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February 27, 2009

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555
Attention: Document Control Desk

Subject: Duke Energy Carolinas, LLC
Oconee Nuclear Station, Unit 2
Docket Number 50-270
Unit 2 Cycle 24 Startup Testing Report

Pursuant to the requirements in Section 16.13.9,"Startup Report," from the Selected Licensee Commitments Manual, Duke Energy-Corporation hereby submits to the Commission the Oconee Nuclear Station Unit 2 (ONS-2), Cycle 24 Startup Testing Report. The premise of the report is to provide the Staff with the satisfactory results from the ONS-2 cycle 24 startup tests which utilized the stations' initial loading of Mark B-HTP reload fuel. It is also planned to utilize this new fuel assembly design for future ONS-1 and ONS-3 reloads.

If you have any questions or require additional information, please contact Judy Smith, Oconee Regulatory Compliance Group, at (864) 885-4309.

This letter and its attachment do not contain any NRC commitments.

Sincerely,

Richard J. Freudenberger

for Dave Baxter
Vice President
Oconee Nuclear Station

Attachment

IE26
NRR

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DUKE POWER COMPANY

OCONEE NUCLEAR STATION

OCONEE 2 CYCLE 24

STARTUP TESTING REPORT

Part 1: Fuel Design

Part 2: Zero Power Physics Test

Part 3: Power Escalation Test

Prepared by: Ralph Williams III

OCONEE 2 CYCLE 24
Startup Testing Report
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Oconee 2 Cycle 24
STARTUP TESTING REPORT
Part 1: Fuel and Core Design

1.0 Summary

The Unit 2 Cycle 24 (O2C24) core consists of 177 fuel assemblies, each of which is a 15 by 15 array containing 208 fuel rods, 16 guide tubes and one incore instrument guide tube. The fuel consists of dished-end, cylindrical pellets of uranium dioxide. Both the reinserted fuel and fresh fuel are clad in M5 and have M5 guide tubes. The O2C24 fuel assemblies have an average nominal fuel loading of 490 kg uranium in the Mk B-HTP assemblies and 459 kg uranium in the Mk B11A assemblies.

The O2C24 core loading for this cycle consists of the following:

- 16 fresh Mk B-HTP fuel assemblies with 3.53 wt% U-235 each with 16 radial zoned reduced enrichment fuel pins at 3.23 wt% U-235 (designated Batch 26B).

- 52 fresh Mk B-HTP fuel assemblies with 3.33 wt% U-235 each with 16 radial zoned reduced enrichment fuel pins at 3.03 wt% U-235 (designated Batch 26A).

- 56 reinserted Mk B11A assemblies with 4.13 wt% U-235 each containing 16 radial zoned reduced enrichment fuel pins at 3.83 wt% U-235 (designated Batch 25)

- 53 reinserted Mk B11A assemblies with 4.24 wt% U-235 each containing 16 radial zoned reduced enrichment fuel pins at 3.94 wt% U-235 (designated Batch 24B)

Figure 1 shows the batch loading pattern. Figure 2 shows the assembly radial zoning pattern.

All assemblies have 6.05 inch blanket regions (top and bottom) enriched to 2.50 wt% U-235. The core periphery is composed of Batch 24B assemblies. Batch 26A and 26B assemblies are distributed throughout the core interior with Batches 24B and 25. The reinsert fuel is comprised of Mk B11A fuel. No fuel assemblies or burnable poison rods from the spent fuel pool are being used in O2C24.

Cycle 24 will operate in a rods-out, feed and bleed mode. Core reactivity control is supplied mainly by soluble boron and is supplemented by 61 full length Ag-In-Cd control rods and 52 burnable poison rod assemblies (BPRAs). In addition to the full length control rods, eight Inconel (gray) axial shaping rods (APSRs) are provided for additional control of the axial power distribution.

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Part 1: Fuel and Core Design

Oconee 2 Cycle 24 is the first Unit 2 batch with Mk B-HTP fuel. The Mk B-HTP design offers improvements in grid to rod fretting (GTRF) resistance. The Mark-B HTP fuel assembly has significant differences in the spacer grid design, lower end fitting debris filtering feature, and restraint system relative to previous Mark-B designs (including the Mk B11A design).

The Mark-B HTP fuel assembly utilizes a welded cage structure. This structure is formed by welding the M5 grids directly to the guide tubes and securing the Inconel lower end grid to the guide tubes with spacer capture rings above and below the grid. The 16 guide tube assemblies use M5 structural tubing that is cold-finished and recrystallized. The spacer grids utilize the HTP technology that produces line contacts with the fuel rods to provide improved resistance to fuel rod to spacer grid fretting. The top 7 spacer grids are M5 HTP spacers (including the upper end grid), while the lower end grid is an Inconel HMP spacer. The key dimensional difference between the HTP (High Thermal Performance) and HMP (High Mechanical Performance) spacer grids is the flow channel, which is bent for the HTP to promote flow mixing around the rod. The channel is straight for the HMP.

The main advantage of the Mark-B-HTP design, relative to the Mark-B11 design, is the better performance relative to grid-to-rod fretting induced cladding failure. This is mainly a result of the intermediate grid design, thicker cladding, and the welded cage construction. The larger diameter fuel rod of the Mark-B-HTP design also allows for a larger pellet, and therefore a higher UO2 loading. The main disadvantage of the Mark-B-HTP design, relative to the Mark-B11 design, is the absence of mixing vane grids. This results in a loss in DNB performance. The Mark-B-HTP design also has a higher overall pressure drop, which reduces flow in the Mark-B-HTP assemblies, in particular during a mixed core configuration.

The debris filtering lower-end-fitting utilizes brazed vanes which form a tortuous path that has been demonstrated to capture a wider variety of debris than previous designs.

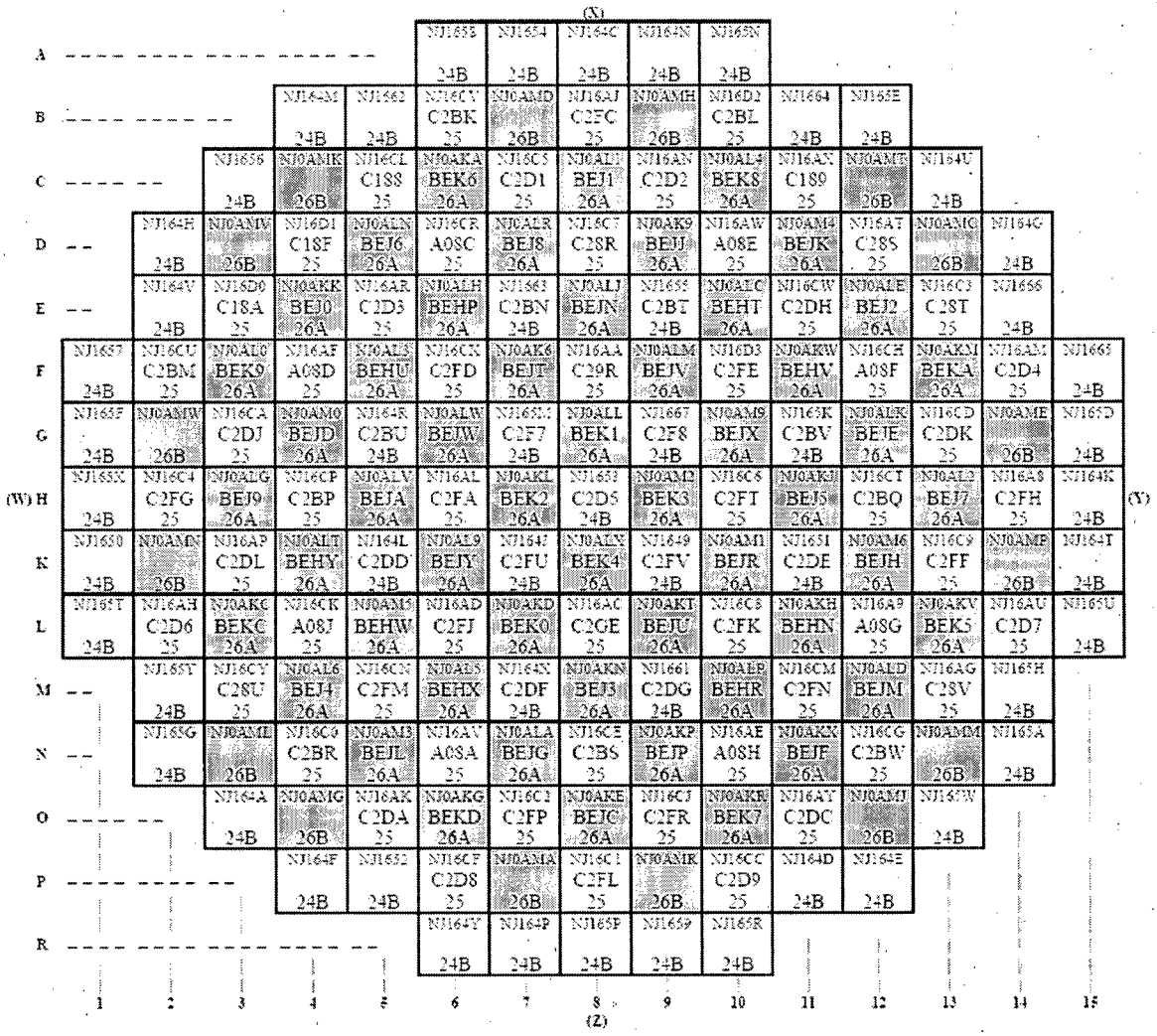
The M5 fuel rod and pellet diameters are larger than the current Mk B11A rod. The diameters are 0.430 (HTP) versus 0.416 (B11A) for the fuel rod and 0.3735" (HTP) versus 0.3615" (B11A) for the pellet. The M5 fuel rod has a stack length of 143.00 inches. The fuel rod cladding and end caps are M5 material. The fuel rods are lifted 0.120 inch, nominally, above the upper surface of the lower end fitting.

The upper end fitting (UEF) utilizes a reconstitutable, crimped top hat nut to connect the UEF to the guide tubes. The design has the same six-leaf cruciform holddown spring assembly currently used on the Mk B11A.

The Mk B-HTP design is planned for use in all three Oconee Units.

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Part 1: Fuel and Core Design

Figure 1: O2C24 Core Design



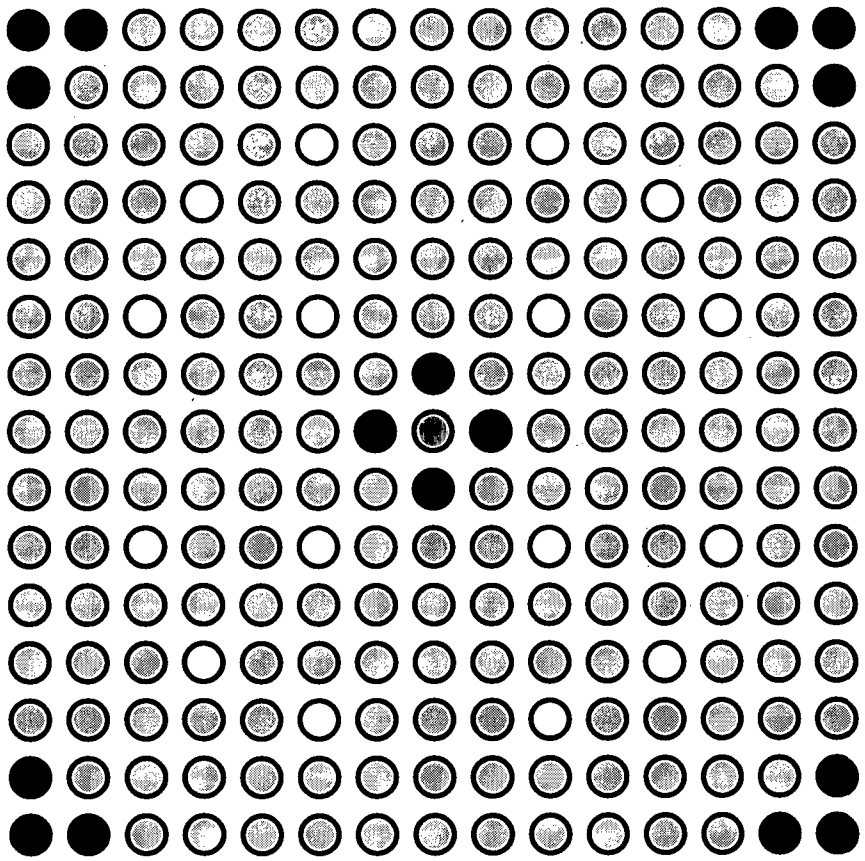
Fuel ID
Control Component ID & Type (A = APSR, B = BPRA**, C = CRA)
Fuel Batch

Notes: Batches 24B and 25 are Mk-B11A assemblies; Batches 26A and 26B are Mk-B-HTP assemblies

** All BPRAs are Mk-B5:
BEHN - BEHX = 2.30 BPRA,
BEHY, BEJ0 - BEJ9, and BEJA - BEJP = 1.70 BPRA,
BEJR - BEJY, and BEK0 = 1.40 BPRA,
BEK1 - BEK4 = 0.80 BPRA,
BEK5 - BEK9, and BEKA - BEKD = 0.50 BPRA.

Fresh fuel assemblies are shaded. All other fuel assemblies are from O2C23

Figure 2: Pin Map Showing Layout for Radial Zoned Fuel Assemblies



One (1) Centered Instrument Tube

Sixteen (16) Empty Guide Tubes

192 Fuel Pins at nominal enrichment

16 Fuel Pins at reduced enrichment

No fuel assemblies or burnable poison rods from the spent fuel pool are being used in O2C24.

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Part 2: Zero Power Physics Test

2.0 Introduction and Summary

The Oconee 2 Cycle 24 Zero Power Physics Test (ZPPT) was conducted from December 9 through 11, 2008 per station procedure PT/0/A/0711/001. This testing was conducted to verify the nuclear parameters upon which the Oconee 2 Cycle 24 core design, safety analysis and Technical Specifications are based.

Zero Power Physics Testing measurements were made with reactor power, Reactor Coolant System (RCS) pressure and RCS temperature as required by procedure. The following nuclear parameters were measured:

(a) All-Rods-Out Critical Boron Concentration (Enclosure 1.0)

(b) Differential Boron Worth (Enclosure 1.0)

(c) Integral Rod Worth for Control Rod Groups 6 and 7 (Enclosure 2.0)

(d) Temperature and Moderator Coefficients of Reactivity (Enclosure 3.0)

The AREVA Reactivity Measurement and Analysis System (RMAS) was used to record RCS temperature, intermediate range power levels and control rod positions. Reactivity was calculated by the RMAS computer.

On December 11, 2008 at 1600, ZPPT was declared complete. All acceptance criteria were met.

2.1 Approach to Criticality

The full RCS temperature and pressure necessary for unit startup were achieved and rod withdrawal for the Control Rod Drive Trip Time Test (CRDTTT) began at 1632 on December 9, 2008. The CRDTTT was performed at hot shutdown conditions (i.e., > 1% $\Delta k/k$ shutdown) per station procedure PT/0/A/0300/001. Each control rod group was individually withdrawn. The CRDTTT was satisfactorily completed at 2043 on December 10, 2008.

Rod withdrawal for approach to criticality began on December 11, 2008 at 0347. The estimated critical position was calculated to be Group 7 at 84% per station procedure PT/2/A/1103/015. Criticality was achieved at 0648 on December 11, 2008 with rod Groups 1-6 at 100% wd (withdrawn), Group 7 at 81.4% wd, Group 8 at 35% wd, an RCS average temperature of 532 ^{o}F, and an RCS boron concentration of 1793 ppmB.

2.2 Pre-Physics Measurements

After establishing stable conditions with the reactor critical, reactor power was slowly increased to perform the reactimeter checkout and approach the POAH. The point of adding sensible heat was found to be 0.1146% FP. From the sensible heat determination, the upper testing limit on the wide range NIs (as indicated on the Control Room Chart Recorder) was established for ZPPT.

An on-line OAC reactimeter checkout was performed for both a positive and negative power ramp. The positive ramp involved a reactivity change of ~360 μρ and the measured doubling times were within -1.84% of the calculated doubling times. The negative ramp involved a reactivity change of about -450 μρ and the measured doubling times were within 2.53% of the calculated doubling times. The measured doubling times were well within the ±5% acceptance criteria for the positive ramp and the ±7% acceptance criteria for the negative ramp.

2.3 Physics Testing

A. All Rods Out (ARO) Boron Concentration Measurement

The RCS ARO boron concentration was calculated starting from a configuration of Groups 1-6 at 100% wd, Group 7 at 80.9% wd, and APSR Group 8 at 35% wd. The control rods were moved to their all-rods-out position (Groups 1-7 at 100% wd, Group 8 at 35% wd) and the associated reactivity change was converted to a boron equivalent in ppmB. The All Rods Out Boron Concentration was then calculated and verified to be within procedure acceptance criteria. Refer to Enclosure 1.0 for more detailed results.

B. Reactivity Coefficient Measurements

The temperature coefficient measurement was made while maintaining equilibrium boron concentration in the RCS, with control rod Group 7 withdrawn to 81.3% wd and with APSR Group 8 at 35% wd. This test measured the reactivity change associated with a ramp increase in RCS temperature of approximately 4.82 °F and a subsequent decrease of 9.22 °F. The data from the two temperature ramps was averaged using the ΔT magnitudes as weighting factors. The change in reactivity was divided by the change in RCS temperature to calculate the temperature coefficient. The measured temperature coefficient was corrected for the difference in RCS average test temperature and reference temperature (532 °F). The moderator temperature coefficient was calculated by subtracting the predicted isothermal Doppler coefficient from the measured temperature coefficient. The isothermal and moderator temperature coefficient were verified to be within the procedure acceptance criteria. Refer to Enclosure 3.0 for more detailed results.

C. Control Rod Integral Worths and Differential Boron Worth Measurement

The worth of Group 7 from 80.9 to 100% wd was measured during the ARO test. The remaining worth of Group 7 and all of Group 6 was measured by steadily deborating the RCS and compensating for the resulting positive reactivity addition by inserting control rods from 81.5% wd on Group 7 to 0% wd on Group 6 (with no rod overlap). The reactivity changes resulting from the discrete control rod insertions were summed for each group to obtain the group integral rod worth. Each of the measured groups passed their individual acceptance criteria. Refer to Enclosure 2.0 for more detailed results.

The differential boron worth was calculated by dividing the rod worths of the measured groups inserted between the initial and final boron samples by the corresponding change in RCS boron concentration. The initial value for the boron concentration was recorded at ARO critical equilibrium conditions. The final value of boron concentration was recorded as reactivity approached steady-state. The measured differential boron worth met procedure acceptance criteria. Refer to Enclosure 1.0 for more detailed results.

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Part 3: Power Escalation Test

3.0 Introduction and Summary

The Oconee 2 Cycle 24 Power Escalation Test was performed between December 11, 2008 and December 16, 2008 per station procedure PT/0/A/0811/001. Testing was performed at 19% Full Power (FP), 73% FP and 100% FP to verify nuclear parameters upon which the Oconee 2 Cycle 24 core design, safety analysis and Technical Specifications are based. The following tests and verifications were performed:

(a) Initial Core Symmetry Check at 19% FP (Enclosure 7.0);

(b) NSSS Heat Balance at 19% FP, 73% FP, and 100% FP (Enclosure 4.0);

(c) Incore Detector Checkout at 19% FP, 40% FP, and 100%FP;

(d) Power Imbalance Detector Correlation Slope Measurement at 73% FP;

(e) Core Power Distribution at 19% FP, 40% FP, and 100% FP (Enclosures 5.0 through 5.3 and 6.0);

(f) All-Rods-Out Critical Boron Concentration at 100% FP (Enclosure 1.0).

The unit reached 19% FP at 0015 on December 12, 2008. Low power testing (LPT) was completed at 1000 on 12/12/08. The unit reached 73% FP at 1244 on 12/14/08. Testing at this intermediate plateau (Intermediate Power Testing, IMPT) was completed at 2012 on 12/14/08. The unit reached the Full Power Testing plateau on 12/15/08 at 0730. Full Power Testing (FPT), consisting of Incore Detector Checkout, Core Power Distribution, NSSS Heat Balance, All-Rods-Out Critical Boron, RCS Flow Calculation/Calibration, and update of the RPS RCS Reference Flow was performed at this plateau. FPT was concluded at 1540 on 12/16/08. Power Escalation Testing was declared complete on 12/16/08 at 1629.

3.1 NSSS Heat Balance/RCS Flow Verification

Off-line secondary heat balances were performed at 19% FP, 73% FP and 100% FP. An off-line primary heat balance was performed at 100% FP. These tests verified the accuracy of the on-line plant computer program which performs primary and secondary-side heat balances. The plant on-line computer accuracy was verified by performing an off-line calculation using the same inputs that feed the on-line computer. The on-line and off-line results were compared for the same period, and verified to agree within 2% FP. This same method was used to verify that RCS flow was greater than the required flow per the Core Operating Limits Report (COLR). Normalization of the plant computer RCS flow

constants (used to calculate flow from the primary delta-P instrumentation) was performed during FPT and the on-line power calculations were then verified to agree within 2% FP. Refer to Enclosure 4.0 for more detailed results.

3.2 Core Power Distribution

Core Power Distribution tests were conducted at 19% FP, 40% FP and at 100% FP. These tests verified that reactor power imbalance, quadrant power tilt and radial/total power peaks did not exceed their respective specified limits.

Specific checks were made as follows:

> Incore imbalance was compared to the error adjusted imbalance LOCA limit curve and was verified to be within specified limits (based on Core Operating Limits Report).
>
> The maximum positive quadrant power tilt was verified to be less than the error adjusted LOCA limit (based on Core Operating Limits Report).

Prior to performing the radial and total peaking factor comparisons, PT/0/A/0302/006 (Review and Control of Incore Instrumentation Signals) was performed to identify and evaluate erroneous Self Powered Neutron Detector signals. This test was performed as a prerequisite to core power distribution tests at 19% FP, 40% FP and 100% FP.

The radial and total peaking factors were measured and compared to the predicted values at 40% FP and 100% FP. All acceptance criteria were satisfied. Refer to Enclosures 5.0 - 5.3 along with Enclosure 6.0 for more detailed results. The results of the initial core symmetry check and evaluation can be found in Enclosure 7.0.

3.3 Power Imbalance Detector Correlation

The Power Imbalance Detector Correlation was performed at 73% FP. The purpose of this test was to measure the excore to incore power imbalance correlation slopes for NI Channels 5, 6, 7, and 8, and to verify these slopes met acceptance criteria.

The excore/incore imbalance correlation slope for each NI Channel (5-8) was determined by a least squares fit of excore to incore imbalance indications. A total of 19 incore imbalance points which ranged between –11.60% and + 2.29% FP were used. All the slopes were verified to meet acceptance criteria.

3.4 All Rods Out Critical Boron Measurement at Power

The All Rods Out Critical Boron at Power measurement was made at 100% FP, and the difference between measured and predicted reactivity (in terms of ppmB) was verified to be acceptable. Refer to Enclosure 1.0 for more detailed results.

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 1.0

ALL-RODS-OUT CRITICAL BORON CONCENTRATION
AND DIFFERENTIAL BORON WORTH RESULTS

	Zero Power ARO Critical Boron Concentration	**At-Power ARO Critical Boron Concentration**	**Differential Boron Worth**
CONDITIONS	Initial Critical 0 EFPD Gp 7 @ 80.9% wd Gp 8 @ 35% wd 1793 ppmB	100% FP 1.43 EFPD Gp 7 @ 87.6% wd Gp 8 @ 35% wd 1339 ppmB	**Initial Sate:** Gp 7 @ 81.5% wd Gp 8 @ 35% wd 1793 ppmB **Final State:** Gp 4 @ 100% wd Gp 5 @ 91.1% wd Gp 8 @ 35% wd 1561 ppmB
MEASURED VALUE	1807.4 ppmB	1287 ppmB	-0.00803 $\%^{\Delta k}/_{k\ ppmB}$
PREDICTED VALUE	1805 ppmB	1298 ppmB	-0.00776 $\%^{\Delta k}/_{k\ ppmB}$
DEVIATION	-2.4 ppmB	-11 ppmB	-3.30%*
ACCEPTANCE CRITERIA	Predicted ± 50 ppmB	Predicted ± 50 ppmB	±15% dev. from predicted

$$* \ \frac{(\text{Predicted} - \text{Measured}) * 100}{\text{Measured}}$$

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 2.0

INTEGRAL GROUP ROD WORTH MEASUREMENTS

PARAMETER	MEASURED VALUE (%Δk/k)	PREDICTED VALUE (%Δk/k)	DEVIATION* (%)	ACCEPTANCE CRITERION
Gp 7 Integral Worth	-1.049807	-1.0010	-4.6	± 15% Deviation
Gp 6 Integral Worth	-0.883705	-0.9060	2.5	± 15% Deviation
Gp 6&7 Integral Worth	-1.933511	-1.9070	-1.4	± 10% Deviation

* % Dev. = $\frac{\text{Predicted - Measured} * 100}{\text{Measured}}$

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 3.0

REACTIVITY COEFFICIENTS

PARAMETER	CONDITIONS	MEASURED VALUE	PREDICTED VALUE	DEVIATION (Meas-Pred)	ACCEPTANCE CRITERIA
Hot Zero Power Temperature Coefficient (ARO)	T_{ave}=533.1 F Gp 7 @ 81.3% wd Gp 8 @ 35% wd 1793 ppmB	+0.02191E-4 $\frac{\Delta k}{k\ ^{o}F}$	+0.04108E-4 $\frac{\Delta k}{k\ ^{o}F}$	-0.01917 E-4 $\frac{\Delta k}{k\ ^{o}F}$	Measured -Predicted = $\pm$0.2E-4 $\frac{\Delta k}{k\ ^{o}F}$
Hot Zero Power Moderator Temperature Coefficient (ARO)	T_{ave}=533.1 F Gp 7 @ 81.3% wd Gp 8 @ 35% wd 1793 ppmB	+0.18832E-4 $\frac{\Delta k}{k\ ^{o}F}$	+0.20749E-4 $\frac{\Delta k}{k\ ^{o}F}$	-0.01917E-4 $\frac{\Delta k}{k\ ^{o}F}$	Measured - Predicted = $\pm$0.2E-4 $\frac{\Delta k}{k\ ^{o}F}$ and Measured $\leq$+0.5E-4 $\frac{\Delta k}{k\ ^{o}F}$

NSSS HEAT BALANCE/RCS FLOW VERIFICATION

Test Plateau	Plant Computer Online Primary Power Level (%FP)	Plant Computer Online Sec. Power Level (%FP)	Offline[1] Calculated Primary Power Level	Offline[1] Calculated Secondary Power Level	RCS Flow [1, 2] (%DF)
LPT	18.96	19.40	18.91	19.33	115.17
IMPT	72.47	72.61	72.57	72.53	114.27
FPT	100.02	100.0	100.17	99.91	113.02

[1]Calculated by the online plant computer
[2]Required to be > Core Operating Limit Report RCS flow of 108.5 % Design Flow (DF)

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 5.0

RADIAL PEAKING FACTORS AT IMPT

	8	9	10	11	12	13	14	15
H	1,1,Gp4 0.95 0.95 0.0%	2,2 1.30 1.24 4.5%	3,4,Gp3 1.38 1.39 -0.4%	4,10 1.26 1.21 4.3%	5,14,Gp7 1.13 1.15 -1.7%	6,21 1.26 1.26 0.2%	7,30,Gp6 0.99 1.01 -2.1%	8,37 0.32 0.33 -1.5%
K		9,3,Gp3 1.06 1.04 2.0%	10,6+8 1.32 1.27 4.6%	11,Inner,Gp1 1.10 1.10 -0.2%	12,15+20 1.29 1.26 3.0%	13,22+29,Gp 5 1.30 1.34 -2.5%	14,31+36 1.17 1.16 1.3%	15,45 0.32 0.33 -3.2%
L			16,12,Gp6 1.34 1.28 4.5%	17,17+18 1.30 1.24 4.5%	18,24+27,Gp 8 1.31 1.35 -2.5%	19,Outer 1.33 1.32 1.1%	20,38+44,Gp 4 0.82 0.84 -2.4%	21,46 0.22 0.22 1.1%
M				22,26,Gp5 1.33 1.35 -1.6%	23,33+34 1.29 1.25 3.3%	24,40+42,Gp 2 1.13 1.15 -2.0%	25,49 0.48 0.49 -2.5%	
N					26,41,Gp7 1.06 1.12 -5.1%	27,48 0.97 1.05 -7.8%	28,51 0.26 0.28 -8.3%	
O						29,52 0.35 0.38 -8.6%		

Predicted
Measured
% Dev

$$\% \text{ Dev.} = \frac{\text{Predicted - Measured} * 100}{\text{Measured}}$$

Core Conditions

Power	40.55 %FP
Group 5	100% wd
Group 6	100%wd
Group 7	46.4% wd
Group 8	35% wd
Imbalance	-6.80
RCS Boron	1492 ppmB

Max 1/8 Core % Deviation is 4.6 % at K10	Acceptance criteria: + 15% of Predicted
Min 1/8 Core % Deviation is–8.6% at O13	Acceptance criteria: - 15% of Predicted
Max Peak Deviation is 0.4%	Acceptance Criteria: <+5%
Root Mean Square of Deviations is 3.5%	Acceptance Criteria: <+7.5%

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 5.1

TOTAL PEAKING FACTORS AT IMPT

	8	9	10	11	12	13	14	15
H	1,1,Gp4 1.20 1.17 3.0%	2,2 1.69 1.56 8.4%	3,4,Gp3 1.84 1.86 -0.9%	4,10 1.79 1.69 6.1%	5,14,Gp7 1.89 1.90 -0.6%	6,21 1.85 1.84 0.4%	7,30,Gp6 1.38 1.39 -0.6%	8,37 0.44 0.44 0.0%
K		9,3,Gp3 1.37 1.33 2.6%	10,6+8 1.77 1.63 8.6%	11,Inner,Gp1 1.51 1.49 1.5%	12,15+20 1.88 1.82 3.7%	13,22+29,Gp 5 1.85 1.92 -3.3%	14,31+36 1.66 1.64 1.4%	15,45 0.43 0.44 -1.8%
L			16,12,Gp6 1.80 1.74 3.3%	17,17+18 1.80 1.70 6.0%	18,24+27,Gp 8 1.88 1.95 -3.6%	19,Outer 1.90 1.89 0.9%	20,38+44,Gp 4 1.15 1.17 -1.9%	21,46 0.30 0.29 3.6%
M				22,26,Gp5 1.89 1.90 -0.6%	23,33+34 1.92 1.86 3.7%	24,40+42,Gp 2 1.66 1.70 -2.6%	25,49 0.68 0.69 -1.9%	
N					26,41,Gp7 1.85 1.95 -5.1%	27,48 1.52 1.47 3.3%	28,51 0.38 0.40 -6.2%	
O						29,52 0.54 0.60 -10.3%		

Predicted
Measured
% Dev

% Dev. = Predicted - Measured * 100
Measured

Core Conditions

Power	40.55 %FP
Group 5	100% wd
Group 6	100%wd
Group 7	46.4% wd
Group 8	35% wd
Imbalance	-6.80
RCS Boron	1492 ppmB

Max 1/8 Core % Deviation is 8.6 % at K10	Acceptance criteria: + 20% of Predicted
Min 1/8 Core % Deviation is -10.3 % at O13	Acceptance criteria: - 20% of Predicted
Maximum Peak Deviation is 1.4%	Acceptance Criteria: <+7.5%

Oconee 2 Cycle 24
STARTUP TESTING REPORT
Enclosure 5.2

RADIAL PEAKING FACTORS AT FPT

	8	9	10	11	12	13	14	15
H	1,1,Gp4 0.89 0.90 -0.9%	2,2 1.20 1.16 3.7%	3,4,Gp3 1.31 1.33 -1.5%	4,10 1.26 1.21 4.0%	5,14,Gp7 1.32 1.32 -0.4%	6,21 1.28 1.27 0.6%	7,30,Gp6 0.98 1.00 -2.2%	8,37 0.33 0.34 -3.5%
K		9,3,Gp3 1.00 1.00 0.0%	10,6+8 1.25 1.21 3.5%	11,Inner,Gp1 1.09 1.10 -0.8%	12,15+20 1.30 1.27 2.8%	13,22+29,Gp 5 1.29 1.32 -2.0%	14,31+36 1.15 1.13 1.8%	15,45 0.32 0.33 -2.7%
L			16,12,Gp6 1.27 1.23 3.6%	17,17+18 1.25 1.21 3.7%	18,24+27,Gp 8 1.28 1.31 -1.8%	19,Outer 1.30 1.28 1.3%	20,38+44,Gp 4 0.81 0.84 -3.3%	21,46 0.22 0.23 -2.6%
M				22,26,Gp5 1.32 1.34 -1.7%	23,33+34 1.31 1.28 2.3%	24,40+42,Gp 2 1.15 1.18 -2.5%	25,49 0.49 0.52 -5.6%	
N					26,41,Gp7 1.27 1.32 -4.2%	27,48 1.04 1.03 1.4%	28,51 0.28 0.30 -7.7%	
O						29,52 0.39 0.43 -9.8%		

Predicted
Measured
%Dev

% Dev. = $\frac{\text{Predicted - Measured * 100}}{\text{Measured}}$

Core Conditions

Power	100 %FP
Group 5	100% wd
Group 6	100%wd
Group 7	91.8% wd
Group 8	35% wd
Imbalance	2.98
RCS Boron	1298 ppmB
Max 1/8 Core % Deviation is 4.0 % at H11	Acceptance criteria: + 15% of Predicted
Min 1/8 Core % Deviation is –9.8% at O13	Acceptance criteria: - 15% of Predicted
Max peak Deviation is 1.7%	Acceptance Criteria: <+5%
Root Mean Square of Deviations is 3.0%	Acceptance Criteria: <+7.5%

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TOTAL PEAKING FACTORS AT FPT

	8	9	10	11	12	13	14	15
H	1,1,Gp4 1.07 1.09 -1.7%	2,2 1.46 1.42 2.7%	3,4,Gp3 1.58 1.56 1.4%	4,10 1.52 1.42 7.3%	5,14,Gp7 1.61 1.59 1.3%	6,21 1.56 1.52 2.8%	7,30,Gp6 1.20 1.19 0.7%	8,37 0.40 0.41 -3.4%
K		9,3,Gp3 1.20 1.18 1.4%	10,6+8 1.51 1.45 4.3%	11,Inner,Gp1 1.30 1.28 1.7%	12,15+20 1.57 1.50 4.9%	13,22+29,Gp 5 1.58 1.55 1.6%	14,31+36 1.42 1.40 1.9%	15,45 0.39 0.41 -4.4%
L			16,12,Gp6 1.53 1.44 6.5%	17,17+18 1.49 1.42 5.1%	18,24+27,Gp 8 1.55 1.57 -1.5%	19,Outer 1.57 1.54 2.3%	20,38+44,Gp 4 0.99 0.99 0.1%	21,46 0.27 0.27 0.0%
M				22,26,Gp5 1.58 1.55 1.6%	23,33+34 1.58 1.52 4.2%	24,40+42,Gp 2 1.39 1.39 0.0%	25,49 0.59 0.62 -4.5%	
N					26,41,Gp7 1.55 1.60 -3.1%	27,48 1.29 1.27 1.2%	28,51 0.33 0.36 -7.5%	
O						29,52 0.47 0.51 -7.3%		

Predicted
Measured
%Dev

% Dev. = Predicted - Measured * 100 / Measured

Core Conditions

Power	100 %FP
Group 5	100% wd
Group 6	100%wd
Group 7	91.8% wd
Group 8	35% wd
Imbalance	2.98
RCS Boron	1298 ppmB

Max 1/8 Core % Deviation is 7.3 % at H11	Acceptance criteria: + 20% of Predicted
Min 1/8 Core % Deviation is –7.5 % at N14	Acceptance criteria: - 20% of Predicted
Max Peak Deviation is –0.60%	Acceptance Criteria: <+7.5%

CORE POWER DISTRIBUTION DATA SUMMARY AT

IMPT AND FPT PLATEAUS

Power Level (% FP)	40.55	100
Group 7/8 Positions (% wd)	46.4/35	92/35
RCS Boron Concentration (ppmB)	1492	1298
Incore Imbalance (% FP)	-6.80	2.98

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Core Symmetry Results at LPT

% Deviation= Highest-Lowest/AVG * 100%

Detector Number	Assembly Power	% Dev	Detector Number	Assembly Power	% Dev
6	3.88		24	3.81	
8	3.90		27	3.78	
AVG	3.89	0.51	AVG	3.80	0.79
5	3.28		23	3.97	
7	3.21		28	3.83	
9	3.19		32	3.66	
11	3.16		35	3.65	
13	3.19		39	3.76	
16	3.19		43	3.64	
19	3.18		47	3.62	
25	3.25		50	3.60	
AVG	3.21	3.74	AVG	3.72	9.96
			44	2.37	
			38	2.37	
			AVG	2.37	0.00
15	3.46		33	3.23	
20	3.47		34	3.34	
AVG	3.47	0.29	AVG	3.29	3.35
29	3.75		42	3.08	
22	3.78		40	3.12	
AVG	3.77	0.80	AVG	3.10	1.29
31	3.28				
36	3.28				
AVG	3.28	0.00			
17	3.56				
18	3.62				
AVG	3.59	1.67			

The following analyses were performed by the General Office Nuclear Design personnel due to the failure to meet the review criteria of core symmetry tests at the low power and intermediate power plateaus by the outer symmetric ring of detectors. Each unit at Oconee is designed with an incore detector system with nominally 52 incore detectors in service. Of these 52 detectors, there are 9 symmetric pairs, and an inner and outer symmetric ring of detectors, each consisting of eight incore detectors. The General Office (GO) evaluation concluded in both cases that increasing power would result in an improvement in incore tilts and asymmetry, and recommended increasing power. As was predicted, the incore tilts and asymmetry did improve with the additional time and power escalation.

Low Power Testing Symmetry GO Analysis

During the performance of the Oconee 2 Cycle 24 (O2C24) low power test (LPT) plateau core symmetry test, the outer symmetric ring of incore detectors passed the 10% acceptance criteria, but failed the 8% review criteria dictated by the ONS work process manual. The failure was primarily due to quadrant power tilts as follows (data from December 12, 2008 at 0200 hours):

WX -1.1
XY +3.4
YZ -1.7
ZW -0.6

The large low power tilts likely produced and exacerbated the observed asymmetry.

Due to failing the referenced review criteria, an evaluation was performed. The justifications made during this evaluation are shown below:

- Past experience (including O1C20, O2C19, O3C20, O3C21, O3C22, O1C24, O2C23, and O1C25) have indicated excessive tilts and asymmetries at low powers. While a definite cause has not been found, it has been seen that the excessive tilts and asymmetries improved drastically as power escalation continued.
- During the LPT, Group 6 was inserted to approximately 92% WD. Past experience has indicated that the symmetry results and excessive tilts improve when Gp 6 is fully withdrawn. Likewise, experience also indicated that tilts improve with power escalation and initial cycle exposure.
- The measured and predicted LPT core power distributions were reasonable and comparable to past cycles considering the low power level (19% FP).
- The measured power distributions indicated no severe localized power peaks. Thus it is unlikely that there is a mis-loaded assembly, mis-aligned control rod, or a gross error in fuel/BPRA manufacturing.
- During the time interval at the LPT power level, the tilts and core asymmetry steadily decreased. It is expected that this behavior will continue with power escalation and initial cycle exposure.

Recommendation

The ONS nuclear design personnel recommended that power escalation be continued and that further power escalation would improve the symmetry test results similar to past Oconee cycles. The power escalation was continued and symmetry was monitored by ONS nuclear design personnel.

IMPT Symmetry GO Analysis

Upon reaching the IMPT plateau, it is noted that the outer symmetrics (8.5% deviation) still did not meet the 8% review criteria, however they do pass the 10% acceptance criteria.

As with the LPT plateau, the asymmetry is being driven by incore tilts. The incore tilts and the asymmetry have improved since the LPT. It is reasonable that these will improve even more with additional time and further escalation of power.

The review of the O2C24 BOC LPT symmetry test concluded that it is unlikely that the cause of the LPT asymmetry was a mis-loaded assembly, mis-aligned control rod, or a gross error in fuel/BPRA manufacturing problem. ONS Design's surveillance during power escalation has not changed that conclusion.

All procedural criteria (from PT/0/A/0811/001) for the IMPT CPD were met.

Recommendation

The ONS nuclear design personnel recommended that power escalation be continued based on the above discussion and on the IMPT CPD results. The power escalation was continued and tilts improved.