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D.1 Test Program Summary Description

The Monticello Nuclear Generating Plant (MNGP) is owned by Northern States Power Company, a Minnesota corporation (NSPM). NSP is a wholly owned utility operating subsidiary of Xcel Energy Corporation (Xcel Energy). Operating authority was transferred to Northern States Power Company, a Minnesota corporation (NSPM) and approved by the Nuclear Regulatory Commission (NRC) in License Amendment 156. 01197746

The prime contractor, General Electric was responsible for the design, engineering, furnishing, installation, testing, and placing into operation the machinery, apparatus, and equipment necessary for the complete nuclear powered steam turbo-generator plant. General Electric also had the contract responsibility which included the design, engineering, and construction of the necessary buildings and structures.

The General Electric Company directed the pre-operational test program performed by General Electric, Northern States Power, and subcontractor (Bechtel) personnel.

The startup test program was a joint effort by General Electric and Northern States Power. The responsibility for licensed operation during the program was assumed by Northern States Power under the technical direction of the General Electric Company.

The following paragraphs describe the testing program activities and represents a general scope of the testing of the Monticello Plant.

D.1.1 Construction Testing

Construction testing covered a wide range of checks to determine that all components were properly installed and adjusted according to the applicable manufacturers instructions, manufacturers drawings, AE drawings, control drawings (P and IDs and electrical installation drawings) and that the appropriate system cleanliness had been established. These tests were performed by Bechtel personnel, subcontractors, or vendors under Bechtel direction. General Electric, as well as Northern States Power, had the opportunity to be present at all tests. Construction tests results were made available to NSP and GE, and were prerequisite to further testing.

D.1.2 General Conduct of the Pre-Operational and Startup Testing

Pre-operational tests were intended to prove by as built test conditions that system design criteria were satisfied. The test procedures were prepared by General Electric or Bechtel Corporation depending upon system design responsibility. These procedures were specific regarding intent, method, and operating requirements. Summary descriptions of planned tests were supplied in Section 4 and Section 5 of this appendix.

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

1. The purpose and scope of the test.
2. Prerequisites.
3. The detailed procedures followed and a brief summary of the test method.
4. Clearly defined limitations for areas pertaining to reactivity and/or safety of operation.
5. Cautions observed stating any difficulties peculiar to the tests which were expected.
6. Remedial action to be taken if deviations from expected conditions occur.
7. Expected results and appropriate test limits.
8. Acceptance criteria (normally contained throughout the body of the procedure).
9. Identify special instrumentation required.
10. Any testing requiring the simulation of a plant parameter had the method to be used detailed in the procedure.

All General Electric and Bechtel approved procedures were submitted to the NSP Operations Committee for review. No pre-operational tests were run without approved procedures.

Approved procedures were released to the personnel conducting the test. If changes to the procedures were necessary, which were beyond the scope of the test personnel, the test procedure was considered as unapproved and further review was necessary. Changes to the original procedure then required formal approval.

Tests which could not be successfully completed because of improper equipment or instrumentation, or malfunction of equipment or instrumentation were suspended until satisfactory resolution of the shortcoming was completed. If these items cannot be resolved, additional Operations Committee review was necessary.

Additional testing, if required, was recommended by Bechtel, General Electric or Northern States Power and was performed when formal approval was obtained.

D.1.2.1 The Pre-Operational Testing

Pre-operational test procedures were submitted to NSP for review by the Operations Committee. All questions relating to the procedures or the condition of the plant systems were resolved prior to performance of the test. The pre-operational test program was periodically reviewed with the Safety Audit Committee. If any member of the Safety Audit Committee or Operations Committee believed that any test procedure needed formal review by the Safety Audit Committee, the review was conducted and the committee made appropriate recommendations.

Pre-operational testing was performed by NSP operations personnel under the direction of GE or Bechtel personnel. Procedure change policies were specified by the Operations Committee.

Formal review by the Operations Committee of the test results and reports was required before each test was considered complete. If sufficient cause was shown, any previously accepted plant system could have been considered as unacceptable and require further pre-operational type testing. All plant systems had to be operationally acceptable when the plant is transferred to NSP control after the power capability performance test.

Certain pre-operational tests were completed after the initiation of the startup testing; however, the complete pre-operational test program was reviewed by NSP Operations Committee and Safety Audit Committee as to completeness and status prior to the initiation of any startup testing.

D.1.2.2 Startup Testing

The Monticello startup test program is defined and summarized in the Startup Test Specification document (22A2190) prepared and released by General Electric. This document was reviewed by the Operations Committee and the NSP Safety Audit Committee to determine if the scope of the startup testing met the requirements to safely startup the plant, gradually increased to full power operation. Additional testing could be recommended by NSP.

The detailed test procedures were prepared in a General Electric Topical Report, 22A2192, "Monticello Nuclear Plant Startup Test Procedures." Copies of this document was available at the Monticello Site approximately three months before fuel loading.

The Startup Test Procedures were reviewed by the Operations Committee and Safety Audit Committee prior to initiation of the tests.

The startup tests were performed by NSP personnel under the technical direction of GE startup personnel. Significant deviations from expected test results required a suspension of testing until the deviation was understood. Testing was not resumed until the Operations Committee had reviewed these deviations.

The results of the startup testing program were continually evaluated to determine if additional testing was required to prove the safety of the reactor and plant operations. The results of all testing was formally reviewed by the Operations Committee and Safety Audit Committee before the tests were considered complete. The startup tests were conducted at several power levels during the escalation of full power. Power level increases for testing up to 1469 MWt occurred prior to the Safety Audit Committee review of previous testing. However, Operations Committee review of previous test results was required before escalation to the higher power level. Operations at power levels between 1469 MWt and 1670 were not performed until the Safety Audit Committee and the Operations Committee had reviewed the results of all testing up to and including the 1469 MWt power level.

D.2 Test Program Considerations

The following key points were considered in developing the sequence of tests.

1. 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 make up water supply systems.

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

3. Stringent controls of plant operation and maintenance work were required following fuel loading. To minimize possible contamination problems, pre-operational testing was performed before fuel loading on all systems which could consequently be exposed to radioactive contamination.

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

5. Temporary construction power could be required for initial tests at the beginning of the pre-operational test program. However, the use of temporary power and improvised set-ups was minimized.

6. Electrical jumpers were used to facilitate pre-operational testing in some instances, but their use was minimized and controlled by proper identification of such jumpers by log book records. All jumpers were removed before fuel loading.

7. Immediately prior to bringing fuel into the reactor building, the plant access control procedures for the reactor building before were enforced by the Plant Superintendent. No construction work was performed in the reactor building without the permission of the GE Operations Manager and the knowledge and concurrence of the Radiation Protection Engineer. These controls complied with the NRC regulations pertaining to radiation safety. In addition, strict control was enforced on access to the control room, cable spreading room, and radioactive waste building. Other areas to be controlled were determined by the Operations Committee.

D.3 Construction Tests

D.3.1 General Scope

Certain testing requirements preceded pre-operational testing and were categorized as construction tests. These tests were performed by Bechtel or GE with occasional NSP support. Generally, a formal test was prepared. Reporting was in the form of quality control documentation and construction test results forms prepared by Bechtel. The Reactor Pressure Vessel Hydrostatic Test, and the Containment Leak Tests, had reports following completion of the test.

Construction testing included but was not limited to the following examples:

a. Containment final leak rate testing.

b. System hydrostatic tests.

c. Chemical cleaning and flushing.

d. Wiring continuity checks.

e. Megger tests.

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

g. Initial adjustment and bumping of motors.

h. Checked control and interlock functions of instruments, relays, and control devices.

i. Calibrated instruments and checked or set initial trip set points.

j. Pneumatic tests of instrument and service air system and blow out of lines.

k. Adjustments such as alignment, greasing, and tightening of bolts.

l. Surveillance of proper equipment operation during pre-operational tests, as required. The primary intent of this item was to cover those instances where measurements such as the above were required to ensure proper operation, but were not obtainable until the entire system was operated during pre-operational test. Examples included measuring motor current and voltage; bearing, lubricating oil, cooling water and seal temperatures; vibration; torque; rpm; etc. These measurements are primarily of importance for protection of equipment, troubleshooting, or supplementing installed instrumentation.

m. Verified relief and safety valve settings.

n. Complete tests of motor operated valves including adjustment of motor operator switches and limit switches, checked all interlocks and controls, measured motor current and operating speed, and checked leak-tightness of stem packing and valve seat during hydrotests.

o. Completed tests of air operated valves including checking all interlock and controls; adjusted limit switches, measured operating speed, checked leak-tightness of pneumatic operators, and checked for proper operation of controllers, pilot solenoids, etc.

D.3.2 Documentation of Test Results

D.3.2.1 Electrical Construction Tests

Test ET-1 specified that basic electrical test requirements for the distribution system up to and including the individual component breakers, megger tests, bumping of motors, stroking of valves and adjusting limit switches. Data sheets ET-2, ET-3, ET-4 provided the basic documentation for the electrical tests. Logic control circuits for each system were functionally checked and recorded on a red lined elementary diagram.

D.3.2.2 Mechanical Construction Test

Mechanical checks consisted of alignment, coupling, installation, lubrication, system hydrostatic or pressure tests, cleaning and flushing. Documentation of the above checks was available for review prior to the conduct of the applicable pre-operational test.

D.4 Summary Of Pre-Operational Test Content

D.4.1 General Electrical APED Prepared Procedures

D.4.1.1 Reactor Vessel Components

a. Verified calibration and tested reactor vessel flange leak detection instrumentation.

b. Set reactor vessel stabilizers.

c. Checked all reactor vessel thermocouples.

d. Checked stud tensioner operation.

D.4.1.2 Main Steam Safety and Relief Valves

a. Safety and Relief valves were installed as received from the factory, where set points were adjusted, verified, and indicated on the valve.

b. Verified proper operation of the remotely operated relief valves both manually and as part of the Automatic Pressure Relief System.

c. Checked operation of vacuum breaker valves on the relief outlet lines.

d. Checked operation of all main steam isolation valves, checked both for proper isolation action and test operation.

D.4.1.3 Control Rod Drive System

a. Verified instrument calibration.

b. Functional checkout of Reactor Manual Control System circuits.

c. Set and verified proper operation of rod control timing circuits.

d. Verified alarm and inputs to RWM.

e. Filled and vented CRD Hydraulic Systems.

f. Placed the system in operation and obtained pump performance data.

g. Set systems pressures and flows.

h. Stroked each drive and verified rod position indication.

i. Obtained friction data and measure rod scram time.

j. Rod drift alarm circuit tests performed.

D.4.1.4 Recirculation System and M-G Sets

a. Operated and verified leak tightness of all recirculation loop valves.

b. Verified control circuits and interlocks.

c. Verified instrument calibration and checked for proper response.

d. Operated recirculation pumps within the limitations of cold water conditions.

D.4.1.5 RHR System

a. Verified instrument calibration and checked set points.

b. Checked operation of all motor operated valves.

c. Checked interlocks in valve and pump control circuits.

d. Measured system pressures where possible and determined flow rates from pump characteristic curve for various modes of operation; i.e., shutdown cooling, LPCI, test, vessel head cooling, and fuel pool backup.

e. Measured closing time of isolation valves.

D.4.1.6 Reactor Water Cleanup System

a. Verified instrument calibration.

b. Verified operation of valves and interlocks.

c. Verified operation of demineralizer controls and charged demineralizers with resins.

d. Checked operation of cleanup recirculation pumps.

e. Verified system flows and checked water quality and demineralizer exit.

D.4.1.7 Standby Liquid Control System

a. Verified instrument calibration setpoints.

b. Filled the neutron absorber tank with demineralized water and operated the injection pumps, recirculating to the neutron absorber tank.

c. Checked the set point of the pump discharge relief valves.

d. Checked the control circuits for neutron absorber injection valves thoroughly before connecting to the valves. (Used a dummy resistance to simulate the valve.)

e. Fired the injection valves and measured pumping rates into the reactor. Replaced the firing cartridge and valve internals.

f. Checked interlocks with the cleanup filter-demineralizer system that ensure isolation when the standby liquid control system is actuated.

g. Checked operation of neutron absorber tank temperature controls air sparger.

h. Filled test tank with demineralized water and operated the neutron absorber injection pumps in simulated test mode, recirculating to the test tank.

i. After the system had been demonstrated by foregoing tests, added the required amount of neutron absorber material to the neutron absorption tank. Mixed and sampled. This was done very shortly before fuel loading.

D.4.1.8 Core Spray System

a. Verified instrument calibration.

b. Checked alarms, controls and interlocks including complete verification of automatic system starting controls.

c. Operated pumps by recirculating to the torus in the test mode. Verified pump and system performance from manufacturer's head-flow curves and measured system pressures.

d. Checked operation of all motor operated valves.

D.4.1.9 RCIC System

a. Verified instrument calibration.

b. Verified proper operation of controls interlocks.

c. Operated the turbine driven pump using heating steam.

NOTE: System operation under design conditions was demonstrated during the Startup Testing.

D.4.1.10 Fuel Handling Equipment

Equipment in this category was tested with dummy fuel or blade guide assemblies through dry run simulations of the required operations. This was not one coordinated test of a system, but consisted of many separate operations using different pieces of equipment. The equipment was tested on the operating floor, in the fuel storage pool, and both over and in the reactor vessel.

a. Tests in the storage pool

1. Installed fuel pool gates and filled pool with water.

2. Checked fuel penetration machine with dummy fuel assembly. This also checked auxiliary tools such as channel handling tool and channel bolt wrench.

3. Set up inspection equipment and checked with dummy fuel assembly.

4. Checked fixed lights and movable underwater lights to assure adequate visibility for fuel and blade handling and transfer operations.

5. Checked underwater vacuum cleaners.

6. Operated refueling platform over storage pool. Checked all equipment on the refueling platform. Transferred fuel assemblies and control blades between storage racks with the grapple. Checked all grapple controls and interlocks.

7. Used jib crane to transport dummy fuel assemblies from storage racks with the grapple. Checked all grapple controls and interlocks.

b. Tests Over Reactor Vessel

1. Set service platform assembly on vessel flange. Mounted jib crane on service platform and used for installing, removing or shuffling dummy fuel assemblies, control blades and poison curtains.

2. Raised water level in reactor well and checked leak-tightness of vessel to drywell seal and drywell to pool seal. Lowered water level and checked ability of fuel pool cooling system to drain these seals or associated low points.

3. Established best procedural methods and tools for:

   a) Removal and replacement of steam dryer.

   b) Removal and replacement of steam separator head.

   c) Removal of control curtains.

   d) Removal and replacement of fuel supports castings and control rod blades.

   e) Removal and replacement of incore flux monitor strings.

   f) Removal and replacement of jet pump nozzles and risers (under water).

All of the above tests recognized the shielding requirements of doing the job “hot” and should attempt to simulate “normal operating” conditions.

4. Transferred dummy fuel assemblies and control blades between the storage pool and the reactor vessel, simulating a refueling operation.

5. Obtained representative values of time required to do all operations normally in the critical path of a refueling outage.

D.4.1.11 HPCI System

a. Verified instrument calibration.

b. Verified proper operation of controls interlocks.

c. Operated turbine driven pumps using heating system.

NOTE: System operation under design conditions was demonstrated during Startup Testing.

D.4.1.12 Feedwater Control System

a. Verified instrument calibration.

b. Simulated inputs of flow, level, and pressure to the control system to demonstrate proper control system response, including feedwater control valve motion.

c. Checked steam leak detection system setpoints and operation.

d. Demonstrated proper operation of failure modes.

D.4.2 General Electric NID Prepared Procedures

D.4.2.1 Reactor Protection System (RPS)

Demonstrated that all components of the RPS operated correctly and the integrated system functioned as specified. All system relays were checked by simulating inputs to their associated sensors and/or actually operated associated valves to trip position switches.

D.4.2.2 TIP System

a. Set core top and bottom limits, for each tube, into the correct Drive Control Unit Channel.

b. Loaded TIP cables into the Drive Mechanism.

c. Set flux amplifier sensitivities.

d. Set recorder X-axis nulls into the Drive Control Units.

e. Demonstrated proper operation of each TIP System and associated subsystem, i.e., Drive Control Units, X-Y Recorders, Valve Control Monitors, In-Core Monitors, Drive Mechanisms, Chamber Shields, Ball Valves and Indexers.

f. Verified that Shear Valve squibs were intact.

D.4.2.3 Neutron Monitoring System Test

The following functions were verified:

a. All neutron monitoring instruments were operable and in calibration.

b. Integrity of all signal and high voltage cables.

c. All instruments had correct trip settings.

d. All interlocks and bypass functioned correctly.

e. Trip annunciation was correct.

f. Scram relay in the protection system panels, that operated as a function of the neutron monitoring system, were operating correctly.

g. Rod withdrawal permissive interlocks, that were a function of the neutron monitoring system, operated correctly.

h. Source and Intermediate Range retract drives functioned correctly.

i. LPRM, APRM, and RBM systems functioned correctly.

D.4.2.4 Off-Gas

a. Verified that Off-Gas Monitors were operable, in calibration, had correct trip settings and performed specified annunciators functions.

b. Demonstrated that the Off-Gas hold-up system activated after a time delay under the following conditions:

1. Two Upscale Trips.

2. Two Downscale Trips.

3. One Upscale and one Downscale trip.

c. “Bugged” the detector with a 10 mr/hr or larger gamma source. Determined LRM sensitivity from known source strength and geometry.

D.4.2.5 Stack Monitoring

a. Verified that both Stack Gas Monitors were operable, in calibration, had correct trip settings and performed specified annunciator functions Up or Downscale trips.

b. Verified that Stack Gas Panel operated correctly including alarms.

c. Verified that Purge Control and Source check network functioned correctly.

d. Verified that the Process Radiation Sampler operated correctly.

D.4.2.6 Environs Monitoring

Demonstrated or verified that all Environs Monitoring (Fixed Stations on Site) Stations were operable, in calibration, had correct trip settings and performed specified annunciator functions (if any) on high or low trip.

D.4.2.7 Area Rad Monitoring

Demonstrated or verified that all Sensor Converters, Trip and Indicator units, were operable, in calibration, had correct trip settings and performed specified annunciator functions on high or low trip.

D.4.2.8 Rod Worth Minimizer (RWM)

a. Simulated rod position inputs into Rod Position Indication System (RPIS) and verified that the RWM received correct rod identification and position data.

b. Verified that the RWM Display Panel functioned correctly.

c. Verified that the RWM initiated a rod block under the following conditions:

1. Withdrawal error;

2. Insert error.

D.4.2.9 Liquid Process

Verified that Liquid Process Monitors and associated recorders were operable, in calibration, had correct settings and performed specified annunciator functions on Upscale or Downscale trips.

D.4.2.10 Steam Line

a. Verified that all Steam Line Radiation Monitors were operable, in calibration, had corrected trip settings, performed specified annunciator functions on Upscale and Downscale trips, and operated correct scram relays in panel 9-15 and 9-17.

b. “Bugged” the detector with a 10 mr/hr or larger gamma source. Determined LRM sensitivity from geometry and know source strength.

D.4.2.11 Ventilation Exhaust Monitoring

a. Demonstrated that all ventilation exhaust monitors were operable in calibration, had correct trip settings and performed specified annunciator functions on Upscale and Downscale trips.

b. Verified that Standby Gas Treatment and closure of the Reactor Building Main Vent System was initiated under the following conditions:

Upscale trip on either channel.

Two Downscale trips (one per channel).

D.4.2.12 Rod Position Indication System (RPIS)

a. Simulated inputs to the RPIS.

b. Verified that the full core display was correct for each rod and rod position.

c. Verified that the correct 4-rod group was displayed when any rod was selected.

d. Verified rod digit alarm operation for each rod at least once.

D.4.3 Bechtel Corp. Prepared Procedures

D.4.3.1 Service Water Systems

The test included the Service Water System, the RHR Service Water System, the Emergency Service Water System, and the Chlorination System.

a. Verified instrument calibration.

b. Checked all alarms, interlocks, and valve operations.

c. Demonstrated all system performance.

D.4.3.2 Fire Protection System

a. Operated diesel and electric driven fire pumps and checked performance.

b. Operated fire system jockey pump and screen wash pump backup and checked performance.

c. Checked all interlocks, remote controls, and automatic start features.

D.4.3.3 Compressed Air System

This system included the instrument and service air compressors, the instrument air dryer, the distribution piping and service air blower.

a. Checked set points for compressor control; manual, off, auto mechanical unloading, and annunciator alarms.

b. Measured capacity of each compressor and service air blower.

c. Checked dryer performance.

d. Demonstrated system isolation interlocks.

D.4.3.4 Make-up Demineralizer System

The make-up system was placed in−service to provide demineralized water for cleaning, flushing, hydrotesting, and initial filling of plant systems.

In testing the system, all pumps, valves, controls and instruments were checked individually. The system was operated under simulated normal conditions before charging resins and using chemicals. This reduced the risk of damaging or depleting the resins or using chemicals excessively before the system was in proper adjustment.

D.4.3.5 Condensate and Demineralized Water Storage and Transfer System

The tests consisted of demonstration of the ability to transfer water from the Demineralized Water Storage tank to the Condensate Storage tanks and the transfer of water from these tanks to various service water requirements throughout the plant.

D.4.3.6 Condensate Demineralizer System

The test included the demineralizers, precoat and body feed equipment, and holding pump and associated controls. Piping had to be completed from the main inlet to the main outlet valves.

a. Checked calibration for all instruments.

b. Checked operation of all valves.

c. Checked all controls for both automatic and remote control.

d. Verified proper operation of system pump.

e. Demonstrated precoat slurry and powder resin transfer from demineralizer to regeneration system.

f. Demonstrated all phases of regeneration with actual water and air flow.

g. Demonstrated backwash of resins from demineralizers.

D.4.3.7 Condensate System and Hotwell Control

This system consisted of the condensate pumps, the condenser hotwell, the low pressure heaters and drain coolers.

a. Verified instrument calibration.

b. Checked all controls, alarms, and interlocks.

c. Operated all remote operated valves.

d. Checked performance of condensate pumps recirculating to the hotwell through the make-up, reject, and recirculation lines.

e. Checked hotwell high level reject and low level make-up controls and valves.

D.4.3.8 Reactor Feedwater System

This system consisted of the feedwater pumps and the high pressure heaters.

a. Verified instrument calibration.

b. Checked all alarms, controls, and interlocks.

c. Checked performance of the feedwater pumps recirculating to the hotwell through the 8 inch connection downstream from the high pressure feedwater heaters.

D.4.3.9 Extraction and Feedwater Heater Control

a. Verified instrument calibration.

b. Checked all alarms, controls, and interlocks.

c. Checked proper operation of valves from level and trip signals.

D.4.3.10 Reactor Building Cooling Water System

a. Following hydrotest and cleaning, filled the system with inhibited water.

b. Verified instrument calibration.

c. Operated pumps to verify pump performance.

d. Checked operation of surge tank level controls and alarms.

e. Checked all interlocks, alarms, controls and remote indicating devices.

D.4.3.11 Fuel Pool Cooling System

This system consisted of the fuel pool water pumps, heat exchangers, surge tanks, storage pool, reactor well, and dryer-separator storage pool.

a. Verified instrument calibration.

b. Checked alarms, controls, and interlocks.

c. Filled pools with demineralized water.

d. Recirculated through the heat exchangers; checked pump performance.

D.4.3.12 Fuel Pool Filter/Demin System

This system consisted of the Filter-Demineralizer Tanks, the holding pumps, and the associated controls.

a. Verified instrument calibration.

b. Checked alarms, controls, and interlocks.

c. Checked operation of filter/demineralizer valves and precoat pumps.

d. Demonstrated resin precoat operation and spent resin transfer to radwaste system.

e. Demonstrated satisfactory operation of filter/demin while recirculating through the fuel pool cooling system.

D.4.3.13 Traveling Screens and Screen Wash System

This system consisted of the traveling screens and the screen wash pump and the trash rake.

a. Checked level alarms and controls.

b. Demonstrated proper system performance.

D.4.3.14 Condenser Circulating Water-Cooling Tower System

This system consisted of the Circulating water pumps, Cooling Tower pumps, the cooling towers water scavenge pumps and the valves and gates used in various modes of operation.

a. Verified instrument calibration.

b. Checked alarms, controls and interlocks.

c. Demonstrated satisfactory performance of pumps and demonstrated various modes of operation (i.e., closed cycle, open cycle and partial cycle).

D.4.3.15 Condenser Vacuum and Off-Gas System

This system consisted of the steam jet air ejectors, gland steam exhausters, mechanical vacuum pump, and off-gas piping, the standby gas treatment system, and the off-gas stack.

a. Verified instrument calibration.

b. Checked all alarms, controls, and interlocks.

c. Checked proper operation of mechanical vacuum pump.

d. Checked proper operation of mechanical equipment in off-gas system and stack.

e. Checked proper operation of Standby Gas Treatment System.

D.4.3.16 Liquid and Solid Radioactive Waste

a. Verified instrument calibration.

b. Checked all controls and interlocks.

c. Checked all air-operated valves.

d. Pumps and tanks

    1. Cleaned tanks mechanically.

    2. Filled with demineralized water.

    3. Checked pump operation in recirculation, wherever possible.

    4. Demonstrated operations associated with the particular tank, such as draining or filling, recirculating, sampling, and processing to a filter, demineralizer, another tank, or discharge to river.

e. Demineralizers, Radwaste

    1. Transferred fluids from waste collector to waste sample tank through the demineralizer.

    2. Checked operation of all components including bypass circuit.

    3. Checked instrument and level gage indications.

f. Spent resin system

    1. Stimulated transfer of sludge and resins from the fuel pool, waste, condensate, and cleanup demineralizers to the waste sludge tank and cleanup phase separator tank.

    2. Verified cleanup and condensate sludge resin transfer capability by actual transfer of materials (performed near end of test program with little or no radioactivity present or devised means for catching and reclaiming resins).

3. Verified capability to pump spent resin mixture to centrifuge.

g. Sumps, (Drywell, Reactor, Turbine, and Radwaste Buildings)

1. Filled sumps with water.

2. Checked operation of sump pumps and proper functioning of level controls, including isolation valves on containment.

3. Verified discharge to proper collection tank in radwaste with no backflow or leakage enroute.

h. Solid Waste Handling, storage and disposal.

1. Checked loading operations from centrifuge hopper.

2. Checked drum handling, loading, capping and transfer to storage. Used sand, drying material and filter aid material to represent solid wastes.

3. Checked drum removal for off-site shipment.

4. Checked baler.

D.4.3.17 Turbine and Auxiliary Systems

The turbine-generator system included:

a. Turbine oil system.

b. Lube oil purification.

c. Steam seal.

d. Hydrogen and carbon dioxide.

e. Gland Exhaust.

f. Stator cooling.

g. Turbine control system including control valves.

h. Generator seal oil system.

i. Exciter.

The preoperational procedure included the following:

a. Verified instrument calibration.

b. Checked alarms, controls, and interlocks.

c. Checked performance of all pumps.

d. Verified satisfactory purge out of generator, filled generator with H_2.

e. Verified satisfactory performance of stator cooling demineralizer.

f. Verified steam seal and gland exhaust utilizing auxiliary heating boiler steam.

D.4.3.18 Standby Diesel Generator System

a. Verified instrument calibration.

b. Checked all controls, alarms and interlocks.

c. Checked operation of diesel-generator auxiliaries including fuel pumps and cooling water systems.

d. Checked automatic start of diesel generator, closing of breaker and load pickup.

e. Operated the diesel generator at full rated load for 4 hours to demonstrate load carrying capability. Operated for two hours at 10% overload. (110% of rated).

f. An integrated systems check of the ECCS was performed simulating a simultaneous loss of off-site power.

D.4.3.19 Heating, Ventilating and Air Conditioning System

This system consisted of the heating boiler, fans, dampers, and ventilating units that are installed in the reactor building, turbine building, and radwaste building.

a. Verified instrument calibration.

b. Verified balance of ventilation air flows

c. Verified satisfactory performance of ventilating units.

d. Demonstrated safe operation of the plant heating boiler.

D.4.3.20 Primary Containment Atmospheric Control System

This system consisted of the drywell coolers, and the primary containment vacuum breakers.

a. Verified instrument calibration.

b. Checked all alarms, controls and interlocks.

c. Demonstrated operation of drywell coolers

d. Functionally checked vacuum breakers.

D.4.3.21 Diesel Oil System

This system consisted of the Diesel Oil Storage tank, transfer pump, service pump, and associated day tanks.

a. Verified instrument calibration.

b. Checked all alarms and controls.

c. Demonstrated system performance by transfer of oil to various day tanks.

D.4.3.22 Reactor Building Crane

a. Checked all controls and interlocks.

b. Demonstrated crane performance.

D.5 Startup And Power Test Program

D.5.1 General Requirements

The startup and power test program was performed to assure that the plant is capable of operating safely and satisfactorily. Systems and components, which could not be fully checked out in preoperational test phase were tested at power during this 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 rod and control curtains were calculated with methods which were continuously compared with results of experiments in the Vallecitos Atomic Laboratory's critical facilities, including measurements of similar or identical components. In addition, startup tests and operating data from other boiling water reactors in commercial operation and other measurements throughout the nuclear industry were used to confirm the applicability of the analytical methods.

Several restrictions were necessary during the initial startup program. All operations and tests complied with the safety and warranty limitations specified by the General Electric Co. as well as safety limitations and limiting conditions specified by licensing authorities. Additional restrictions were minimized because the prime objective of the startup program was to demonstrate the plant capability and safety up to full power. A two hour net heat rate demonstration was performed at an electrical output corresponding to 1469 MWt. At one hundred hour test was run at 1469 MWt.

D.5.2 General Procedures

The startup procedures were, with individual detailed subsections.

D.5.3 Fuel Loading and Tests at Atmospheric Pressure

The initial fuel loading and critical testing were performed at near-zero power, and at atmospheric pressure, with the reactor pressure vessel open. The following tests were performed during this phase of the startup program:

a. **Chemical and Radiochemical tests** were conducted to establish water conditions prior to initial operation and to maintain these throughout the test program. Chemical and radiochemical checks were made at primary coolant, off-gas exhaust, waste and auxiliary system sample locations. Base or background radioactivity levels were determined at this time for use in fuel assembly failure detection and long range activity buildup studies.

b. **Control Rod Drive System tests** were performed on all drives prior to fuel loading to assure proper operability and to measure and adjust operating speeds. Drive line friction and scram times were determined for all drives at zero reactor pressure. Functional testing of each drive was performed with dummy fuel just prior to and then following the fuel loading in each cell.

c. **Radiation Measurements** were made prior to nuclear operation to establish base levels in the plant and the nearby environs.

d. **Fuel Loading** was, according to detailed, step-by-step written procedures. The core assembled, with control curtains in place, to the full-sized core.

e. **Shutdown Margin** It was demonstrated periodically during fuel loading that the reactor was subcritical by more than a specified amount with the strongest single control rod withdrawn. The shutdown margin requirement was a limitation on the amount of radioactivity which can be loaded into the core. The magnitude of the margin was chosen with consideration for credible reactivity changes after the test, and for the accuracy of measurement. The test had three parts: (a) The analytical determination of the strongest control rod, (b) the calibration of an adjacent control rod, experimentally or analytically, and (c) the demonstration of subcritcality with strongest rod fully withdrawn and the second at the position equal to the margin. This demonstration was made for the fully loaded core, and with selected smaller core loadings.

f. The specified **Control Rod Sequences** were evaluated to verify that the stated criteria of safety, simplicity, and operating requirements were met during routine cold startups. The reactor made critical by withdrawing control rods in a specified sequence and reactivity addition rates were measured near critical. The preselected sequence could be modified if necessary to meet criteria. A small number of non-standard arrays were utilized to check out the operation of the rod worth minimizer.

g. **Source Range Monitor (SRM) Performance** The performance of the source range monitors were evaluated based on data taken with the installed source range monitoring instrumentation and installed operational sources. The SRM System was calibrated to reactor power and its performance was compared to stated criteria on noise, signal-to-noise ratio and response to change in core reactivity.

h. **Intermediate Range Monitor (IRM) Calibration** Calibration of the intermediate range monitors was performed to provide level calibration for the intermediate range monitors adequate for this phase of the test program.

i. **Process Computer** As plant process variable signals become available to the computer, verifications were made of these signals and of the computerized systems performance calculations.

D.5.4 Heatup From Ambient to Rated Temperature and Pressure

Following satisfactory completion of the core loading and low power test program, the core components were visually verified for proper installation, and the additional in-vessel hardware was installed. This included special monitoring instrumentation, and steam separator and dryer assemblies.

The reactor head was installed, followed by a hydrostatic test to assure satisfactory sealing of the vessel head. The drywell head was installed and shield plugs placed over it. A sequence of tests was performed to confirm a number of the nuclear steam supply system characteristics as the temperature and pressure were increased. Sufficient tests were performed at each incremental step increase in power or change in pressure, and the tests and operating procedures were evaluated, to assure that the succeeding change in operating conditions could be made safely. The following tests were conducted during this phase of the startup.

a. **IRM Calibration** was improved by using data obtained from heatup rates observed during nuclear testing.

b. **SRM Performance** was determined in the power overlap region with the IRM System. The SRM System was recalibrated by comparison to the IRM System readings in the region.

c. **Reactor Vessel Temperatures** were monitored during heatup cooldown to determine that temperature differences were not excessive.

d. **System Expansion** checks were made during heatup to verify to verify freedom of major equipment and piping to move.

e. **Control Rod Drive** systems test were made by measuring scram times on a selected number of drives at two intermediate pressures, scram times and drive line friction tests on a representative set of drives at rated reactor pressure and on a selected number of drives without accumulators at rated reactor pressures.

f. **Control Rod Sequence** to be used during heatup was checked periodically for satisfactory performance.

g. **Radiation Measurements** were made periodically during nuclear heating and a complete survey was made at rated temperatures.

h. **Chemical and Radiochemical** checks were be made during the heatup.

i. **Core Performance Evaluations** were made near or at rated temperature and pressure. This included a reactor heat balance at rated temperature.

D.5.5 From Rated Temperature to 1670 MWt Power

Reactor power was increased to 1670 MWt in increments of approximately 10% with major testing at 15, 25, 50, 75, 88 (1469 MWt) and 100% power. The turbine was placed in service and tested during this phase. The test program included the following, but not necessarily at each increment of power. All were performed during the 1670 MWt tests.

a. **Chemical and Radiochemical** tests were continued.

b. **Radiation Measurements** of limited extent were made at 25% of rated power and complete surveys were made at 50 and 100% power.

c. **System Expansion** tests were continued on a limited basis as reactor power was increased.

d. **Main Steam Isolation Valve** functional and operational tests were made as reactor power was increased.

e. **RCIC System** tests were made to demonstrate proper performance in regard to flow rate and leak tightness were made at a low power level.

f. **HPCI System** tests were made to demonstrate proper performance of the system including the steam turbine driven pumping system.

g. **Recirculating Pump Trips** and their effects on the jet pumps and the reactor were tested periodically during power increase.

h. **Flow Control** capabilities were determined at specified power levels.

i. **Turbine Trip** tests were made to determine the effects of turbine trips on the reactor and the auxiliaries of the unit.

j. **Generator Trip** tests were performed to determine speed and reactor response.

k. **Pressure Regulator** tests were made to determine the response of the reactor and the turbine governor system. Regulator settings were optimized using data from this test.

l. **Bypass Valves** measurements were performed by opening a turbine bypass valve and recording the resulting reactor transients. Final adjustments to the bypass valves were made.

m. **Feedwater Pumps** were used to change reactor subcooling and the resulting transients were measured to determine system response.

n. **Flux Response** to rods was determined in both equilibrium and transient conditions. Steady-state noise was measured as was flux response to control rod motion. Power-void loop stability was verified from this data.

o. **LPRM Calibrations** including use of the TIP system, were made at 15, 25, 50, and 100% of rated power. Each local power range monitor was calibrated to read in terms of local fuel rod surface heat flux.

p. **APRM Calibrations** were performed after making significant power level changes. Reactor heat balances formed the basis of these calibrations of the average power range monitor.

q. **Core Performance Evaluations** were made periodically to assure that the core operated within allowable limits on maximum local surface heat flux and Minimum Critical Heat Flux Ratio. This test included reactor heat balance determinations.

r. **Calibration of Rods** were performed to obtain reference relationships between control rod motion and reactor power and steam flow in the specified control rod sequence.

s. **Axial Power Distribution** measurements were made with the traversing in-core probe system after significant changes in power, control rod, pattern, or flow rate. The TIP system supplied data for core performance evaluations and LPRM calibrations.

t. **Rod Pattern Exchanges** were demonstrated from one specified sequence to the other at the highest practical reactor power.

u. **Loss of Auxiliary Power Test** was performed to demonstrate proper response of the reactor and the plant electrical equipment and systems.

v. **Process Computer** functions were verified as sensed variables come into range during the ascension to and at rated power.