BRUNSWICK UNIT 2, CYCLE 12
STARTUP REPORT

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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 (±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 ≤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 Scam 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% Δk/k compared to a predicted value of 1.768% Δk/k, an absolute difference of 0.190% Δk/k. The acceptance criteria for minimum shutdown margin is defined in Technical Specification 3.1.1, which requires the shutdown margin be ≥ 0.38% Δk/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% Δk/k, was applied to the BOC measured shutdown margin. This resulted in an inferred minimum shutdown margin for Cycle 12 of 1.303% Δk/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% Δk/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 ±1% Δk/k, and the deviation was measured at 0.190% Δk/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% Δk/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% Δk/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

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

Maximum Average 2x2 Scram Insertion Time Technical Specification 3.1.3.4			
Insertion	**Position/Notch**	**Tech Spec Limit (sec)**	**Average Measured Insertion Time (sec)**
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

Medium Power Testing Plateau 70.3% CMWT, 96MAR23 16:04:35, 49 MWD/MTU				
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

High Power Testing Plateau 92.7% CMWT, 96MAR25, 02:02:40, 74 MWD/MTU				
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

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

                     CORE PERFORMANCE LOG -- SHORT EDIT
        TLOO  BOC to EOC-2000 MWD/MT ODYNB POW 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   FCBB       1.729
 PR     970.5 PSIA     WTFLAG      2  CAQA   0.1024   CMPF       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
 CRD    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  0.48 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  25-36-15   |  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      |  0.781   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
       02  06  10  14  18  22  26  30  34  38  42  46  50
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Attachment 2 to the B2C12 Startup Report
(cont...)

High Power Testing Plateau Statepoint Report

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

                      CORE PERFORMANCE LOG -- SHORT EDIT
        TLOO  BOC to EOC-2000 MWD/MT ODYNB POW DEP MCPR
   CALCULATION TYPE : XENON-FOLL    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   CMPF       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  CAPD  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
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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)