March 4, 2002
NG-02-0187

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Washington, DC 20555-0001

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Startup Test Report for Extended Power Uprate – Phase I
File: A-117, SPF-189

Dear Sir(s):

In accordance with the Duane Arnold Energy Center (DAEC) Updated Final Safety Analysis Report (UFSAR) Section 17.2.14.6 commitments, Nuclear Management Company hereby submits the Extended Power Uprate (EPU) Startup Test Report – Phase I. This report summarizes the startup testing performed on the DAEC following implementation of Operating License Amendment # 243 (Extended Power Uprate). Testing was conducted over the period of November 10, 2001 to December 3, 2001. Although some minor problems were encountered during the testing, the final results of the testing and data gathering demonstrated successful operation at the Phase I target power level of 1790 MWt.

Follow-up reports will be submitted in accordance with UFSAR 17.2.14.6, as testing is completed for subsequent phases of the EPU implementation.

No additional commitments are being made or revised in this letter.

Please contact this office should you require additional information regarding this matter.

Very truly yours,

Kenneth S. Putnam
Manager, Nuclear Licensing

Enclosure: Duane Arnold Energy Center Extended Power Uprate Startup Test Report Phase – I

IE26

cc: T. Browning
G. Van Middlesworth (NMC)
B. Mozafari (NRC-NRR)
J. Dyer (Region III)
D. McGhee (State of Iowa)
NRC Resident Office
Docu

Enclosure to
NG-02-0187

DUANE ARNOLD ENERGY CENTER

EXTENDED POWER UPRATE

STARTUP TEST REPORT

PHASE - I

March, 2002

Prepared by: Roy A. Browning

Reviewed by: Allan J. Roderick
Power Uprate Project Manager

Approved by: Terry A. Evans
Chariman, Power Uprate Expert Panel

Duane Arnold Energy Center
Extended Power Uprate
Startup Test Report
Phase - I

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1.0 Executive Summary

The Duane Arnold Energy Center (DAEC) Extended Power Uprate (EPU) Startup Test Report is submitted to the Nuclear Regulatory Commission (NRC) in accordance with regulatory commitments contained in the DAEC Updated Final Safety Analysis Report (UFSAR), Section 17.2.14.6. The report summarizes the startup testing performed as part of the implementation of EPU. EPU was approved by the NRC in Operating License Amendment No. 243 on November 6, 2001.

DAEC was previously licensed to operate at a maximum reactor power level of 1658 MWt. The result of EPU is a licensed power increase of 15.3% to a new maximum of 1912 MWt. The DAEC is implementing the EPU in planned phases that support a schedule for the necessary modifications needed to achieve the full EPU. The current phase, Phase I, has a target power level of 1790 MWt, an 8% increase in thermal power.

All testing specified in the DAEC UFSAR Section 14.2 was addressed and evaluated for applicability to EPU. Special test procedures were written and implemented in combination with existing surveillance test procedures, as described in this report. All required tests were completed up to the target power of 1790 MWt. Testing was conducted over the period from November 10, 2001 to December 3, 2001. Test results were reviewed by an Expert Panel for acceptability. Although some equipment problems were encountered during the testing, the final results of the testing and data gathering demonstrated successful operation at the Phase I target power level of 1790 MWt.

2.0 Purpose

In accordance with UFSAR Section 17.2.14.6 requirements, this report summarizes the testing performed following the implementation of the DAEC EPU, approved as Amendment #243 to Operating License DPR-49. While Amendment # 243 approved a new licensed thermal power limit of 1912 MWt, an increase of 15.3%, the implementation of the EPU is being conducted in planned phases. This report summarizes the testing performed as part of Phase I, which resulted in a steady-state operating thermal power of 1790 MWt, an increase of ~8% above the previous licensed limit of 1658 MWt. Each test performed is described in Section 6.0 of this report. Follow-up reports, as required by UFSAR Section 17.2.14.6, will be made as the subsequent phases are implemented and core thermal power is increased up to the licensed limit.

3.0 Program Description

The EPU startup testing program requirements were developed primarily from:

- Review of the original startup testing program, as described in UFSAR Section 14.2;
- Section 10.4 of the DAEC Power Uprate Safety Analysis Report (PUSAR), NEDC-32980P;
- General Electric (GE) Uprate Test Program recommendations.

The in-plant testing was begun on November 10, 2001, shortly after receipt of Amendment #243, on November 6, 2001 and was completed on December 3, 2001. The results of the testing verified the unit's ability to operate at the Phase - I target power level of 1790 MWt.

All startup testing specified in UFSAR Section 14.2 was evaluated for applicability to the EPU testing program. Special Test Procedures (SpTPs) were written to coordinate and control the startup testing program. Where possible, the testing program took credit for existing Surveillance Test Procedures (STP). Table 1 lists the UFSAR startup tests and delineates that testing required to be performed for the EPU.

The majority of the testing falls within the following categories:

- Verification that the control systems (i.e., Condensate and Feedwater and EHC-Pressure Regulation) are stable at uprated conditions.
- Collection of system performance data to verify modifications made to support EPU operation were performing as expected.
- Establishment of steady state power levels for performing routine testing of Turbine and Main Steamline Isolation Valves.

- Collection of general plant data (i.e., radiation surveys, coolant chemistry, thermal performance) for comparison to previous plant rated conditions.

Table 2 presents the Test Conditions at which startup testing was performed. Reactor core flow could be any flow within the safe operating region of the power/flow map (Figure 1) that will produce the required power level. Testing at a given power level was completed and thoroughly reviewed prior to proceeding to the subsequent Test Condition. Test results were reviewed by an Expert Panel, a multi-disciplinary group, chaired by the Operations Manager, who made the recommendation to the Test Coordinator that it was acceptable to increase power and proceed to the next Test Condition. The Plant Manager's approval to exceed the previous licensed thermal power of 1658 MWt was also required.

Above 1658 MWt, in between Test Conditions, intermediate power levels were defined for evaluating overall plant stable operation. Power ascension was stopped at these intermediate points and the plant was allowed to stabilize at the new condition. No special tests were performed at these points. Routine plant monitoring was used to assess operation at each level. Barring unexpected behavior, the Test Coordinator and Operations Shift Manager would make the decision that the plant was operating as expected and authorize further power ascension to the next level.

4.0 Acceptance Criteria

For each recommended test, individual test abstracts will define the purpose of the test, the appropriate test conditions and the associated acceptance criteria.

Test criteria for each test have up to two levels of importance. The criteria associated with plant safety are classified as Level 1. The criteria associated with design expectations are classified as Level 2.

1. Level 1 Variable or Criteria

Data trend, singular value, or information relative to a Technical Specifications margin and/or plant design in a manner that requires strict observance to ensure the safety of the public, safe operation of the plant, continued operation at power, worker safety, and/or equipment protection.

Failure to meet Level 1 criteria constitutes failure of the specific test. The plant must be placed in a safe condition, based upon prior testing, until the problem is resolved, and the test is satisfactorily repeated, if necessary.

2. Level 2 Variable or Criteria

Data trend, singular value, or information relative to optimizing system or equipment performance that does not fall under the definition of Level 1 criteria.

Level 2 criteria do not constitute a test failure or acceptance; they serve as information only. It is not required to repeat a test due to a Level 2 criterion failure.

5.0 EPU Startup Test Program Summary

Post-modification testing was performed as part of startup from Refuel Outage 17 on May 27, 2001 and baseline data was collected during power ascension to the previous licensed power level of 1658 MWt. The EPU license amendment (Amendment #243) was approved on November 6, 2001. During implementation of the amendment, as a prerequisite to the actual testing, instrument recalibrations were performed to allow operation above the previous licensed power level. The EPU test program was officially begun on November 10, 2001 and the final test sequence at 1790 MWt was conducted on December 3, 2001. The Expert Panel review of the last set of data was conducted on December 7, 2001 and the recommendation was made to the Plant Manager to approve steady state operation at the Phase I target power level of 1790 MWt.

As discussed in Section 6.2, during performance of the test program, some Acceptance Criteria needed to be modified, as the original FSAR startup testing requirements were no longer applicable to the current plant configuration. A problem in the Feedwater Level Control System was discovered that required maintenance and reperformance of those tests at 1658 MWt. Also, based upon review of test data at lower power levels, the test matrix at high power was simplified and some tests were not performed, as they would not have provided useful data.

The completed testing at the Phase I target power level of 1790 MWt demonstrated stable plant operation. Changes in plant chemistry and radiological conditions were minor, vibration monitoring of main steam and feedwater piping was normal, and no plant equipment anomolies were noted.

6.0 Testing Requirements

Each of the Startup tests discussed in UFSAR Section 14.2 was evaluated for applicability to EPU. Pre-operational tests used to confirm construction of systems was per design are excluded and not discussed further. Throughout the following discussion, the test numbers and titles are consistent with the original Startup Test Specification.

Section 6.1: This section identifies each Section 14.2 test not required to be performed for EPU. The purpose of the test and the rationale for exempting the test from the power uprate program are discussed.

Section 6.2: This section identifies each Section 14.2 test required to be performed for EPU. The purpose of the test, a description of the test, Acceptance Criteria, and the test results are included.

Section 6.3: This section identifies additional test/data collection that was performed to assess the performance of the unit at EPU conditions. The purpose of the test, a description of the test, and the test results are included.

Table 1 identifies all the Section 14.2 tests and their applicability to EPU. Table 2 lists the fifteen Test Conditions and the associated percent of the EPU licensed power level. Note that many surveillance tests similar to the original FSAR Chapter 14 tests are performed periodically, often during each startup. Therefore, the EPU test program takes credit for many existing plant procedures.

6.1 UFSAR Section 14.2 Tests Not Required for EPU

6.1.1 Test No. 3 - Fuel Loading

This test demonstrates the ability to safely and efficiently load fuel to the full core size. Fuel loading is performed during every refueling outage in accordance with site procedures. Extended power uprate has no impact on this evolution; therefore, no additional testing was required for extended power uprate.

6.1.2 Test No. 4 - Full Core Shutdown Margin

The purpose of this test is to demonstrate that the reactor will be sub-critical throughout the fuel cycle with any single control rod fully withdrawn. Technical

Specifications ensure that adequate shutdown margin is available. Thus, this test is not specifically required for EPU.

6.1.3 Test No. 5 - Control Rod Drive (CRD) System

The purpose of this test is to demonstrate that the CRD system operates properly over the full range of primary coolant temperatures and pressures from ambient to full power. Technical Specifications ensure that the CRD system operates in accordance with the safety analysis. In addition, with no reactor pressure increase due to the EPU, no additional testing of the CRD system is required.

6.1.4 Test No. 6 - Source Range Monitor (SRM) Response and Control Rod Sequence

The purpose of this test is to demonstrate that the operational sources, SRM instrumentation, and rod withdrawal sequences provide adequate information to the operator to achieve criticality and power ascention during startup. The Technical Specifications ensure proper SRM response during startup. Thus, this test is not specifically required for EPU.

6.1.5 Test No. 9 - Water Level Measurement

The purpose of this test is to verify the calibration and agreement of the GEMAC (narrow range) and YARWAY (wide range) water level instrumentation under various plant conditions. This instrumentation was not affected by EPU. Thus, this testing is not specifically required. Any anomalous behavior would be observed as part of other testing activities.

6.1.6 Test No. 10 – Intermediate Range Monitor (IRM) Performance

This test ensures the ability to adjust the IRMs to obtain optimum overlap with the SRMs and the average power range monitors (APRMs). The Technical Specifications ensure proper IRM response during startup. Thus, this test is not specifically required for EPU.

6.1.7 Test No. 11 - Local Power Range Monitor (LPRM) Calibration

The purpose of this test is to calibrate the LPRMs to read proportional to the neutron flux. The LPRM system was not modified as a part of EPU implementation. The Technical Specifications ensure proper LPRM calibration. Thus, this test is not specifically required for EPU.

6.1.8 Test No. 12 – Average Power Range Monitor (APRM) Calibration

The purpose of this test is to calibrate the APRMs, using the calorimetric heat balance, referenced to the EPU rated thermal power. The APRM system was not

modified as a part of EPU implementation. The Technical Specifications ensure proper APRM calibration. Thus, this test is not specifically required for EPU.

6.1.9 Test No. 13 – Process Computer

This test verifies the performance of the process computer under plant operating conditions. Extended power uprate does not affect the functions of the process computer; however, some input variables required modification. This test was not specifically required for EPU.

6.1.10 Test No. 14 - Reactor Core Isolation Cooling (RCIC) System

This test verifies the proper operation of the RCIC system over its expected operating pressure range. The RCIC system was not modified as a part of EPU implementation. Since extended power uprate is accomplished without increasing reactor pressure, special testing was not required.The Technical Specifications ensure proper RCIC system operation. Thus, this test is not specifically required for EPU.

6.1.11 Test No. 15 – High Pressure Coolant Injection (HPCI) System

This test verifies the proper operation of the HPCI system over its expected operating pressure range. The HPCI system was not modified as a part of EPU implementation. Since extended power uprate is accomplished without increasing reactor pressure, special testing was not required.The Technical Specifications ensure proper HPCI system operation. Thus, this test is not specifically required for EPU.

6.1.12 Test No. 16 – Selected Process Temperatures

This test establishes the minimum recirculation pump speed (low speed limiter) needed to maintain water temperature in the bottom head of the reactor pressure vessel (RPV) within 145°F of the reactor coolant saturation temperature determined by reactor pressure. This test ensures the measured bottom head drain line thermocouple is adequate to measure the bottom head coolant temperature during normal operations. Temperature stratification limits are defined in the Technical Specifications. This test was not required for extended power uprate.

6.1.13 Test No. 17 – System Expansion

The purpose of this test is to verify that the reactor drywell piping systems are free and unrestrained with regard to thermal expansion, and that suspension components are functioning in the specified manner. The test also provides data for calculation of stress levels in nozzles and weldments. An analysis for extended power uprated conditions indicated the piping systems were acceptable for extended power uprate; therefore, further testing was not required.

6.1.14 Test No. 18 – Core Power Distribution

This test determines core power distribution in three dimensions, confirms reproducibility of Traversing Incore Probe (TIP) System readings, and determines core power symmetry. Existing site procedures verify proper TIP operation and core power symmetry. Extended power uprate does not significantly impact these parameters. TIP operation is not affected by extended power uprate. Thus, special testing is not required.

6.1.15 Test No. 20 – Steam Production

This test demonstrates the ability to operate continuously at rated reactor power, demonstrating that the Nuclear Steam Supply System (NSSS) provides steam at a sufficient rate and quality. This test is the initial warranty run, which is not applicable to extended power uprate.

6.1.16 Test No. 21 – Flux Response to Rods

The purpose of this test is to demonstrate the stability of the core local power-reactivity feedback mechanism with regard to small perturbations in reactivity caused by rod movement. This was an initial startup test requirement that is no longer applicable, due to the incorporation of thermal-hydraulic instability requirements on the power/flow map (Figure 1).

6.1.17 Test No. 23 – Feedwater System

The major objectives of this startup test are to:

- Demonstrate vessel water level control.
- Evaluate and adjust feedwater controls.
- Demonstrate the capability of the automatic flow runback feature to prevent a low water level scram following a single Reactor Feed Pump (RFP) trip.
- Demonstrate adequate response to feedwater heater loss.
- Demonstrate general reactor response to inlet subcooling changes.
- Confirm the acceptability of the calibration of the feedwater flow elements at EPU conditions (added requirement based on previous plant power uprate experiences).

During initial startup, the five original objectives were demonstrated through the performance of different tests. The tests performed specifically for EPU Phase I

are included in Section 6.2.7. The tests that were not performed for extended power uprate are as follows:

Loss of Feedwater Heating (LOFH)

The LOFH test performed during initial startup testing demonstrates adequate response to LOFH. The transient event is caused by an equipment failure or operator error that causes isolation of one or more feedwater heaters. Plant-specific transient analyses from previous cycles show acceptable response relative to fuel thermal limits; i.e., minimum critical power ratio (MCPR) and fuel overpower.

The LOFH transient was reanalyzed for extended power uprate, and fuel thermal limits were acceptable. Therefore, the LOFH test was not required for extended power uprate.

Single RFP Trip

This test verifies the capability of the automatic recirculation pump runback to prevent a low water level scram following a single RFP trip. As discussed in PUSAR Section 7.4.2, transient analyses were performed, which concluded that scram avoidance is not assured after EPU. However, this is a similar result as pre-EPU. This information has been included in control room operator training and is modelled on the plant-specific simulator. Thus, the peformance of this test would not provide any further useful information on feedwater system performance.

6.1.18 Test No. 25 Main Steam Isolation Valves

The major objectives of this test are to:

- Functionally check the main steam isolation valves (MSIVs) for proper operation at selected power levels.
- Determine reactor transient behavior during and following simultaneous full closure of all MSIVs and following closure of one MSIV.
- Determine MSIV closure times.
- Determine the maximum power level at which a single valve closure can be made without scram.

- Confirm the acceptable calibration of the main steam flow elements at EPU conditions (added requirement based on previous plant power uprate experiences).

During initial startup, the four original objectives were demonstrated through the performance of different tests. The tests performed specifically for EPU Phase I of are included in Section 6.2.9. The tests that were not performed for extended power uprate are as follows:

Functional Check

As there was no pressure increase with EPU, system performance is not expected to change. Technical Specifications ensure proper operation of the safety function of these valves.

Transient Behavior

As discussed in the NRC Safety Evaluation for Amendment #243, Section 10.3.4, the full MSIV closure transient test is deferred until operation at 1823.8 MWt. Thus, this testing was not required for EPU Phase I.

MSIV Closure Time

As there was no pressure increase with EPU, system performance is not expected to change. Because these valves close in the direction of main steam flow, the increase in flow due to EPU could slightly decrease the stroke time. Technical Specifications ensure proper closure time of these valves. Thus, a specific test for EPU was not required.

6.1.19 Test No. 26 – Relief Valves

The purposes of this test are to verify proper operation of the primary system relief valves; determine their capacity and response characteristics; and, verify their proper seating (i.e., leaktightness) following operation. As there was no pressure increase associated with EPU, valve operation is not affected. Technical Specifications ensure proper operation of these valves. Thus, special testing was not required.

6.1.20 Test No. 27 – Turbine Stop and Control Valve Trips

The purpose of these tests are to demonstrate the response of the reactor and its control systems to protective trips of the turbine (i.e., turbine trips) and main generator (i.e., generator load rejects). Based upon transient analyses for EPU, the plant response to the turbine trip is similar to that of the generator load rejection event. Thus, it is not necessary to perform the turbine trip test for EPU.

As discussed in the NRC Safety Evaluation for Amendment #243, Section 10.3.4, the full genrator load rejection transient test is deferred until operation at 1906.7 MWt. Thus, this testing was not required for EPU Phase I.

6.1.21 Test No. 28 – Shutdown from Outside the Control Room

This test demonstrates the ability to shut down the reactor from normal steady-state operating conditions to the point where cooldown is initiated and under control with reactor pressure and water level controlled from outside the main control room. Extended power uprate does not alter the capability of the reactor to be shut down from outside the main control room; therefore, this test was not required for extended power uprate.

6.1.22 Test No. 29 – Flow Control

The purposes of this test are to determine the plant response to changes in recirculation flow; adjust all flow control elements; and, to demonstrate the plant load following capability in local manual, master manual, and automatic flow control modes. EPU does not significantly affect either the recirculation flow control system, as the increase in pump speed and drive flow needed to achieve rated core flow is minor (< 2.7%). The licensed maximum core flow limit is not being changed by EPU (Figure 1). In addition, the DAEC only operates in manual control mode. Thus, this testing is not required for EPU.

6.1.23 Test No. 30 – Recirculation System

The purposes of this test are to evaluate the recirculation flow and power level transients following trips of one or both of the recirculation pumps; calibrate the jet pumps in order to determine reactor core flow and jet pump flow consistency; and, verify no recirculation system cavitation will occur on the operable region of the power/flow map.

The transient analyses performed for EPU demonstrate that the transient behavior of the recirculation system is acceptable. Thus, transient testing is not required for EPU. As there is no increase in core flow for EPU, the jet pumps are not affected and the routine Technical Specification Surveillance Requirements are sufficient for ensuring proper operation. The cavitation protection line on the power/flow map (Figure 1) is not changed due to EPU, but remains at its previous value, based upon MWt. Thus, testing is not required.

6.1.24 Test No. 31 – Loss of Turbine-Generator and Offsite Power

The purpose of this test is to determine the reactor transient performance during the loss of the main generator and all offsite power, and to demonstrate acceptable

performance of the station electrical supply system. The loss-of-offsite power (LOOP) results in a generator load reject event, which is discussed in Test No. 27 above. The performance of the electrical distribution system is confirmed by individual equipment tests (i.e., changes in equipment protective relay settings), thus, an integrated test of the entire electrical distribution system is not required.

6.1.25 Test No. 32 – Recirculation MG Set Speed Control

The purposes of this test are to determine the individualized characteristics of the recirculation control system (i.e., Drive Motor, Fluid Coupler, Generator, Drive Pump, and Jet Pumps), to obtain acceptable speed control system performance by the adjustment of the linear and non-linear controller elements, and to determine the maximum allowable pump speed.

As stated previously for Test No. 29, rated core flow is not changed for EPU, thus specific testing of the recirculation system, including individual components in the control system, is not required.

6.1.26 Test No. 34 – Recirculation and Jet Pump Instrumentation Calibration

The purpose of this test is to obtain a complete integrated calibration of the installed jet pump and recirculation pump flow instrumentation with the reactor shutdown prior to the jet pump flow calibration (Test No. 30). Similar to Test No. 30, as there is no change in rated core flow due to EPU, the ability to calibrate these instruments over their required ranges is also not affected. Thus, no testing is required.

6.1.27 Test No. 70 – Reactor Water Cleanup System

This test demonstrates the specific aspects of the mechanical operability of the Reactor Water Cleanup (RWCU) System. Detailed evaluations show the impact of the new licensed power is minor changes in RWCU System operating requirements, due to the changes in feedwater flow and temperature. These changes are well within the system's design parameters. No specific RWCU testing was performed for EPU.

6.1.28 Test No. 71 – Residual Heat Removal System

The purpose of this test is to demonstrate the ability of the Residual Heat Removal (RHR) System to remove residual and decay heat from the nuclear system so that refueling and nuclear servicing can be performed and to condense steam while the reactor is isolated from the main condenser. The capability of the RHR System to remove residual and decay heat has been demonstrated many times over the years. The effect of EPU on system performance is merely an increase in reactor cooldown time, i.e., system mission time. The RHR System will continue to perform acceptably. The steam condensing mode of RHR has

been removed and thus, is not a factor. Therefore, the RHR System startup test was not performed for EPU.

6.1.29 Test No. 72 – Drywell Atmosphere Cooling System

The purpose of this test is to verify the ability of the Drywell Atmosphere Cooling System to maintain design conditions in the drywell during operating conditions and post scram conditions.

The evaluation for EPU determined that the normal operating temperatures inside the Drywell will increase less than 2°F, thus the impact on the cooling system is negligible and no testing is required.

6.1.30 Test No. 73 – Cooling Water Systems

The purpose of this test was to verify the performance of the cooling water systems for the reactor and turbine buildings, and other service water systems was adequate with the reactor at rated temperature. The impact of EPU operation on these systems was evaluated and found to be small.

Modifications were made to the General Service Water (GSW) system to provide additional main generator stator cooling to maintain adequate design margins. Selected steady-state temperature data for specific GSW loads (e.g., main generator stator and isophase bus cooling) were obtained during EPU testing (see Section 6.3.4); however, no specific tests were performed.

6.1.31 Test No. 74 – Offgas System

The purposes of this test are to verify the proper operation of the Offgas System over its expected operating parameters, and to determine the performance of the activated carbon adsorbers. The impact of EPU on Offgas operation is well within the original system design specifications, thus no testing is required. The performance of the carbon adsorbers is administratively controlled, via both Technical Specifications and Offsite Dose Assessment Manual (ODAM), to meet regulatory requirements under 10 CFR Part 20 and 10 CFR Part 50, App. I. These limits are unaffected by EPU.

6.1.32 Test No. 90 – Vibration Monitoring

This initial startup test demonstrated the mechanical integrity of the reactor system under conditions of flow-induced vibration by taking vibration measurements and correlating them to analytical models. The impact of EPU on reactor internals vibration was evaluated at the uprated power and maximum core flow. The maximum licensed core flow was not increased for EPU, and it was determined the reactor vessel internals design continued to comply with existing

structural requirements. Thus, no specific vibration testing/monitoring of the vessel internal is required for EPU.

6.2 UFSAR Section 14.2 Tests Required for EPU

6.2.1 Test No. 1 – Chemical and Radiochemical Monitoring

Purpose: The purpose of this test is to maintain control of and knowledge about the quality of the reactor coolant chemistry and radiochemistry at EPU conditions.

Description: Samples were taken and measurements were made at the uprated conditions to determine 1) the chemical and radiochemical quality of reactor water and reactor feedwater and 2) gaseous release.

Test Conditions: 1, 2 ,3 and 4

Acceptance Criteria:

Level 1: a) Chemical factors defined in the Technical Specifications, Fuel Warranty, and Technical Requirements Manual are maintained within the limits specified.
b) The activity of gaseous and liquid effluents conforms to license limitations.

Level 2: Water quality is known at all times and remains within the guidelines of the water quality specifications.

Results: All Acceptance Criteria were met at all Test Conditions. No abnormalities were observed.

6.2.2 Test No. 2 – Radiation Monitoring

Purpose: The purpose of this test is to monitor radiation at the EPU conditions to assure that personnel exposures are maintained ALARA, that radiation survey maps are accurate and that radiation areas are properly posted.

Description: Gamma dose rate measurements and, where appropriate, neutron dose rate measurements were made at specific limiting locations throughout the plant to assess the impact of EPU on actual plant area dose rates. UFSAR radiation areas will be monitored for any required posting changes.

Test Conditions: 1, 2, 3 and 4

Acceptance Criteria:

Level 1: The radiation doses of plant origin and the occupancy times of personnel in radiation areas shall be controlled consistent with the guidelines of The Standard for Protection Against Radiation outlined in 10CFR20.

Level 2: Not Applicable.

Results: Radiation surveys were conducted with hydrogen water chemistry in service. The dose rates were comparable to those experienced at the previous licensed power level. As a conservative measure, the posting for the Turbine Building roof was upgraded to a High Radiation Area, as the dose rate increased from 80 to 95 mR/hr. Radiation dose rates remain compliant with all applicable regulatory limits.

6.2.5 Test No. 19 – Core Performance

Purpose: The purpose of this test is to measure and evaluate the core thermal power and fuel thermal margin to ensure a careful, monitored approach to the EPU level.

Description: Core thermal power was measured using the current plant methods of monitoring reactor power. Demonstration of the fuel thermal margin was performed and was projected to the next test condition to show expected acceptance margin and was satisfactorily confirmed by the measurements taken at each test condition before advancing further.

Test Conditions: 1, 2, 3, and 4

Acceptance Criteria:

Level 1: a) Average Planar Linear Heat Generation Rates (APLHGR) shall be less than or equal to the limits specified in the Core Operating Limits Report (COLR).
b) Minimum Critical Power Ratios (MCPR) shall be greater than or equal to limits specified in the COLR.
c) Maximum Linear Heat Generation Rate (LHGR) shall be less than or equal to the limits specified in the COLR.
c) Steady-state reactor power shall be limited to values on or below the Maximum Extended Load-Line Limit Analysis (MELLLA) upper boundary.
d) Core flow shall not exceed its rated value.

Level 2: Not Applicable.

Results: Per normal operating practices, thermal limits are continuously monitored during power ascensions. Specific core monitoring cases were peformed at the specified Test Conditions. Projections at the next Test Condition were made to determine if adjustments in control rod position would be necessary to maintain thermal limits within Acceptance Criteria. By adjusting the control rod patterns in the core, as needed, the Acceptance Criteria were met at all power levels.

6.2.6 Test No. 22 – Pressure Regulator

Purpose: The purposes of this test are to:

a) confirm the adequacy of the setting for the pressure control loop used in the analysis of the transients induced in the reactor pressure control system using the pressure regulators,
b) demonstrate the takeover capability of the backup pressure regulator upon failure of the controlling pressure regulator and to set spacing between the setpoints at an appropriate value,
c) demonstrate smooth pressure control transition between the control valves and bypass valves when reactor steam generation exceeds steam used by the turbine, and
d) demonstrate that other affected parameters are within acceptable limits during pressure regulator induced transient maneuvers in preparation for operation at uprated conditions.

Description: The pressure regulator system tuning was performed in accordance with the guidance of Service Information Letter (SIL) 589, "Pressure Regulator Tuning."

During testing, step changes in reactor pressure, of increasing magnitude, were simulated, and the resulting transients were recorded. The data for each step change were analyzed for acceptable performance and scram margins prior to performing the next increased pressure step change. Step changes were first performed with pressure regulator "A" in control and second with pressure regulator "B" in control.

The pressure regulator control system was tested by simulating a failure of the selected pressure regulator so the backup pressure regulator will take over control.

Starting at ~ 15% reactor rated steam flow, turbine first-stage pressure, reactor and turbine steamflows, turbine valve position and pressure regulator output were recorded at approximately every 2% increase in turbine steamflow, up to ~88% of rated turbine

steamflow (~1776 MWt). The data were plotted to confirm pressure regulation linearity.

Test Conditions: A, G, and H;
1, 2, and 4

NOTES: 1) Post outage testing was also performed at ~30% power (574 MWt).
2) Pressure regulator failure testing was performed at ~30% power and at Test Conditions A and H.

Acceptance Criteria:

Level 1: The transient response of the turbine inlet (throttle) pressure to any test input must not diverge. This can be visually verified by observing that the successive peaks of the same polarity are of equal or decreasing amplitude.

NOTE: The Level 1 criterion was subsequently revised during the testing to eliminate the second sentence regarding decreasing magnitude. Due to the actual system dynamic response, "classical" oscillations were not observed; thus, this clarification of non-divergent behavior was not always met, although the system response was not actually diverging.

Level 2: a) The decay ratio of the turbine inlet (throttle) pressure must be less than or equal to 0.25. (This criterion does not apply to tests involving simulated failure of one regulator with the backup regulator taking over).
b) The pressure response time from initiation of pressure setpoint change to the turbine inlet (throttle) pressure peak shall be less than 10 seconds.
c) Pressure control system deadband, delay, etc., shall be small enough that steady state limit cycles (if any) shall produce steam flow variations no larger than ± 0.5 percent of rated steam flow.
d) The peak neutron flux and peak vessel pressure shall remain below the scram settings by 7.5 percent and 10 psi, respectively, for all pressure regulator transients.
e) The variation in incremental regulation, over the range from approximately 10% to 100% of rated core thermal power, shall meet the following:

Percent Steam Flow	Variation
0% to 85%	< 4 : 1
85% to 97%	< 2 : 1
85% to 99%	< 5 : 1

Results: The system response to step changes at each power level was satisfactory. No signs of divergence occurred. Pressure response time and margins to scram setpoints were adequate in all test cases. All Level 1 (as modified, above) and Level 2 Acceptance Criteria were satisfied. It should be noted that limit cycle oscillations by the control valves were observed during the approach to Test Condition 2 (~1680 MWt), which increased in magnitude with increasing power. At Test Condition 2, the TCVs oscillated ± 3.5 % about their steady state open positions. Investigation concluded that, at this operating condition (turbine steamflow), there is a "break point" in the control system logic, where there is a slope change in the diode function generator control curve. Consequently, the control system was "hunting" between the two curve segments, causing the oscillation. Evaluation of the oscillatory behavior concluded that these oscillations did not pose a threat to the valves or plant operation. However, it was decided to not perform the step change tests at Test Condition 2, due to the oscillations, which would have given anomolous test results. The test was successfully completed at Test Condition 4.

The transition from the primary to backup pressure regulator was satisfactory. No signs of divergence occurred. Pressure response time and margins to scram setpoints were adequate in all cases. No limit cycles were observed. All Level 1 (as modified, above) and Level 2 Acceptance Criteria were satisfied.

Pressure regulator linearity was also confirmed over the range of turbine steam flow tested.

6.2.7 Test No. 23 – Feedwater System

6.2.7.1 Test No. 23A – Feedwater Control System

Purpose: The purposes of this test are to adjust the feedwater control system for acceptable reactor water level control and to demonstrate stable reactor response to subcooling changes.

Description: Small step changes in reactor water level (±1, ±2, ±3, and ±5 inches) were inserted to evaluate level control stability and any oscillatory response. These step changes were performed in both "A" and "B" Level Control and each set in both single-element and three-element control. A total of 32 level setpoint change tests were planned at each Test Condition. System responses (steamflow, feedflow and vessel water level) were monitored for overall stability.

Small step changes in system flow were introduced by making level adjustments (±1 and ±2 inches) with the Master Feedwater Regulating Valve (FRV) in Automatic, and one individual FRV controller in Automatic and the other FRV controller in Manual. The tests were repeated with the individual FRV controller settings reversed. A total of 8 system flow tests were planned at each Test Condition. System responses (steamflow, feedflow and vessel water level) were monitored for overall stability.

Test Conditions: C and G
1, 2, 3, and 4

Acceptance Criteria:

Level 1: The transient response of any feedwater level control system related variable to any test input must not diverge.

Level 2: a) Level control system-related variables may contain oscillatory modes of response. In these cases, the decay ratio for each controlled mode of response shall be less than or equal to 0.25.
b) Following a ± 3 inch level setpoint adjustment in three element control, the time from the setpoint change until the level peak occurs shall be less than 35 seconds without excessive feedwater swings (changes in feedwater flow greater than 25% of rated flow).

NOTE: The Level 2 (b) criterion was subsequently modified from 35 seconds to 60 seconds, based upon an evaluation of the existing control system settings. These settings had been changed as a result of a previous modification that installed new flow controllers in 1996. The settings had been changed to give a controlled water level response, with no overshoot – a very dampened system. Such settings have a slower response than the original settings, upon which the test Acceptance Criteria were based.

Results: All tests performed ultimately met the modified Acceptance Criteria. Based upon test results at Test Condition 1, the test matrix was simplified at Test Conditions 2, 3 and 4 by omitting the ±1 and ±2 inch level setpoint change tests, i.e., only the ±3 and ± 5 inch tests were performed. Also, given the similarity of response between "A" and "B" level control tests, only the "A" single element level control test was performed at Test Condition 4. At no time was unstable control system behavior observed. As

noted below, a problem in the control circuit was discovered during the testing at Test Condition 1 that required maintenance and reperformance of that test.

During Expert Panel review of the test results at Test Condition 1, it was observed that there was a "bias" in the output of the level control system, such that for a given level setpoint change, the corresponding actual water level response was approximately doubled. For example, a 1 inch level setpoint change resulted in an approximately 2.75 inch actual change in water level and for the 3 inch level setpoint change, an actual level change of over 5.5 inches was observed. Testing was halted and the ±5 inch test was not performed, as it could have led to an unacceptable level response. Extensive troubleshooting of the control system was undertaken. The bias was only observed when the control system was in 3-Element control. Subsequent troubleshooting determined that one of the controllers (FY4450E) was causing the bias. It was replaced with a spare unit and the testing was repeated satisfactorily, including the ±5 inch test, with no further observance of the level bias.

At Test Condition 3, a projection of feedwater system performance determined that the transient testing at Test Condition 4 had the potential to cause a feedwater pump trip on low suction pressure. Thus, testing was halted until Engineering could evaluate the pump NPSH requirements that form the basis for the suction trip setpoint. It was determined that the setpoint could be lowered to provide adequate margin, the trip setpoint was changed and the testing at Test Condition 4 was authorized. The testing was satisfactorily completed at Test Condition 4 with no observed problems with inadequate NPSH.

6.2.7.2 Test No. 23B – Feedwater Flow Element Calibration

Purpose: The purpose of this test is to confirm acceptable calibration of the feedwater flow elements at uprated power conditions.

Description: In order to verify accurate feedwater flow input to the process computer, feedwater flow data from the flow elements will be compared against a known flow source information (i.e., the ultrasonic flow meter).

Test Conditions: 1, 2, 3, and 4

Acceptance Criteria:

Level 1: Not Applicable.

Level 2: The accuracy of the feedwater flow venturi indication relative to the calibrated flow information shall be within acceptable tolerance for flow rates between 20 and 125 percent rated. The process signal noise shall be within acceptable tolerance of rated flow.

Results: The venturies were within the required tolerances at each Test Condition. No anomolies were observed.

6.2.8 Test No. 24 – Bypass Valves

Purpose: The purpose of this test is to demonstrate that a bypass valve can be tested for proper functioning at high power without causing a scram.

Description: The response of the reactor to bypass valve surveillance tests was measured at several Test Conditions to evaluate the impact on the maximum test power level due to EPU. A maximum power test condition was determined from the data. For all tests, the proximity to pressure scram, neutron flux and APRM flow biased scram, and main steam line high flow isolation was closely monitored. Each test was manually initiated and reset. Rate of valve stroking and timing of the close-open sequence was such that the minimum practical disturbance was introduced.

Test Conditions: A, B, D, E, F, G, H, I, J and K

Acceptance Criteria:

Level 1: Not Applicable.

Level 2: a) Peak neutron flux must be at least 7.5% below the APRM flow-biased scram trip setting. Peak vessel pressure must remain at least 10 psi below the high pressure scram setting.
b) Peak steam flow in each line must remain 10% below the high flow isolation trip setting.

Results: All test criteria were met up through Test Condition K (1630 MWt), where testing was halted based upon reaching the maximum power level for testing other valves. To coincide with the testing of other turbine valves, Test Condition J (1600 MWt) was chosen for performing this routine surveillance test.

6.2.9 Test No. 25 – Main Steam Isolation Valves

6.2.9.1 Test No. 25D – Single MSIV Closure Test

Purpose: The purpose of this test is to determine maximum power at which a single valve closure can be made without causing a scram.

Description: At several Test Conditions, the response of the reactor to the closure of an individual MSIV was measured to evaluate the impact of the EPU and MELLLA implementation on the maximum closure power level. During this test the proximity to pressure scram, neutron flux and APRM flow biased scram, and main steam line high flow isolation was closely monitored.

Test Conditions: A, B, D, E, F, and G

Acceptance Criteria:

Level 1: Not Applicable.

Level 2: a) Peak neutron flux must be at least 7.5% below the APRM flow-biased scram trip setting. Peak vessel pressure must remain at least 10 psi below the high pressure scram setting.
b) Peak steam flow in each line must remain 10% below the high flow isolation trip setting.

Results: While all Acceptance Criteria were met at Test Condition G, both a Reactor High Pressure and Low Reactor Water Level Alarm were received during the test. Consequently, Condition F (1460 MWt) was chosen as the maximum power level to perform this routine surveillance test.

6.2.9.2 Test No. 25E – Main Steam Flow Element Calibration

Purpose: The purpose of this test is to confirm acceptable calibration of the main steam flow elements at uprated power conditions.

Description: In order to verify accurate steam flow input to the process computer, steam flow data from the flow elements will be compared against a known flow source information.

Test Conditions: 1, 2, 3, and 4

Acceptance Criteria:

Level 1: Not Applicable.

Level 2: The accuracy of the main steamline flow venturi relative to the calibrated feedwater flow shall be within ± 5 percent of rated steam flow at flow rates between 20 and 125 percent rated. The process signal noise shall be within ± 5 percent of rated steam flow.

Results: The main steamline flow venturies were within the required tolerances at each Test Condition. No anomolies were observed.

6.2.10 Test No. 33 – Main Turbine Stop Valve Surveillance Test

Purpose: The purpose of this test is to demonstrate an acceptable procedure for turbine stop valve surveillance testing at a power level as high as possible without producing a reactor scram.

Description: At several Test Conditions, the response of the reactor to stop valve surveillance tests was measured to evaluate the impact on the maximum test power level as a consequence of the implementation of EPU. A maximum power test condition was determined from the data. For all tests the proximity to pressure scram, neutron flux and APRM flow biased scram, and main steam line high flow isolation was closely monitored. Each test was manually initiated and reset. Rate of valve stroking and timing of the close-open sequence was such that the minimum practical disturbance was introduced.

Test Conditions: A, B, D, E, F, G, H, I, and J

Acceptance Criteria:

Level 1: Not Applicable.

Level 2: a) Peak neutron flux must be at least 7.5% below the APRM flow-biased scram trip setting. Peak vessel pressure must remain at least 10 psi below the high pressure scram setting.
b) Peak steam flow in each line must remain 10% below the high flow isolation trip setting.
c) Bypass valves should not open for this test.

Results: While all Acceptance Criteria were met at Test Condition J, projections of the data indicated that Main Steamline Flow would exceed the range of the control room indicator at Test Condition K. Thus, Test Condition J (1600 MWt) was chosen as the maximum power level for performing this routine surveillance test.

6.3 Additional Tests

6.3.1 Steady-State Data Collection

Purpose: To obtain steady-state data of important plant parameters during EPU operation.

Description: Plant parameters, both Nuclear Steam Supply System (NSSS) and Balance of Plant (BOP) were recorded at various Test Conditions and evaluated for anomolous behavior prior to increasing power to the next Test Condition.

Test Conditions: 1, 2, 3, and 4

Results: Review of the plant data did not identify any anomolous behavior. This data will be used to project system/component performance during Summer high ambient temperature conditions, which are more demanding on plant equipment.

6.3.2 Power Conversion System Piping Vibration Monitoring

Purpose: The purpose of this test is to gather vibration and displacement measurements on the Main Steam and Feedwater system piping to evaluate the vibration stress effect due to the EPU.

Description: During the EPU power ascension, main steam and feedwater piping points, coincidental with those in the initial startup vibration measurements report or evaluated as representative of the piping system, were monitored for vibration. Vibration measurements taken above that of the previous test will permit a thorough assessment of the impact of EPU.

Test Conditions: C (In addition, data was taken at 43% power/829 MWt)
1, 2, and 4

Results: Screening criteria (frequency and magnitude) were established for evaluating this data. If the "Negligible" values in the screening criteria were exceeded, Engineering evaluation of the data was required. Only one set of data at Test Conditions 1, 2 and 4, for a single location on the main steam piping, exceeded the Negligible level. The Engineering evaluation determined that the resulting stress effect of the recorded vibration was well within the acceptance criteria. One sensor failed during the testing. Engineering evaluated the loss of this data set and concluded that sufficient sensors remained to adequately predict the stresses in the piping.

6.3.3 Turbine Combined-Intermediate Valve (CIV) and Turbine Control Valve (TCV) Surveillance Testing

Purpose: The purpose of this test is to demonstrate an acceptable procedure for turbine CIV and TCV surveillance testing at a power level as high as possible without producing a reactor scram. While not an original FSAR Startup Test, this testing was added, as it is similar in nature to the Turbine Stop Valve Test (Test No. 33, above).

Description: At several Test Conditions, the response of the reactor to CIV and TCV surveillance tests was measured to evaluate the impact on the maximum test power level as a consequence of the implementation of EPU. A maximum power test condition was determined from the data. Similar to Test No. 33, the proximity to pressure scram, neutron flux and APRM flow biased scram, and main steam line high flow isolation was closely monitored. Each test was manually initiated and reset. Rate of valve stroking and timing of the close-open sequence was such that the minimum practical disturbance was introduced.

Test Conditions: A, B, D, E, F, G, H, I, J and K

NOTE: Due to limits on MSR drain capacity, the CIVs were only tested at Conditions A, B, D, E, F and G

Results: A demand signal was received to open one of the Turbine Bypass Valves at Test Condition K, which is one of the Level 2 criteria used for the Turbine Stop Valves. Although the TBV itself did not move, (i.e., the Level 2 criterion was satisfied), Test Condition J (1600 MWt) was chosen as the maximum power level for performing this routine surveillance test.

6.3.4 General Service Water (GSW) Heat Exchanger Performance Monitoring

Purpose: To gather data on GSW system performance to optimize cooling capacity to individual components.

Description: Obtain GSW flow (ultrasonic), GSW inlet temperature (contact pyrometer), GSW outlet temperature, and throttle valve positions for various component heat exchangers. The GSW system piping was replaced for EPU with piping of a larger size to increase the cooling to critical components, such as generator stator hydrogen cooling. This testing was to confirm adequate cooling and to provide data for further system balancing (i.e., optimize cooling to critical components.)

Test Conditions: 1, 2, 3, and 4

Results: Initial review of the data did not indicate that any components were receiving inadequate cooling flow. The collected data will be used to project performance during Summer high ambient temperatures and allow adjustments in flow balancing, as needed.

Table 1

UFSAR Section 14.2 Tests

Test No.	Test Title	Required for EPU
1	Chemical and Radiochemical Monitoring	Yes
2	Radiation Monitoring	Yes
3	Fuel Loading	No
4	Full Core Shutdown Margin	No (a)
5	Control Rod Drive (CRD) System	No (a)
6	Source Range Monitor (SRM) Response and Control Rod Sequence	No (a)
9	Water Level Measurement	No
10	Intermediate Range Monitor (IRM) Performance	No (a)
11	Local Power Range Monitor (LPRM) Calibration	No (a)
12	Average Power Range Monitor (APRM) Calibration	No (a)
13	Process Computer	No
14	Reactor Core Isolation Cooling (RCIC) System	No (a)
15	High Pressure Coolant Injection (HPCI) System	No (a)
16	Selected Process Temperatures	No (a)
17	System Expansion	No
18	Core Power Distribution	No
19	Core Performance	Yes
20	Steam Production	No
21	Flux Response to Rods	No
22	Pressure Regulator	Yes (b)
23	Feedwater System	Yes (b)
24	Bypass Valves	Yes
25	Main Steam Isolation Valves	Yes (b) (c)
26	Relief Valves	No (a)
27	Turbine Stop and Control Valve Trips	Yes (c)
28	Shutdown from Outside the Control Room	No
29	Flow Control	No
30	Recirculation System	No (a)
31	Loss of Turbine-Generator and Offsite Power	No
32	Recirculation MG Set Speed Control	No
33	Main Turbine Stop Valve Surveillance Test	Yes
34	Recirculation and Jet Pump Instrumentation Calibration	No
70	Reactor Water Cleanup System	No
71	Residual Heat Removal System	No
72	Drywell Atmosphere Cooling System	No
73	Cooling Water Systems	No
74	Offgas System	No
90	Vibration Monitoring	No

Notes: (a) Credit was taken for existing Technical Specification Surveillances.
(b) The original test contains multiple sub-tests. Only those sub-tests affected by EPU were performed.
(c) While required for EPU, some tests were not performed during Phase I, as their required power levels are beyond those targeted for Phase I.

Table 2

Test Conditions

Test Condition	% of Rated Thermal Power (based upon 1912 MWt)	Thermal Power (MWt)
A	60	1150
B	65	1240
C	67	1275
D	69	1320
E	73	1400
F	76	1460
G	78	1500
H	80	1540
I	82	1570
J	84	1600
K	85	1630
1	87	1658
2	90	1720
3	92	1760
4	94	1790

Figure 1
DAEC Power/Flow Operating Map for EPU