Progress Energy

JUN 1 7 2004

SERIAL: BSEP 04-0076

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Brunswick Steam Electric Plant, Unit No. 1
Docket No. 50-325/License Nos. DPR-71
Extended Power Uprate
Implementation Test Report - Phase 2

Ladies and Gentlemen:

In accordance with NEDC-33039P, "Safety Analysis Report for Brunswick Steam Electric Plant Units 1 and 2 Extended Power Uprate," dated August 2001 (i.e., the Power Uprate Safety Analysis Report (PUSAR)), Section 10.4, "Required Testing," and the Brunswick Steam Electric Plant (BSEP) Updated Final Safety Analysis Report (UFSAR), Section 13.4.2.1, "Startup Report," Carolina Power & Light Company, now doing business as Progress Energy Carolinas, Inc., is providing the implementation test report for the second and final phase of implementation of extended power uprate (EPU) for Unit 1.

Implementation of Phase 2 of EPU for Unit 1 was completed during the spring 2004 refueling outage which ended on March 31, 2004. Implementation testing was competed on April 27, 2004; the results of this testing demonstrated acceptable performance of the unit at the full licensed power level of 2923 megawatts thermal.

Please refer any questions regarding this submittal to Mr. Leonard R. Beller, Supervisor - Licensing/Regulatory Programs, at (910) 457-2073.

Sincerely,

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Enclosure:

Unit 1 Extended Power Uprate - Final Implementation Test Report

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Enclosure

Unit 1 Extended Power Uprate
Final Implementation Test Report

Brunswick Steam Electric Plant

Unit 1 Extended Power Uprate

Final Implementation Test Report

Prepared by: _____
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1.0 Executive Summary

The Brunswick Steam Electric Plant (BSEP), Unit 1 Extended Power Uprate (EPU) Implementation Test Report is submitted to the Nuclear Regulatory Commission (NRC) in accordance with the BSEP Updated Final Safety Analysis Report (UFSAR), Section 13.4.2.1. This report summarizes the testing performed as part of the second phase of the implementation of EPU on Brunswick Unit 1. Extended Power Uprate was approved by the NRC in Amendment No. 222 to Facility Operating License DPR 71 (i.e, Unit 1) on May 31, 2002. Testing for the final phase of implementation of EPU on Unit 1 was completed on April 27, 2004, with a final steady state operating power level of 2923 MWt.

Testing specified in the BSEP Power Uprate Safety Analysis Report (PUSAR), NEDC-33039P, was addressed. Special test procedures were implemented in combination with existing plant procedures, as described in this report. All required tests have been completed to support operation at the licensed power level of 2923 MWt. Testing was conducted over the period from March 31, 2004 to April 27, 2004. Test results were reviewed for acceptability and results reported to the Plant Nuclear Safety Committee (PNSC). Final results of the testing and equipment performance data gathering have demonstrated successful continued operation at the licensed power level of 2923 MWt.

2.0 Purpose

This report summarizes the testing performed on Unit 1 following the implementation of the final phase of the BSEP EPU, approved by the NRC in Amendment No. 222 to Facility Operating License DPR 71 (i.e, Unit 1) on May 31, 2002. While the amendment approved a new licensed thermal power of 2923 MWt, the implementation of the EPU has been conducted in two planned phases. This report summarizes the testing performed at power levels above 2755 MWt which demonstrated the acceptability of a steady-state operating thermal power of 2923 MWt (i.e., licensed thermal power) on Unit 1. The testing performed is described in Section 7.0 of this report.

3.0 Program Description

The EPU testing program was conducted as described in Section 10.4 of the BSEP PUSAR.

The in-plant testing for the second phase of implementation on Unit 1 began on March 31, 2004 following completion of the Unit 1 refuel/maintenance outage, and was completed on April 27, 2004. The results of the testing validated continuous operation of Unit 1 at 2923 MWt.

Special Procedures (SPs) were developed to coordinate the implementation program and to control performance of specific one-time tests. Plant surveillance test procedures were

used, to the extent possible, to satisfy required testing. Table 2 lists the test conditions and is used in denoting the testing performed for the second phase of EPU implementation.

The majority of the testing performed is categorized as follows:

- Verification that the control systems [i.e., Electro-Hydraulic Control (EHC) and Digital Feedwater Control] are stable at uprated conditions.
- Collection of system performance data to verify modifications made to support uprated operation were performing as expected.
- Collection of general plant data (e.g., radiation surveys, coolant chemistry, thermal performance) for comparison to previous plant rated conditions.

Reactor core flow was permitted anywhere within the safe operating region of the power/flow map that would establish the required power. Power levels were established on or near the maximum permitted rod line in preparation for the various test conditions. Testing at specific power levels was completed and results evaluated prior to proceeding to the next testing plateau.

4.0 Acceptance Criteria

For each test performed in the power ascension test program, the test purpose, test conditions, and associated acceptance criteria were defined within the test.

Test criteria for each test had a maximum of two levels of acceptance criteria. Level 1 criteria were associated with safe unit operation. Level 2 criteria were associated with system/component performance expectations.

If a Level 1 criterion was not met:

- The plant would be placed in a hold condition judged to be satisfactory and safe, based upon prior testing.
- Tests consistent with that hold condition could be continued.
- Resolution of the problem would be immediately pursued by equipment adjustments or through engineering evaluation as appropriate. Following resolution, the applicable test portion was required to be repeated to verify that the Level 1 requirement was satisfied.

If a Level 2 criterion was not met:

- Plant operations or EPU power ascension test plans would not necessarily have to have been altered (i.e., the limits stated in this category were usually associated with expectations of system transient performance, and whose characteristics could be improved by equipment adjustments).

- For each controller-related parameter failing to satisfy its Level 2 criterion, either:
  - The temporary Level 2 test criterion failure was resolved by equipment adjustment and the applicable test portion was repeated to verify that the Level 2 requirement was satisfied, or
  - If resolution was not practical (i.e., equipment in service), a Level 2 test criterion exception was initiated for that portion of the test referring to the parameter failing to satisfy the Level 2 requirement.
- Test exceptions involving Level 2 criteria were evaluated before the conclusion of the EPU power ascension test program. The evaluation considered the magnitude of the parameter deviation from the Level 2 criterion, possible impact on plant operations, justification for the resolution, and any potential corrective action.

5.0 EPU Power Ascension Test Program Summary

Equipment post-modification testing was performed as part of the startup following the B115R1 refueling outage. The power ascension test program commenced on March 31, 2004 and the final power level of 2923 MWt (licensed power level) was achieved on April 27, 2004. Following a review of the results of the testing program and reporting to the PNSC, Plant General Manager approval was obtained to operate at a steady state power level of 2923 MWt.

6.0 Testing Requirements

Section 7.0 identifies the UFSAR tests that were performed for the EPU implementation as identified in the PUSAR Section 10.4. The purpose of each test, a description of the test, Acceptance Criteria, and test results are included. Section 7.0 identifies additional test/data collection that was performed to evaluate the performance of the unit at EPU conditions. Descriptions of the tests/data collection and associated results are included.

Table 2 identifies the associated power levels referenced for the tests described in Section 7.0. These power levels are given a corresponding letter designation. The Section 7.0 tests indicate the power level at which they were performed via this letter designation.

7.0 UFSAR Section 14.2 Tests Required For EPU

7.1 Test No. 1 – Chemical and Radiochemical Monitoring

The purpose of this monitoring is to verify control of the quality of the reactor coolant chemistry and radiochemistry at EPU conditions is maintained.

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

Test Conditions: G

Acceptance Criteria:

Level 1:
a) Chemical factors defined in the Technical Specifications and Fuel Warranty must be maintained within the limits specified.

b) The activity of gaseous and liquid effluents conforms to license limitations.

c) Quality of the reactor water and reactor feedwater are known at all times and remains within the guidelines of the Progress Energy chemistry program.

Level 2: NA

Results:

All acceptance criteria were met at all Test Conditions. No abnormalities were observed.

7.2 Test No. 2 – Radiation Measurements

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

Dose rate measurements were made at specific locations throughout the plant to assess the impact of EPU on actual dose rates.

Test Conditions: G

Acceptance Criteria:

Level 1: The radiation doses of plant origin and the occupancy times of personnel in radiation zones shall be controlled consistent with the guidelines of The Standard for Protection Against Radiation outlined in 10 CFR 20.

Level 2: NA

Results:

Radiation surveys were conducted at the EPU licensed power level (2923 MWt) and compared to the levels observed prior to EPU implementation. Increases in radiation does rates were within the expected ranges for the power increase achieved during this phase of implementation. In all cases the radiation dose rates remained in compliance with all applicable regulatory limits.

Data at site boundary monitoring locations will be collected during normal quarterly data collection and evaluated to assess the impact of EPU. The results of these evaluations will be maintained onsite and be available for NRC review. As required by Technical Specification 5.6.2, the Annual Radiological Environmental Operating Report is submitted by May 15 of each year. This report includes summaries, interpretations, and analyses of trends of the results of the Radiological Environmental Monitoring Program for the reporting period.

7.3 Test No. 16 – Core Performance

The purpose of this test is to 1) evaluate the core thermal power and core flow and 2) evaluate that core performance parameters are within limits to ensure a careful, monitored approach to the EPU maximum achievable power level.

Routine measurements of reactor parameters were taken at prescribed power levels. Core thermal power and fuel thermal margin were calculated using accepted methods to ensure compliance with license conditions. Power increases were made along the constant rod pattern line intended to be used for the increase to maximum uprated power in incremental steps to support a careful, monitored approach to the maximum achievable power, with core response predictions being performed at each power plateau prior to continuing power ascension.

Test Conditions: **F, G**

Acceptance Criteria:

Level 1:

a) All Average Planar Linear Heat Generation Rates (APLHGRs) shall be less than or equal to the limits specified in Technical Specifications.

b) All Minimum Critical Power Ratios (MCPRs) shall be greater than or equal to the MCPR operating limits as specified in Technical Specifications.

c) Steady state reactor power shall be limited to the maximum values on or below the lesser of either the LPU or Maximum Extended Load Line Limit Analysis (MELLLA) upper boundary.

d) Core flow shall not exceed its maximum value depicted on the Power-Flow Map as found in the cycle Core Operating Limits Report (COLR).

Level 2: NA

Results:

Core performance and thermal limits were monitored throughout the entire power ascension test program. Power predictions were utilized during the power ascension program to support proper control rod configuration. All acceptance criteria were met throughout the power ascension.

7.4 Test No. 19 – EHC Pressure Step Changes/EHC Regulator Failover

The purpose of this test is to 1) confirm the adequacy of the settings of the pressure control loop by inducing transients in the reactor pressure control system (i.e., EHC) using the pressure regulators, 2) demonstrate the takeover capability of the backup pressure regulator via simulated failure of the controlling pressure regulator, and 3) validate the turbine first stage pressure scram bypass setpoint.

Test Conditions:

Turbine First Stage Pressure Scram Bypass	**A**
EHC Pressure Regulator Step Changes	**B, C, D, E, F**
EHC Pressure Regulator Failover	**B, D**

Acceptance Criteria:

Level 1:

a) Turbine First Stage Pressure Scram Bypass will disable at $\leq$26% uprated power level.

b) The decay ratio must be less that 1.0 for each process variable that exhibits oscillatory response to pressure regulator changes.

Level 2:

a) The decay ratio of any oscillatory variable must be $\leq$0.5, with recommendation that each control system be adjusted to meet $\leq$0.25 unless there is an identifiable performance loss at higher power levels.

b) Pressure control system dead band, delay, etc., shall be small enough that steady state limit cycles, if any, shall produce turbine steam flow variations no larger than $\pm$0.5% of rated flow.

c) The response time from setpoint input until pressure peak must be within 20 seconds in the recirculation system manual mode.

d) The normal difference between pressure regulator setpoints must be small enough that the peak neutron and thermal flux and/or peak vessel pressure shall remain below the scram settings by 7.5% and 10 psi, respectively. This criterion is also applicable to pressure regulator failure tests.

Results:

During power ascension, turbine first stage pressure and reactor power were monitored and determination made that the first stage turbine pressure scram bypass was disabled prior to exceeding a reactor power of 26%.

At the power levels specified, EHC pressure step changes were performed with the "A" pressure regulator in service and, subsequently, the "B" pressure regulator in service. Additionally, at the power levels specified, EHC pressure regulator failover was performed, first from the "A" regulator to the "B" regulator and, then, from the "B" regulator to the "A" regulator.

All Level 1 and Level 2 criteria were met for all levels of testing (i.e., First Stage Turbine Pressure Scram Bypass, EHC Pressure Step Changes, EHC Regulator Failover Testing).

7.5 Test No. 20 – Feedwater System Testing

The purpose of the this test is to verify the feedwater control system has been adjusted to 1) provide acceptable reactor water level control over EPU operating conditions and subcooling changes and 2) confirm feedwater flow calibration.

Test Conditions:

Feedwater Flow Calibration **F, G**

Reactor Water Level Control **F**

Acceptance Criteria:

Level 1: a) The decay ratio must be less than 1.0 (i.e., must not diverge) for each process variable that exhibits oscillatory response to feedwater system changes.

b) The system shall provide level control accuracy to within ±2 inches of the optimum reactor water level setpoint during steady state operation in both single and three element control.

c) The system shall provide level control accuracy to within ±1 inch of the reactor water level equilibrium during steady state operation in both single and three element control.

Level 2: a.) The system should have the following response characteristics to an approximate ±4 inch level step change of the master level controller setpoint or an approximately 10% flow step change:

• Peak Overshoot (% of demand)	≤15%
• Time to 10% maximum	≤3.0 seconds
• Time from 10% to 90% maximum	≤15.0 seconds
• Settling time to within ±5% of final value	≤30.0 seconds
• Dead Time	≤2.0 seconds
• Decay Ratio	≤0.25
• Equilibrium Range off final	≤ ± 0.5 inch setpoint

b.) Following a ≈ 2 inch level setpoint step adjustment in three element control or ≈ 10% flow step change, the time from setpoint step change until the water level peak (tpeak) occurs should be less than 35 seconds without excessive feedwater swings (i.e., changes in feedwater flow greater than 25% rated flow).

c.) For manual flow changes of ≈ 10%, the average rate of response (computed between 10% and 90% of response) of the feedwater flow to the step flow demand shall be between 10% and 25% of rated pump flow per second (Rated = 13,900 gpm; therefore, 1390 gpm / sec ≤ rate of change ≤ 3475 gpm / sec).

d.) During steady state conditions, the RFPT control valves must exhibit stable behavior, as determined by the RFPT system engineer. Excessive control valve oscillation can result in premature failure of the control valve and associated linkages.

Results:

The test performed involved the introduction of level setpoint step changes and flow step changes and verifying the feedwater control system maintained system performance within acceptable limits.

For verification of feedwater flow element calibration, the total output of the feedwater flow element transmitters was compared to the total output of the reactor feed pump suction flow transmitters to determine if the flow transmitter response was consistent at the uprated conditions. The flow element transmitters were also compared to data taken from temporarily installed highly accurate ultrasonic flow transmitters for individual loop flow and total flow. A conservative adjustment for indicated flow was made as a result of this comparison.

Level 1 criteria were met for all test conditions.

Certain Level 2 criteria were not met for the 4 inch level changes at all power levels. Dead Time, Equilibrium Range, pump flow response and control valve motion at steady state were all met for all test conditions. The remaining level 2 criteria were occasionally missed by a small margin at some test levels, except for settling time which was consistently not met. The responsible system engineer and the feedwater power ascension team evaluated the overall performance of the system following the collating of the test data. Although the Level 2 criteria noted were not all consistently met, it was determined that the response of the system was excellent and system tuning was optimized for steady state and transient response. Attempts to change the tuning of the system to meet the criteria noted would result in impacts on other criteria (i.e., peak overshoot and control valve oscillations). Station management accepted a recommendation to not change the tuning of the Digital Feedwater Control System, based on evaluation of system performance and resulting recommendations by the system engineer.

7.6 Test No. 30 – Vibration Measurements

The purpose of the test was to gather vibration measurements on the main steam and feedwater system piping, both inside and outside the primary containment, to evaluate the vibration stress effect due to the EPU.

During the post-outage and implementation of the EPU power ascensions, designated main steam and feedwater piping locations were monitored for vibration and assessments were made regarding piping vibration impacts of the EPU.

Test Conditions: **F, G**

Acceptance Criteria:

Level 1: NA

Level 2: Acceptance criteria were established based on governing piping codes and standards.

Results:

Criteria were established for evaluation of the vibration data collected at the power ascension plateaus. A total of 15 locations were monitored using remote sensors during the power ascension, with no locations approaching maximum allowable vibration. Evaluations determined that the resulting stress effect from the measured vibration was well within acceptance criteria. Four channels in the monitoring system failed during the testing. Engineering evaluated the loss of the data points and determined that sufficient channels remained to support adequate predicting of the associated pipe stresses. Accessible areas were monitored by Engineering personnel via remote camera observation and/or walk downs. Observed systems vibrations in these areas were noted to be acceptable.

8.0 System Performance Monitoring

During power ascension following the B115R1 refueling outage up to the licensed power level (2923 MWt), various parameters and equipment performance were monitored for proper operation. Included in this group were containment temperatures, Main Steam Isolation Valve (MSIV) pit temperature, main generator and supporting auxiliaries performance, main condenser performance (i.e., vacuum, condensate temperature), and balance-of-plant component cooling. All parameters and equipment performance responded consistently within projected ranges over the entire range of power operation.

9.0 Summary

The Brunswick Steam Electric Plant (BSEP), Unit 1 Extended Power Uprate (EPU) Implementation was completed on April 27, 2004. Appropriate equipment was tested and parameters monitored during the power ascension program. All specified Level 1 criteria were met for the testing associated with the test program. Level 2 criteria were met or, where previously noted, evaluated for impact on equipment operation. Test results were reviewed and reported to the Plant Nuclear Safety Committee. Based on the results of the testing and monitoring, recommendation was made that Unit 1 be operated at a licensed power level of 2923 MWt with the recommendation being adopted by station management.

10.0 Tables

Table 1
Glossary of Terms

APLHGR	Average Linear Heat Generation Rate
BSEP	Brunswick Steam Electric Plant
COLR	Core Operating Limits Report
EHC	Electro-hydraulic Control
EPU	Extended Power Uprate
LPU	Licensed Power Uprate
MCPR	Minimum Critical Power Ratio
MELLLA	Maximum Extended Load Line Limit Analysis
MSIVs	Main Steam Isolation Valves
MWt	Megawatts Thermal
NRC	Nuclear Regulatory Commission
PNSC	Plant Nuclear Safety Committee
PUSAR	Power Uprate Safety Analysis Report, NEDC-33039P
SPs	Special Procedures
UFSAR	Updated Final Safety Analysis Report

TABLE 2: TEST CONDITIONS							
Test	**A[1]**	**B**	**C**	**D**	**E**	**F**	**G**
Power Level MWt	**384 to 767**	**1754**	**2280**	**2558**	**2689**	**2806**	**2923**
Test No. 1							✓
Test No. 2							✓
Test No. 16						✓	✓
Test No. 19	✓	✓	✓	✓	✓	✓	
Test No. 20						✓	✓
Test No. 30						✓	✓

[1] First Stage Turbine Bypass data was collected at approximately 25 MWt intervals.