DUKE POWER COMPANY
OCONEE NUCLEAR STATION

UNIT 2, CYCLE 5
STARTUP TESTING SUMMARY

OCTOBER 1980

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I. INTRODUCTION

The Startup Test Program for Oconee Unit 2, Cycle 5 consisted of pre-critical tests, zero power physics tests, and power escalation tests. This report provides a summary of the zero power and power escalation test results and includes, where appropriate, comparisons of measured and predicted values of important core parameters. The test methodology and acceptance criteria used in the Oconee Unit 2, Cycle 5 Startup Test Program are in accordance with the "Oconee Nuclear Station Generic Startup Physics Test Program", submitted to the staff on July 11, 1980.

Pre-critical testing for Oconee Unit 2, Cycle 5 involved measurement of the control rod drop times. All rods were verified to fall to 75% insertion within 1.40 seconds after release.

The zero power physics testing was initiated on June 21, 1980, and was completed on June 23, 1980. Testing was conducted with the reactor at Hot Zero Power conditions (532^{o}F, 2155 psig, and 0% FP). The core parameters measured included all-rods-out critical boron concentration, isothermal temperature and moderator coefficients of reactivity, individual control rod groups and total group reactivity worths, core symmetry/ejected rod worth measurements, and differential boron worth measurements. The results are described in Section II.

Following satisfactory completion of zero power physics testing, the power escalation testing began on June 24, 1980 and was completed on July 9, 1980. The power escalation tests included core power distribution measurements at approximately 40% FP, 75% FP and 100% FP, and measurements of reactivity coefficients at power. Section III summarizes the results of these tests.

II. ZERO POWER PHYSICS TESTING (ZPPT)

The approach to initial criticality of Cycle 5 commenced on June 21, 1980, with the reactor at hot shutdown conditions. (532^{o}F, 2155 psig). The control rods were withdrawn from the core and a continuous, regulated deboration of the Reactor Coolant System (RCS) was started. During the deboration, the reactor's neutron population changes were monitored with an inverse multiplication plot. Initial criticality was achieved at 1125 hours on June 21, 1980, with Control Rod Group 7 at 85% withdrawn, Group 8 at 37.5% withdrawn, and an RCS boron concentration of 1492 ppm.

Reactor power was stabilized and held at zero power while a series of physics tests were performed. These tests and their results are given in Table 1. All acceptance criteria were satisfactorily met.

III. POWER ESCALATION TESTING (PET)

Power escalation of Oconee 2, Cycle 5 started on June 24, 1980. Testing of the reactor was performed at test plateaus of 40%, 75%, and 100% full power. On July 9, 1980, with all testing, data reduction, and analyses completed and all test results verified as acceptable for all test plateaus, the Oconee 2 Cycle 5 Power Escalation Test was declared complete.

The results of the testing performed at the various test plateaus are given in Tables 2 and 3 and in Figures 1 through 6. All acceptance criteria were satisfactorily met.

TABLE 1
OCONEE 2 CYCLE 5 ZPPT RESULTS

PARAMETER MEASURED	RELEVANT REACTOR CONDITIONS	MEASURED VALUE	PREDICTED VALUE	DEVIATION*	MAX. ACCEPTABLE DEVIATION
All Rods Out Boron Conc.	CRA Gp 7 @ 99% WD Gp 8 @ 37.5% WD	1447	1430	17 ppm	±50 ppm
Temperature Coefficient 1	CRA Gp 5 @ 7% WD 1075 ppm Boron	-7.80×10^{-5} ΔK/K per °F	-8.33×10^{-5} ΔK/K per °F	-0.53×10^{-5} ΔK/K per °F	$\pm 3.0 \times 10^{-5}$ ΔK/K per °F
Moderator Coefficient 1	CRA Gp 5 @ 7% WD 1075 ppm Boron	-5.80×10^{-5} ΔK/K per °F	-6.33×10^{-5} ΔK/K per °F	-0.53×10^{-5} ΔK/K per °F	$\pm 3.0 \times 10^{-5}$ ΔK/K per °F
Temperature Coefficient 2	CRA Gp 7 @ 70% WD 1444 ppm Boron	-0.16×10^{-5} ΔK/K per °F	-1.26×10^{-5} ΔK/K	-1.10×10^{-5} ΔK/K per °F	$\pm 3.0 \times 10^{-5}$ ΔK/K per °F
Moderator Coefficient 2	CRA Gp 7 @ 70% WD 1444 ppm Boron	$+1.84 \times 10^{-5}$ ΔK/K per °F	$+0.74 \times 10^{-5}$ ΔK/K per °F	-1.10×10^{-5} ΔK/K per °F	$\pm 3.0 \times 10^{-5}$ ΔK/K per °F
CRA Gp 5 Integral Worth	N/A	-1.366 %ΔK/K	-1.56 %ΔK/K	+14.2%	±15%
CRA Gp 6 Integral Worth	N/A	-0.8825 %ΔK/K	-0.83 %ΔK/K	-5.95%	±15%
CRA Gp 7 Integral Worth	N/A	-1.523 %ΔK/K	-1.50 %ΔK/K	-1.51%	±15%
Total Worth of Groups 5,6, & 7	N/A	-3.772 %ΔK/K	-3.89 %ΔK/K	+3.13%	±10%

TABLE 1 (Cont'd)
OCONEE 2 CYCLE 5 ZPPT RESULTS

PARAMETER MEASURED	RELEVANT REACTOR CONDITIONS	MEASURED VALUE	PREDICTED VALUE	DEVIATION*	MAX. ACCEPTABLE DEVIATION
Differential Boron Worth	1261 ppm Average	-0.983%ΔK/K per 100 ppm	-0.920%ΔK/K per 100 ppm	-6.41%	±15%
Pseudo Ejected Rod Worth (Rod 6-4)	Gp 5 @ 7.0% WD	-0.61 %ΔK/K	-0.71 %ΔK/K	+16.4%	±20%

		Core Location	Rod	Measured			
		N-12	7-6	-0.456 %ΔK/K		+10.5%	±20%
		N-4	7-9	-0.478 %ΔK/K		+6.2%	From Average
Symmetry	N/A	D-4	7-12	-0.502 %ΔK/K	N/A	+1.5%	Measured Value
Checks		D-12	7-3	-0.602 %ΔK/K		-18.2%	

*Deviation = Predicted-Measured; %Deviation = $\frac{\text{predicted - measured}}{\text{measured}} \times 100$

TABLE 2
OCONEE 2 CYCLE 5 PET RESULTS
TABULATED RESULTS OF MINIMUM DNBR AND MAXIMUM LHR CALCULATIONS

POWER LEVEL %FP	WORST CASE MAXIMUM LINEAR HEAT RATE (KW/FT)	MAXIMUM ACCEPTABLE WORST CASE MAXIMUM LHR (KW/FT)	WORST CASE MINIMUM DNBR	EXTRA-[1] POLATION POWER LEVEL	WORST CASE EXTRA-POLATED MAXIMUM LHR (KW/FT)	MAXIMUM ACCEPTABLE WORST CASE EXTRAP. MAXIMUM LHR (KW/FT)	WORST CASE EXTRA-POLATED MINIMUM DNBR	MINIMUM ACCEPTABLE WORST CASE EXTRAP. MINIMUM DNBR
40	5.25	15.5	8.17	85.0	13.10	20.15	3.50	1.30
75	8.76	15.5	4.52	105.5	14.40	20.15	2.90	1.30
100	11.08	15.5	3.30	105.5	13.70	20.15	2.66	1.30

[1]The extrapolation power level is the overpower trip setpoint of the next power level plateau in the escalation sequence.

Note: All extrapolations at the 40% F.P. test plateau were to 85% F.P.

TABLE 3
OCONEE 2 CYCLE 5 PET RESULTS
REACTIVITY COEFFICIENTS AT POWER

PARAMETER	MEASURED VALUE	ACCEPTANCE CRITERION
Hot Full Power BOC Temperature Coefficient extrapolated to 95% F.P.	$-0.903 \times 10^{-4}(\Delta K/K)/^{o}F$	More negative than $-0.144 \times 10^{-4}(\Delta K/K)/^{o}F$ at 95% FP
Hot Full Power Temperature Coefficient extrapolated to EOC	$-2.52 \times 10^{-4}(\Delta K/K)/^{o}F$	More positive than $-3.0 \times 10^{-4}(\Delta K/K)/^{o}F$ at 100% FP
Hot Full Power Power Coefficient	$-0.934 \times 10^{-4}(\Delta K/K)/\%FP$	More negative than $-0.55 \times 10^{-4}(\Delta K/K)/\%FP$ at 100% FP

FIGURE 1
OCONEE 2 CYCLE 5 PET RESULTS
40% FP RADIAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	0.78	0.95	1.04	1.18	1.01	1.22	0.91	0.81
8	0.79	0.98	1.06	1.22	1.03	1.20	0.89	0.72
		1.25	1.36	1.07	1.17	1.09	1.15	0.62
	9	1.31	1.41	1.11	1.18	1.06	1.12	0.56
			1.12	1.32	1.00	1.20	0.94	0.45
		10	1.14	1.39	1.00	1.17	0.92	0.42
				1.24	1.28	0.96	0.69	
			11	1.28	1.29	0.96	0.66	
					1.09	1.06	0.44	
				12	1.12	1.10	0.43	
						0.62	Measured	
					13	0.59	Predicted	

Largest Measured Peak = 1.36
Largest Predicted Peak = 1.41
Deviation From Measured = -3.68%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 32.0% wd

Imbalance = +0.26%

Core Burnup = 2.0 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 82.5% wd

Group 8 = 31.8% wd

Imbalance = +3.23%

Tilt WX = -.83
XY = +.45
YZ = +.35
ZW = +.03

Core Burnup = 0.88 EFPD

FIGURE 2
OCONEE 2 CYCLE 5 PET RESULTS
40% FP TOTAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	1.00	1.19	1.32	1.54	1.24	1.55	1.21	1.10
8	0.91	1.15	1.25	1.42	1.18	1.44	1.09	0.88
		1.63	1.81	1.36	1.49	1.29	1.49	0.83
	9	1.56	1.68	1.30	1.37	1.28	1.34	0.68
			1.53	1.76	1.43	1.54	1.22	0.60
		10	1.40	1.66	1.28	1.38	1.10	0.50
				1.63	1.70	1.24	0.91	
			11	1.55	1.56	1.15	0.79	
					1.50	1.36	0.60	
				12	1.40	1.36	0.52	
						0.86	Measured	
					13	0.73	Predicted	

Largest Measured Peak = 1.81
Largest Predicted Peak = 1.68
Deviation From Measured = +7.18%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 32.0% wd

Imbalance = +.026%

Core Burnup = 2.0 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 82.5% wd

Group 8 = 31.8% wd

Imbalance = +3.23%

Tilt WX = -.83
XY = +.45
YZ = +.35
ZW = +.03

Core Burnup = 0.88 EFPD

FIGURE 3
OCONEE 2 CYCLE 5 PET RESULTS
75% FP RADIAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	0.77	0.95	1.04	1.18	1.00	1.22	0.93	0.82
8	0.80	0.99	1.06	1.21	1.03	1.19	0.90	0.74
		1.25	1.35	1.06	1.16	1.09	1.15	0.63
	9	1.30	1.39	1.10	1.18	1.06	1.12	0.58
			1.13	1.31	1.01	1.19	0.94	0.46
		10	1.14	1.37	1.00	1.16	0.93	0.43
				1.23	1.28	0.96	0.70	
			11	1.27	1.27	0.96	0.67	
					1.10	1.06	0.45	
				12	1.12	1.10	0.44	
						0.64	Measured	
					13	0.60	Predicted	

Largest Measured Peak = 1.35
Largest Predicted Peak = 1.39
Deviation From Measured = -2.96%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 22.3% wd

Imbalance = +1.49%

Core Burnup = 3 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 89.1% wd

Group 8 = 21.1% wd

Imbalance = -2.22%

Tilt WX = -.54
XY = +.61
YZ = -.02
ZW = -.05

Core Burnup = 2.54 EFPD

FIGURE 4
OCONEE 2 CYCLE 5 PET RESULTS
75% FP TOTAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	0.86	1.08	1.18	1.38	1.13	1.44	1.12	0.99
8	0.95	1.18	1.28	1.46	1.24	1.44	1.13	0.93
		1.44	1.60	1.23	1.36	1.31	1.36	0.74
	9	1.57	1.70	1.35	1.46	1.25	1.37	0.71
			1.38	1.60	1.25	1.40	1.10	0.54
		10	1.45	1.74	1.39	1.46	1.15	0.54
				1.49	1.55	1.13	0.83	
			11	1.62	1.65	1.22	0.84	
					1.36	1.22	0.54	
				12	1.46	1.40	0.56	
					0.81	Measured		
				13	0.77	Predicted		

Largest Measured Peak = 1.60
Largest Predicted Peak = 1.74
Deviation From Measured = -8.75%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 22.3% wd

Imbalance = +1.49%

Core Burnup = 3 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 89.1% wd

Group 8 = 21.1% wd

Imbalance = -2.22%

Tilt WX = -.54
XY = +.61
YZ = -.02
ZW = -.05

Core Burnup = 2.54 EFPD

FIGURE 5
OCONEE 2 CYCLE 5 PET RESULTS
100% FP RADIAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	0.78	0.95	1.04	1.18	1.00	1.22	0.93	0.83
8	0.80	0.98	1.06	1.20	1.03	1.19	0.91	0.75
		1.25	1.34	1.06	1.16	1.08	1.15	0.63
	9	1.29	1.38	1.10	1.17	1.06	1.12	0.59
			1.12	1.30	1.01	1.19	0.94	0.46
		10	1.13	1.35	0.99	1.16	0.93	0.44
				1.22	1.27	0.96	0.70	
			11	1.26	1.27	0.97	0.68	
					1.09	1.07	0.45	
				12	1.12	1.10	0.45	
						0.65	Measured	
					13	0.61	Predicted	

Largest Measured Peak = 1.34
Largest Predicted Peak = 1.38
Deviation From Measured = -2.99%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 22.3% wd

Imbalance = -2.06%

Core Burnup = 4 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 89.5% wd

Group 8 = 21.1% wd

Imbalance = -4.51%

Tilt WX = +0.46
XY = +0.67
YZ = -0.21
ZW = -0.00

Core Burnup = 4.67 EFPD

FIGURE 6
OCONEE 2 CYCLE 5 PET RESULTS
100% FP TOTAL PEAKING FACTORS

	H	G	F	E	D	C	B	A
	0.86	1.10	1.19	1.36	1.14	1.46	1.14	1.01
8	0.94	1.16	1.25	1.41	1.20	1.44	1.12	0.93
		1.44	1.56	1.22	1.33	1.32	1.37	0.74
	9	1.54	1.64	1.30	1.40	1.28	1.37	0.72
			1.35	1.56	1.25	1.38	1.09	0.54
		10	1.39	1.66	1.35	1.41	1.12	0.53
				1.46	1.52	1.12	0.82	
			11	1.55	1.58	1.18	0.83	
					1.33	1.24	0.54	
				12	1.40	1.35	0.55	
						0.84	Measured	
					13	0.75	Predicted	

Largest Measured Peak = 1.56
Largest Predicted Peak = 1.66
Deviation From Measured = -6.41%

Core Conditions for Predicted Peaking Factors

Group 6 = 100% wd

Group 7 = 87.1% wd

Group 8 = 22.3% wd

Imbalance = -2.06%

Core Burnup = 4 EFPD

Core Conditions for Measured Peaking Factors

Group 6 = 100% wd

Group 7 = 89.5% wd

Group 8 = 21.1% wd

Imbalance = -4.91%

Tilt WX = +0.46
XY = +0.67
YZ = -0.21
ZW = -0.00

Core Burnup = 4.67 EFPD