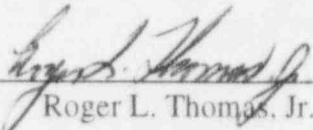


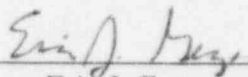
## BRUNSWICK UNIT 2, CYCLE 12 STARTUP REPORT

April 1996

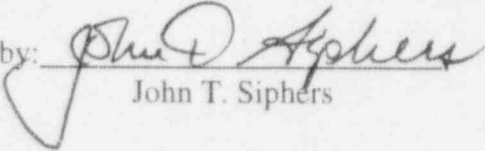
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## 1.0 Introduction

This report summarizes observed data from the initial Brunswick Unit 2, Cycle 12 (B2C12) startup tests. The Cycle 12 core employs the new GE13 fuel type, which among other design differences represents a change from an 8x8 to 9x9 fuel rod array.

Pursuant to the requirements of Section 6.9.1.1 of the Unit 2 Technical Specifications, a summary report of plant startup and power escalation testing shall be submitted to the NRC should any one of four conditions occur. Condition (3) applies: "...installation of fuel that has a different design or has been manufactured by a different fuel supplier." This report shall include results of startup tests following core reloading as described in the UFSAR.

## 2.0 UFSAR Section 14.4.1, Item 1: Core Loading Verification

A Core Loading Pattern Verification was performed per BNP Engineering Procedure ENP-24.13, "Core Verification." The core was verified to be loaded in accordance with the Recommended Full Core Loading Pattern.

## 3.0 UFSAR Section 14.4.1, Item 2: TIP Operability and Core Power Symmetry

### a. TIP Uncertainty

A TIP uncertainty determination was completed according to BNP Engineering Procedure PT 50.3, "Tip Reproducibility and Uncertainty Determination." The acceptance criteria for this test requires the TIP Total Noise Uncertainty to be  $\leq 7.10\%$ . The measured uncertainty was 1.72%, thus meeting the criteria.

### b. Core Power Symmetry

Core power symmetry is indirectly verified via the standard traversing in-core probe (TIP) uncertainty measurement performed per PT 50.3, described in Section 3.0.a.

Direct power symmetry measurement utilizing computed bundle powers is no longer performed at Brunswick with the improved POWERPLEX core monitoring system. POWERPLEX methodology does not require core symmetry. Therefore, the Core Power Symmetry Test was replaced by a more appropriate Predicted Versus Measured Bundle Power Test. The test results and acceptance criteria are provided in c. below.

### 3.0 UFSAR Section 14.4.1, Item 2: TIP Operability and Core Power Symmetry (cont...)

#### c. Predicted Versus Measured Bundle Powers

BNP Engineering procedure PT 50.0, "Reactor Engineering Refueling Outage Testing," was revised to replace the Core Power Symmetry Test ( $\pm 15\%$  symmetric bundle power agreement acceptance criteria) with a Predicted Versus Measured Bundle Powers test. This test compares the MICROBURN-B design code's calculation of predicted bundle powers to the plant process computer's measured bundle powers. The comparison must verify that the absolute difference between measured and predicted bundle powers meets the acceptance criteria of  $\leq 8.64\%$ . Bundles located in peripheral control cells or uncontrolled peripheral locations are excluded.

The acceptance criteria was met with the maximum absolute difference measured as 2.99%.

### 4.0 UFSAR Section 14.4.1, Item 3: Control Rod Mobility

Control rod mobility is verified by two tests: friction testing and scram timing. The results of these tests and their acceptance criteria are described below.

#### a. Friction Testing

Friction Testing was performed prior to startup per BNP Engineering Procedure PT 90.2, "Friction Testing of Control Rods." Control rods were verified to complete full travel without excessive binding or friction and the reactor was observed to remain subcritical during the withdrawal of each control rod.

#### b. Scram Time Testing

Scram Time Testing was performed for each control rod prior to exceeding 40% power per BNP Engineering Procedure PT 14.2.1, "Single Rod Scram Insertion Times Test." The acceptance criteria for this test are found in Technical Specifications 3.1.3.2, 3.1.3.3, and 3.1.3.4. The maximum 90% insertion time was measured as 2.898 seconds meeting the 7.0 seconds acceptance criteria of Technical Specification 3.1.3.2. Acceptance criteria for the Core Average Scram Insertion and Maximum Average 2x2 Scram Insertion times were also met as illustrated in Attachment 1.

The average 20% insertion time measured from the low power testing was 0.839 seconds, thus meeting the ODYN Option B time requirement of 0.861 seconds. ODYN Option B MCPR limits were therefore installed at BOC.

## 5.0 UFSAR Section 14.4.1, Item 4: Reactivity Testing

Reactivity Testing consists of a shutdown margin measurement, reactivity anomaly check, and measured critical  $K_{eff}$  comparison to predicted values. The results of these tests are provided below with the acceptance criteria.

### a. Shutdown Margin

Shutdown margin measurements were performed per BNP Engineering Procedure PT 14.3.1, "Insequence Critical Shutdown Margin Calculation." The initial BOC shutdown margin was measured as 1.958%  $\Delta k/k$  compared to a predicted value of 1.768%  $\Delta k/k$ , an absolute difference of 0.190%  $\Delta k/k$ . The acceptance criteria for minimum shutdown margin is defined in Technical Specification 3.1.1, which requires the shutdown margin be  $\geq 0.38\%$   $\Delta k/k$  for the entire cycle. To calculate the minimum shutdown margin for the cycle, the maximum predicted decrease in shutdown margin over the cycle relative to BOC, -0.655%  $\Delta k/k$ , was applied to the BOC measured shutdown margin. This resulted in an inferred minimum shutdown margin for Cycle 12 of 1.303%  $\Delta k/k$ . Therefore, the acceptance criteria is met.

### b. Cold Critical Eigenvalue ( $K_{eff}$ )

The cold critical  $K_{eff}$  was calculated by applying the 0.190%  $\Delta k/k$  reactivity difference between measured and predicted shutdown margin to the predicted  $K_{eff}$  of 1.00237. The cold critical  $K_{eff}$  is therefore 1.00427. Since the acceptance criteria requires predicted versus measured agreement within  $\pm 1\%$   $\Delta k/k$ , and the deviation was measured at 0.190%  $\Delta k/k$ , the acceptance criteria is met.

### c. Reactivity Anomaly

A reactivity anomaly test was performed at rated conditions per BNP Engineering Procedure PT 14.5.2, "Reactivity Anomaly Check." The acceptance criteria is defined by Technical Specification 3.1.2 which requires the difference between actual and predicted control rod density (CRD) not exceed 1%  $\Delta k/k$ . The measured and predicted values for CRD were 0.038 and 0.029, respectively, an absolute difference of 0.009. Since for Cycle 12 1%  $\Delta k/k$  is equivalent to 0.027 CRD, the acceptance criteria is met.

## 6.0 Additional Testing Results

Additional key testing and checks beyond those specified in the UFSAR are performed during initial startup and power ascension. The results are provided below.

### a. Core Monitoring Software Comparisons to Design Code

Thermal limits calculated by the online POWERPLEX Core Monitoring Software System were compared to those calculated by the MICROBURN-B design code at medium and high power levels. The results of these comparisons and the POWERPLEX statepoints are provided as Attachment 2. The acceptance criteria specified in PT 50.0 require the two codes' thermal limits agree within 0.15 for medium power testing and 0.10 for high power testing. The acceptance criteria were met.

### b. Hot Full Power Eigenvalue

After establishing a sustained period of full power equilibrium operation the design and core follow Hot Full Power Eigenvalues ( $K_{eff}$ ) are compared. At 267 MWD/MT the core follow  $K_{eff}$  was calculated as 1.00393 and the design  $K_{eff}$  is 1.00470. The difference between the core follow and design values is -0.077%  $\Delta k/k$  of reactivity which is well within  $\pm 1\%$   $\Delta k/k$  reactivity anomaly requirements.

## 7.0 Summary

Evaluation of the Brunswick Unit 2, Cycle 12 startup data concludes the core has been loaded properly, the behavior of the new GE13 fuel design can be accurately predicted, and the core is operating as expected. The startup and initial operating conditions and parameters compare well to predictions. Core thermal peaking design predictions and measured peaking comparisons met the startup acceptance criteria. The BOC shutdown margin demonstration indicates adequate shutdown margin will exist throughout B2C12. All prescribed and additional tests met their acceptance criteria.

## **Attachment 1 to the B2C12 Startup Report**

### **Results of Control Rod Scram Time Testing**

<b>Core Average Scram Insertion Time Technical Specification 3.1.3.3</b>			
<b>Insertion</b>	<b>Position/Notch</b>	<b>Tech Spec Limit (sec)</b>	<b>Average Measured Insertion Time (sec)</b>
5%	46	0.358	0.299
20%	36	1.096	0.839
50%	26	1.860	1.387
90%	6	3.419	2.582

<b>Maximum Average 2x2 Scram Insertion Time Technical Specification 3.1.3.4</b>			
<b>Insertion</b>	<b>Position/Notch</b>	<b>Tech Spec Limit (sec)</b>	<b>Average Measured Insertion Time (sec)</b>
5%	46	0.379	0.311
20%	36	1.162	0.879
50%	26	1.971	1.479
90%	6	3.624	2.767

## Attachment 2 to the B2C12 Startup Report

### Core Monitoring Software Comparisons to Design Code

<b>Medium Power Testing Plateau</b> <b>70.3% CMWT, 96MAR23 16:04:35, 49 MWD/MTU</b>				
Thermal Limit	POWERPLEX On-Line Monitoring	MICROBURN-B Design Code	Difference	Acceptance Criteria
MFLCPR	0.853	0.840	0.013	±0.15
MAPRAT	0.789	0.742	0.047	±0.15
MFLPD	0.562	0.572	-0.010	±0.15

<b>High Power Testing Plateau</b> <b>92.7% CMWT, 96MAR25, 02:02:40, 74 MWD/MTU</b>				
Thermal Limit	POWERPLEX On-Line Monitoring	MICROBURN-B Design Code	Difference	Acceptance Criteria
MFLCPR	0.796	0.807	-0.011	±0.10
MAPRAT	0.862	0.857	0.005	±0.10
MFLPD	0.772	0.729	0.043	±0.10

## Attachment 2 to the B2C12 Startup Report (cont...)

### Medium Power Testing Plateau Statepoint Report

BRUNSWICK-2 WK 9612 96MAR23-16.04.35 49 MWD/MTU TRIGR-OD1FIN REV-JAN96

CORE PERFORMANCE LOG -- SHORT EDIT  
TL00 BOC to EOC-2000 MWD/MT ODBN PDW DEP MCPR  
CALCULATION TYPE : NORMAL CONVERGENCE : TIGHT SYMMETRY : FULL  
CTP CALCULATION : HEAT BALANCE CYCLE : 12

STATE CONDITIONS	FLOW RATES	CORE PARAMETERS	NUCLEAR LIMITS	LOCATION
GMWE 568.44	WT 44.2	CMEQ 0.3023	P-PCS 0.18	27-20-15
CMWT 1711.8 (70.3%)	WTSUB 43.63	CAEQ 0.1605	FCBR 1.729	
FR 870.5 PSTA	WTFLAG 2	CACA 0.1024	CMPE 2.337	31-26-15
DHS 26.81	WFW 6.99	CAVF 0.4494	CMFLCPR 0.853	29-24
WT 44.23 (57.4%)	WD 18.87	CAPD 34.5448	P=1.512 F=1.360	
CRO 0.091		RWL 187.1539	CMAPRAT 0.789	33-26-15
CYCEXP 49 MWD/MTU	ERATIO 0.93	CDLP 7.5057	P=0.845 F=0.846	
MEASURED/CALCULATED	LPRM READINGS	DPCC 12.4093	CMFLPD 0.562	09-20-10
AVG: 6.18% MAX: 14.60%		KEFF 0.9979	CMFLEX 0.813	49-16-09

LOCATION	1	2	3	4	5	6	7	8	9	10	11	12
AXIAL REL POWER	0.49	1.05	1.14	1.14	1.23	1.27	1.27	1.22	1.11	0.93	0.75	0.42
REGION REL POWER	0.89	1.02	0.87	1.03	1.28	1.03	0.87	1.02	0.88			
RING REL POWER	1.34	1.35	1.24	1.17	1.09	1.04	0.68					
APRM GAFS	0.99	0.99	0.98	1.00	0.96	0.96						

#### \*\*\*\*\* NUCLEAR LIMITS BY REGION \*\*\*\*\*

7	8	9
0.715 15-38	0.777 29-38	0.719 37-38
0.530 17-44-10	0.552 33-44-10	0.530 43-36-10
0.699 17-42-11	0.761 29-36-15	0.697 41-36-11

4	5	6	*****
0.775 15-30	0.853 29-24	0.781 37-30	* MFLCPR *
0.562 09-20-10	0.529 33-26-15	0.552 43-20-11	* MFLPD *
0.765 17-26-15	0.789 33-26-15	0.770 35-26-15	* MAPRAT *

1	2	3
0.717 15-16	0.791 29-16	0.718 37-16
0.543 09-18-10	0.558 19-10-10	0.534 43-18-10
0.712 11-18-11	0.768 27-18-15	0.704 41-18-11

#### \*\*\*\*\* CONTROL ROD DATA \*\*\*\*\*

	02	06	10	14	18	22	26	30	34	38	42	46	50
51													51
47													47
43					32		04		32				43
39													39
35			32		00		24		00		32		35
31													31
27			04		24		40		24		04		27
23													23
19			32		00		24		00		32		19
15													15
11					32		04		32				11
07													07
03													03

## Attachment 2 to the B2C12 Startup Report (cont...)

### High Power Testing Plateau Statepoint Report

BRUNSWICK-2 WK-9613 96MAR25-02.02.40 75 MWD/MTU TRIGR=XE30 REV=JAN96

CORE PERFORMANCE LOG - SHORT EDIT  
TLOD BOC to EOC-2000 MWD/MT OBYNB POW DEP MCPR  
CALCULATION TYPE : XENON-FULL CONVERGENCE : TIGHT SYMMETRY : FULL  
CTP CALCULATION : HEAT BALANCE CYCLE : 12

STATE CONDITIONS	FLOW RATES	CORE PARAMETERS	NUCLEAR LIMITS	LOCATION
GMWE 755.72	WT 80.3	CMEQ 0.2182	P-PCS 0.73	19-26-11
CMWT 2257.8 (92.7%)	WTSUB 82.81	CAEQ 0.1211	FCBB 2.142	
PR 1007.1 PSIA	WTFLAG 2	CAQA 0.1350	CMFF 2.326	17-40-05
DHS 17.29	WFW 9.56	CAVF 0.4089	CMFLCPR 0.796	23-24
WT 80.33(104.3%)	WD 36.10	CARD 45.5626	P=1.398 F=1.200	
CRD 0.068		RWL 186.5443	CMAPRAT 0.862	19-26-11
CYCEXP 74 MWD/MTU	ERATIO 0.93	CDLP 24.9039	P=0.962 F=1.000	
MEASURED/CALCULATED	LPRM READINGS	DPCC 30.5175	CMFLPD 0.772	09-18-05
AVG: 3.67% MAX: 15.15%	KEFF 1.0032	CMFLEX 0.813		49-16-09

LOCATION	1	2	3	4	5	6	7	8	9	10	11	12
AXIAL REL POWER	0.49	1.14	1.29	1.27	1.26	1.23	1.16	1.09	1.02	0.90	0.74	0.41
REGION REL POWER	0.88	1.03	0.85	1.05	1.27	1.04	0.86	1.04	0.87			
RING REL POWER	1.35	1.33	1.25	1.17	1.13	1.04	0.65					
APRM GAFS	0.99	0.99	0.99	0.99	0.98	0.98						

#### \*\*\*\*\* NUCLEAR LIMITS BY REGION \*\*\*\*\*

7	8	9	
0.681 17-40	0.750 29-38	0.682 37-38	
0.749 17-44-05	0.752 33-44-05	0.750 43-36-05	
0.826 11-36-06	0.850 25-36-11	0.824 41-36-06	
4	5	6	*****
0.753 15-30	0.796 23-24	0.752 37-30	* MFLCPR *
0.767 09-20-05	0.653 31-26-11	0.748 43-34-05	* MFLPD *
0.858 17-26-11	0.862 19-26-11	0.855 35-26-11	* MAPRAT *
1	2	3	*****
0.682 17-14	0.746 23-16	0.675 39-18	
0.772 09-18-05	0.759 19-10-05	0.736 43-18-05	
0.848 11-18-05	0.851 27-18-11	0.814 41-18-06	

#### \*\*\*\*\* CONTROL ROD DATA \*\*\*\*\*

02	06	10	14	18	22	26	30	34	38	42	46	50
51												51
47												47
43				42		12		42				43
39												39
35			42		00		32		00		42	35
31												31
27			12		32			32		12		27
23												23
19			42		00		32		00		42	19
15												15
11				42		12		42				11
07												07
03												03
02	06	10	14	18	22	26	30	34	38	42	46	50

ENCLOSURE 2

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2  
NRC DOCKET NO. 50-324  
OPERATING LICENSE NO. DPR-62  
BRUNSWICK UNIT 2, CYCLE 12 STARTUP REPORT

LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Carolina Power & Light Company in this document. Any other actions discussed in the submittal represent intended or planned actions by Carolina Power & Light Company. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the Manager-Regulatory Affairs at the Brunswick Nuclear Plant of any questions regarding this document or any associated regulatory commitments.

Commitment	Committed date or outage
1. Incorporate the changes resulting from these Unit 2 Cycle 12 start-up tests into Sections 14.4.1 and 14.4.2.2 of the Updated FSAR.	The next scheduled revision to the Updated FSAR, (Currently 5/97)