APPENDIX J

PRE-OPERATIONAL AND STARTUP TESTS

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APPENDIX J – PRE-OPERATIONAL AND STARTUP TESTS

J.1 TEST PROGRAM SUMMARY DESCRIPTION

The initial testing and startup operation of the unit systems prior to commercial full power operation of the unit was divided into the following four phases:

A. Preoperational

1. Construction Testing
2. Pre-Operational Testing

B. Startup

1. Low Power Testing
2. Power Testing

The purpose of this program was to make certain that the equipment was installed and would operate in accordance with the design and licensing requirements; to determine values of core parameters significant to the design and operation; and to bring the unit to its rated capacity in a safe and orderly fashion. Systems operations throughout the program, except for Construction Testing, were conducted by the station operating staff following specific written procedures. Those procedures included a delineation of administrative procedures and test responsibility, equipment clearance procedures, and overall sequence of startup operations.

Westinghouse, Pioneer Service & Engineering, and NSP’s Plant Construction and Engineering Department provided technical direction for preoperational testing, initial core loading, low power testing, and during the power escalation program.

J.1.1 Construction Testing

Construction testing covered a wide range of checks to determine that components and systems were properly installed and adjusted, according to the applicable codes, manufactures instructions and drawings, AE instructions and drawings, and to minimize the potential for equipment damage. Construction test results were recorded and filed by system to allow easy retrieval for review prior to further testing.

J.1.2 Preoperational Testing

Preoperational tests were intended to prove that a system functioned as designed under test conditions. The test procedures were prepared under the cognizance of the Plant Operating Staff based on design verification requirements supplied by the Nuclear Plant Projects Engineering Section. The procedures were specific regarding intent, method, and operating requirements. A list of tests is shown in Table J.4-1.

The contents of the procedures for this program generally included the following:

a. Prerequisites

b. Test Objectives

c. System boundaries and initial condition

d. Acceptance Criteria

e. Data collection

f. Special precautions

g. Detailed procedure

h. Documentation of test results

All preoperational test procedures were submitted to the Operations Committee and the Nuclear Plant Project Engineering Section for review and approval. No preoperational test was performed without approved procedures.

Preoperational testing was performed by operations and startup personnel under administrative direction of the Startup Manager.

Approved procedures were released to the Test Leadman. The Test Leadman had the responsibility of conducting the test and decided if changes required during testing were within the test intent. Changes determined outside the test intent were formally reviewed.

Results of tests were documented and reviewed by the Operations Committee and the Nuclear Plant Project Engineering Section, and as appropriate, incorporated in plant operating procedures. Any modifications required to equipment during the performance of testing or as a result of test data were documented and became part of the official plant test records. Temporary changes to systems were documented in the procedures and following completion of the test were restored to normal conditions and verified.

At the conclusion of testing, the completed test procedure along with all data was documented and filed for ready reference.

The Operations Committee and the Nuclear Plant Project Engineering Section review of the test results and reports were required before each test was considered complete. If sufficient cause was shown, any previously accepted plant system could have been considered as unacceptable and further preoperational type testing would have been required.

The preoperational test program was reviewed by the Operations Committee and the Safety Audit Committee as to completeness and status prior to the initiation of any startup testing.

J.1.3 Startup Testing

The Prairie Island startup test program was defined and summarized in the Startup Test Specification document prepared and releases by the Nuclear Plant Projects Engineering System with technical assistance provided by the Westinghouse Corporation and the Pioneer Service and Engineering Company. This document was reviewed by the Operations Committee and Safety Audit Committee to determine if the scope of the startup testing program met the requirements of safe plant startup with gradual power increases to full power operation. Additional testing could have been recommended by either the Operations Committee or the Safety Audit Committee.

The detailed test procedures were prepared by the Projects - Startup Section with technical assistance from Westinghouse and the Nuclear Plant Projects Engineering Section.

The Startup Test Procedures were reviewed by the Operations Committee and Nuclear Plant Projects Startup Section.

The startup tests were performed by operating and startup personnel with technical assistance of Westinghouse and supervision of the Nuclear Plant Projects Startup Section. If significant deviations from expected test results occurred, testing was suspended until those deviations were reviewed by the Operations Committee and the Startup Section and it was concluded that they were acceptable.

The results of all testing were reviewed formally and had to be approved by the Operations Committee before the tests were considered complete. Since startup tests were conducted at several power levels during the escalation to full power, a review of previous test results by the Operations Committee was required at specified power levels. The Safety Audit Committee reviewed and concurred with the test results prior to commercial operation.

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J.2 TEST PROGRAM CONSIDERATIONS

The following key points were considered in developing the sequence and schedule of tests:

a. Systems were sequenced for early testing and placed in routine operation to provide necessary auxiliary services for other systems. Examples are plant electrical systems, instrument air and makeup water supply systems.

b. Pre-operational testing was conducted with construction to permit fuel loading as early as possible, without compromising nuclear safety or impeding construction work.

c. To minimize possible contamination problems, pre-operational testing was performed before power operation on systems which could consequently be exposed to radioactive contamination.

d. Pre-operational tests provided an important phase of the reactor plant operators training program and were scheduled on key systems to permit maximum participation by all operators prior to licensing examinations.

e. Temporary construction power may have been required for initial tests at the beginning of the pre-operational test program. However, such practice was minimized.

f. Prior to bringing fuel into the plant, the access control procedures for the reactor and auxiliary buildings were implemented. Construction work in the fuel storage area then required approval of the Plant Superintendent or his designee. These controls complied with the existing AEC regulations pertaining to radiation safety. Other areas to be controlled were reviewed by the Operations Committee.

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J.3 CONSTRUCTION TESTS

J.3.1 General Scope

Certain testing requirements preceded pre-operational testing and were categorized as construction tests. Those tests were performed under Nuclear Plant Projects Construction of Startup Section supervisor. Reporting was in the form of completion check lists, calibration records and construction test result forms prepared by the Construction or Startup Section. The Reactor Pressure Vessel Hydrostatic Test, and the Containment Leak Rate Test had formal reports following completion of the test.

Construction test activity included but was not limited to the following:

a. Containment final leak rate testing

b. System hydrostatic tests

c. Chemical cleaning and flushing

d. Functional circuit checks

e. Electrical system tests including energizing, e.g., checking grounding, relay checks, checking circuit breaker operation and controls, continuity checks, megger tests, phasing checks, and energizing of buses

f. Initial rotation check of motors

g. Check control and interlock functions of instruments, relays, and control devices

h. Calibrate instruments and check or set initial trip set points

i. Pneumatic test of instrument and service air system and blow out lines

j. Equipment adjustments such as alignment, greasing, and tightening of bolts

k. Verifying relief and safety valve name plate data and/or settings

l. Tests of motor operated valves including adjusting motor operator switches and limit switches, checking controls, and checking leak-tightness where applicable

m. Complete tests of air operated valves including checking all interlocks and controls; adjusting limit switches, measuring operated speed of pneumatic operators, and checking for proper operation of controls, pilot solenoids, etc.

J.3.2 Documentation of Test Results

The Prairie Island construction test program was defined and summarized in the Construction Test document prepared by the Engineering Section of the Project Group. A general Construction Test Procedure was prepared for major equipment and/or plant systems. This procedure included the following:

a. A summary description of the test

b. Description of test methods

c. A list of required data

d. A list of required instruments

e. Acceptance criteria

f. Data sheets for tabulating all required data

Pertinent construction test procedures and results were available for review prior to the conduct of preoperational tests. Construction tests could be run concurrent with preoperational tests and be documented with preoperational data.

J.4 PREOPERATIONAL TESTS

Testing performed during the preoperational test program is outlined in Table J.4-1. Preoperational tests were defined as those functional tests intended to be performed prior to fuel loading. In general, it is expected that all preoperational testing will be completed before fuel loading. In some cases it was necessary to defer certain preoperational tests until after core loading. These include such tests as the complete rod control system, rod position indication and complete incore moveable detector system. These tests were included in the Startup Program and have been identified in Table J.4-1. Prior to the performance of hot testing, sufficient cold testing was done to be reasonably sure that hot testing would be successful. An example of these tests was the cold rod drop timing tests.

Prior to the preoperational testing of a system, the following general prerequisites were satisfied:

a. Quality assurance activities associated with the system were completed and documented.

b. Field inspection was made to verify readiness for operation, proper fabrication, cleanliness, checkout of wiring to plan, wiring continuity checks, verification of protective devices and adjustment settings, verification of torque limiting devices, setting of temperature controllers and limit switches, adjustment of relief valves, etc.

c. Confirmation that test equipment was operable and properly calibrated.

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J.5 STARTUP AND POWER TEST PROGRAM

A detailed description of the standard startup test program for the Westinghouse NSSS was filed with the AEC in Chapter 14 of RESAR III (Reference 1). In the preparation of this documentation, the AEC Guides:

> “Guide for the Planning of Preoperational Testing Programs,”
> USAEC December 7, 1970 and,
>
> “Guide for the Planning of Initial Startup Program,”
> USAEC, December 7, 1970 (revised),

were followed and in most cases, utilized the same wording as much as possible in order to more clearly show the guides were completely addressed.

J.5.1 General Requirements

The startup and power testing was performed to assure that the plant was capable of operating safely and satisfactorily. Systems and components, which could not be fully checked out in the preoperational test phase, were tested at power during the phase of the unit startup to confirm reactor parameters and characteristics determined by an extensive program of analysis and tests executed prior to initial fuel loading. The nuclear characteristics of fuel, control rods, poison rods, and chemical shim were calculated and compared with results of Westinghouse design data. Startup tests and operating data from other pressurized water reactors in commercial operation were used to confirm the applicability of the analytical methods.

Accident considerations for rod worth and shutdown margin tests were identified with respect to Technical Specifications 3.10.D.5 (since deleted) and are discussed in response to AEC question 15.31 in Section J.6.

J.5.2 Core Loading

After pre-operational tests were satisfactorily completed, plant conditions were established under which the initial nuclear fuel loading could be accomplished. Water in the reactor vessel was borated to maintain the effective multiplication constant of the core at or below 0.90 at all stages of the core loading. The Reactor Coolant System was isolated and provisions made to prevent unauthorized change in the boron concentration. The boric acid tank was filled with concentrated boric acid solution and provisions made to inject concentrated boric acid if required. The residual heat removal system was available to provide moderator mixing and temperature control if required. A detailed preloading checkoff list was followed to insure that all systems, equipment and conditions affecting the handling operation were met. Periodically, the checkoff list was reviewed to insure that systems and equipment continued to meet requirements of the core loading operation.

The core loading sequence followed a step-by-step procedure to insure at each loading step that:

a. Fuel assemblies of the correct enrichments were installed in the proper locations.

b. Rod cluster control assemblies were inserted into the proper fuel assemblies prior to loading the assemblies into the core.

c. Burnable poison rods were inserted into the proper fuel assemblies prior to loading the assemblies into the core.

d. Control rod guide tube plugging devices were inserted into the proper fuel assemblies prior to loading the assemblies into the core.

e. Neutron sources and neutron detectors were properly located in the core during fuel loading. Radiation monitoring was provided at the core loading stations during fuel handling and core loading operations.

After the core was loaded, the upper internals package was installed and the reactor vessel head assembled on the vessel. The following test and/or checks were then performed:

a. Source range monitor performance

b. Incore instrumentation program

c. Primary system leakage

d. RCC drive mechanism, electrical and mechanical operation

e. RCC Position indication

f. RCC Drop Times, Cold (with and without reactor coolant flow)

g. Reactor protection trips

h. Reactor control system

i. Rod Drop Time, Hot (with and without reactor coolant flow)

j. Design RCS Flow Verification

J.5.3 Power Escalation

In order to ensure that operation of the Prairie Island core was as expected in all respects, and that achievement of rated power was under carefully controlled conditions, a Power Escalation Test Program was established to carry the plant from completion of low power physics testing through full power operation. The Power Escalation Test Program provided the stepwise achievement of full power, with careful review of significant core parameters at each step, to ensure that fuel and control rod mechanical performance, flux distribution, temperature distribution, hot channel factors and reactivity control worths were acceptable, before additional escalation was undertaken.

The Power Escalation Test Program provided for measurements to be made at convenient power levels in the vicinity of minimum self sustaining power, discrete levels approaching 100%, and at rated power. In each case, progress to higher levels was contingent upon acceptable core performance.

In order to monitor performance, the following analytical results had to be on hand before power escalation was undertaken:

1. Expected values for local power ratios in each of the incore flux detector thimbles.

2. Expected values for relative power in each fuel assembly and in individual fuel rods of interest in various control group configurations.

3. Expected values of nuclear peaking factors.

4. Combined power and programmed temperature reactivity defect as a function or primary power level at expected boron concentration.

5. Equilibrium xenon reactivity defect as a function of primary power level.

6. Identification and integral reactivity worth of the most significant single RCC assemblies in the control group, when fully withdrawn, with various operating control rod configurations.

7. Identification and integral reactivity worth of the most significant single RCC assemblies among all groups.

Other conditions that had to be met before commencement of the Power Escalation Test Program were as follows:

1. The following plant conditions were established:

   a. The Low Power Reactor Physics Test Program was successfully completed as prescribed. Experimental values of low power reactivity parameters were deduced and were available for guidance in the elevated power program.

   b. Discrepancies between analytically predicted and experimentally measured values of reactivity parameters were identified and appropriate revisions were made in values of expected primary coolant boron concentrations and RCC group positions listed in the Power Escalation Test Sequence.

   c. The Reactor Coolant System and all required components of the Secondary Coolant System were fully assembled, mechanically tested and ready for service as required.

   d. All control protection and safety systems were fully installed. All required pre-operational tests were satisfactorily completed and all components were ready for service as required.

   e. The reactor coolant was at the required temperature and pressure, and lithium and boron concentrations.

   f. Demineralized water was available in adequate quantity for extensive boron dilution.

   g. Concentrated boric acid solution was available in sufficient quantity to permit increases in main coolant boron concentration as required.

   h. All special equipment and instrumentation required for the Power Escalation Test Program was installed and calibrated and was available for service as specified.

   i. Thermocouple correction constants derived from the hot isothermal calibrations.

2. A pre-test check-off list indicating the required status of all systems and auxiliary equipment affecting the Power Escalation Test Program was available. The pre-test check-off list included but was not limited to, provisions for verification and certification of all items specified in Condition 1, above.

3. Experimental procedures suitable for executing the Power Escalation Test Sequence, were approved by the Operations Committee for distribution to all personnel concerned with the Power Escalation Test Program.

4. The procedure, schedule and personnel assignments and responsibilities were thoroughly discussed with, and understood by operational and startup test personnel.

During power escalation, measurements were made to verify that plant parameters were consistent with those used in the various accident analyses and were no more limiting than those assumed in the accident analyses, which were the limiting values. Examples of such parameters were rod drop times, measurement accuracy of instrumentation, in-core power distribution and shutdown capability, etc.

Measurements of these parameters was made at various points in the power escalation program. Since each power step was relatively small, a high degree of reliability could be associated with the prediction of these plant parameters. The accuracy of the prediction obtained for each power level was a necessary factor for determining further power escalations.

Detailed procedures containing data sheets, discussion of precautions and methods, etc., were prepared for each test.

Table J.5-1 presents a typical list of pre-critical and power escalation tests.

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J.6 RESPONSE TO QUESTION ON ACCIDENT CONSIDERATIONS FOR CONTROL ROD WORTH AND SHUTDOWN MARGIN TESTS

Question 15.31

Proposed Specification 3.10.D.5. would permit the reactor to be critical for tests to measure control rod worth and shutdown margin with all but one full-length control rod inserted and part-length rods fully withdrawn. Provide the assumptions, methods, and results of analyses that demonstrate acceptable consequences if the control rod fails to insert on a trip signal for anticipated operational occurrences or postulated accidents including a control rod ejection accident.

Answer

The test proposed in Specification 3.10.D.5. is performed under controlled conditions. That is, measurements are being taken and the likelihood of an unusual occurrence going unnoticed is extremely small. Specification 3.10.D.5. has been written to minimize the likelihood of any unacceptable transients during the performance of this test by requiring one full-length and all part-length control rods to be fully withdrawn.

An evaluation has been made of anticipated transients and postulated accidents, assuming that they occur during the portion of this test when the reactor is critical with all full-length control rods except one fully inserted and part-length rods withdrawn. Further, the withdrawn full-length rod is assumed not to trip. Since this test is conducted at a very lower power level, only those incidents which could cause an increase in reactivity, and therefore reactor power, were considered. These incidents are as follows:

1. boron dilution
2. rod withdrawal
3. startup of an inactive loop
4. excessive feedwater addition and/or excessive load increase
5. steam line break
6. rod ejection

1. Boron dilution would result in a relatively slow reactivity insertion and increase in core power. However, the test specifies boron dilution in order to insert the control rods while maintaining criticality. Any inadvertent dilution would therefore be immediately noticed and could be terminated by operator action.

2. Also, since the test consists of inserting rods, an accidental withdrawal would be immediately detected and the operator could initiate a manual trip. Further, nuclear overpower reactor trips are at their lower setpoint for this test. Even with the assumption that one control rod fails to trip, the control rod insertion would consist of tripping the same rods which were being withdrawn, thus terminating the incident.

3. Since the test conditions specify operation of both reactor coolant pumps, startup of an inactive loop could not occur during the test.

4. Excess feedwater addition or excess load increase are not likely because of the plant status during this test. However, should they occur, the resultant power increase would be less severe than for the steam line break downstream of the flow restrictor discussed below.

5. For the evaluation of the steam line break accident, it is assumed that the initial conditions are:

   a. Critical with all but one full-length control rod inserted and part-length rods withdrawn.

   b. Initial core temperatures corresponding to no-load temperatures.

   c. For this particular plant, the critical boron concentration in this configuration will be greater than 700 ppm.

   d. The withdrawn rod fails to insert on a trip signal.

With these assumptions, the postulated accident differs from the cases presented in the FSAR in two areas: a) a lack of shutdown margin, and b) a less negative moderator temperature coefficient for the beginning-of-life condition for startup physics tests.

For a break downstream of the flow restrictor, the resulting peak heat flux and DNBR will be no worse than the FSAR case of a break upstream of the flow restrictor. Therefore, the DNB ratio will be above 1.30. 97424

For a break upstream of the flow restrictor, the resulting equilibrium heat flux may be higher than that presented in the FSAR because of lack of shutdown margin, and hence the possibility of core DNB exists. However, even if core damage does result, any core fission product release would be low because of the low fission product inventory during initial startup physics testing, and further, would be contained within the reactor coolant system.

Thus, for the initial startup physics tests, this test will not endanger the health and safety of the public even in the event of highly improbable accidents coupled with the failure of the withdrawn control rod to trip. To perform this test later in life is equally valuable. Although the consequences of the steam line break later in life will become worse, it is felt that the likelihood of a steam line break during the portion of this test when all (but one) full-length rods are inserted, together with the withdrawn rod failing to trip, is extremely small.

6. For the evaluation of the rod ejection accident, it is assumed that the initial conditions are the same as in 5. above. The calculated F_{xy}^{*} and ΔK for zero-power BOL conditions, all rods in except worst stuck rod (H-8) are 3.52 and 0.843% respectively. (see Table J.6-1 and Figure J.6-1 showing results calculated by normal nuclear design methods). Even assuming a conservative axial peaking factor of 2.0, the corresponding F_Q^N is 7.0. These data are consistent with the FSAR analysis for BOL zero power rod ejection, which show an F_Q^N of 6.26 and an ejected rod worth of 0.73%ΔK for control rod banks C and D fully inserted (less the ejected rod). The tabulated FSAR rod ejection results are reproduced as the attached Table J.6-2.

Note that these power distributions are applicable to zero power. As power is increased, local feedback flattens the power shape and reduces the peaking factor.

The rod configuration is shown as Figure J.6-2.

Considering ejection of a second rod from an all-rods-in-less-stuck rod configuration, the second rod out may increase the zero-power radial peaking factors if adjacent near the first rod. Reactivity worth of the second rod is less than the first rod. Figures J.6-3 and J.6-4 show the X-Y power distributions for rod H8 withdrawn and rods H8 and G7 withdrawn, respectively. Note that the second rod out has a significantly lower ΔK (0.52% ΔK versus .84%ΔK), and the F_{xy} for both rods out is 4% higher than for one rod only (3.55 vs 3.70).

This slight increase in F_{xy} at zero power is small compared to flattening caused by local Doppler and moderator feedback with power generation. Figures J.6-5, J.6-6 and J.6-7 and illustrate the power flattening effect at 10, 20, and 30% power for both-rods-out case. Note that the 20% power case has an F_{xy} 10% less than the zero power case.

* For definition of peaking factors, see Section 3.2 and Technical Specification 3.10.

Thus, for the initial startup physics test, this test will not endanger the health and safety of the public even in the event of highly improbable accidents couples with the failure of the withdrawn control rod to trip. To perform this test later in life is equally valuable. Although the consequences of the steam line break later in life will become worse, it is felt that the likelihood of a steam line break during the portion of this test when all (but one) full-length rods are inserted, together with the withdrawn rod failing to trip, is extremely small.

J.7 REFERENCES

1. Reference Safety Analysis Report, Revision 3, Westinghouse Nuclear Energy Systems, June 1972.

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TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	I. REACTOR COOLANT SYSTEM	
A. System Test		
1. Vibration, frequency and amplitude	Hot Plant prior to core-loading	Comprehensive vibration measurements have been made during hot functional testing prior to core loading for Rochester Gas and Electric, Unit No. 1. The results of these tests have been documented and submitted to the AEC Director of Reactor Licensing. These data will be the basis for acceptance of follow plants of similar design without repeating these tests. Following hot functional testing for all plants the internals will be removed and inspected for vibration effects prior to core loading. Vibration sensors on the main coolant pumps monitor the amplitude of vibrations during startup and operation to insure they are within specified limits. Prior to operation of the pumps this equipment is calibrated to a known signal.
2. Expansion and Restraint	Prior to the core loading, during heatup and cooldown	During the heatup to operating temperature, components and piping of the reactor coolant system is checked at selected temperatures to verify that they can expand unrestricted. At cold plant conditions prior to heatup, base line data is established for making measurements during heatup. Any restraints detected during the heatup are corrected prior to increasing the temperature. Following cooldown to ambient temperature, the piping and components are checked to confirm that they return to their cold plant base points.
3. Integrated Hot Functional Tests	Heatup at temp. and during cooldown. (Hydrostatic testing shall be satisfactorily completed and RCS instruments aligned and operational.)	Using pump heat the reactor coolant system is tested to check heatup and cooldown procedures and to demonstrate satisfactory performance of components and systems that are exposed to coolant system temperature. To verify proper operation of instrumentation, controllers and alarms, and provide design operating conditions for checking of auxiliary systems. Among the demonstrations performed are:

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
		a. That water can be charged by the chemical and volume control system at rated flow against normal reactor coolant pressures. b. To check letdown design flow rate for each pressure reduction situation. c. To check response of system to change in pressurizer level. d. To check procedures and components used in boric acid batching and transfer operations. e. To check operation of the excess letdown and seal water flow paths. f. Check steam generator level instrumentation response to level changes. g. Perform isothermal calibration of resistance temperature detectors and incore thermocouples. h. Operationally checkout the residual heat removal system.
B. Component Test		
1. Pressurizer	At operating temperature. (The hydrostatic testings shall have been satisfactorily completed, and the pressurizer heaters and spray control checked out.)	During the hot functional testing the pressure controlling capability of the pressurizer shall be verified. With RC pumps operating the pressure reducing capability of the pressurizer is verified. With the spray secured and all heaters energized, the pressure increasing capability of the pressurizer is verified. Acceptance criteria is provided in the test procedures by curves showing pressure response vs. time for pressure decreases and increases. Also, at operating temperature the heat loss of the pressurizer is determined.
2. Pumps and Motors	Hot Functional	At operating conditions, pumps and motors are checked for: a. Direction of rotation b. Vibration

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
		c. Lubrication d. Cooling e. Recirculation flow f. Flow characteristics Flow and pressure data is taken to verify these parameters are within values used in systems analysis or used in the functional requirements. Other results are verified to manufacturers specifications or published standards.
3. Steam Generators	At ambient conditions and during heatup and at power and temperature. (The secondary system shall have been satisfactorily hydrostatically tested.)	During heatup and at temperature the instrumentation and control systems of the steam generators are checked out under operating conditions. The functioning of the blowdown system is also checked out. Prior to heatup the secondary chemistry is adjusted to within specifications. During power operation the steam quality of the steam generators is measured, to determine if in design limits.
4. Relief Valves	At operating temperature & pressure	Relief valves will be checked at operating temperature and pressure for proper operation and setting.
5. Safety Valves	Prior to heatup	Prior to hot functional testing the safety valves will have been bench checked in a cold condition to confirm their operability.
6. Main Steam Isolation Valve	At operating temperature and no flow.	At zero power conditions and with pressure equalized across the valve, the operation of main steam stop valves is verified. The operating times are verified to be within values specified in the test procedures.
7. Miscellaneous Valves	At ambient and pressure conditions.	At ambient condition, the operation and timing of miscellaneous system valves are checked and the specified operating times and valve leakage measured where applicable.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
C. Pressure Boundary Integrity Tests		
1. Base Line Data for Inservice Testing	During construction and Fabrication (construction test)	During construction non-destructive test records are generated which provide data on as built conditions. Following erection and prior to operation, a base line survey of the primary system will be done using non-destructive techniques applicable for future surveys.
D. Plant Instrumentation		
1. Nuclear Instrumentation (Excore)	Prior to core loading and prior to initial criticality. (Neutron source available)	Prior to core loading the source range channels will be aligned and operationally checked out. The detector response to a neutron source will also be verified. Prior to criticality, all channels will be checked to verify high level trip settings; alarm features, audible count rates, and that strip chart recorders and auxiliary equipment operates properly.
2. Process Instrumentation (RCS Temp. pressure level and flow.)	Ambient; at temperature and at power (equipment may have been aligned per manufacturer's instructions and applicable test procedures)	During fill and pressurization and during heatup and hot functional testing, the calibration, alignment, and operation of these instruments will be verified by comparison with one another. At power, the temperature and secondary flow instruments are calibrated at the various steady rate power levels and setpoints adjusted as required by results of data.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	II. REACTIVITY CONTROL SYSTEMS	
A. Chemical and Control System Tests	At ambient conditions. System components shall have been operationally checked out.	A checkout of the chemical control system is performed to verify the ability of the blender to blend boron and water to a correct and uniform concentration. Where required the adequacy of the heat tracing to maintain the highest concentration in solution is also verified. The ability to adequately sample, and the sampling techniques for boron analyses are also verified.
B. Emergency Boron Shutdown System Tests	At ambient conditions prior to core loading.	The pressure flow characteristics of the safety injection pumps are verified to be within limits of safety analysis, by pumping into the reactor coolant system loops.
C. Automatic Reactor Power Control System Test		
1. Reactor Power	Preoperational conditions. (Installation checks shall have been made.)	An open loop alignment is performed at pre-operational conditions to demonstrate the response of the system under open loop conditions to simulated inputs. These tests are performed to verify that the systems will operate satisfactorily at power. At power the closed loop alignment of the system is verified by programmed step changes and under test transient conditions.
2. Steam Dump Control System Tests	Preoperational conditions. (Installation checks shall have been completed.)	An open loop alignment is performed at pre-operational conditions to demonstrate the response of the system under open loop conditions to simulated inputs. These tests are performed to verify that the systems will operate satisfactorily at power. At power the closed loop alignment of the system is verified by programmed step changes and under test transient conditions.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
D. Thermocouple and Chamber Check		
1. Incore Thermocouples	During heatup and at temperature	During heatup and at temperature the incore thermocouples are calibrated to the average of the reactor coolant system resistance temperature detectors. All readout and temperature compensating equipment is checked during the calibration and isothermal corrections for the thermocouples determined.
2. Moveable Detector System	At ambient conditions prior to core loading. (Construction test)	Prior to core loading, the functioning of the moveable detector system is verified under the various modes of operation, the indexing is checked using a dummy cable to the thimble positions. The response of each channel is verified using simulated detector inputs. Following core loading and insertion of the thimbles in the core, the system is checked out to insure free passage to all positions and set the limit switches. During flux mapping at power, the detectors response to neutron flux are verified.
E. Control Rod System Tests		
1. Rod Control System	Ambient conditions (Construction test)	Following the installation check of this system it is energized and operationally checked out using a single mechanism to each power supply. The ability of the system to step and latch the mechanism at the correct rate of speed is verified, the alarm functions checked out and the correct values of system parameters adjusted. Following core loading and after installation of the mechanisms additional tests are performed to verify rod group selection, correct bank movement and overlap.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
2. Scram Performance	Cold and hot plant conditions with and without flow following core loading	At cold and hot plant conditions following core loading the drop times of each full length rod shall be measured by monitoring the position indication detector primary windings with both windings disconnected from a power source. The movement of the rod following the deenergization of the stationary winding induces a changing voltage in the primary winding which is monitored on a high speed recorder. The drop time is measured from the release of the rod until the rod enters the top of the dashpot. This time is verified to be less than the maximum value specified in the Technical Specifications.
3. Rod Position Indication	At ambient conditions and at temperature following core loading.	During rod control system tests prior to core loading the rod position indication system is grossly aligned to provide rod movement indication during rod withdrawal and insertions. Rod bottom bistables setpoints are also adjusted during these tests.
F. Auxiliary Startup Instrumentation Test	Prior to core loading	Separate temporary source range instruments will be installed in the core during core loading operations. One of these channels will serve as a spare to the other two channels. During the core loading operations these detectors are relocated at specific loading steps to provide the most meaningful neutron count rate. The response of each channel to a neutron source is verified prior to core loading. During core loading a minimum count rate, following a specified point in the core loading procedure is required.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	III. PROTECTION SYSTEM	
A. Reactor Protection System	Shutdown prior to initial criticality. (Installation checks shall have been performed.)	Prior to initial criticality the operation of the reactor protection system is verified under all conditions of logic and with outputs or simulated outputs from each of the Nuclear and process and other protection sensors. Individual protection channels are tested, to test the redundancy of the systems. Trips are initiated with and without blocking signals to verify their function. The protection channels are verified through to tripping of the reactor trip breakers. The trip times of each reactor protection signal is also measured from the output of the sensor tripping of the reactor trip breaker. These times are verified to be less than the maximum specified in the test procedure.
B. Safeguards System	Shutdown prior to initial criticality. (Installation checks shall have been performed.)	Prior to initial criticality the operation of the safeguards logic systems shall be verified under all conditions of trip logic. Testing will be performed with each of the sensor inputs or simulated input. Trips are initiated with and without blocking signals to verify their effectiveness. The safeguards channels are verified through to the relay or controller that actuates the safeguards device.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
IV. POWER CONVERSION SYSTEM		
A. Systems Tests		
1. Vibration Frequency and Amplitude (Turbine Generator)	Hot Functional	
2. Expansion and Restraint	During heatup at temperature and cooldown prior to core loading	Prior to heatup for hot functional tests gage base line data is established to verify movement of power conversion system components and insure that they are not restrained during heatup. After cooldown components are checked to verify that they have returned to base line points.
B. Components and Individual Systems		
1. Reactor System Components	At ambient conditions, during heatup and at power.	During cold functional testing and at hot functional temperature, reactor coolant system components are verified under operating conditions.
2. Auxiliary Feedwater Pumps	Hot shutdown prior to initial criticality and during low power physics tests.	Prior to initial criticality the emergency feedwater system is checked out to verify its ability to feed the steam generators. Automatic starting is checked during checkout of the safeguards logic systems tests. During low power physics test the ability of the system to feed the steam generators at low power (~5%) is verified.
3. Turbine Control and Bypass Valves	Prior to criticality and at power.	At shutdown conditions open loop alignment of the turbine controller and steam dump system is verified. During load change at power and during load reduction and plant trips these systems are verified under transient conditions.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
4. Feedwater and Feedwater Control System	Prior to criticality and at power.	The feedwater and condensate pumps are operationally checked out prior to startup. During power escalation the power is slowly increased and the ability of the feedwater pumps to maintain level in the steam generators is verified. The steam generator level control system is aligned prior to filling the system and during fill the system is used to monitor level in the steam generator. Prior to startup the ability of the feedwater regulating valve control system to control the valves using simulated signals is demonstrated. During startup when at power the ability of the system to control level under transient conditions is also verified.
5. Condenser Circulating Water	Prior to criticality and at power.	Prior to hot functional tests the main circulating water pumps are operationally checked out. During hot functional testing, while dumping steam to the condensers, the circulating water system and condenser operation is verified. During power escalation the ability of the system to maintain design temperature and back pressure is verified to 100 percent load conditions.
6. Turbine Steam Seal and Blowdown Systems	Hot Functional Testing	To verify valve and control operability and setpoints, flushing and hydrostatic testing where applicable, inspection for completeness and integrity.
7. Turbine and Turning Gear Test	Following turbine erection and checkout	Following turbine erections and checkout and when lubrication system is operational, this system is checked out and the turbine placed on the turning gear.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	V. AUXILIARY SYSTEMS	
A. Reactor Coolant System Makeup Test	Hot Functional Testing	Prior to hot functional testing components of this system are operationally checked out and setpoints made. During hot functional testing and power operation the ability to makeup to the reactor coolant system is demonstrated.
B. Reactor Pump Seal and Cooling Water	Prior to preoperational and at temperature.	Prior to pump operation and with the system pressurized, flow to the pump seals and cooling water flow is adjusted to specified values using installed instruments. During hot functional testing when at operating temperature and pressure seal and cooling flows and temperatures are checked and verified to specified values.
C. Vent and Drain System Test	During initial fill	The vent and drain capability is checked with each system or component as it is filled or drained during testing.
D. Component Cooling System Test	During hot plant conditions and during cooldown.	Component cooling to the various components in the system is adjusted. During hot functional testing and during cooldown data is taken to verify that adequate cooling is achieved to each component and temperature limits are being maintained.
E. Residual Heat Removal Test	During initial core loading and cooldown following hot functional.	This system is operationally checked out prior to initial core loading by verifying pressure and flows for the various flow paths. The system is used to recirculate ambient temperature water during initial core loading. During cooldown following hot functional testing the heat removal capability of the system will be checked.
F. Chemical Volume Control System Test	Operating Temperature prior to core loading.	During hot functional testing with the demineralizers charged with resin, operations of the purification system is demonstrated by verification of flow, pressure drops and temperatures.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
G. Fire Protection System Test	Prior to plant startup.	Components and equipment of the fire protection system is checked for completeness and operationally tested to verify systems pressure at full flow conditions. Operations are also conducted from diesel engine source to demonstrate the capability of these system.
H. Cooling Water System Test	Prior to and during hot plant testing before core loading.	The system is operationally checked out to verify specified pressure and flow. Cooling water flow is verified to components in the system. Operation is demonstrated from the diesel engine source.
I. Auxiliary Building Ventilation	Prior to Plant Startup	The system is operated to demonstrate and balance flows to the areas supplied from the system and to verify motor currents, make setpoints and check alarms. Tests are performed to check out the isolation features of the system under simulated conditions that require isolation.
J. Shield Building Ventilation	Prior to Plant Startup	The system is operated to balance air flows to the various systems, and to verify motor currents, speeds make setpoints, and check alarms.
K. Instrument Air System Tests - (Plant response to loss of instrument air)	Prior to Plant Startup	Operation of air operated equipment shall be verified within the range of design operating pressure values and any other air operated components will be tested to insure that they fail in the design mode upon loss of operating pressure.
L. Reactor Vessel Head Cooling Test	Prior to heatup following core loading.	The system is operationally checked out to verify design air flow, motor current, speed and make setpoints and check alarms.
M. Ring gap Cooling System	Prior to plant startup	The system is operationally checked out to verify design air flow, motor current speed and make setpoints and check alarms.
N. Leak Detection System Tests (Ability to detect leaks).	Prior to and during preoperational tests	Thermocouples in the drain lines from safety valves and reactor vessel head seal are checked to verify ability to detect leaks and checkout alarm functions. The reactor drain tank level and temperature sensors are calibrated and associated alarms checked out.

TABLE J.4-1 PREOPERATIONAL TESTS

	TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
		VI. ELECTRICAL SYSTEMS	
A.	Normal Distribution Test (Trans, Motors, Relay switches, power supplies, etc.) Phasing and meggering where applicable	Prior to plant startup and systems operation (construction test)	The integrity of these components are verified prior to energization and operation by meggering hi pot testing, continuity tests and operational testing of controlling devices as applicable. After energization loading, phasing and voltage regulation test are performed where applicable.
B.	Vital but test (Full load test using all power sources).	Prior to plant operation	Tests are performed to verify that the vital bus load can be supplied from all power sources under normal and power failure conditions. In particular tests are performed to verify that transfers take place under loss of power and redundant features function per design.
C.	D. C. Systems Test (Full load and duration test).	Prior to plant operation	The redundant features of the battery, battery charger and inverters are checked out. The capacity of the battery and voltage regulation is verified. The recharging of a discharged battery within a specified period is also verified. The ability of each inverter to maintain design output under varying dc input is verified.
D.	Communications Systems Test (Telephone, public address, intercomms. and evacuation signals).	Prior to fuel loading (construction test)	To verify proper communications between all onsite stations and interconnection to commercial telephone service. To balance and adjust amplifiers and speakers and verify that evacuation alarms can be heard at all stations throughout the plant. Also to verify that all temporary communications at the fuel loading stations and control stations are functioning properly.
E.	Emergency Power Systems (Manual start and synchronization, fuel automatic loading test, under loss of all A. C. power)	Prior to hot functional test	The automatic starting and loading of the diesel generators is demonstrated under loss of normal AC power. The operation of the logic and sequencing of circuit breakers is demonstrated. Load duration test are demonstrated over regulation tests. The adequacy of the fuel oil storage and fuel transfer systems is verified.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	VII. CONTAINMENT SYSTEMS	
A. Post Accident Heat Removal System Tests		
1. Containment Air Handlers	Prior to plant operation	The system is operated to verify design air flows, pressure drops, motor currents, speeds and check alarms and setpoints and operation of the system.
2. Containment Sprays	Prior to plant operation	Tests are performed to verify response to control signals, sequencing of the pumps, valves and controllers as specified in the system description and manufacturer's technical manuals, and to check the time required to actuate the system after a containment high - high pressure signal is received.
B. Containment Isolation Tests	Prior to plant operation (Construction Test)	The operation of systems and components used for containment isolation will be demonstrated and their tightness verified.
	VIII. FILTRATION SYSTEMS	
A. Filtration Systems (testing performed of particulate filter system in containment and auxiliary structures for post accident and routine release gaseous effluent)	Prior to plant operation	Testing will be performed to verify design flows, pressure flows, pressure drops, and effectiveness of these systems in performing their filtering system.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	IX. EMERGENCY CORE COOLING SYSTEM	
A. System Tests (Expansion and restraints, vibration frequency and amplitude)	Prior to plant operation	During system heatup and operation the systems will be checked for movement expansion and unacceptable vibrations.
B. High Head Safety Injections Tests	Prior to plant operation	This system is operationally checked to verify pressure/flow values used in safety analysis. Tests are also conducted to check pump motor currents, and system setpoints, and to verify operation from normal and emergency power sources. More specifically that: Items in C below are tested.
C. Low Head Safety Injection	Prior to plant operation	The low head safety injection system is checked to verify design flow, flow paths, motor current speeds and setpoints. Tests are conducted to verify operation from normal and emergency power sources. More specifically that: a. Manual and remotely operated valves are operable manually and/or remotely. b. Valves installed for redundant flow paths operate as designed. c. Pumps perform their pressure/flow design functions satisfactorily. d. The proper sequencing of valves and pumps occurs on initiation of a safety injection signal. e. The fail position on loss of power for each remotely operated valve is as specified. f. Valves receiving signals on high containment pressure operate when supplied with these signals. g. Level and pressure instruments are set at the specified points and provide alarm and reset at the required location(s).
D. Accumulator Tests	Prior to plant operation	A piping resistance analysis is performed for each plant to insure that the blowdown characteristics of the accumulators are within design predictions.

TABLE J.4-1 PREOPERATIONAL TESTS

	TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	X. FUEL STORAGE AND HANDLING SYSTEM		
A.	Spent Fuel Pit Cooling System Test	Prior to plant operation	Testing is performed to demonstrate filling and emptying the SFP, circulation through the SFP demineralizers and heat exchanger loops, operation of the skimmer loop and to verify alarm setpoints and determine that valves, instruments, and control function correctly.
B.	Refueling Equipment	Prior to initial core loading	Tests are performed prior to core loading to demonstrate the functioning of the fuel transfer system and the fuel handling tools using a dummy assembly.
C.	Refueling Canal Water System Tests	Prior to Plant Operation	Operations are performed to demonstrate filling and emptying the systems, to check instruments and controls and to verify water tightness of the system.
D.	Spent Fuel Pit Vent and Special Vent System	Prior to plant operation	Tests are performed to demonstrate flows, check alarms and set points and to check out isolation of normal ventilation under simulated conditions that require isolation.
	XI. REACTOR COMPONENTS HANDLING SYSTEM		
A.	Reactor Component Handling System	Prior to installation of components (construction tests)	Load testing is conducted on cranes and other handling equipment. Indexing is performed, motor currents and speeds verified and limit switch setpoints set.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
	XII. RADIATION PROTECTION SYSTEM	
A. Process, Criticality and Area Monitor Tests	Prior to Core loading and plant operation	Prior to core loading the radiation alarms associated with core loading are checked out and alarm points set and verified. Process and area monitor sensors and channels are calibrated per manufacturer's instructions and alarm setpoints made.
B. Personnel Monitor and Survey Instrument Tests	Prior to plant startup	Prior to plant startup and equipment use these instruments are calibrated to reference standards. Following this initial calibration the instruments are recalled periodically for recalibration.
C. Laboratory Equipment Test	Prior to and during startup	Prior to plant startup laboratory equipment is checked out to verify equipment and checkout personnel performance. Chemical analyses are performed on known samples prior to startup. During startup the equipment and personnel receive additional checkout by normal use of equipment.
	XII. RADIOACTIVE WASTE SYSTEM	
A. Radioactive Waste System	Prior to plant operation	To verify satisfactory flow characteristics through the equipment, to demonstrate satisfactory performance of pumps and instruments; to check for leak tightness of piping and equipment, to checkout the operation of packaging and waste reduction equipment and to verify proper operation of alarms and control. More specifically, that: a. All piping and components are properly installed as per design specification. b. Manual and automatic valves are operable. c. Instrument controllers operate properly. d. Alarms are operable at required locations. e. Pumps perform their design function satisfactorily.

TABLE J.4-1 PREOPERATIONAL TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
		f. Pump indicators and controls are operable at required locations. g. The waste gas compressors operate as specified. h. The gas analyzers operate as specified. i. The waste evaporators are operational. j. The hydrogen and nitrogen supply packages are sufficient for all modes of operation.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
PRECRITICAL TESTS AFTER FUEL LOADING		
1. Mechanical and Instrument Test on Control Rod Drive and Rod Position Indicators	Prior to initial criticality	Operational testing of the rod control systems is conducted to checkout the controlling features, adjust setpoint and verify rod speeds and sequencing of power to the rod drives. Following core loading and installation of the rod mechanisms, operations are conducted to verify the rod mechanisms over their full travel, the latching and releasing features and calibration of the position indicators are performed over the full rod travel to within ± 5% of the power supply step counter.
2. Reactor Trip Circuit and Manual Scram Tests	Prior to initial Criticality	Operational testing is conducted to verify the reactor protection circuits in the various modes of tripping, including manual reactor trip up to the tripping of the reactor trip breakers. Following core loading the release and scram of each full length mechanism is demonstrated.
3. Rod Drop Measurement Cold and Hot at Rated Recirculation Flow and no Recirculation Flow	Prior to initial Criticality	The drop time for each full length rod is measured from the release of the mechanism until the rod enters the dashpot and bottoms. Drop times are measured at cold and hot plant conditions, with and without flow. The drop times are verified to be less than the maximum value specified in the Tech. Spec.
4. Final Hydrostatic Test of Reactor Coolant System	Prior to initial Criticality	Following core loading and installation of the RV head and torquing of the reactor vessel heads studs, pressure testing is performed at 100 psi above operating pressure to verify that there is no leakage past head and vessel seal. The pressure integrity of the reactor coolant system will have been verified at one and one quarter times design pressure prior to core loading.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
5. Chemical and Radio-Chemical Tests (to establish water quality)	Prior to fill, heat up and after startup	Water for reactor coolant system fill and makeup is analyzed for chloride content, conductivity, total dissolved solids, PH, clarity and fluorides and verified to be within acceptable limits. Prior to exceeding 250°F oxygen is scavenged by addition of hydrogen to within specified limits. Prior to, at criticality and during power escalation, boron and radio chemical analysis are performed to verify requirements.
6. Calibration and Neutron Response Check to Source Range Monitor	Prior to core loading	Prior to core loading the source range channels are aligned and operationally checked out. The detector anode voltage is set based on data derived from using a neutron source. After a power history has been established on the core the detector anode and discriminator voltages are reset based on data obtained at that time.
7. Mechanical and Electrical Test of Traversing Incore Monitor	Prior to initial criticality	Prior to core loading the moveable detector system is operationally checked out in all modes of operation to verify the indexing and to insure free passage of detectors into all positions. Following core loading and insertion of the detector thimbles, the system is again operationally checked out by insuring the free passage of detectors into all inserted thimbles. Electrical tests are performed using simulated signals to checkout the recorders and input to the P-250 computer, if installed. During physics measurements the system is operationally checked when doing flux mapping.
8. Cold and Hot Flow Tests to Determine Effects of Core Installation	Prior to plant startup	Prior to and following core loading measurements of pump currents and elbow tap differential pressure are made to make relative comparisons to determine the effects of core installation. At hot shutdown (Mode 3, Hot Standby in IT.S.) conditions following core loading measurements of pump power, and loop elbow differential pressure drops are made. Using this data with the reactor coolant pump performance curve the reactor coolant design flow is verified. 02-055

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING	
9. Pressurizer Effectiveness Test	At hot shutdown following core loading	At hot shutdown (Mode 3, Hot Standby in IT.S.) temperature and normal operating pressure the effectiveness of the pressurizer heaters in maintaining and increasing system pressure is demonstrated. The heaters are energized and the pressure increase is compared with the expected pressure rise given in the procedure. The ability of the spray system to reduce pressure is also demonstrated. The spray valves are opened and the pressure decrease is compared with the expected pressure decrease given in the procedure.	02-055
INITIAL CRITICALITY AND LOW POWER TESTS			
1. Initial Criticality	Plant at hot shutdown (Mode 3, Hot Standby in IT.S.): temperature at normal no load and pressure at normal operating Reactor coolant borated for refueling shutdown concentration.	The objective is to bring the reactor critical for the first time from the plant conditions specified. Prior to start of rod withdrawal the nuclear instrumentation shall have been alignment checked and conservative reactor trip setpoints made. All rods are withdrawn except the last controlling group, which is left inserted sufficiently to provide enough worth for effective control once criticality is achieved by boron dilution. At preselected points in rod withdrawal and boron dilution data is taken and ICCR plots made to enable extrapolating to the expected critical point. Once criticality is reached power is raised to check the point of nuclear heating, and reactivity measuring instruments checked out.	02-055
2. Radiation Surveys	At steady state conditions during power escalation	Radiation surveys are made during the power escalation to determine dose-levels at preselected points throughout the plant due to radiation leakage. Instruments used are calibrated to known sources, and the calibration is rechecked following the survey.	

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
3. Calibration of Nuclear Instruments with Power and Determine Overlap (Determine temperature effects)	After startup and during escalation	After initial criticality and during escalation into the intermediate and power ranges data is taken to verify at least one decade overlap between the source and intermediate ranges and full overlap between the intermediate and power ranges. This data is repeated during de-escalation until the overlaps are firm and re-escalation established. During low power escalation the power range detector currents are monitored and compared with the intermediate range currents to verify response of the power range detectors. With a flat T cold program and T_{avg} programmed to vary with power the effects of T_{avg} change on detector current is not significant. The calibration of the power range nuclear channels are calibrated to reactor thermal output based on measurement of feedwater, feedwater temperature and steam pressure.
4. Effluent Radiation Monitors (Calibration against known effluent concentration)	Prior to plant startup	These instruments are calibrated to a known radiation source or to analog signals which have been calibrated to known radiation sources.
5. Moderator Temperature Reactivity Coefficient and Defect	Low Power Tests	At normal no load temperature and no nuclear heating, reactor cooldown system cooldown and heatup is initiated using the steam dump and reactor coolant pumps. About a 5°F change in temperature is initiated and during these changes T_{avg} and reactivity are recorded on an X-Y recorder. From these data the temperature coefficient and temperature defect are determined.
6. Pressure Reactivity Coefficient Measurement		Direct measurements of pressure coefficient of reactivity are not made since the effects of pressure on reactivity are of second order when compared with other effects.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
7. Control Rod Reactivity Worths - Determination of individual and group differential and integral worth and verification of worth for shutdown capability	During low power physics tests.	At low power conditions at or near operating temperature and pressure the nuclear design predictions for all rod cluster control assembly (RCCA) groups differential worths are validated. These validations are made from boron concentration sampling data, RCCA group positions and recorder traces of reactivity. From these data the integral RCCA group worths are determined. The minimum boron concentration for maintaining the reactor shutdown with the most reactive RCCA stuck in the full out position is determined. The determination is made from analysis of boron concentration and RCCA worths. From this data the shutdown criteria are verified.
8. Boron Reactivity Worth Measurement	At power	Differential boron worth measurements are made by monotonically increasing or decreasing main coolant boron concentration. Compensation for the reactivity effect of the boron concentration change will be made by withdrawing or inserting, respectively, control rods to maintain moderator average temperature and power level constant and observing the resultant accumulated change in core reactivity corresponding to recessive rod motion steps.
9. Comparison of Initial Critical Boron and Reactivity Holddown Valve with Predicted Boron	Low power	Following the achievement of initial criticality a prescribed program of nuclear design checks is performed at low power and at near operating temperature and pressure. With normal RCCA group configurations the following verifications are made: a. That nuclear design predictions for boron concentration endpoints are valid. b. That nuclear design predictions for isothermal temperature coefficients are valid. Verifications are made from boron sampling analysis, RCCA position data and recorder traces of reactivity and reactor coolant system temperature using plant instrumentation.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
10. Flux Distribution Measurement with Normal Rod Patterns	At steady state power	At preselected (about 50, 75 and 100%) power levels during the power escalation phase incore measurements are made using the moveable detector and thermocouple and systems along with the data thermal power measurements are also made. These measurements are made at steady state conditions and with normal rod patterns. This data is used in analysis to determine that incore parameters are valid for design predictions.
11. Chemical and Radio Chemical Tests to Demonstrate Ability to Control Water Quality	Prior to criticality and during power escalation	Prior to criticality the procedures and equipment for performing radio-chemical analysis of primary and secondary systems are demonstrated and the performance of personnel checked out. During power escalation, sampling is performed and analysis done to verify that plant chemistry is within specifications.
12. Pseudo Rod Ejection Test, to Verify Safety Analysis (Hot)	Hot Zero Power	Incore measurements are made with individual rods withdrawn out of bank position to determine the resulting hot channel factors and verify that they are within expected limits. These determinations are made from moveable detector and thermocouple data.
POWER ASCENSION TESTS		
1. Natural Circulation Test to Confirm Sufficient Cooling Capacity	Low Power conditions	The ability of natural circulation to remove decay heat has been demonstrated at the Rochester Gas and Electric Co. Ginna plant for two loop plants.
2. Power Reactivity Coefficient Evaluation and Power Defects Measurement (25%, 50%, 75% 100%)	During power escalations	During power escalation recorder traces are made of reactor power and reactivity changes while maintaining prescribed temperature conditions. From these traces the power coefficient of reactivity and power defects are determined.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
3. Plant Response to Manual and Automatic Load Changes (25%, 50%, 75% and 100%)	During Power Escalation	Plant response to the following load changes is demonstrated: a. ± 10% step load change from 30, 75 & 100% b. 50% load reduction from 75 and 100% c. Plant trips from power levels up to 100% During the performance of these tests recordings are made of plant parameters on high speed recorders. These recordings are analyzed for control systems behavior, and requirements for realignment. Acceptance criteria such as plant not tripping (where applicable) relief and safety valves not lifting and steam dump operating correctly are given in the individual procedures. At about 15-30 percent power the automatic control systems are checked out by simulating controlling parameters with a test signal and observing controller response, by programming a step change in the control parameter and switching to automatic and observing the ability of the parameter to achieve the new setting without appreciable overshoot or oscillation. During the plant transient tests, these systems are operationally checked out under actual design load changing conditions.
5. Chemical and Radio-Chemical Analysis - (25%, 50%, 75%, 100%)	During power escalation	During low power physics tests and at selected 25, 50, 75 and 100% power samples of reactor coolant are taken and analysis performed to verify that results are within design predictions.
6. Effluents and Effluents Monitoring Systems (25%, 50%, 75%, 100%)	During power escalation	Effluent monitors are installed at selected locations in the plant to monitor for radioactive constituents in the effluents. These instruments monitor for gross gamma and are calibrated prior to use to a known source. During power escalation these instruments detect relative changes in gross gamma with power, and alert the operator as to when radiochemical analysis should be performed.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
7. Evaluation of Core Performance Margins From DNB (25%, 50%, 75%, 100%)	During power escalation	At steady state power points up to about 75% incore data is obtained and analysis performed to verify that the core performance margins are within design predictions, for expected normal and abnormal rod configurations. This data is plotted and extrapolated to 100% power and analyzed; prior to escalation to 100%.
8. Loss of Flow (50 to 100%)		Reactor coolant systems response to loss of flow for various combinations of pump stops is determined from hot zero power conditions. The decay of flow is maintained by recording the elbow tap D/P detector voltage on a high speed recorder. From these data low flow trip mounts are verified. Plant tripping due to loss of flow above 10% power will be demonstrated.
9. Turbine Trip (50 and 100%)	At power	Turbine trip will be performed from 100% power and probably from several power levels below 100% to verify that safety valves do not lift and that the plant can be maintained in a hot shutdown (Mode 3, Hot Standby in IT.S.) condition. During these trips certain plant parameters are monitored on high speed recorders to verify that they behave in the manner expected. 02-055
10. Generator Trip (100%)	At power	To verify control systems performance as evidenced by plant parameter variations.
11. Shutdown from Outside the Control Room	10% power	Instrumentation and controls are available outside the Control Room to maintain the plant in a hot shutdown (Mode 3, Hot Standby in IT.S.) condition. The ability to maintain the plant in a hot shutdown (Mode 3, Hot Standby in IT.S.) using these controls will be demonstrated. 02-055
12. Loss of Offsite Power	10% power	Tests are performed in which a simulated loss of voltage is initiated and starting of the diesels and the connecting of the emergency loads on the emergency bus is demonstrated. The initiation of complete loss of power and the operation of the emergency power system to assume emergency loads will be demonstrated.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
13. Radiation Surveys and Shielding Effectiveness (50 and 100%)	At power	The surveys to verify the effectiveness of the shielding has been discussed under Radiation Survey. These surveys will be conducted up to and including 100% power.
14. Part Length Rod Insertion Removal Effectiveness to Control Xenon Transient (75%)	Approximately 80% power	At approximately 80 percent of full power, tests are performed to verify the effectiveness of the part length RCCA bands in containing and suppressing axial Xenon oscillations.
15. Vibration Measurements on Reactor Internals (25%, 50%, 75% and 100%)		Refer to discussion under Vibration Measurements on vessel Internals Item (1), Table J.5-1.
16. Pseudo Rod Ejection Test to Verify Safety Analysis	50 - 75%	Incore Measurements are made with individual rods withdrawn out of bank position to determine the resulting hot channel factors, and verify that they are within expected limits. These determinations are made from moveable detector and thermocouple data.
17. Dynamic Xenon Transient Worth Measurements		Integral xenon worth transient measurements are made at elevated power, after a change in power level, by adjusting control rod position to maintain moderator average temperature and power level constant during the reactivity transient associated with the transient change in effective xenon concentration and observing the resultant accumulated change in core reactivity corresponding to successive compensating rod motion steps.
18. Dynamic Control Rod Worth Measurements		Control rod differential worth measurements are made at elevated power by initiating a transient change in boron concentration in the coolant and adjusting control rod position during the transient to maintain moderation average temperature and power level essentially constant. The worths are obtained by observing the compensating change in core reactivity due to control rod movement as indicated by the reactivity computer.

TABLE J.5-1 CRITICAL AND POWER ESCALATION TESTS

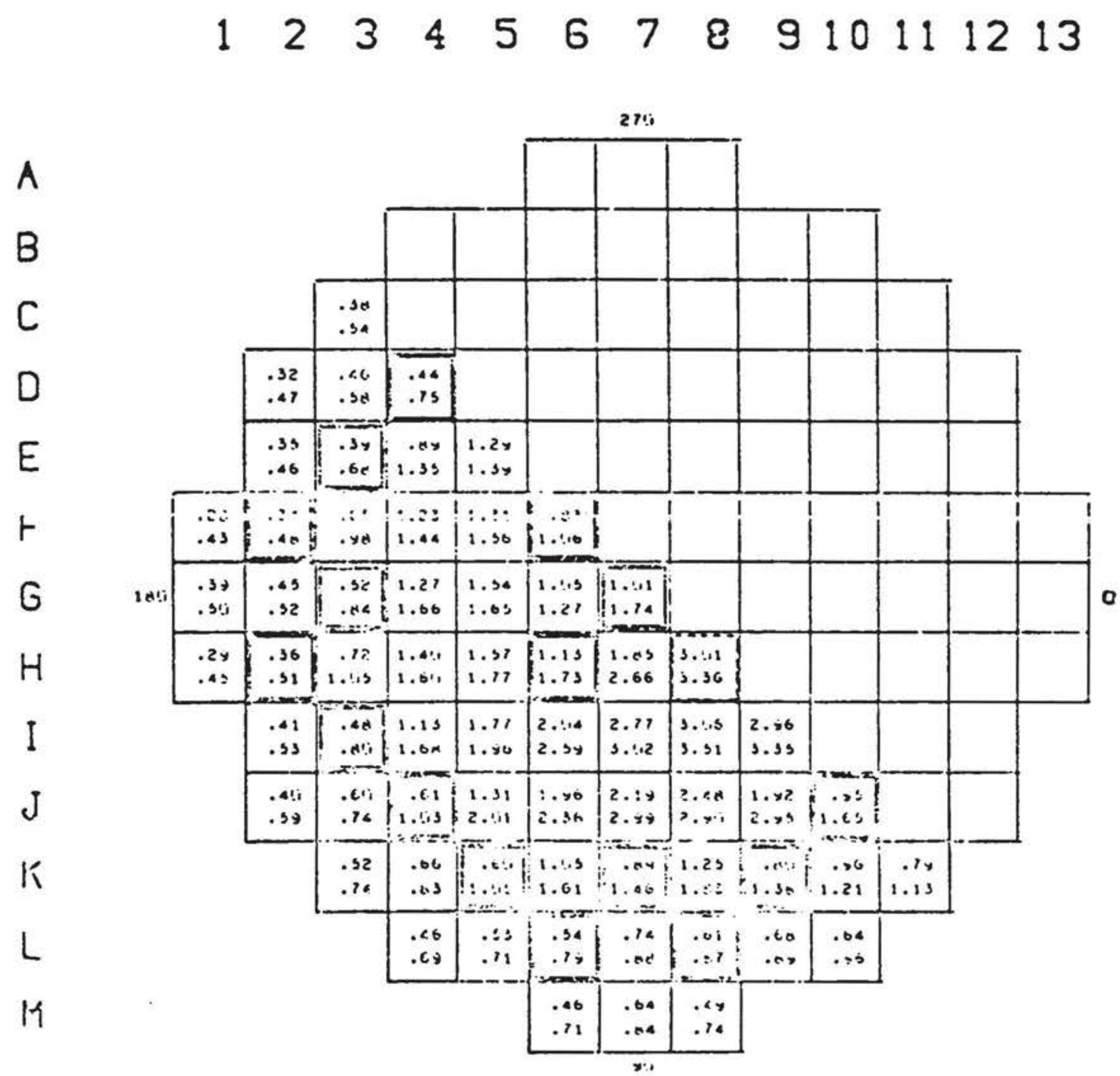
TITLE OF TEST/SYSTEM OR MEASUREMENT	PLANT/CONDITION/ PREREQUISITE	TEST OBJECTIVE AND SUMMARY OF TESTING
19. Dynamic Boron Water Measurements		Differential boron worth measurements are made as elevated power by monotonically increasing main coolant boron concentration. Compensation for the reactivity effect of the boron concentration change is made by withdrawing or inserting, respectively, control rods to maintain moderator average temperature and power level constant and observing the resultant accumulated change in core reactivity corresponding to successive rod motion steps.
20. Thermal power Measurements and Nuclear Instrumentation Calibration		To verify all power range instrumentation consisting of power range nuclear channels, and reactor coolant RTD's are responsive to changes in reactor power and temperature and to calibrate the several systems.
21. Dynamic RCC Assembly Drop Test		To verify automatic detection of dropped RCC assembly, and subsequent automatic rod withdrawal stop and turbine cutback.

TABLE J.6-1 STUCK ROD WORTHS

Core Condition and Number	Stuck Rod Location	28 Rod Worth (%Δρ)	Stuck Rod Worth (%Δρ)	F^N_{xy}
BOL, HZP, #18	H8	-6.137	.843	3.516
BOL, HZP, #19	G7	-6.582	.343	2.124
BOL, HZP, #20	H8	-6.152	.773	3.328
BOL, HZP, #21	J10	-6.285	.640	3.369
BOL, HZP, #22	K7	-6.406	.519	3.146
BOL, HZP, #23	K9	-6.462	.463	2.991
BOL, HZP, #24	L8	-6.689	.236	2.367

TABLE J.6-2 PARAMETERS FOR ROD EJECTION ACCIDENT

Time in Life		**Beginning**	**Beginning**	**End**	**End**
Power Level		0%	100%	0%	100%
Ejected rod worth %ΔK		.73	.46	.59	.39
Delayed neutron fraction %		.70	.70	.50	.50
Feedback reactivity weighting		1.60	1.60	1.60	1.60
Trip Reactivity % ΔK/K		2	5	2	5
Initial hot spot gap heat transfer coefficient	Btu/hr ft^2 °F	750	4400	750	4400
Transient hot spot gap heat transfer coefficient	Btu/hr ft^2 °F	10000	10000	10000	10000
Initial moderator density coefficient	ΔK/gm/cm^3	+.01	+.03	+.24	+.26
F_q before rod ejection		2.80	2.80	2.80	2.80
F_q after rod ejection		6.26	4.34	4.88	3.47
Number of pumps operational		1	2	1	2



CONDITION 18 H8 STUCK
BOL HZP SRW = .843

FIGURE J.6-1

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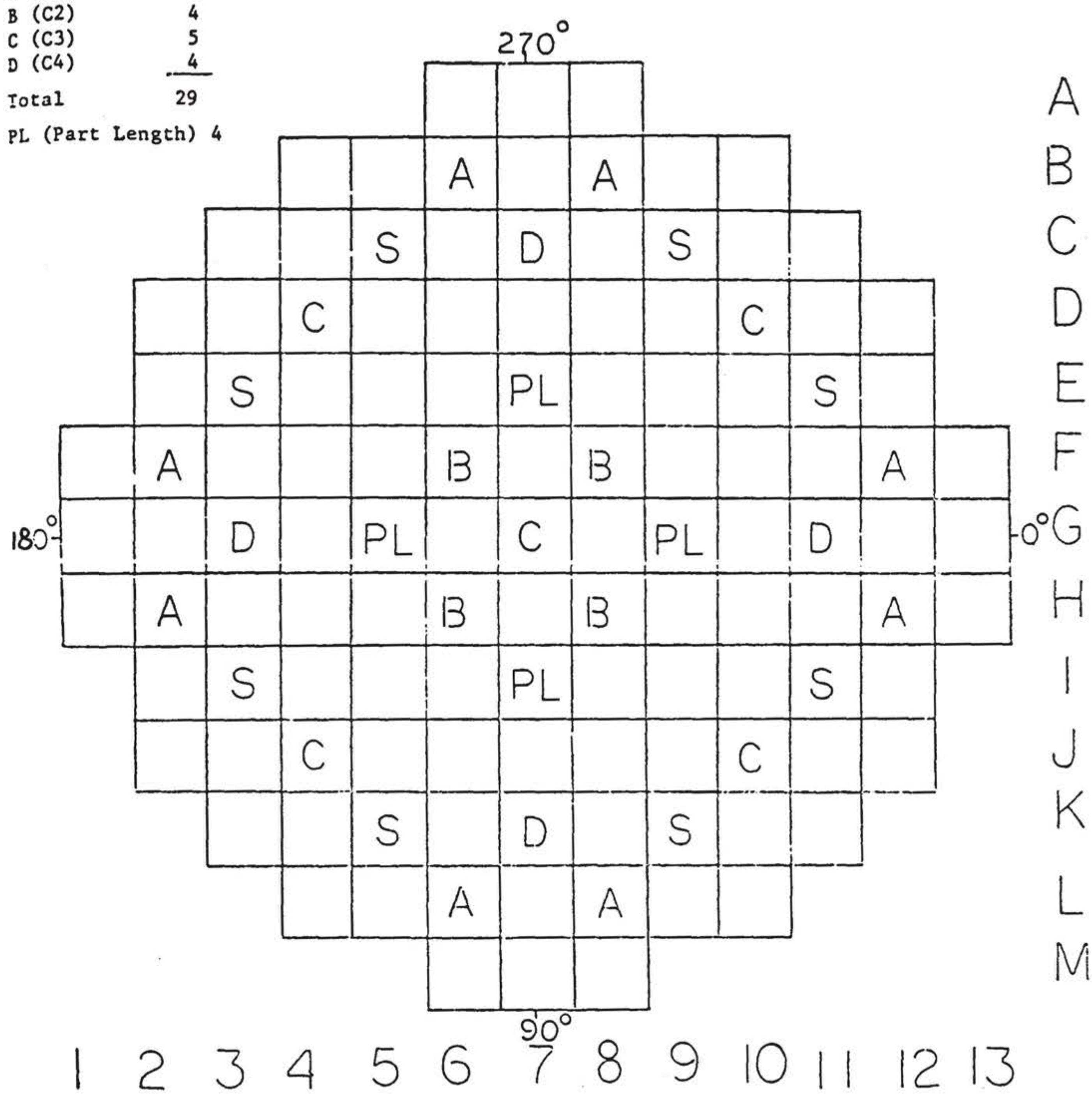
S (Shutdown)	8
A (C1)	8
B (C2)	4
C (C3)	5
D (C4)	4
Total	29
PL (Part Length)	4



CONTROL BANK LOCATIONS

FIGURE J.6-2

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FIGURE J.6-3

AVERAGE ASSEMBLY POWER DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B													
C			.371										
D		.309	.459	.435									
E		.343	.387	.981	1.275								
F	.275	.327	.645	1.217	1.301	.816							
G	.383	.444	.518	1.259	1.536	1.049	1.002						
H	.289	.355	.721	1.397	1.568	1.125	1.887	3.070					
I		.408	.473	1.128	1.773	2.061	2.813	3.111	3.019				
J		.392	.505	.603	1.318	1.982	2.218	2.525	1.946	.953			
K			.514	.566	.597	1.057	.893	1.266	.808	.979	.791	℄	
L				.460	.536	.538	.754	.609	.689	.644			
M						.457	.647	.491					

All Rod in less H8
Fxy = 3.55
Worth of H8 .84%

FIGURE J.6-4

AVERAGE ASSEMBLY POWER DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B													
C			.344										
D		.285	.431	.421									
E		.319	.372	.977	1.307								
F	.249	.305	.628	1.229	1.385	.999							
G	.346	.412	.503	1.275	1.656	1.445	2.262						
H	.260	.328	.632	1.385	1.624	1.296	2.313	3.357					
I		.372	.444	1.090	1.749	2.086	2.891	3.132	2.944				
J		.353	.551	.564	1.260	1.915	2.158	2.433	1.849	.883			
K			.450	.502	.551	.989	.837	1.183	.744	.879	.701	℄	
L				.410	.480	.484	.676	.548	.616	.570			
M						.400	.565	.430					

All Rods in less G7 and H8

Fxy = 3.70

Worth of G7 .52%

FIGURE J.6-5

10% Power

AVERAGE ASSEMBLY POWER DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B													
C			.375										
D		.311	.457	.450									
E		.346	.399	.323	1.361								
F	.273	.329	.664	1.280	1.429	1.018							
G	.377	.443	.529	1.315	1.696	1.447	2.214						
H	.283	.350	.721	1.416	1.638	1.283	2.235	3.198					
I		.395	.452	1.111	1.748	2.043	2.776	2.982	2.803				
J		.373	.575	.577	1.250	1.880	2.088	2.336	1.781	.863			
K			.481	.522	.558	.984	.825	1.157	.731	.870	.698	℄	
L				.425	.492	.491	.681	.548	.615	.569			
M						.410	.576	.437					

All rods less G7 and H8

Fxy = 3.51

$\int_0^{10} \Delta K \text{ (power)} = 0.34\%$

FIGURE J.6-6

20% Power

AVERAGE ASSEMBLY POWER DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B													
C			.401										
D		.333	.497	.473									
E		.369	.419	.957	1.400								
F	.292	.349	.692	1.316	1.458	1.031							
G	.402	.468	.548	1.342	1.713	1.447	2.174						
H	.301	.368	.743	1.437	1.645	1.273	2.176	3.075					
I		.413	.477	1.125	1.743	2.008	2.688	2.868	2.696				
J		.390	.595	.588	1.259	1.851	2.035	2.263	1.731	.848			
K			.498	.637	.554	.981	.817	1.138	.722	.865	.697	℄	
L				.437	.502	.497	.686	.550	.615	.570			
M						.418	.586	.443					

All rods less G7 and H8

Fxy = 3.36

$\int_0^{20} \Delta K \text{ (power)} = .67\%$

FIGURE J.6-7

30% Power

AVERAGE ASSEMBLY POWER DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B													
C			.423										
D		.352	.521	.491									
E		.388	.435	.983	1.426								
F	.308	.356	.714	1.341	1.477	1.040							
G	.424	.488	.554	1.361	1.723	1.445	2.141						
H	.317	.383	.761	1.450	1.647	1.264	2.128	2.977					
I		.429	.493	1.136	1.736	1.978	2.616	2.777	2.611				
J		.404	.612	.597	1.258	1.827	1.992	2.205	1.692	.838			
K			.512	.551	.570	.979	.812	1.125	.716	.862	.697		
L				.448	.512	.503	.591	.552	.617	.572			
M						.426	.595	.450					

℄

All rods less G7 and H8

Fxy = 3.25

$\int_0^{30} \Delta K \text{ (power)} = .95\%$