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Docket 50-305
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Kewaunee Nuclear Power Plant
Cycle 19 Startup Report

In accordance with our practice of reporting the results of physics tests, enclosed is a copy of the Kewaunee Nuclear Power Plant Cycle 19 Startup Report.

Sincerely,

C A Schrock

C. A. Schrock
Manager - Nuclear Engineering

BJD/cjt

cc - US NRC - Region III - w/o attach.
US NRC Senior Resident Inspector - w/o attach.

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50-305 KEWAUNEE WPSC

CYCLE 19 STARTUP REPORT

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KEWAUNEE NUCLEAR POWER PLANT

CYCLE 19
STARTUP REPORT
MAY 1993

WISCONSIN PUBLIC SERVICE CORPORATION
WISCONSIN POWER & LIGHT COMPANY
MADISON GAS & ELECTRIC COMPANY

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KEWAUNEE NUCLEAR POWER PLANT

STARTUP REPORT

CYCLE 19

MAY 1993

WISCONSIN PUBLIC SERVICE CORPORATION

GREEN BAY, WISCONSIN

KEWAUNEE NUCLEAR POWER PLANT

STARTUP REPORT

CYCLE 19

MAY 1993

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Reviewed By: Date: 5-25-93
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Reviewed By: Date: 5-25-93
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Reviewed By: Date: 6-1-93
Licensing & Systems Superintendent

Approved By: Date: 6-1-93
Vice President - Energy Supply

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1.0 INTRODUCTION, SUMMARY, AND CONCLUSION

1.I Introduction

This report presents the results of the physics tests performed during startup of Kewaunee Cycle 19. The core design and reload safety evaluation were performed by Wisconsin Public Service Corporation (1) using methods previously described in WPS topical reports (2,3). The results of the physics tests were compared to WPS analytical results to confirm calculated safety margins. The tests performed and reported herein satisfy the requirements of the Reactor Test Program (4).

During Cycle 18-19 refueling, 36 of the 121 fuel assemblies in the core were replaced with fresh fuel assemblies. Thirty-two are Siemens Power Corporation Design (5), enriched to 3.4 weight percent U235 and four are Westinghouse design enriched to 3.1 weight percent U235. The Cycle 19 core consists of the following regions of fuel:

Region	ID	Vendor	Initial U235 W/O	Number of Previous Duty Cycles	Number of Assemblies
13	M	SPC	3.4	3	1
17	S	SPC	3.5	3	8
18	T	SPC	3.4	2	8
18	T	SPC	3.5	2	8
19	U	SPC	3.46	2	28
20	W	SPC	3.4	1	32
21	X	SPC	3.4	0	32 (Feed)
21	X	WES	3.1	0	4 (Feed)

The core loading pattern, assembly identification, RCCA bank identification, instrument thimble I.D., thermocouple I.D., and burnable poison rod configurations for Cycle 19 are presented in Figure 1.1.

On April 14, 1993, at 1015 hours, initial criticality was achieved on the Cycle 19 core. The schedule of physics tests and measurements is outlined in Table 1.1.

1.2 Summary

RCCA measurements are shown in Section 2. All RCCA drop time measurements were within Technical Specification limits. RCCA bank worths were measured using the rod swap reactivity comparison technique previously described (4,6). The reactivity comparison was made to the reference bank, Bank C, which was measured using the dilution technique. All results were within the established acceptance criteria (4), and thereby demonstrated adequate shutdown margin.

Section 3 presents the boron endpoint and boron worth measurements. The endpoint measurements for ARO and Bank C In core configurations were within the acceptance criteria (4). The available boron letdown data covering the first month of reactor operation is also shown. The agreement between measurements and predictions meets the review and acceptance criteria (4).

Section 4 shows the results of the isothermal temperature coefficient measurements. The differences between measurements and predictions were within the acceptance criteria (4).

Power distributions were measured via flux maps using the INCORE code for beginning of cycle (BOC) core conditions covering power escalation to 100 percent full power equilibrium xenon. The results indicate compliance with Technical Specification limits (7) and are presented in Section 5. Section 6 discusses the various calibrations performed during the startup of Cycle 19.

1.3 Conclusion

The startup testing of Kewaunee's Cycle 19 core verified that the reactor core has been properly loaded and the core characteristics satisfy the Technical Specifications (7) and are consistent with the parameters used in the design and safety analysis (1).

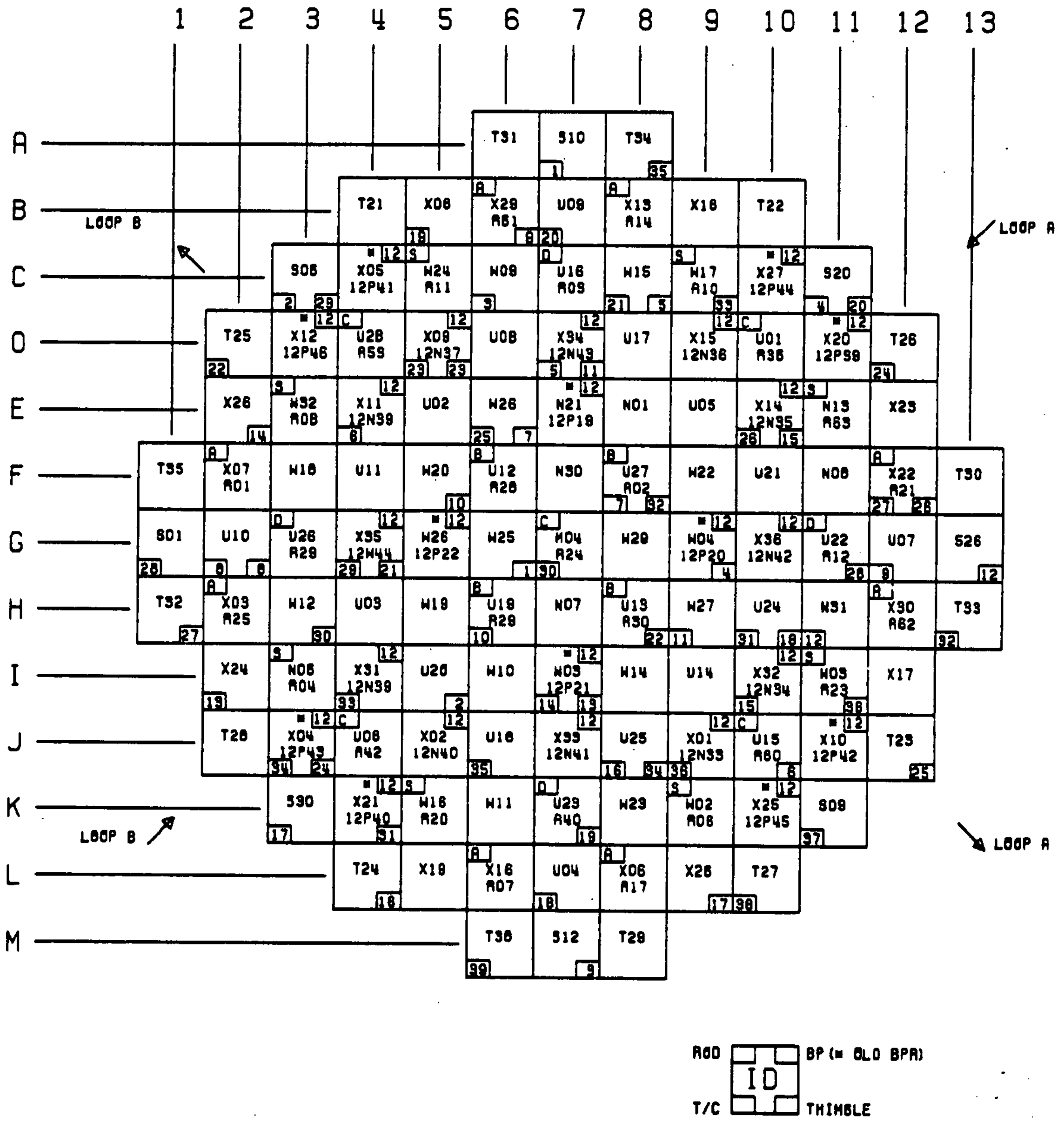
TABLE 1.1

Kewaunee Nuclear Power Plant

BOC Cycle 19 Physics Test

Test	Date Completed	Time Completed	Plant Conditions
Control Rod Operability Test	4/11/93	1000	Cold SD
Hot Rod Drops	4/13/93	0137	HSD
RPI Calibrations	4/13/93	1200	HSD
Initial Criticality	4/14/93	1015	HZP
Reactivity Computer Checkout	4/14/93	0130	HZP
ARO Endpoint	4/15/93	0356	HZP
Bank C Worth (Dilution)	4/15/93	0600	HZP
Bank C In-ORO Endpoint	4/15/93	0640	HZP
Bank C (Boration)	4/15/93	1107	HZP
ITC Determination	4/15/93	1524	HZP
Power Ascension Flux Map 1901	4/16/93	1152	23%
Power Ascension Flux Map 1902	4/19/93	1009	35%
Power Ascension Flux Map 1903	4/23/93	1051	75%
Power Ascension Flux Map 1904	4/26/93	0944	89%
Power Ascension Flux Map 1905	4/27/93	1454	100%
Power Ascension Flux Map 1906	4/30/93	0901	100%

Figure 1.1
Core Loading Map



CYCLE NINETEEN

2.0 RCCA MEASUREMENTS

2.1 RCCA Drop Time Measurements

RCCA drop times to dashpot and rod bottom were measured at hot shutdown core conditions. The results of the hot shutdown measurements are presented in Table 2.1. The acceptance criterion (4) of 1.8 seconds to dashpot is adequately met for all fuel.

2.2 RCCA Bank Measurements

During Cycle 19 startup the reactivity of the reference bank (Bank C) was measured during dilution using the reactivity computer. The reactivity worth of the remaining banks was inferred using rod swap reactivity comparisons to the reference bank.

2.2.1 Rod Swap Results

The worth of the reference bank (Bank C) measured during dilution differed from the WPSC predicted Bank C worth by 18.2 pcm or 1.9 percent. A comparison of the measured to predicted reference bank integral and differential worth is presented in Figure 2.1.

Rod swap results for the remaining banks are presented in Table 2.2. The measured to predicted total rod worth difference is 2.1 percent which is within the acceptance criteria of 10.0 percent. All individual bank worths were within the 15.0 percent measured to predicted review criterion.

2.3 Shutdown Margin Evaluation

Prior to power escalation a shutdown margin evaluation was made to verify the existence of core shutdown capability. The minimum shutdown margins at beginning and end of cycle are presented in Table 2.3. A 10 percent uncertainty in the calculation of rod worth is allowed for in these shutdown margin analyses. Since the measured rod worths resulted in less than a 10 percent difference from predicted values, the analysis in Table 2.3 is conservative and no additional evaluations were required.

TABLE 2.1

Kewaunee Cycle 19

RCCA Drop Time Measurements

Hot Zero Power

	<u>All Fuel</u>
Average Dashpot Delta T (Sec)	1.279
Standard Deviation	0.029
Average Rod Bottom Delta T (Sec)	1.788
Standard Deviation	0.034

TA8LE 2.2

Kewaunee Cycle 19

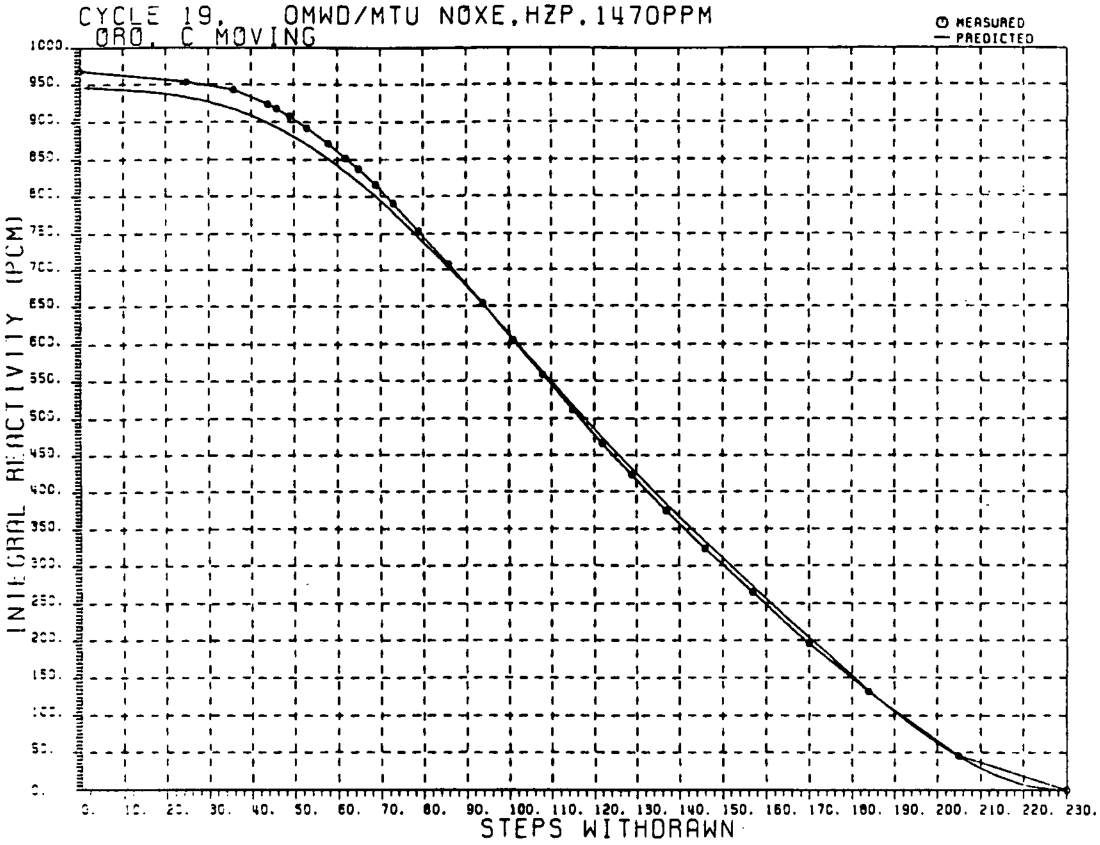
RCCA Bank Worth Summary

Reference Bank Measured by Dilution/Reactivity Computer

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Predicted Worth (PCM)	Difference (PCM)	Percent Difference
D	621.3	641	-19.7	-3.1
C*	968.2	950	18.2	1.9
B	655.4	634	21.4	3.4
A	1038.5	981	57.5	5.9
SA	845.6	833	12.6	1.5
SB	843.2	833	10.2	1.2
Total	4972.2	4872	100.2	2.1

* Reference bank

RCCA Bank C Integral and Differential Worth



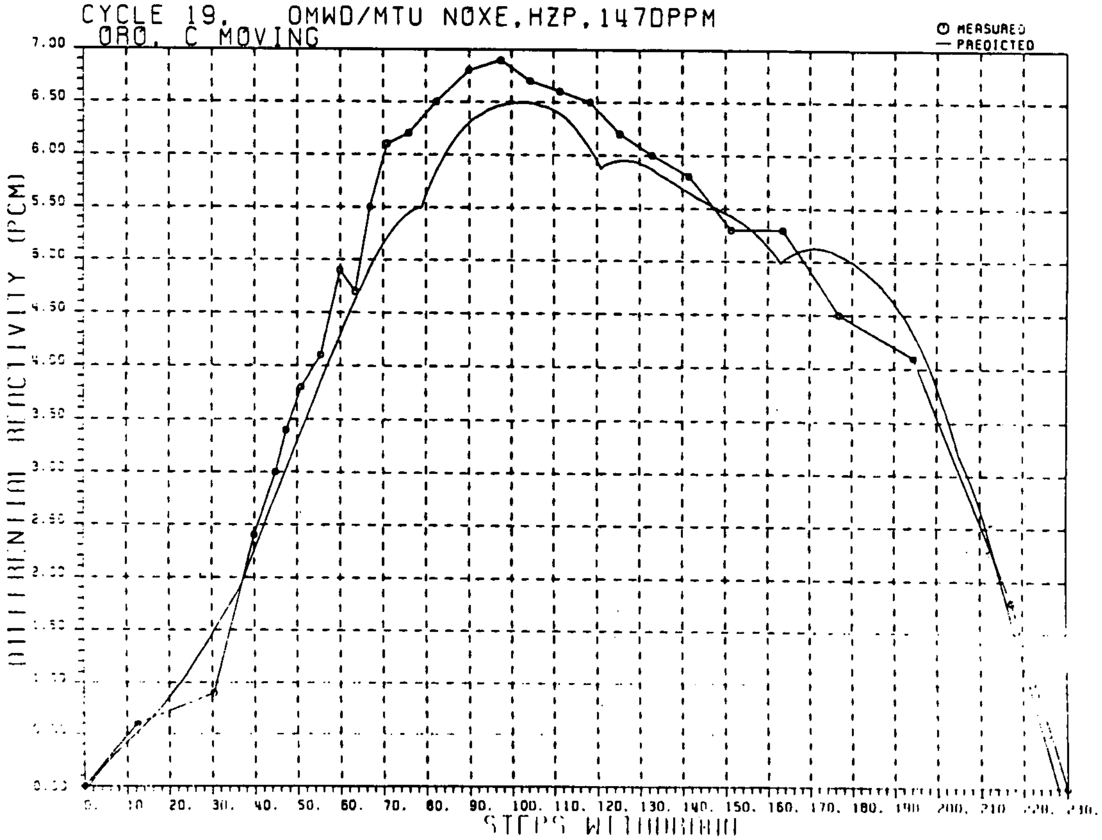


TABLE 2.3

Kewaunee Cycle 19

Minimum Shutdown Margin Analysis

RCCA Bank Worths (PCM)	BOC	EOC
N	6444	6485
N-1	5589	5726
Less 10 Percent	559	573
Sub Total	5030	5153
Total Requirements (Including Uncertainties)	2385	2878
Shutdown Margin	2645	2275
Required Shutdown Margin	1000	2000

3.0 BORON ENDPOINTS AND BORON WORTH MEASUREMENTS

3.1 Boron Endpoints

Dilution is stopped at the near ARO and at the Reference Bank nearly inserted core conditions. Boron concentration is allowed to stabilize. The critical boron concentration for these core configurations is then determined by boron endpoint measurement.

Table 3.1 lists the measured and WPSC predicted boron endpoints for the RCCA bank configurations shown. The results indicate a difference of 4 ppm and 7 ppm for the ARO and Bank C In conditions, respectively. The acceptance criterion on the all rods out boron endpoint is +100 PPM, thus, the boron endpoint comparisons are considered acceptable.

.2 Differential Boron Worth

The differential boron worth is calculated by dividing the worth of control Bank C by the difference in boron concentration of the corresponding bank out and bank in configuration. Table 3.2 presents a comparison between measured and predicted boron concentration change and differential boron worth. No acceptance criteria are applied to these comparisons.

3.3 Boron Letdown

The measured boron concentration data for the first month of power operation is corrected to nominal core conditions and presented versus cycle burnup in Figure 3.1. The predicted boron letdown curve is included for comparison.

TABLE 3.1

Kewaunee Cycle 19

RCCA Bank Endpoint Measurements

RCCA Bank Configuration	Measured Endpoint (PPM)	WPS Predicted Endpoint (PPM)	Difference (PPM)
All Rods Out	1530	1526	4
Bank C In	1420	1413	7

TABLE 3.2

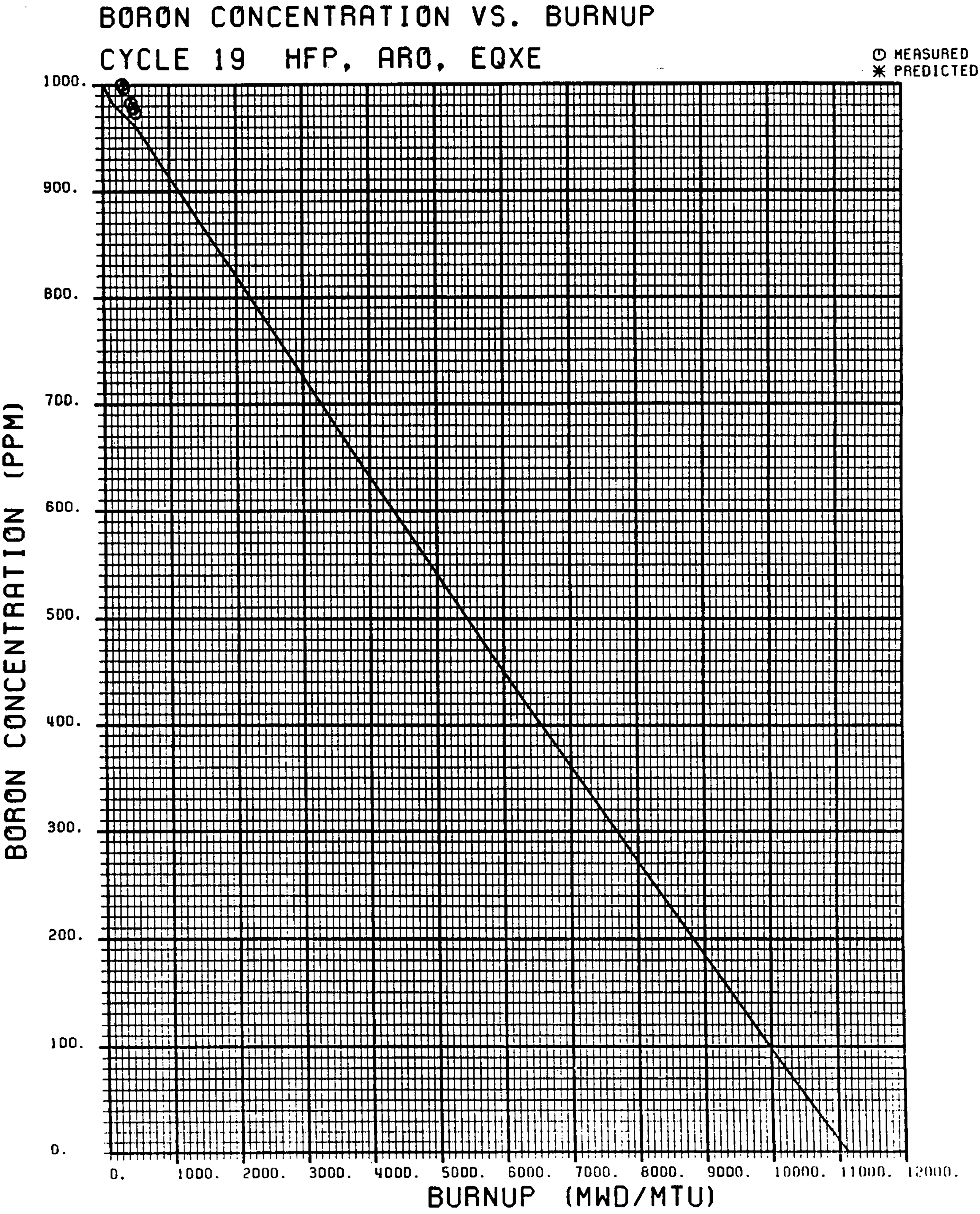
Kewaunee Cycle 19

Differential Boron Worth

RCCA Bank Configuration	CB Change Measured (PPM)	CB Change Predicted (PPM)	Percent Difference
ARO to C Bank In	110	113	-2.7

RCCA Bank Configuration	Measured Boron Worth (PCM/PPM)	Predicted Boron Worth (PCM/PPM)	Difference (PCM/PPM)
ARO/C Bank In	-8.8	-8.4	-0.4

FIGURE 3.1


BORON CONCENTRATION VS. BURNUP
CYCLE 19 HFP, ARO, EQXE
○ MEASURED
✳ PREDICTED
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
0.
BORON CONCENTRATION (PPM)
0.
1000.
2000.
3000.
4000.
5000.
6000.
7000.
8000.
9000.
10000.
11000.
12000.
BURNUP (MWD/MTU)

4.0 ISOTHERMAL TEMPERATURE COEFFICIENT

The measurement of the isothermal temperature coefficient was accomplished by monitoring reactivity while cooling down and heating up the reactor by manual control of the steam dump valves. The temperature and reactivity changes were plotted on an X-Y recorder and the temperature coefficient was obtained from the slope of this curve.

Core conditions at the time of the measurement were Bank D slightly inserted, all other RCCA banks full out, with a boron concentration of 1524 ppm. These conditions approximate the HZP, all rods out core condition which yields the most conservative (least negative) isothermal temperature coefficient measurement.

Table 4.1 presents the heatup and cooldown core conditions and compares the measured and predicted values for the isothermal temperature coefficient. The review criterion (4) of ±3 PCM/°F was met.

TABLE 4.1

Kewaunee Cycle 19

Isothermal Temperature Coefficient

Cooldown

Tave Start - 549.2°F

Tave End - 544.1°F

Bank D - 204 Steps

Boron Concentration - 1524 PPM

Measured ITC (PCM/°F)	WPSC Predicted ITC (PCM/°F)	Difference (PCM/°F)
-3.58	-3.14	-0.44

Heat Up

Tave Start - 547.1°F

Tave End - 548.4°F

Bank D - 204 Steps

Boron Concentration - 1524 PPM

Measured ITC (PCM/°F)	WPSC Predicted ITC (PCM/°F)	Difference (PCM/°F)
-3.35	-3.32	-0.03

5.0 POWER DISTRIBUTION

.1 Summary of Power Distribution Criteria

Power distribution predictions are verified through data recorded using the incore detector system and processed through the INCORE computer code. The computer code calculates FQEQ and FDHN which are limited by technical specifications. These parameters are defined as the acceptance criteria on a flux map (4).

The review criterion for measurement is that the percent differences of the normalized reaction rate integrals of symmetric thimbles do not exceed 10 percent at low power physics test conditions and 6 percent at equilibrium conditions (4).

The review criterion for the prediction is that the standard deviation of the percent differences between measured and predicted reaction rate integrals does not exceed 5 percent.

The review criteria for the INCORE calculated quadrant powers are that the quadrant tilt is less than 4 percent at low power physics test conditions and less than 2 percent at equilibrium conditions (4).

5.2 Power Distribution Measurements

Table 5.1 identifies the reactor conditions for each flux map recorded at the beginning of Cycle 19.

Comparisons of measured to predicted power distributions for the flux maps are exhibited in Figures 5.1 through 5.6. As evidenced by the figures, the central region of the core is initially overpredicted by approximately 3 percent and decreases with burnup to less than 3 percent.

Table 5.2 identifies flux map peak FDHN and minimum margin FQEQ. This table addresses acceptance criteria by verifying that technical specification limits are not exceeded. Table 5.2 also identifies FQW for the four Westinghouse assemblies and verifies that applied limits are reviewed. The Cycle 19 flux maps met all acceptance criteria.

Table 5.3 addresses the established review criteria for the flux maps. All review criteria were met for all the Cycle 19 flux maps.

TABLE 5.1

Flux Map Chronology and Reactor Characteristics

Map	Date	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MDW/MTU
1901	4/16/93	23	NON-EQ.	1479	132	0
1902	4/19/93	35	NON-EQ.	1218	171	33
1903	4/23/93	75	NON-EQ.	1164	205	94
1904	4/26/93	89	NON-EQ.	1071	211	179
1905	4/27/93	100	NON-EQ.	1022	230	221
1906	4/30/93	100	EQ.	997	230	319

TABLE 5.2

Verification of Acceptance Criteria

Flux Map	Core Location	FQEQ	Limit
1901	K-06 DE,33	2.57	4.56
1902	E-10 ML,26	2.30	4.50
1903	E-11 DJ,23	2.14	2.99
1904	E-11 DJ,23	2.08	2.50
1905	E-03 KJ,33	2.10	2.28
1906	E-03 KJ,33	2.08	2.28

Flux Map	W Assembly Core Location	FQW	Limit
1901	G10	2.15	4.10
1902	G10	2.06	4.10
1903	D07	1.97	2.73
1904	D07	1.95	2.28
1905	D07	1.94	2.05
1906	D07	1.94	2.05

Flux Map	Core Location	FDHN	Limit
1901	E-10 ML	1.55	1.79
1902	E-11 DJ	1.53	1.75
1903	E-11 DJ	1.53	1.63
1904	E-11 DJ	1.51	1.58
1905	E-11 DJ	1.51	1.55
1906	E-11 DJ	1.50	1.55

FQEQ, FQW, and FDHN include appropriate uncertainties and penalties.

Limit on FQEQ and FQW is a function of core power and axial location.

Limit on FDHN is a function of Core Power and Assembly Burnup.

TABLE 5.3

Verification of Review Criteria

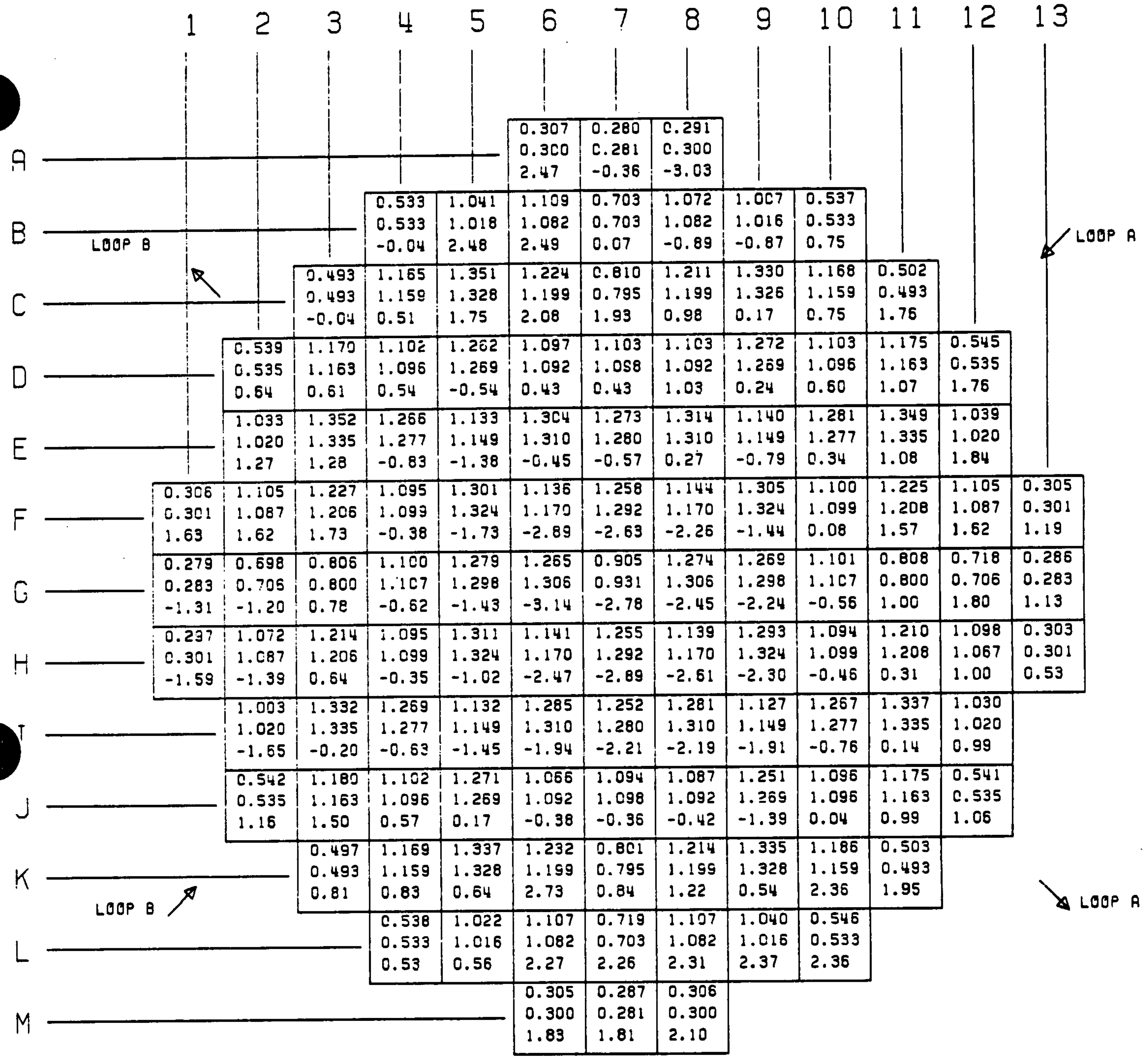
Flux Map	(a) Maximum Percent Difference	(b) Standard Deviation	(c) Maximum Quadrant Tilt
190I	1.7	2.1	0.2
1902	2.1	1.7	0.3
1903	1.3	2.0	0.4
1904	1.0	1.8	0.5
1905	1.0	2.0	0.4
1906	0.9	1.8	0.4

(a) Maximum Percent Difference between symmetric thimbles for measured reaction rate integrals. Review criterion is 10 percent at low power. Review criterion is 6 percent at equilibrium power.

(b) Standard Deviation of the percent difference between measured and predicted reaction rate integrals. Review criterion is 5 percent.

(c) Percent Maximum Quadrant Tilt from normalized calculated quadrant powers. Review criteria are 4 percent at low power and 2 percent at equilibrium power.

Figure 5.1
Power Distribution for Flux Map 19D1



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.307 0.300 2.47	0.280 0.281 -0.36	0.291 0.300 -3.03					
B				0.533 0.533 -0.04	1.041 1.018 2.48	1.109 1.082 2.49	0.703 0.703 0.07	1.072 1.082 -0.89	1.007 1.016 -0.87	0.537 0.533 0.75			
C			0.493 0.493 -0.04	1.165 1.159 0.51	1.351 1.328 1.75	1.224 1.199 2.08	0.810 0.795 1.93	1.211 1.199 0.98	1.330 1.326 0.17	1.168 1.159 0.75	0.502 0.493 1.76		
D		0.539 0.535 0.64	1.170 1.163 0.61	1.102 1.096 0.54	1.262 1.269 -0.54	1.097 1.092 0.43	1.103 1.098 0.43	1.103 1.092 1.03	1.272 1.269 0.24	1.103 1.096 0.60	1.175 1.163 1.07	0.545 0.535 1.76	
E		1.033 1.020 1.27	1.352 1.335 1.28	1.266 1.277 -0.83	1.133 1.149 -1.38	1.304 1.310 -0.45	1.273 1.280 -0.57	1.314 1.310 0.27	1.140 1.149 -0.79	1.281 1.277 0.34	1.349 1.335 1.08	1.039 1.020 1.84	
F	0.306 0.301 1.63	1.105 1.087 1.62	1.227 1.206 1.73	1.095 1.099 -0.38	1.301 1.324 -1.73	1.136 1.170 -2.89	1.258 1.292 -2.63	1.144 1.170 -2.26	1.305 1.324 -1.44	1.100 1.099 0.08	1.225 1.208 1.57	1.105 1.087 1.62	0.305 0.301 1.19
G	0.279 0.283 -1.31	0.698 0.706 -1.20	0.806 0.800 0.78	1.100 1.107 -0.62	1.279 1.298 -1.43	1.265 1.306 -3.14	0.905 0.931 -2.78	1.274 1.306 -2.45	1.269 1.298 -2.24	1.101 1.107 -0.56	0.808 0.800 1.00	0.718 0.706 1.80	0.286 0.283 1.13
H	0.237 0.301 -1.59	1.072 1.087 -1.39	1.214 1.206 0.64	1.095 1.099 -0.35	1.311 1.324 -1.02	1.141 1.170 -2.47	1.255 1.292 -2.89	1.139 1.170 -2.61	1.293 1.324 -2.30	1.094 1.099 -0.46	1.210 1.208 0.31	1.098 1.067 1.00	0.303 0.301 0.53
I		1.003 1.020 -1.65	1.332 1.335 -0.20	1.269 1.277 -0.63	1.132 1.149 -1.45	1.285 1.310 -1.94	1.252 1.280 -2.21	1.281 1.310 -2.19	1.127 1.149 -1.91	1.267 1.277 -0.76	1.337 1.335 0.14	1.030 1.020 0.99	
J		0.542 0.535 1.16	1.180 1.163 1.50	1.102 1.096 0.57	1.271 1.269 0.17	1.066 1.092 -0.38	1.094 1.098 -0.36	1.087 1.092 -0.42	1.251 1.269 -1.39	1.096 1.096 0.04	1.175 1.163 0.99	0.541 0.535 1.06	
K			0.497 0.493 0.81	1.169 1.159 0.83	1.337 1.328 0.64	1.232 1.199 2.73	0.801 0.795 0.84	1.214 1.199 1.22	1.335 1.328 0.54	1.186 1.159 2.36	0.503 0.493 1.95		
L				0.538 0.533 0.53	1.022 1.016 0.56	1.107 1.082 2.27	0.719 0.703 2.26	1.107 1.082 2.31	1.040 1.016 2.37	0.546 0.533 2.36			
M						0.305 0.300 1.83	0.287 0.281 1.81	0.306 0.300 2.10					

MEASURED FOHN
PREDICTED FOHN
PERCENT DIFFERENCE

FLUX MAP 1901

δ= 1.50

Figure 5.2
Power Distribution for Flux Map 1902

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.315 0.310 1.51	0.294 0.296 -0.44	0.303 0.310 -2.32					
B				0.532 0.532 0.09	1.032 1.017 1.50	1.119 1.102 1.51	0.736 0.737 -0.15	1.094 1.102 -0.78	1.009 1.017 -0.77	0.536 0.532 1.22			
C			0.489 0.486 0.10	1.147 1.139 0.69	1.335 1.316 1.41	1.247 1.223 1.96	0.900 0.886 1.61	1.235 1.223 0.96	1.316 1.316 -0.02	1.153 1.139 1.21	0.501 0.488 2.68		
D		0.536 0.534 0.41	1.148 1.143 0.38	1.065 1.077 0.72	1.241 1.244 -0.28	1.100 1.092 0.73	1.123 1.117 0.54	1.104 1.092 1.04	1.246 1.244 0.12	1.087 1.077 0.91	1.161 1.143 1.54	0.546 0.534 2.68	
E		1.028 1.021 0.70	1.331 1.322 0.70	1.244 1.251 -0.58	1.118 1.130 -1.11	1.267 1.289 -0.16	1.259 1.262 -0.21	1.298 1.269 0.67	1.123 1.130 -0.58	1.256 1.251 0.37	1.339 1.322 1.25	1.043 1.021 2.15	
F	0.315 0.312 1.06	1.118 1.106 1.05	1.244 1.229 1.21	1.095 1.100 -0.47	1.262 1.302 -1.55	1.121 1.150 -2.51	1.240 1.268 -2.21	1.126 1.150 -1.90	1.287 1.302 -1.19	1.094 1.100 -0.52	1.241 1.229 0.96	1.119 1.106 1.13	0.316 0.312 1.44
G	0.295 0.297 -0.51	0.734 0.741 -0.97	0.893 0.891 0.19	1.115 1.128 -0.95	1.263 1.279 -1.28	1.247 1.281 -2.70	0.901 0.919 -1.89	1.260 1.281 -1.67	1.258 1.279 -1.63	1.114 1.126 -1.11	0.894 0.891 0.36	0.749 0.741 1.08	0.301 0.297 1.38
H	0.310 0.312 -0.67	1.094 1.106 -1.13	1.230 1.229 0.04	1.092 1.100 -0.78	1.289 1.302 -0.98	1.124 1.150 -2.24	1.242 1.268 -2.09	1.129 1.150 -1.85	1.261 1.302 -1.59	1.091 1.100 -0.79	1.226 1.229 -0.26	1.111 1.106 0.43	0.314 0.312 0.74
I		1.012 1.021 -0.92	1.320 1.322 -0.15	1.243 1.251 -0.64	1.113 1.130 -1.54	1.264 1.269 -1.91	1.243 1.262 -1.48	1.271 1.269 -1.44	1.117 1.130 -1.13	1.244 1.251 -0.55	1.326 1.322 0.33	1.033 1.021 1.18	
J		0.544 0.534 2.02	1.166 1.143 1.98	1.066 1.077 0.64	1.246 1.244 0.15	1.061 1.092 -1.03	1.108 1.117 -0.81	1.083 1.092 -0.81	1.233 1.244 -0.89	1.060 1.077 0.26	1.157 1.143 1.18	0.540 0.534 1.26	
K			0.494 0.488 1.15	1.152 1.139 1.12	1.325 1.318 0.68	1.232 1.223 0.74	0.888 0.886 -0.01	1.229 1.223 0.44	1.321 1.316 0.35	1.156 1.139 1.52	0.498 0.486 2.09		
L				0.535 0.532 0.58	1.023 1.017 0.62	1.116 1.102 1.31	0.747 0.737 1.32	1.117 1.102 1.38	1.033 1.017 1.51	0.540 0.532 1.52			
M						0.316 0.310 1.90	0.301 0.296 1.89	0.316 0.310 1.71					

LOOP B

LOOP A

LOOP B

LOOP A

☐
- MEASURED FDHN
- PREDICTED FDHN
- PERCENT DIFFERENCE

FLUX MAP 1902

δ= 1.25

Figure 5.3
Power Distribution for Flux Map 1903

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.332 0.322 2.98	0.313 0.313 -0.10	0.312 0.322 -3.04					
B				0.527 0.533 -1.09	1.033 1.003 2.97	1.132 1.099 2.97	0.768 0.767 0.13	1.093 1.099 -0.59	0.998 1.003 -0.54	0.541 0.533 1.48			
C			0.484 0.489 -1.08	1.114 1.112 0.13	1.319 1.291 2.18	1.258 1.232 2.13	0.980 0.963 1.73	1.245 1.232 1.06	1.300 1.291 0.69	1.126 1.112 1.47	0.499 0.489 1.96		
D		0.537 0.535 0.43	1.119 1.115 0.34	1.066 1.064 0.21	1.226 1.226 0.02	1.109 1.102 0.59	1.144 1.140 0.33	1.114 1.102 1.10	1.237 1.226 0.91	1.080 1.064 1.45	1.134 1.115 1.69	0.545 0.535 1.95	
E		1.024 1.005 1.85	1.320 1.296 1.86	1.226 1.233 -0.54	1.116 1.126 -0.91	1.279 1.262 -0.24	1.253 1.260 -0.56	1.281 1.282 -0.12	1.123 1.126 -0.29	1.250 1.233 1.40	1.329 1.296 2.51	1.042 1.005 3.65	
F	0.328 0.323 1.55	1.119 1.102 1.53	1.258 1.238 1.63	1.106 1.109 -0.32	1.277 1.294 -1.31	1.127 1.153 -2.29	1.237 1.264 -2.14	1.128 1.153 -2.14	1.281 1.294 -1.00	1.099 1.109 -0.91	1.251 1.238 1.01	1.106 1.102 0.40	0.328 0.323 1.30
G	0.311 0.314 -0.99	0.764 0.770 -0.83	0.976 0.969 0.72	1.144 1.148 -0.37	1.261 1.275 -1.14	1.244 1.277 -2.62	0.910 0.933 -2.36	1.249 1.277 -2.18	1.250 1.275 -1.97	1.127 1.148 -1.86	0.969 0.969 -0.02	0.772 0.770 0.18	0.318 0.314 1.11
H	0.320 0.323 -1.17	1.092 1.102 -0.95	1.246 1.238 0.63	1.106 1.109 -0.27	1.282 1.294 -0.94	1.128 1.153 -2.15	1.236 1.264 -2.26	1.129 1.153 -2.11	1.269 1.294 -1.92	1.097 1.109 -1.10	1.229 1.238 -0.71	1.095 1.102 -0.62	0.320 0.323 -1.05
I		1.000 1.005 -0.47	1.308 1.296 0.90	1.232 1.233 -0.06	1.105 1.126 -1.85	1.258 1.282 -1.85	1.235 1.260 -2.02	1.256 1.282 -2.03	1.105 1.126 -1.85	1.232 1.233 -0.06	1.304 1.296 0.60	1.020 1.005 1.50	
J		0.549 0.535 2.66	1.143 1.115 2.51	1.076 1.064 1.10	1.229 1.226 0.20	1.084 1.102 -1.63	1.121 1.140 -1.66	1.083 1.102 -1.71	1.201 1.226 -2.01	1.077 1.064 1.19	1.132 1.115 1.50	0.543 0.535 1.53	
K			0.496 0.489 1.27	1.126 1.112 1.23	1.296 1.291 0.54	1.217 1.232 -1.20	0.948 0.963 -1.57	1.231 1.232 -0.06	1.299 1.291 0.64	1.147 1.112 3.13	0.498 0.489 1.60		
L				0.535 0.533 0.39	1.008 1.003 0.45	1.087 1.099 -1.12	0.758 0.767 -1.12	1.103 1.099 0.35	1.035 1.003 3.13	0.549 0.533 3.13			
M						0.319 0.322 -1.02	0.310 0.313 -1.02	0.326 0.322 1.02					

LOOP B

LOOP A

LOOP B

LOOP A

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 1903

δ= 1.54

Figure 5.4
Power Distribution for Flux Map 1904

LOOP B

LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.335 0.327 2.63	0.319 0.319 -0.18	0.317 0.327 -2.79					
B				0.531 0.535 -0.58	1.025 0.999 2.62	1.126 1.097 2.62	0.776 0.774 0.22	1.094 1.097 -0.29	0.997 0.999 -0.24	0.543 0.535 1.52			
C			0.488 0.491 -0.57	1.107 1.105 0.17	1.306 1.283 1.76	1.254 1.231 1.88	0.994 0.977 1.77	1.247 1.231 1.30	1.296 1.263 1.01	1.122 1.105 1.52	0.500 0.491 1.79		
D		0.538 0.536 0.37	1.112 1.108 0.33	1.064 1.062 0.22	1.220 1.221 -0.07	1.112 1.106 0.56	1.153 1.146 0.58	1.121 1.106 1.34	1.233 1.221 0.97	1.078 1.062 1.32	1.123 1.108 1.36	0.546 0.536 1.79	
E		1.014 1.001 1.26	1.304 1.288 1.27	1.223 1.226 -0.39	1.118 1.126 -0.69	1.260 1.281 -0.07	1.260 1.260 -0.02	1.288 1.281 0.55	1.127 1.126 0.07	1.239 1.228 0.93	1.315 1.288 2.12	1.035 1.001 3.36	
F	0.330 0.328 0.79	1.109 1.100 0.80	1.245 1.236 0.70	1.105 1.112 -0.60	1.278 1.293 -1.18	1.137 1.157 -1.72	1.246 1.266 -1.41	1.140 1.157 -1.49	1.283 1.293 -0.75	1.101 1.112 -0.97	1.247 1.238 0.87	1.103 1.100 0.27	0.331 0.328 0.95
G	0.315 0.320 -1.65	0.769 0.777 -1.08	0.984 0.982 0.20	1.148 1.153 -0.42	1.261 1.275 -1.11	1.253 1.278 -1.95	0.923 0.941 -1.84	1.254 1.278 -1.69	1.253 1.275 -1.71	1.134 1.153 -1.67	0.983 0.982 0.09	0.778 0.777 0.08	0.323 0.320 0.75
H	0.322 0.328 -1.80	1.087 1.100 -1.17	1.238 1.236 0.17	1.107 1.112 -0.41	1.279 1.293 -1.07	1.135 1.157 -1.89	1.238 1.266 -2.23	1.131 1.157 -2.28	1.268 1.293 -1.96	1.103 1.112 -0.77	1.233 1.236 -0.26	1.096 1.100 -0.38	0.323 0.328 -1.43
I		0.995 1.001 -0.59	1.300 1.288 0.92	1.229 1.228 0.06	1.109 1.126 -1.55	1.256 1.281 -1.77	1.236 1.260 -1.91	1.257 1.281 -1.90	1.108 1.128 -1.60	1.233 1.228 0.45	1.299 1.268 0.82	1.017 1.001 1.64	
J		0.547 0.536 2.07	1.133 1.108 2.26	1.073 1.062 1.05	1.226 1.221 0.43	1.086 1.106 -1.63	1.129 1.146 -1.50	1.090 1.106 -1.48	1.207 1.221 -1.18	1.083 1.062 1.96	1.126 1.108 1.64	0.545 0.536 1.62	
K			0.496 0.491 1.02	1.116 1.105 1.01	1.289 1.283 0.47	1.215 1.231 -1.33	0.964 0.977 -1.26	1.229 1.231 -0.16	1.289 1.283 0.49	1.126 1.105 2.06	0.498 0.491 1.32		
L				0.536 0.535 0.30	1.003 0.999 0.37	1.084 1.097 -1.15	0.765 0.774 -1.15	1.097 1.097 -0.04	1.020 0.999 2.06	0.545 0.535 2.06			
M						0.323 0.327 -0.98	0.316 0.319 -0.97	0.328 0.327 0.52					

LOOP B

LOOP A

MEASURED FOHN
PREDICTED FOHN
PERCENT DIFFERENCE

FLUX MAP 1904

δ= 1.34

Power Distribution for Flux Map 1905

LOOP B

LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.340 0.330 3.15	0.323 0.324 -0.22	0.319 0.330 -3.42					
B				0.532 0.535 -0.64	1.026 0.996 3.15	1.131 1.096 3.16	0.784 0.782 0.24	1.091 1.096 -0.47	0.992 0.996 -0.40	0.543 0.535 1.49			
C			0.489 0.492 -0.63	1.100 1.099 0.12	1.302 1.277 2.00	1.256 1.233 1.67	1.014 0.996 1.81	1.246 1.233 1.18	1.290 1.277 1.06	1.116 1.099 1.50	0.501 0.492 1.75		
D		0.539 0.537 0.43	1.106 1.102 0.38	1.061 1.059 0.18	1.217 1.217 0.01	1.113 1.108 0.44	1.157 1.151 0.49	1.121 1.108 1.20	1.230 1.217 1.05	1.073 1.059 1.35	1.118 1.102 1.42	0.547 0.537 1.75	
E		1.013 0.996 1.45	1.301 1.282 1.45	1.217 1.223 -0.50	1.117 1.125 -0.69	1.276 1.276 -0.18	1.255 1.258 -0.26	1.279 1.278 0.05	1.124 1.125 -0.11	1.236 1.223 1.05	1.312 1.282 2.34	1.035 0.998 3.68	
F	0.334 0.331 0.75	1.107 1.099 0.78	1.249 1.238 0.86	1.109 1.114 -0.43	1.277 1.290 -1.03	1.137 1.156 -1.87	1.245 1.264 -1.47	1.136 1.156 -1.70	1.279 1.290 -0.84	1.101 1.114 -1.15	1.247 1.238 0.75	1.097 1.099 -0.18	0.333 0.331 0.57
G	0.320 0.326 -1.81	0.776 0.785 -1.21	1.004 1.001 0.29	1.155 1.156 -0.28	1.261 1.273 -0.97	1.251 1.276 -1.98	0.928 0.943 -1.85	1.255 1.276 -1.68	1.251 1.273 -1.73	1.133 1.158 -2.14	0.996 1.001 -0.33	0.782 0.785 -0.43	0.327 0.326 0.34
H	0.325 0.331 -1.99	1.085 1.099 -1.29	1.241 1.236 0.26	1.113 1.114 -0.13	1.280 1.290 -0.76	1.136 1.156 -1.75	1.241 1.264 -1.85	1.134 1.156 -1.87	1.266 1.290 -1.84	1.100 1.114 -1.25	1.227 1.238 -0.91	1.087 1.099 -1.14	0.323 0.331 -2.48
		0.993 0.998 -0.59	1.294 1.282 0.96	1.226 1.223 0.20	1.111 1.125 -1.23	1.258 1.278 -1.60	1.238 1.258 -1.61	1.258 1.278 -1.59	1.108 1.125 -1.55	1.221 1.223 -0.15	1.288 1.282 0.48	1.014 0.996 1.52	
J		0.549 0.537 2.16	1.130 1.102 2.57	1.073 1.059 1.37	1.227 1.217 0.66	1.090 1.108 -1.58	1.133 1.151 -1.59	1.091 1.108 -1.57	1.202 1.217 -1.28	1.075 1.059 1.51	1.119 1.102 1.52	0.545 0.537 1.53	
K			0.498 0.492 1.26	1.113 1.099 1.26	1.287 1.277 0.79	1.214 1.233 -1.56	0.981 0.996 -1.43	1.231 1.233 -0.15	1.265 1.277 0.67	1.126 1.099 2.48	0.499 0.492 1.55		
L				0.539 0.535 0.60	1.003 0.996 0.68	1.080 1.096 -1.49	0.771 0.782 -1.48	1.095 1.098 -0.11	1.021 0.996 2.48	0.549 0.535 2.48			
M						0.325 0.330 -1.42	0.320 0.324 -1.42	0.332 0.330 0.48					

LOOP B

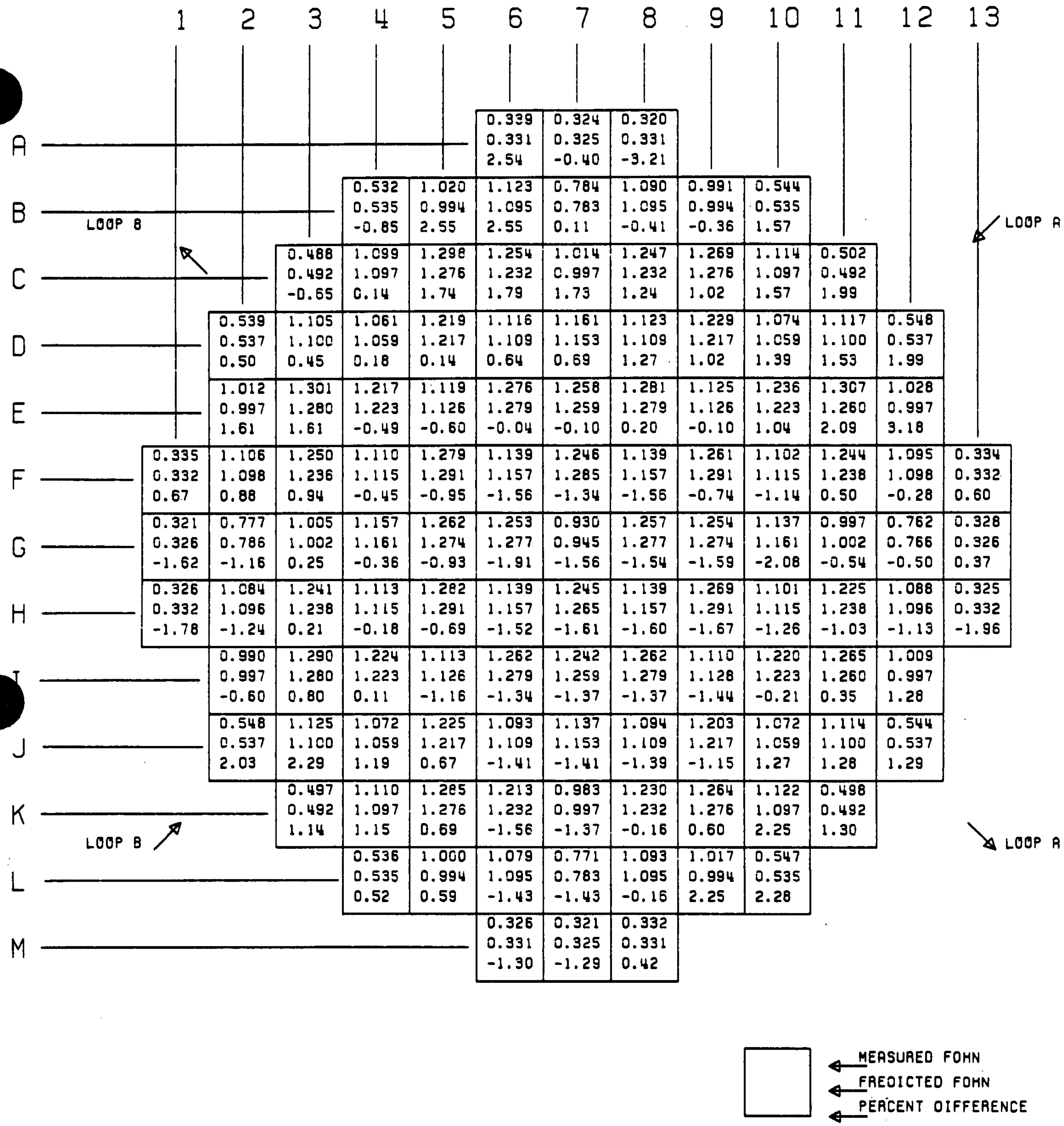
LOOP A

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 1905

δ= 1.44

Figure 5.6
Power Distribution for Flux Map 1906



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.339 0.331 2.54	0.324 0.325 -0.40	0.320 0.331 -3.21					
B				0.532 0.535 -0.85	1.020 0.994 2.55	1.123 1.095 2.55	0.784 0.783 0.11	1.090 1.095 -0.41	0.991 0.994 -0.36	0.544 0.535 1.57			
C			0.488 0.492 -0.65	1.099 1.097 0.14	1.298 1.276 1.74	1.254 1.232 1.79	1.014 0.997 1.73	1.247 1.232 1.24	1.269 1.276 1.02	1.114 1.097 1.57	0.502 0.492 1.99		
D		0.539 0.537 0.50	1.105 1.100 0.45	1.061 1.059 0.18	1.219 1.217 0.14	1.116 1.109 0.64	1.161 1.153 0.69	1.123 1.109 1.27	1.229 1.217 1.02	1.074 1.059 1.39	1.117 1.100 1.53	0.548 0.537 1.99	
E		1.012 0.997 1.61	1.301 1.280 1.61	1.217 1.223 -0.49	1.119 1.126 -0.60	1.276 1.279 -0.04	1.258 1.259 -0.10	1.281 1.279 0.20	1.125 1.126 -0.10	1.236 1.223 1.04	1.307 1.260 2.09	1.028 0.997 3.18	
F	0.335 0.332 0.67	1.106 1.098 0.88	1.250 1.236 0.94	1.110 1.115 -0.45	1.279 1.291 -0.95	1.139 1.157 -1.56	1.246 1.285 -1.34	1.139 1.157 -1.56	1.261 1.291 -0.74	1.102 1.115 -1.14	1.244 1.238 0.50	1.095 1.098 -0.28	0.334 0.332 0.60
G	0.321 0.326 -1.62	0.777 0.786 -1.16	1.005 1.002 0.25	1.157 1.161 -0.36	1.262 1.274 -0.93	1.253 1.277 -1.91	0.930 0.945 -1.56	1.257 1.277 -1.54	1.254 1.274 -1.59	1.137 1.161 -2.08	0.997 1.002 -0.54	0.762 0.766 -0.50	0.328 0.326 0.37
H	0.326 0.332 -1.78	1.084 1.096 -1.24	1.241 1.238 0.21	1.113 1.115 -0.18	1.282 1.291 -0.69	1.139 1.157 -1.52	1.245 1.265 -1.61	1.139 1.157 -1.60	1.269 1.291 -1.67	1.101 1.115 -1.26	1.225 1.238 -1.03	1.088 1.096 -1.13	0.325 0.332 -1.96
I		0.990 0.997 -0.60	1.290 1.280 0.80	1.224 1.223 0.11	1.113 1.126 -1.16	1.262 1.279 -1.34	1.242 1.259 -1.37	1.262 1.279 -1.37	1.110 1.128 -1.44	1.220 1.223 -0.21	1.265 1.260 0.35	1.009 0.997 1.28	
J		0.548 0.537 2.03	1.125 1.100 2.29	1.072 1.059 1.19	1.225 1.217 0.67	1.093 1.109 -1.41	1.137 1.153 -1.41	1.094 1.109 -1.39	1.203 1.217 -1.15	1.072 1.059 1.27	1.114 1.100 1.28	0.544 0.537 1.29	
K			0.497 0.492 1.14	1.110 1.097 1.15	1.285 1.276 0.69	1.213 1.232 -1.56	0.983 0.997 -1.37	1.230 1.232 -0.16	1.264 1.276 0.60	1.122 1.097 2.25	0.498 0.492 1.30		
L				0.536 0.535 0.52	1.000 0.994 0.59	1.079 1.095 -1.43	0.771 0.783 -1.43	1.093 1.095 -0.16	1.017 0.994 2.25	0.547 0.535 2.28			
M						0.326 0.331 -1.30	0.321 0.325 -1.29	0.332 0.331 0.42					

FLUX MAP 1906

δ= 1.32

6.0 REACTOR STARTUP CALIBRATIONS

6.1 Rod Position Calibration

The rod position indicators are calibrated each refueling in accordance with an approved surveillance procedure. The calibration includes the following:

a) The position signal output is checked at 20 and 200 steps for all rods.

b) The rod bottom lamps are checked to assure that they light at the proper rod height.

c) The control room rod position indicators are calibrated to read correctly at 20 and 200 steps.

d) The pulse-to-analog convertor alignment is checked.

e) The rod bottom bypass bi-stable trip setpoint is checked.

The calibration was performed satisfactorily during the Cycle 19 startup; no problems or abnormalities were encountered and site procedure acceptance criteria were met. At full power an adjustment was made to selected RPI channels to compensate for the temperature increase associated with power ascension.

6.2 Nuclear Instrumentation Calibration

The nuclear instrumentation (NI) calibration was performed in accordance with the Kewaunee Reactor Test Program during the Cycle 19 startup (4). A flux map was performed at approximately 75 percent power. The incore axial offset was determined from the data collected during the map. The NI's were then calibrated with a conservative incore axial offset-to-excore axial offset ratio of 1.7.

7.0 REFERENCES

(1) "Reload Safety Evaluation for Kewaunee Cycle 19," Wisconsin Public Service Corporation, January 1993.

(2) "Qualification of Reactor Physics Methods for Application to Kewaunee," Wisconsin Public Service Corporation, October 1978.

(3) "Reload Safety Evaluation Methods for Application to Kewaunee", WPSRSEM-NP-A, Revision 2, October 1988.

(4) "Reactor Test Program, Kewaunee Nuclear Power Plant," Wisconsin Public Service Corporation, May 1979. (Revision 3, March 1987)

(5) "Generic Mechanical and Thermal Hydraulic Design for Exxon Nuclear 14 x 14 Reload Assemblies with Zircaloy Guide Tubes for Westinghouse 2-Loop Pressurized Water Reactors," Exxon Nuclear Corporation, November 1978.

(6) "Rod Exchange Technique for Rod Worth Measurement" and "Rod Worth Verification Tests Utilizing RCC Bank Interchange," Westinghouse Corporation, May 12, 1978.

(7) "Kewaunee Nuclear Power Plant Technical Specifications," Wisconsin Public Service Corporation, Docket 50-305.