cooling System	Established the correct cooling to unit components, demonstrating satisfactory performance of pumps, instruments, alarms, controls and established system integrity.
15.	Primary and Secondary System - Safety and Relief Valves	Verified correct relief and safety valve pressure set-points.
16.	Turbine Steam Seal System	Verified valve and control operability and set-points, flushed and hydrostatically tested where applicable, inspected for completeness and integrity. Functional testing was performed when a steam supply was available.
17.	Turbine and Turning Gear Test	Demonstrated satisfactory operation of these systems.
18.	Chemical Volume and Control System	<p>Verified that the CVCS functioned according to design intent. More specifically that:</p> <ul style="list-style-type: none"> <li>(a) The reactor makeup control regulated blending, dilution and boration as designed.</li> <li>(b) Chemical addition subsystem functioned as specified.</li> </ul>
19.	Emergency Core Cooling System	Verified the performance of the ECCS under full flow conditions.



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**POST CRITICALITY TESTING SUMMARY**

TEST	CONDITIONS	OBJECTIVES
Control Rod Assembly Drop Tests	(a) Cold Shutdown (b) Hot Shutdown	To measure the drop time of control rod assemblies under full flow and no flow conditions
Nuclear Design Check Tests	Normal control group configurations at hot, zero power	To Verify that nuclear design predictions for endpoint boron concentrations, and isothermal temperature coefficient are valid
Control Group Calibration	All control rod assembly groups at power	To verify that nuclear design predictions for control rod assembly group differential worths are valid
Power Coefficient Measurement	Performed at various per levels	To verify that nuclear design predictions for differential power coefficients are valid
Automatic Control Systems Checkout	Approximately 20 percent of rated power	To verify control system response characteristics for the: (a) Steam generator level (b) Control rod assembly automatic control system (c) Turbine control system



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**POST CRITICALITY TESTING SUMMARY**

TEST	CONDITIONS	OBJECTIVES
Power Range/RTD Instrumentation Calibration	During static and/or transient conditions at the following percentages of rated power:  30 percent 50 percent 75 percent 90 percent 100 percent	To verify all power range instrumentation consisting of power range nuclear channels, and reactor coolant RTD's were responsive to change in reactor power to intercalibrate these systems
Load Swing Test	10 percent step load decrease at 50 and 100 percent power	To verify control systems performance as evidenced by plant parameter variations
Turbine Trip	Turbine trip from power	To verify ability of plant to sustain plant trip and bring plant to an orderly hot shutdown
Pressurizer Effectiveness Test	Hot, shutdown	To verify that pressurizer pressure is reduced at the required rate by pressurizer spray actuation
Minimum Shutdown Verification	Hot, zero power	To measure the minimum shutdown boron concentration with one "stuck" control rod assembly
Static Control Rod Assembly Drop Test	50 percent of rated power	To verify that a single control rod assembly inserted fully or part way below the control bank results in hot channel factors below design values
Load Reduction	Reduction from 100 percent to 50 percent of rated power at a ramp rate of 5 percent per minute	To verify control systems performance as evidenced by plant parameter variations





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**POST CRITICALITY TESTING SUMMARY**

TEST	CONDITIONS	OBJECTIVES
Incore Power Distribution Measurements	50 percent 75 percent 100 percent	To verify that nuclear design predicted power distributions are valid for normal control rod patterns and configurations
Dynamic Control Rod Assembly DropTest	50 percent of rated power	To verify automatic detection of dropped control rod assembly, and subsequent automatic rod withdrawal stop and turbine cutback