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Kewaunee Nuclear Power Plant
Cycle 14 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 14 Startup Report.

Sincerely,

C. R. Steinhardt
Manager-Nuclear Power

LAS/jms

Enc.

cc - Mr. Robert Nelson, US NRC - w/attach.
US NRC, Region III - w/attach.

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KEWAUNEE NUCLEAR POWER PLANT

CYCLE 14
STARTUP REPORT
JUNE, 1988

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

DOCKET 50-305

KEWAUNEE NUCLEAR POWER PLANT

STARTUP REPORT

CYCLE 14

JUNE 1988

WISCONSIN PUBLIC SERVICE CORPORATION
GREEN BAY, WISCONSIN

IE26
1/1

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1.0 INTRODUCTION, SUMMARY AND CONCLUSION

1.1 Introduction

This report presents the results of the physics tests performed during startup of Kewaunee Cycle 14. 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 13-14 refueling, 40 of the 121 fuel assemblies in the core were replaced with fresh assemblies of Advanced Nuclear Fuels Design(5), enriched to 3.4 w/o U235. The Cycle 14 core consists of the following regions of fuel:

Region	Vendor	Initial U235 W/O	Number of Previous Duty Cycles	Number of Assemblies
10	ANF	3.2	3	1
10	ANF	3.2	3	4
13	ANF	3.4	3	8
13	ANF	3.4	2	4
14	ANF	3.4	2	32
15	ANF	3.4	1	32
16	ANF	3.4	0	40(Feed)

The core loading pattern, assembly identification, RCCA bank identification, instrument thimble I.D., thermo-couple I.D., and burnable poison rod configurations for Cycle 14 are presented in Figure 1.1.

On April 10, 1988 at 2240 hours, initial criticality was achieved on the Cycle 14 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 A, which was measured using the boration/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 A 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 14.

1.3 Conclusion

The startup testing of Kewaunee's Cycle 14 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).

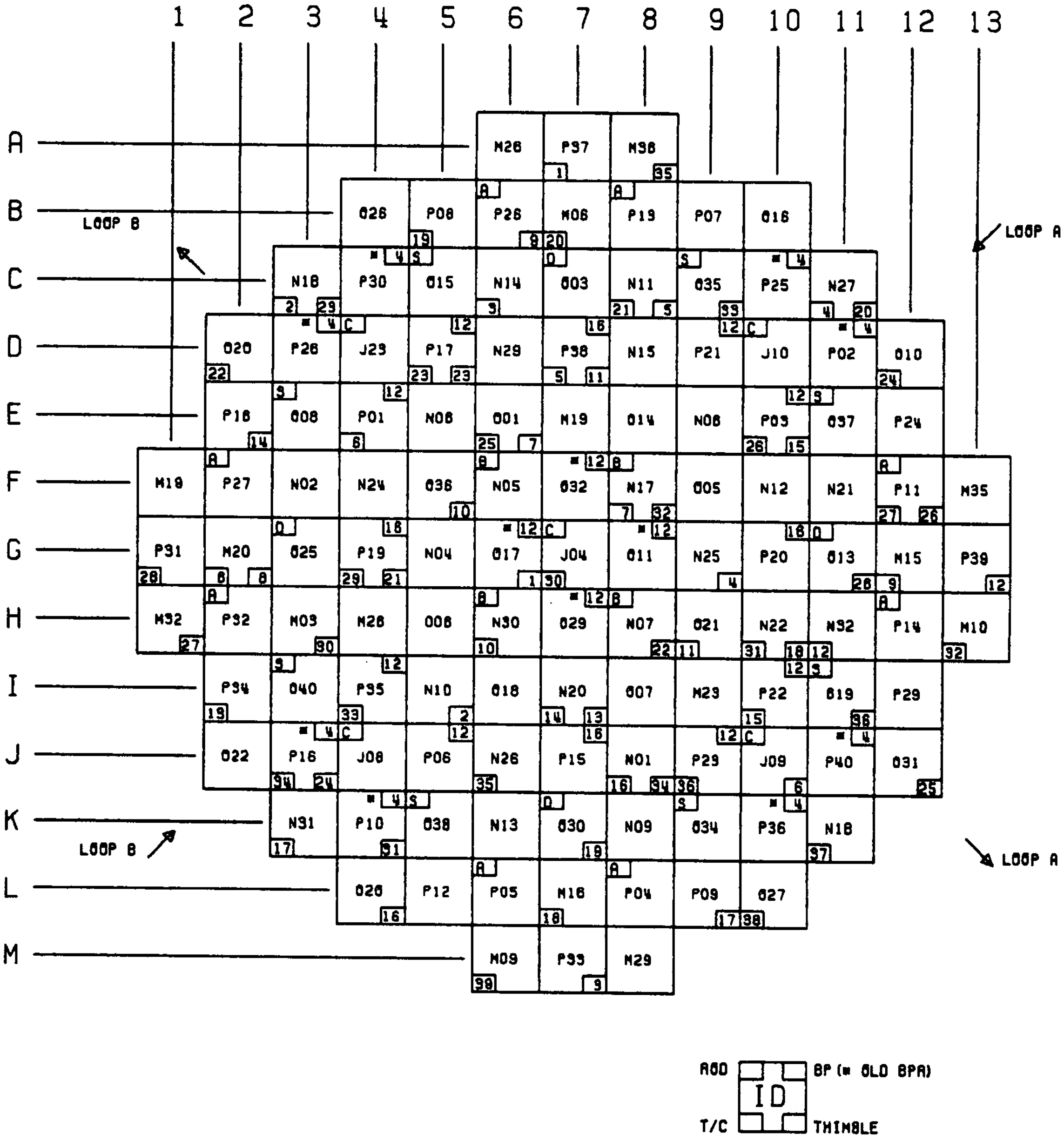
TABLE 1.1

Chronology of Tests

Test	Date Completed	Time Completed	Plant Conditions
Control Rod Operability Test	4/06/88	0825	Cold SD
Hot Rod Drops	4/09/88	2202	HSD
RPI Calibrations	4/10/88	0610	HSD
Initial Criticality	4/10/88	2240	HZP
Reactivity Computer Checkout	4/11/88	0115	HZP
ARO Endpoint	4/11/88	0251	HZP
Bank A Worth (Dilution)	4/11/88	0335	HZP
Bank A In-ORO Endpoint	4/11/88	0527	HZP
Bank A Worth (Boration)	4/11/88	0941	HZP
ITC Determination	4/11/88	1251	HZP
Power Ascension Flux Map 1401	4/14/88	0656	21%
Power Ascension Flux Map 1402	4/15/88	1510	42%
Power Ascension Flux Map 1403	4/18/88	124D	38%
Power Ascension Flux Map 1404	4/21/88	1240	73%
Power Ascension Flux Map 1405	4/21/88	1502	73%
Power Ascension Flux Map 1406	4/21/88	1700	73%
Power Ascension Flux Map 1407	4/21/88	1846	73%
Power Ascension Flux Map 1408	4/24/88	0819	89%
Power Ascension Flux Map 1409	4/26/88	1013	100%

FIGURE 1.1

Core Loading Map



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						M26	P37	M36					
B				026	P08	P26	M06	P13	P07	016			
C			N18	P30	015	N14	003	N11	035	P25	N27		
D		020	P28	J23	P17	N29	P38	N15	P21	J10	P02	010	
E		P18	008	P01	N08	001	M19	014	N06	P03	037	P24	
F	M18	P27	N02	N24	036	N05	032	N17	005	N12	N21	P11	M35
G	P31	M20	025	P19	N04	017	J04	011	N25	P20	013	M15	P39
H	M32	P32	N03	M28	006	N30	029	N07	021	N22	N32	P14	M10
I		P34	040	P35	N10	018	N20	007	M23	P22	019	P29	
J		022	P16	J08	P06	N26	P15	N01	P23	J09	P40	031	
K			N31	P10	038	N13	030	N09	034	P36	N18		
L				026	P12	P05	M16	P04	P09	027			
M						M09	P33	M29					

CYCLE FOURTEEN

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 14 startup the reactivity of the reference bank (Bank A) was measured using the boration/dilution technique and 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 as measured during dilution of the reference bank, Bank A, differed from the WPS predicted Bank A worth by 111 pcm or 11.9 percent, which is outside the 10 percent review criterion. A comparison of the measured to predicted reference bank integral and differential worth is presented in Figures 2.1 and 2.2, respectively.

Rod swap results for the remaining banks are presented in Table 2.2. The measured to predicted total rod worth difference is 9.3 percent which is within the acceptance criteria of 10.0 percent. All individual bank worths adequately met the 15.0 percent measured to predicted review criterion.

As required by the Reactor Test Program (4) the reference bank worth discrepancy was reviewed and the results presented to the Plant Operating Review Committee (PORC meeting 88-071) before reaching 100 percent power. As a result of the review, the Reload Safety Evaluation conclusions were shown to remain valid and no further analyses were required. The excellent agreement of model predictions to boron end point (Section 3.1) and power distribution (Section 5.0) measurements substantiates the model accuracy.

Due to the large, approximately 10 percent, difference between the boration and dilution reference bank worth measurement the rod swap results were reanalyzed with the boration measured reference bank. As shown in Table 2.2 and in Figure 2.2 the rod worth comparisons to predictions are significantly improved. This, coupled with the agreement with boron concentration and power distribution suggests that parameters such as dilution rate may have had an affect on the measurement. Additional sensitivity measurements will be considered during the next refueling startup as schedule permits.

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 14

RCCA Drop Time Measurements

Hot Zero Power

Average Dashpot Delta T (Sec)	1.257
Standard Deviation	0.021
Average Rod Bottom Delta T (Sec)	1.791
Standard Deviation	0.033

TABLE 2.2

Kewaunee Cycle 14
RCCA Bank Worth Summary
Reference Bank Measured by Dilution

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Predicted Worth (PCM)	Difference (PCM)	Percent Difference
D	785.5	736.0	49.5	6.7
C	945.3	889.0	56.3	6.3
B	819.5	714.0	105.5	14.8
A*	1043.8	933.0	110.8	11.9
SA	760.5	704.0	56.5	8.0
SB	761.1	7D4.0	57.1	8.1
Total	5115.7	4680.0	435.7	9.3

* Reference bank

RCCA Bank Worth Summary
Reference Bank Measured by Boration

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Predicted Worth (PCM)	Difference (PCM)	Percent Difference
D	744.1	736.0	8.1	1.1
C	891.0	889.0	2.0	0.2
B	737.5	714.0	23.5	3.3
A*	950.2	933.0	17.2	1.8
SA	726.0	704.0	22.0	3.1
SB	726.7	704.0	22.0	3.2
Total	4775.5	4680.0	95.5	2.0

*Reference bank

FIGURE 2.1

RCCA Bank A Measured by Dilution

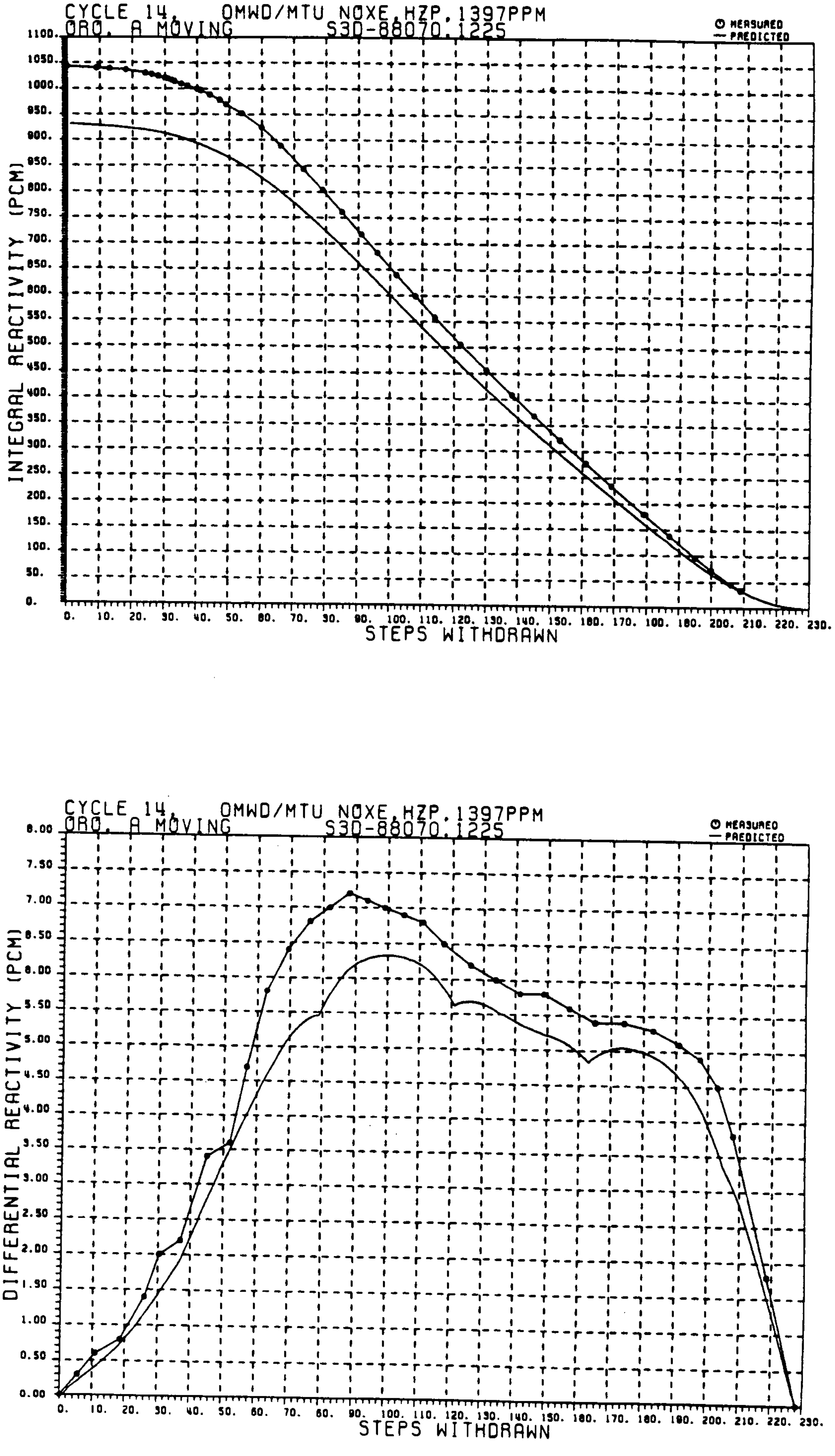
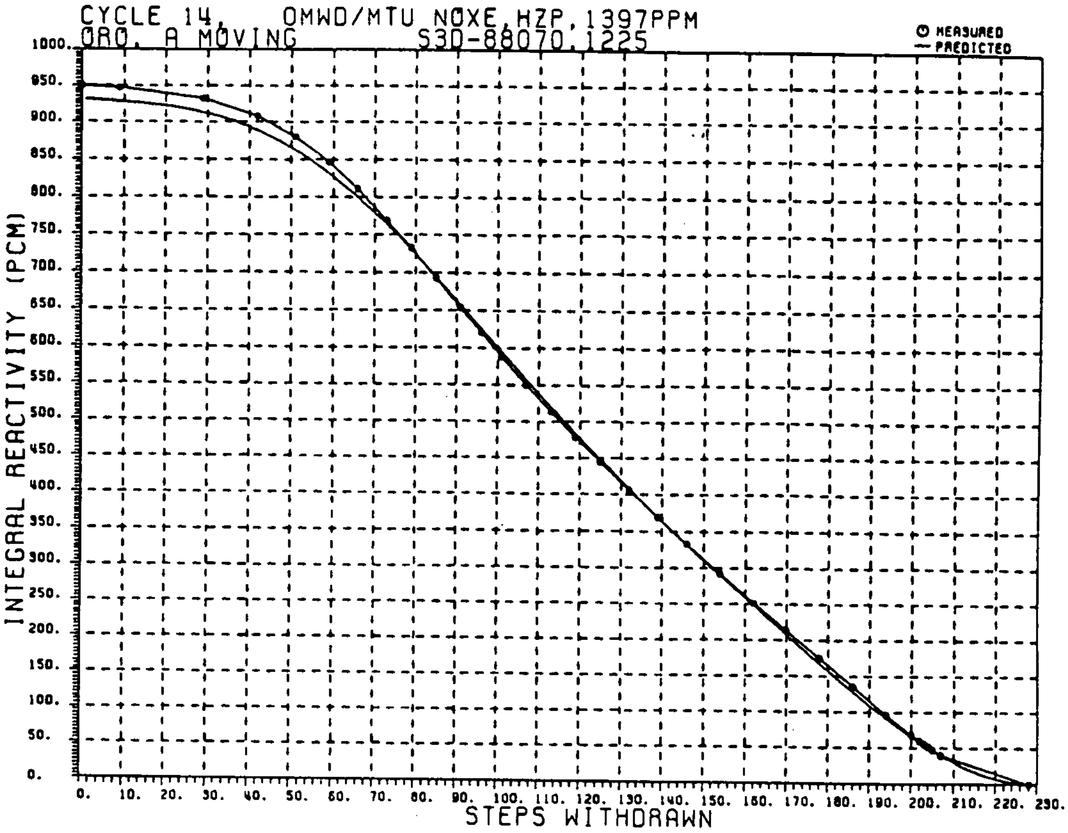


FIGURE 2.2

RCCA Bank A Measured by Boration



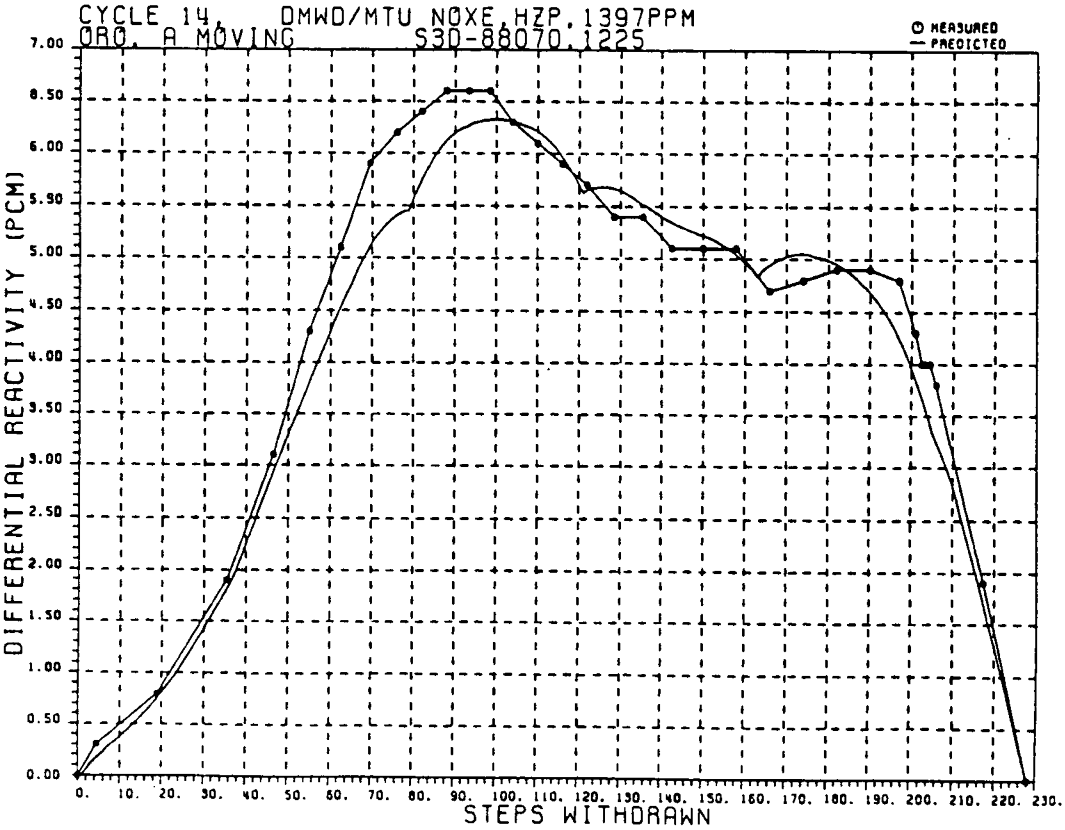


TABLE 2.3

Kewaunee Cycle 14

Minimum Shutdown Margin Analysis

RCCA Bank Worths (PCM)	BOC	EOC
N	6436	6536
N-1	5566	5775
Less 10 Percent	557	578
Subtotal	5009	5197
Total Requirements (Including Uncertainties)	2110	2791
Shutdown Margin	2899	2406
Required Shutdown Margin	1000	2000

3.0 BORON ENDPOINTS AND BORON WORTH MEASUREMENTS

3.1 Boron Endpoints

During rod movements to measure control rod worth and differential boron worth, the dilution was stopped near the fully inserted position of control Bank A to obtain a boron endpoint measurement. The boron concentration was allowed to stabilize and the critical boron concentration was measured for the configuration desired.

Table 3.1 lists the measured and WPS predicted boron endpoints for the RCCA bank configurations shown. The results indicate a difference of 2 ppm and 0 ppm for the ARO and "Bank A In" core configurations, respectively. The acceptance criterion on the all rods out boron endpoint is ±100 PPM, thus, the boron endpoint comparisons are considered acceptable.

3.2 Differential Boron Worth

The differential boron worth was calculated by dividing the worth of control Bank A by the difference in boron endpoint measurement 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 14

RCCA Bank Endpoint Measurements

RCCA Bank Configuration	Measured Endpoint (PPM)	WPS Predicted Endpoint (PPM)	Difference (PPM)
All Rods Out	1456	1454	2
Bank A In	1342	1342	0

TABLE 3.2

Kewaunee Cycle 14

Differential Boron Worth

RCCA Bank Configuration	CB Change Measured (PPM)	CB Change Predicted (PPM)	Percent Difference
ARO to A Bank In	114	112	2.0

RCCA Bank Configuration	Measured Boron Worth (PCM/PPM)	Predicted Boron Worth (PCM/PPM)	Percent Difference
ARO/A Bank In	-9.1	-8.3	9.3

4-28-88 THROUGH 5-31-88

DEPLETION OF CHEM. SHIM
CYCLE 14
KEWAUNEE NUCLEAR POWER PLANT

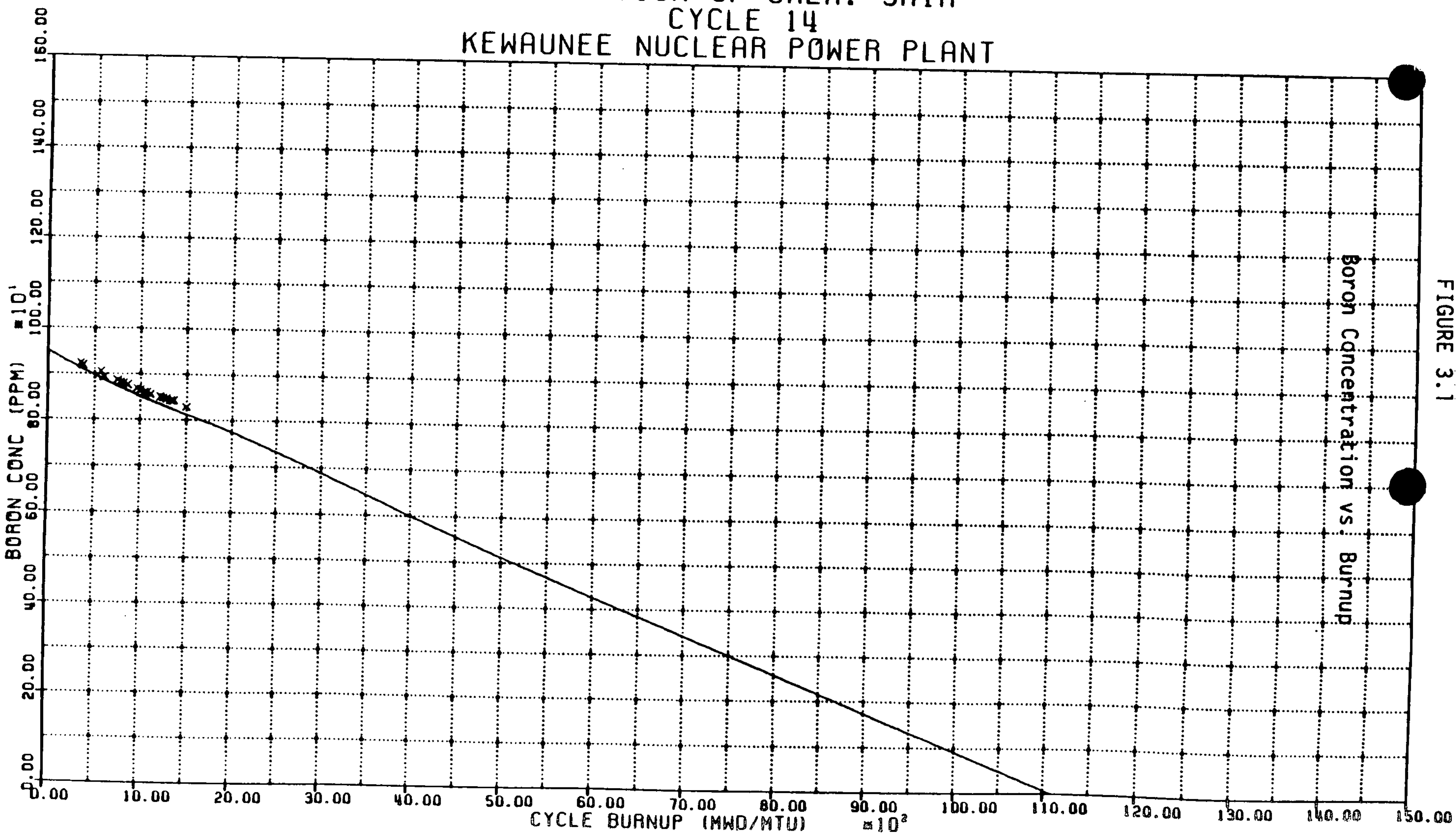


FIGURE 3.1
Boron Concentration vs. Burnup

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 1449 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/Degrees F was met.

TABLE 4.1

Kewaunee Cycle 14

Isothermal Temperature Coefficient

Cooldown

Tave Start - 546.6 Degrees F

Tave End - 541.1 Degrees F

Bank D - 207 Steps

Boron Concentration 1449 PPM

Measured ITC (PCM/Deg F)	WPS Predicted ITC (PCM/Deg F)	Difference (PCM/Deg F)
-3.37	-5.17	1.80

Heat Up

Tave Start - 541.1 Degrees F

Tave End - 545.3 Degrees F

Bank D - 207 Steps

Boron Concentration 1449 PPM

Measured ITC (PCM/Deg F)	WPS Predicted ITC (PCM/Deg F)	Difference (PCM/Deg F)
-3.05	-5.08	2.03

5.0 POWER DISTRIBUTION

5.1 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 FQN 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 14.

Comparisons of measured to predicted power distributions for the flux maps are exhibited in Figures 5.1 through 5.9. As evidenced by these figures the predicted assembly powers in the central region of the core are in very good agreement with the measured assembly powers which differ by only 2 percent in the low power flux maps, 1401 and 1402, and continue to improve to within 1 percent in flux map 1409.

Table 5.2 identifies flux map peak FDHN and minimum margin FQN. This table addresses acceptance criteria by verifying that technical specification limits are not exceeded. The Cycle 14 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 14 flux maps.

TABLE 5.1

Flux Map Chronology and Reactor Characteristics

Map	Date	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MWD/MTU
1401	4/14/88	21	EQ.	1399	169	2
1402	4/15/88	42	EQ.	1196	180	17
1403	4/18/88	38	EQ.	1126	182	57
1404	4/21/88	73	EQ.	1050	208	114
1405	4/21/88	73	EQ.	1050	196	116
1406	4/21/88	73	EQ.	1050	193	118
1407	4/21/88	73	EQ.	1050	188	120
1408	4/24/88	89	EQ.	986	205	195
1409	4/26/88	100	EQ.	937	228	267

TABLE 5.2

Verification of Acceptance Criteria

Flux Map	Core Location	FQN	Limit
1401	B-06 EK,24	2.40	4.38
1402	E-06 KE,26	2.18	4.37
1403	E-08 DE,30	2.18	4.37
1404	F-09 JK,26	2.06	2.96
1405	I-08 DJ,31	2.08	3.01
1406	E-06 KE,31	2.11	3.03
1407	B-06 EK,37	2.13	3.05
1408	F-05 EK,30	2.06	2.49
1409	E-06 KE,32	2.01	2.24

Flux Map	Core Location	FDHN	Limit
1401	G-06 HG	1.57	1.79
1402	I-06 KJ	1.53	1.73
1403	E-06 KE	1.53	1.74
1404	F-05 EK	1.50	1.63
1405	F-05 EK	1.51	1.63
1406	F-05 EK	1.51	1.63
1407	F-05 EK	1.51	1.63
1408	F-05 EK	1.51	1.58
1409	I-08 DJ	1.50	1.55

FQN and FDHN include appropriate uncertainties and penalties.

Limit on FQN is a function of core power, axial location, and rod exposure.

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
1401	3.8	2.7	1.5
1402	2.8	2.2	1.1
1403	2.5	2.0	0.4
1404	1.3	1.8	0.6
1405	1.5	1.7	0.5
1406	1.3	1.9	0.6
1407	1.5	2.0	0.7
1408	1.4	1.8	0.6
1409	0.6	1.7	0.6

(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 1401

LOOP B

LOO

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.348 0.331 5.17	0.616 0.594 3.72	0.339 0.331 2.39					
B				0.533 0.545 -2.09	1.059 1.007 5.16	1.197 1.138 5.16	0.871 0.850 2.49	1.135 1.138 -0.23	1.004 1.007 -0.33	0.535 0.545 -1.80			
C			0.472 0.482 -2.10	1.154 1.165 -0.95	1.245 1.213 2.64	0.997 0.985 1.22	1.083 1.073 0.94	0.969 0.985 -1.64	1.193 1.213 -1.68	1.144 1.165 -1.81	0.479 0.482 -0.60		
D		0.541 0.545 -0.64	1.157 1.165 -0.73	0.924 0.933 -0.89	1.226 1.208 1.52	1.167 1.162 0.45	1.125 1.123 0.18	1.142 1.162 -1.69	1.196 1.208 -0.99	0.923 0.933 -1.07	1.163 1.165 -0.15	0.541 0.545 -0.61	
E		1.014 1.007 0.71	1.223 1.214 0.71	1.245 1.208 3.01	1.119 1.086 3.02	1.354 1.330 1.83	1.120 1.115 0.44	1.319 1.330 -0.83	1.089 1.086 0.27	1.212 1.208 0.33	1.210 1.214 -0.33	0.997 1.007 -1.02	
F	0.331 0.331 0.18	1.140 1.138 0.17	0.980 0.985 -0.54	1.184 1.162 1.91	1.363 1.330 2.49	1.278 1.232 3.76	1.353 1.328 1.87	1.250 1.232 1.47	1.346 1.330 1.19	1.153 1.162 -0.75	0.964 0.985 -2.13	1.104 1.138 -3.00	0.324 0.331 -1.91
G	0.611 0.594 2.95	0.861 0.850 1.27	1.059 1.073 -1.36	1.129 1.123 0.53	1.139 1.115 2.11	1.381 1.328 3.98	1.068 1.058 0.97	1.343 1.328 1.11	1.128 1.115 1.12	1.116 1.123 -0.61	1.050 1.073 -2.13	0.824 0.850 -3.12	0.582 0.594 -1.99
H	0.341 0.331 3.27	1.154 1.138 1.38	0.972 0.985 -1.38	1.143 1.162 -1.63	1.327 1.330 -0.23	1.244 1.232 0.95	1.346 1.328 1.35	1.250 1.232 1.44	1.347 1.330 1.31	1.148 1.162 -1.25	0.958 0.985 -2.76	1.093 1.138 -3.95	0.322 0.331 -2.75
I		1.017 1.007 0.98	1.194 1.214 -1.65	1.190 1.208 -1.49	1.073 1.086 -1.21	1.332 1.330 0.14	1.121 1.115 0.52	1.336 1.330 0.46	1.090 1.086 0.34	1.200 1.208 -0.70	1.213 1.214 -0.06	1.002 1.007 -0.52	
J		0.536 0.545 -1.52	1.144 1.165 -1.78	0.918 0.933 -1.61	1.189 1.208 -1.62	1.141 1.162 -1.85	1.106 1.123 -1.53	1.145 1.162 -1.45	1.211 1.208 0.21	0.921 0.933 -1.27	1.164 1.165 -0.13	0.543 0.545 -0.26	
K			0.478 0.482 -0.85	1.155 1.165 -0.87	1.207 1.213 -0.50	0.928 0.985 -5.79	1.038 1.073 -3.25	0.972 0.985 -1.38	1.223 1.213 0.84	1.181 1.165 1.33	0.489 0.482 1.58		
L				0.543 0.545 -0.37	1.003 1.007 -0.43	1.108 1.138 -2.62	0.828 0.850 -2.61	1.127 1.138 -1.01	1.028 1.007 2.04	0.556 0.545 2.04			
M						0.332 0.331 0.54	0.597 0.594 0.52	0.335 0.331 1.27					

LOOP B

LOO

MEASURED FDHN

PREDICTED FDHN

PERCENT DIFFERENCE

FLUX MAP 1401

δ= 1.90

FIGURE 5.2

Power Distribution for Flux Map 1402

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.357 0.342 4.30	0.639 0.613 4.29	0.357 0.342 4.30					
B				0.543 0.551 -1.38	1.039 1.011 2.74	1.140 1.147 -0.59	0.904 0.867 4.29	1.160 1.147 1.15	1.021 1.011 0.99	0.551 0.551 0.13			
C			0.480 0.487 -1.38	1.167 1.160 0.64	1.241 1.208 2.73	1.007 0.996 1.06	1.094 1.100 -0.59	0.982 0.996 -1.38	1.182 1.208 -2.11	1.181 1.160 0.13	0.498 0.487 2.36		
D		0.549 0.551 -0.24	1.157 1.160 -0.29	0.940 0.933 0.74	1.227 1.194 2.74	1.169 1.157 1.06	1.111 1.118 -0.59	1.142 1.157 -1.33	1.184 1.194 -0.86	0.935 0.933 0.24	1.177 1.160 1.42	0.564 0.551 2.36	
E		1.019 1.011 0.83	1.218 1.208 0.83	1.227 1.194 2.74	1.108 1.079 2.73	1.329 1.315 1.06	1.102 1.108 -0.53	1.308 1.315 -0.52	1.079 1.079 0.00	1.199 1.194 0.44	1.210 1.208 0.14	1.009 1.011 -0.18	
F	0.345 0.342 0.82	1.156 1.147 0.83	1.002 0.996 0.54	1.180 1.157 0.27	1.333 1.315 1.33	1.246 1.217 2.40	1.317 1.305 0.93	1.211 1.217 -0.47	1.315 1.315 -0.02	1.131 1.157 -2.21	0.980 0.996 -1.61	1.124 1.147 -2.03	0.339 0.342 -0.73
G	0.622 0.613 1.45	0.866 0.867 -0.16	1.092 1.100 -0.75	1.111 1.118 -0.66	1.123 1.108 1.34	1.336 1.305 2.40	1.062 1.049 1.23	1.313 1.305 0.62	1.112 1.108 0.40	1.090 1.118 -2.51	1.079 1.100 -1.93	0.849 0.867 -2.14	0.608 0.613 -0.78
H	0.347 0.342 1.43	1.145 1.147 -0.17	0.988 0.996 -0.83	1.148 1.157 -0.75	1.333 1.315 1.33	1.241 1.217 1.99	1.330 1.305 1.88	1.237 1.217 1.64	1.326 1.315 0.82	1.128 1.157 -2.54	0.969 0.996 -2.69	1.111 1.147 -3.10	0.337 0.342 -1.29
I		1.013 1.011 0.18	1.203 1.208 -0.46	1.189 1.194 -0.45	1.096 1.079 1.57	1.336 1.315 1.57	1.120 1.108 1.12	1.329 1.315 1.09	1.085 1.079 0.56	1.175 1.194 -1.56	1.207 1.208 -0.12	1.012 1.011 0.13	
J		0.555 0.551 0.85	1.158 1.160 -0.21	0.930 0.933 -0.30	1.177 1.194 -1.44	1.138 1.157 -1.62	1.106 1.118 -1.08	1.145 1.157 -1.01	1.194 1.194 0.02	0.905 0.933 -3.05	1.161 1.160 0.13	0.553 0.551 0.40	
K			0.487 0.487 0.00	1.159 1.160 -0.07	1.203 1.208 -0.44	0.948 0.996 -4.80	1.071 1.100 -2.59	0.983 0.996 -1.33	1.214 1.208 0.46	1.170 1.160 0.89	0.503 0.487 3.29		
L				0.549 0.551 -0.35	1.007 1.011 -0.39	1.092 1.147 -4.80	0.826 0.867 -4.80	1.126 1.147 -1.87	1.020 1.011 0.89	0.556 0.551 0.89			
M						0.325 0.342 -4.80	0.583 0.613 -4.80	0.345 0.342 0.88					

LOOP B

LOOF

LOOP B

LOOF

MEASURED FDHN

PREDICTED FDHN

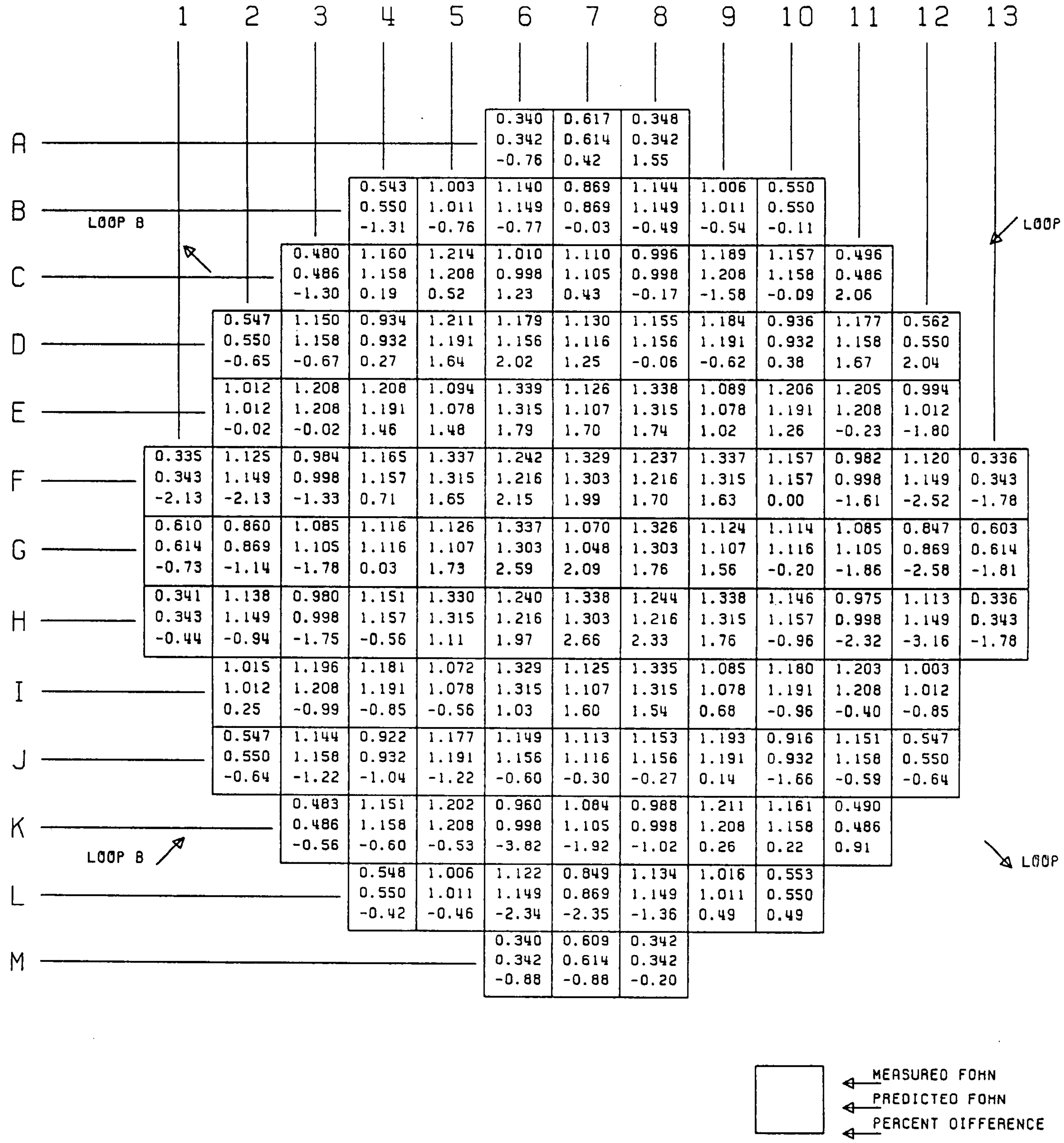
PERCENT DIFFERENCE

FLUX MAP 1402

δ= 1.84

FIGURE 5.3

Power Distribution for Flux Map 1403



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.340 0.342 -0.76	0.617 0.614 0.42	0.348 0.342 1.55					
B				0.543 0.550 -1.31	1.003 1.011 -0.76	1.140 1.149 -0.77	0.869 0.869 -0.03	1.144 1.149 -0.49	1.006 1.011 -0.54	0.550 0.550 -0.11			
C			0.480 0.486 -1.30	1.160 1.158 0.19	1.214 1.208 0.52	1.010 0.998 1.23	1.110 1.105 0.43	0.996 0.998 -0.17	1.189 1.208 -1.58	1.157 1.158 -0.09	0.496 0.486 2.06		
D		0.547 0.550 -0.65	1.150 1.158 -0.67	0.934 0.932 0.27	1.211 1.191 1.64	1.179 1.156 2.02	1.130 1.116 1.25	1.155 1.156 -0.06	1.184 1.191 -0.62	0.936 0.932 0.38	1.177 1.158 1.67	0.562 0.550 2.04	
E		1.012 1.012 -0.02	1.208 1.208 -0.02	1.208 1.191 1.46	1.094 1.078 1.48	1.339 1.315 1.79	1.126 1.107 1.70	1.338 1.315 1.74	1.089 1.078 1.02	1.206 1.191 1.26	1.205 1.208 -0.23	0.994 1.012 -1.80	
F	0.335 0.343 -2.13	1.125 1.149 -2.13	0.984 0.998 -1.33	1.165 1.157 0.71	1.337 1.315 1.65	1.242 1.216 2.15	1.329 1.303 1.99	1.237 1.216 1.70	1.337 1.315 1.63	1.157 1.157 0.00	0.982 0.998 -1.61	1.120 1.149 -2.52	0.336 0.343 -1.78
G	0.610 0.614 -0.73	0.860 0.869 -1.14	1.085 1.105 -1.78	1.116 1.116 0.03	1.126 1.107 1.73	1.337 1.303 2.59	1.070 1.048 2.09	1.326 1.303 1.76	1.124 1.107 1.56	1.114 1.116 -0.20	1.085 1.105 -1.86	0.847 0.869 -2.58	0.603 0.614 -1.81
H	0.341 0.343 -0.44	1.138 1.149 -0.94	0.980 0.998 -1.75	1.151 1.157 -0.56	1.330 1.315 1.11	1.240 1.216 1.97	1.338 1.303 2.66	1.244 1.216 2.33	1.338 1.315 1.76	1.146 1.157 -0.96	0.975 0.998 -2.32	1.113 1.149 -3.16	0.336 0.343 -1.78
I		1.015 1.012 0.25	1.196 1.208 -0.99	1.181 1.191 -0.85	1.072 1.078 -0.56	1.329 1.315 1.03	1.125 1.107 1.60	1.335 1.315 1.54	1.085 1.078 0.68	1.180 1.191 -0.96	1.203 1.208 -0.40	1.003 1.012 -0.85	
J		0.547 0.550 -0.64	1.144 1.158 -1.22	0.922 0.932 -1.04	1.177 1.191 -1.22	1.149 1.156 -0.60	1.113 1.116 -0.30	1.153 1.156 -0.27	1.193 1.191 0.14	0.916 0.932 -1.66	1.151 1.158 -0.59	0.547 0.550 -0.64	
K			0.483 0.486 -0.56	1.151 1.158 -0.60	1.202 1.208 -0.53	0.960 0.998 -3.82	1.084 1.105 -1.92	0.988 0.998 -1.02	1.211 1.208 0.26	1.161 1.158 0.22	0.490 0.486 0.91		
L				0.548 0.550 -0.42	1.006 1.011 -0.46	1.122 1.149 -2.34	0.849 0.869 -2.35	1.134 1.149 -1.36	1.016 1.011 0.49	0.553 0.550 0.49			
M						0.340 0.342 -0.88	0.609 0.614 -0.88	0.342 0.342 -0.20					

FLUX MAP 1403

δ= 1.38

FIGURE 5.4

Power Distribution for Flux Map 1404

LOOP B

LOOP

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.358 0.354 1.10	0.646 0.632 2.25	0.365 0.354 3.34					
B				0.546 0.551 -1.02	1.013 1.002 1.09	1.160 1.147 1.08	0.902 0.892 1.14	1.152 1.147 0.43	1.008 1.002 0.38	0.554 0.551 0.53			
C			0.482 0.487 -1.01	1.140 1.136 0.37	1.213 1.195 1.46	1.024 1.016 0.76	1.155 1.157 -0.22	1.007 1.016 -0.93	1.183 1.195 -1.05	1.142 1.136 0.53	0.498 0.487 2.11		
D		0.553 0.552 0.33	1.139 1.136 0.26	0.932 0.928 0.45	1.199 1.179 1.67	1.168 1.158 0.89	1.129 1.130 -0.09	1.148 1.158 -0.91	1.173 1.179 -0.52	0.933 0.928 0.54	1.151 1.136 1.36	0.583 0.552 2.12	
E		1.018 1.002 1.60	1.214 1.195 1.60	1.194 1.179 1.26	1.088 1.074 1.33	1.313 1.302 0.87	1.114 1.109 0.45	1.301 1.302 -0.05	1.080 1.074 0.53	1.186 1.179 0.56	1.200 1.195 0.42	1.005 1.002 0.28	
F	0.349 0.354 -1.24	1.133 1.147 -1.25	1.006 1.016 -1.03	1.159 1.158 0.04	1.317 1.302 1.14	1.229 1.208 1.75	1.311 1.289 1.67	1.221 1.208 1.07	1.314 1.302 0.94	1.152 1.158 -0.50	1.006 1.016 -1.02	1.130 1.147 -1.45	0.352 0.354 -0.42
G	0.626 0.632 -1.01	0.879 0.892 -1.46	1.132 1.157 -2.18	1.123 1.130 -0.59	1.121 1.109 1.05	1.315 1.289 1.99	1.065 1.049 1.53	1.303 1.289 1.06	1.116 1.109 0.61	1.119 1.130 -1.02	1.138 1.157 -1.62	0.878 0.892 -1.55	0.629 0.632 -0.49
H	0.351 0.354 -0.74	1.132 1.147 -1.30	0.994 1.016 -2.16	1.145 1.158 -1.11	1.309 1.302 0.51	1.220 1.208 1.02	1.309 1.289 1.55	1.222 1.208 1.13	1.310 1.302 0.58	1.144 1.158 -1.25	0.993 1.016 -2.25	1.120 1.147 -2.32	0.350 0.354 -1.13
I		1.002 1.002 -0.03	1.183 1.195 -1.05	1.168 1.179 -0.98	1.065 1.074 -0.84	1.301 1.302 -0.05	1.117 1.109 0.71	1.311 1.302 0.71	1.074 1.074 0.03	1.166 1.179 -1.09	1.192 1.195 -0.25	1.005 1.002 0.29	
J		0.550 0.552 -0.24	1.134 1.136 -0.16	0.924 0.928 -0.37	1.174 1.179 -0.46	1.143 1.158 -1.34	1.120 1.130 -0.90	1.149 1.158 -0.82	1.180 1.179 0.07	0.918 0.928 -1.09	1.137 1.136 0.09	0.554 0.552 0.49	
K			0.487 0.487 0.04	1.137 1.136 0.04	1.197 1.195 0.17	0.977 1.016 -3.88	1.135 1.157 -1.89	1.006 1.016 -0.95	1.198 1.195 0.26	1.138 1.136 0.15	0.493 0.487 1.13		
L				0.553 0.551 0.20	1.004 1.002 0.18	1.125 1.147 -1.91	0.875 0.892 -1.91	1.135 1.147 -1.03	1.009 1.002 0.64	0.555 0.551 0.65			
M						0.354 0.354 0.06	0.632 0.632 0.05	0.355 0.354 0.34					

LOOP B

LOOP

MEASURED FDHN

PREDICTED FDHN

PERCENT DIFFERENCE

FLUX MAP 1404

δ= 1.16

FIGURE 5.5

Power Distribution for Flux Map 1405

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.354 0.353 0.31	0.641 0.630 1.87	0.364 0.353 3.35					
B				0.553 0.553 0.04	1.006 1.003 0.32	1.148 1.144 0.31	0.893 0.886 0.80	1.150 1.144 0.49	1.007 1.003 0.45	0.557 0.553 0.78			
C			0.489 0.489 0.04	1.147 1.140 0.64	1.206 1.196 0.80	1.012 1.011 0.13	1.130 1.138 -0.72	1.000 1.011 -1.04	1.185 1.196 -0.94	1.149 1.140 0.78	0.500 0.489 2.25		
D		0.557 0.553 0.74	1.148 1.140 0.71	0.937 0.931 0.67	1.196 1.182 1.16	1.162 1.158 0.36	1.120 1.126 -0.51	1.146 1.158 -1.04	1.176 1.182 -0.50	0.937 0.931 0.64	1.155 1.140 1.35	0.565 0.553 2.28	
E		1.017 1.003 1.43	1.213 1.196 1.42	1.194 1.182 1.05	1.088 1.077 1.04	1.313 1.306 0.51	1.114 1.112 0.21	1.304 1.306 -0.17	1.083 1.077 0.60	1.187 1.182 0.41	1.198 1.196 0.15	1.002 1.003 -0.12	
F	0.348 0.353 -1.42	1.128 1.144 -1.42	1.000 1.011 -1.06	1.161 1.158 0.25	1.321 1.306 1.12	1.233 1.213 1.62	1.316 1.295 1.60	1.227 1.213 1.15	1.318 1.306 0.93	1.152 1.158 -0.54	0.999 1.011 -1.14	1.129 1.144 -1.34	0.351 0.353 -0.31
G	0.623 0.630 -1.08	0.873 0.886 -1.41	1.115 1.138 -2.04	1.122 1.126 -0.36	1.125 1.112 1.17	1.321 1.295 2.01	1.071 1.054 1.57	1.309 1.295 1.07	1.120 1.112 0.69	1.116 1.126 -0.91	1.120 1.138 -1.58	0.873 0.886 -1.41	0.628 0.630 -0.33
H	0.350 0.353 -0.79	1.130 1.144 -1.23	0.991 1.011 -2.02	1.145 1.158 -1.14	1.311 1.306 0.34	1.223 1.213 0.84	1.316 1.295 1.58	1.226 1.213 1.11	1.314 1.306 0.60	1.144 1.158 -1.17	0.990 1.011 -2.10	1.120 1.144 -2.05	0.351 0.353 -0.51
I		1.005 1.003 0.24	1.188 1.196 -0.68	1.170 1.182 -0.97	1.061 1.077 -1.53	1.302 1.306 -0.28	1.122 1.112 0.93	1.318 1.306 0.93	1.079 1.077 0.16	1.169 1.182 -1.07	1.193 1.196 -0.28	1.005 1.003 0.17	
J		0.554 0.553 0.20	1.142 1.140 0.13	0.927 0.931 -0.41	1.173 1.182 -0.75	1.143 1.158 -1.30	1.121 1.126 -0.48	1.153 1.158 -0.40	1.184 1.182 0.19	0.919 0.931 -1.24	1.139 1.140 -0.06	0.555 0.553 0.36	
K			0.490 0.489 0.27	1.143 1.140 0.27	1.200 1.196 0.31	0.977 1.011 -3.33	1.122 1.138 -1.38	1.005 1.011 -0.54	1.201 1.196 0.42	1.142 1.140 0.13	0.493 0.489 0.92		
L				0.555 0.553 0.34	1.006 1.003 0.33	1.124 1.144 -1.72	0.870 0.886 -1.73	1.134 1.144 -0.84	1.011 1.003 0.83	0.558 0.553 0.83			
M						0.352 0.353 -0.14	0.629 0.630 -0.13	0.354 0.353 0.34					

LOOP B

LOOP

LOOP B

LOOP

☐ ← MEASURED FDHN
← PREDICTED FDHN
← PERCENT DIFFERENCE

FLUX MAP 1405

δ= 1.08

FIGURE 5.6

Power Distribution for Flux Map 1406

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.356 0.353 0.94	0.640 0.630 1.68	0.361 0.353 2.41					
B				0.550 0.553 -0.58	1.012 1.003 0.93	1.155 1.144 0.93	0.890 0.886 0.54	1.142 1.144 -0.16	1.001 1.003 -0.20	0.556 0.553 0.60			
C			0.486 0.489 -0.57	1.146 1.140 0.53	1.212 1.196 1.30	1.017 1.011 0.59	1.132 1.138 -0.55	0.998 1.011 -1.27	1.179 1.196 -1.45	1.147 1.140 0.61	0.501 0.489 2.41		
D		0.555 0.553 0.45	1.144 1.140 0.39	0.936 0.931 0.58	1.203 1.182 1.78	1.169 1.158 0.92	1.123 1.126 -0.23	1.144 1.158 -1.23	1.172 1.182 -0.80	0.936 0.931 0.57	1.157 1.140 1.47	0.566 0.553 2.41	
E		1.017 1.003 1.42	1.213 1.195 1.42	1.199 1.182 1.46	1.094 1.077 1.61	1.320 1.306 1.04	1.118 1.112 0.49	1.303 1.306 -0.20	1.082 1.077 0.43	1.188 1.182 0.50	1.200 1.196 0.33	1.005 1.003 0.17	
F	0.348 0.353 -1.42	1.128 1.144 -1.42	0.998 1.011 -1.28	1.159 1.158 0.12	1.324 1.306 1.36	1.239 1.213 2.15	1.319 1.295 1.83	1.228 1.213 1.21	1.319 1.306 1.03	1.150 1.158 -0.66	0.997 1.011 -1.39	1.122 1.144 -1.89	0.350 0.353 -0.65
G	0.624 0.630 -0.91	0.872 0.886 -1.55	1.109 1.138 -2.50	1.118 1.126 -0.71	1.125 1.112 1.19	1.326 1.295 2.36	1.071 1.054 1.58	1.311 1.295 1.20	1.122 1.112 0.87	1.115 1.126 -0.97	1.117 1.138 -1.83	0.868 0.886 -2.02	0.625 0.630 -0.73
H	0.350 0.353 -0.62	1.128 1.144 -1.37	0.986 1.011 -2.50	1.140 1.158 -1.59	1.309 1.306 0.25	1.225 1.213 1.00	1.318 1.295 1.75	1.230 1.213 1.40	1.318 1.306 0.95	1.143 1.158 -1.27	0.986 1.011 -2.47	1.111 1.144 -2.85	0.347 0.353 -1.47
I		1.005 1.003 0.22	1.186 1.196 -0.87	1.169 1.182 -1.07	1.061 1.077 -1.45	1.303 1.306 -0.20	1.121 1.112 0.81	1.316 1.306 0.80	1.080 1.077 0.23	1.171 1.182 -0.91	1.196 1.196 -0.02	1.007 1.003 0.39	
J		0.556 0.553 0.56	1.141 1.140 0.10	0.927 0.931 -0.43	1.171 1.182 -0.96	1.142 1.158 -1.36	1.117 1.126 -0.76	1.150 1.158 -0.70	1.184 1.182 0.14	0.920 0.931 -1.10	1.143 1.140 0.25	0.556 0.553 0.61	
K			0.491 0.489 0.45	1.145 1.140 0.42	1.201 1.196 0.38	0.974 1.011 -3.65	1.117 1.138 -1.83	1.004 1.011 -0.68	1.203 1.196 0.55	1.147 1.140 0.63	0.496 0.489 1.51		
L				0.555 0.553 0.45	1.007 1.003 0.43	1.122 1.144 -1.94	0.868 0.886 -1.93	1.135 1.144 -0.80	1.017 1.003 1.35	0.560 0.553 1.34			
M						0.352 0.353 -0.23	0.628 0.630 -0.24	0.354 0.353 0.54					

LOOP B

LOOP

LOOP B

LOOP

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 1406

δ = 1.25

FIGURE 5.7

Power Distribution for Flux Map 1407

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.356 0.353 0.91	0.640 0.630 1.68	0.361 0.353 2.41					
B				0.550 0.553 -0.45	1.012 1.003 0.92	1.155 1.144 0.92	0.892 0.886 0.75	1.144 1.144 -0.01	1.002 1.003 -0.05	0.555 0.553 0.47			
C			0.487 0.489 -0.45	1.145 1.140 0.47	1.210 1.196 1.19	1.016 1.011 0.47	1.134 1.138 -0.40	0.999 1.011 -1.14	1.181 1.196 -1.25	1.145 1.140 0.47	0.500 0.489 2.31		
D		0.557 0.553 0.67	1.147 1.140 0.61	0.936 0.931 0.52	1.200 1.182 1.49	1.166 1.158 0.68	1.124 1.126 -0.20	1.145 1.158 -1.13	1.177 1.182 -0.39	0.938 0.931 0.76	1.161 1.140 1.82	0.566 0.553 2.30	
E		1.020 1.003 1.73	1.217 1.196 1.73	1.200 1.182 1.52	1.094 1.077 1.53	1.318 1.306 0.94	1.116 1.112 0.38	1.304 1.306 -0.19	1.087 1.077 0.93	1.198 1.182 1.33	1.203 1.196 0.57	1.001 1.003 -0.22	
F	0.348 0.353 -1.19	1.130 1.144 -1.18	1.000 1.011 -1.13	1.161 1.158 0.29	1.324 1.306 1.36	1.239 1.213 2.14	1.318 1.295 1.75	1.227 1.213 1.12	1.322 1.306 1.23	1.150 1.158 -0.66	0.997 1.011 -1.43	1.119 1.144 -2.19	0.350 0.353 -0.88
G	0.624 0.630 -0.95	0.871 0.886 -1.68	1.109 1.138 -2.58	1.118 1.126 -0.72	1.126 1.112 1.29	1.327 1.295 2.50	1.072 1.054 1.67	1.310 1.295 1.17	1.123 1.112 1.02	1.115 1.126 -1.00	1.116 1.138 -1.90	0.865 0.886 -2.31	0.624 0.630 -0.92
H	0.350 0.353 -0.68	1.126 1.144 -1.54	0.985 1.011 -2.59	1.138 1.158 -1.71	1.309 1.306 0.25	1.226 1.213 1.06	1.319 1.295 1.85	1.230 1.213 1.39	1.321 1.306 1.13	1.143 1.158 -1.28	0.987 1.011 -2.42	1.109 1.144 -3.05	0.347 0.353 -1.50
I		1.002 1.003 -0.05	1.182 1.196 -1.14	1.167 1.182 -1.23	1.062 1.077 -1.40	1.305 1.306 -0.08	1.122 1.112 0.94	1.318 1.306 0.91	1.082 1.077 0.45	1.174 1.182 -0.72	1.197 1.196 0.08	1.006 1.003 0.28	
J		0.555 0.553 0.38	1.141 1.140 0.04	0.927 0.931 -0.44	1.171 1.182 -0.90	1.140 1.158 -1.59	1.115 1.126 -0.99	1.147 1.158 -0.92	1.184 1.182 0.13	0.920 0.931 -1.17	1.142 1.140 0.14	0.556 0.553 0.51	
K			0.492 0.489 0.53	1.146 1.140 0.51	1.203 1.196 0.59	0.965 1.011 -4.56	1.112 1.138 -2.30	1.002 1.011 -0.92	1.203 1.196 0.61	1.148 1.140 0.68	0.496 0.489 1.43		
L				0.557 0.553 0.67	1.009 1.003 0.64	1.116 1.144 -2.46	0.864 0.886 -2.46	1.132 1.144 -1.08	1.018 1.003 1.52	0.561 0.553 1.52			
M						0.351 0.353 -0.37	0.627 0.630 -0.38	0.354 0.353 0.54					

LOOP B

LOOP B

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 1407

δ = 1.33

FIGURE 5.8
Power Distribution for Flux Map 1408

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.361 0.358 1.01	0.648 0.637 1.77	0.367 0.358 2.52					
B				0.550 0.554 -0.74	1.009 0.999 1.00	1.153 1.141 1.00	0.902 0.894 0.90	1.144 1.141 0.26	1.001 0.999 0.22	0.558 0.554 0.65			
C			0.487 0.490 -0.73	1.134 1.131 0.29	1.204 1.190 1.20	1.021 1.017 0.37	1.148 1.152 -0.39	1.007 1.017 -1.00	1.180 1.190 -0.87	1.138 1.131 0.65	0.501 0.490 2.22		
D		0.556 0.554 0.27	1.133 1.131 0.20	0.934 0.930 0.34	1.194 1.177 1.46	1.165 1.159 0.54	1.127 1.130 -0.25	1.147 1.159 -1.02	1.174 1.177 -0.25	0.937 0.930 0.76	1.149 1.131 1.62	0.567 0.554 2.24	
E		1.011 0.999 1.20	1.204 1.190 1.20	1.195 1.177 1.50	1.094 1.078 1.51	1.313 1.302 0.84	1.117 1.114 0.24	1.297 1.302 -0.38	1.086 1.078 0.74	1.189 1.177 0.99	1.195 1.190 0.43	0.997 0.999 -0.16	
F	0.353 0.358 -1.34	1.126 1.141 -1.36	1.004 1.017 -1.31	1.161 1.159 0.20	1.319 1.302 1.27	1.237 1.212 2.08	1.313 1.291 1.67	1.226 1.212 1.16	1.317 1.302 1.15	1.156 1.159 -0.27	1.007 1.017 -1.03	1.121 1.141 -1.74	0.354 0.358 -0.87
G	0.633 0.637 -0.71	0.882 0.894 -1.38	1.125 1.153 -2.45	1.123 1.130 -0.65	1.127 1.114 1.16	1.322 1.291 2.40	1.073 1.057 1.48	1.305 1.291 1.09	1.123 1.114 0.83	1.123 1.130 -0.66	1.136 1.153 -1.51	0.877 0.894 -1.85	0.631 0.637 -0.94
H	0.356 0.358 -0.42	1.127 1.141 -1.22	0.992 1.017 -2.44	1.141 1.159 -1.57	1.304 1.302 0.18	1.224 1.212 0.96	1.311 1.291 1.58	1.227 1.212 1.22	1.314 1.302 0.88	1.148 1.159 -0.94	0.997 1.017 -1.96	1.113 1.141 -2.43	0.352 0.358 -1.57
I		0.999 0.999 0.01	1.176 1.190 -1.22	1.163 1.177 -1.22	1.065 1.078 -1.22	1.300 1.302 -0.14	1.123 1.114 0.79	1.312 1.302 0.78	1.081 1.078 0.27	1.168 1.177 -0.76	1.190 1.190 0.00	1.002 0.999 0.33	
J		0.553 0.554 -0.18	1.128 1.131 -0.30	0.925 0.930 -0.61	1.167 1.177 -0.84	1.144 1.159 -1.33	1.122 1.130 -0.73	1.151 1.159 -0.66	1.179 1.177 0.19	0.921 0.930 -0.99	1.133 1.131 0.16	0.557 0.554 0.54	
K			0.491 0.490 0.12	1.132 1.131 0.11	1.193 1.190 0.27	0.979 1.017 -3.70	1.132 1.152 -1.75	1.010 1.017 -0.74	1.196 1.190 0.46	1.135 1.131 0.38	0.496 0.490 1.20		
L				0.556 0.554 0.34	1.002 0.999 0.30	1.119 1.141 -1.97	0.876 0.894 -1.97	1.130 1.141 -0.95	1.009 0.999 0.98	0.560 0.554 0.99			
M						0.357 0.358 -0.25	0.635 0.637 -0.27	0.359 0.358 0.36					

LOOP B

LOOP

LOOP B

LOOP

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 1408

δ = 1.17

FIGURE 5.9

Power Distribution for Flux Map 1409

LOOP B

LOOP

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.365 0.362 1.11	0.655 0.643 1.88	0.371 0.362 2.60					
B				0.550 0.554 -0.65	1.006 0.995 1.11	1.154 1.141 1.10	0.910 0.903 0.78	1.144 1.141 0.24	0.997 0.995 0.21	0.558 0.554 0.61			
C			0.487 0.490 -0.65	1.124 1.123 0.12	1.198 1.186 1.01	1.029 1.025 0.41	1.172 1.177 -0.40	1.015 1.025 -0.94	1.175 1.186 -0.93	1.130 1.123 0.61	0.499 0.490 1.75		
D		0.558 0.554 0.70	1.130 1.123 0.64	0.930 0.928 0.16	1.184 1.173 0.95	1.163 1.159 0.36	1.130 1.135 -0.43	1.148 1.159 -0.92	1.169 1.173 -0.34	0.935 0.928 0.71	1.138 1.123 1.33	0.564 0.554 1.75	
E		1.015 0.995 1.99	1.210 1.186 1.99	1.184 1.173 0.98	1.086 1.075 0.99	1.304 1.297 0.55	1.114 1.114 0.00	1.291 1.297 -0.49	1.079 1.075 0.37	1.183 1.173 0.88	1.194 1.186 0.68	1.000 0.995 0.48	
F	0.357 0.362 -1.19	1.127 1.141 -1.20	1.013 1.025 -1.18	1.158 1.159 -0.06	1.309 1.297 0.91	1.226 1.207 1.59	1.300 1.285 1.16	1.212 1.207 0.38	1.304 1.297 0.58	1.153 1.159 -0.54	1.017 1.025 -0.76	1.126 1.141 -1.32	0.360 0.362 -0.39
G	0.636 0.643 -1.14	0.888 0.903 -1.63	1.147 1.177 -2.52	1.126 1.135 -0.76	1.124 1.114 0.88	1.310 1.285 1.96	1.068 1.056 1.11	1.292 1.285 0.51	1.119 1.114 0.48	1.127 1.135 -0.74	1.164 1.177 -1.07	0.890 0.903 -1.44	0.640 0.643 -0.45
H	0.359 0.362 -0.86	1.124 1.141 -1.45	0.999 1.025 -2.50	1.140 1.159 -1.67	1.296 1.297 -0.09	1.214 1.207 0.60	1.302 1.285 1.36	1.217 1.207 0.80	1.306 1.297 0.67	1.149 1.159 -0.85	1.009 1.025 -1.53	1.118 1.141 -2.05	0.357 0.362 -1.24
I		0.997 0.995 0.18	1.177 1.186 -0.76	1.160 1.173 -1.12	1.056 1.075 -1.79	1.290 1.297 -0.51	1.123 1.114 0.77	1.307 1.297 0.77	1.079 1.075 0.40	1.168 1.173 -0.43	1.189 1.186 0.29	1.002 0.995 0.70	
J		0.557 0.554 0.54	1.125 1.123 0.22	0.924 0.928 -0.44	1.161 1.173 -0.99	1.142 1.159 -1.47	1.128 1.135 -0.57	1.153 1.159 -0.49	1.177 1.173 0.31	0.921 0.928 -0.76	1.127 1.123 0.38	0.559 0.554 0.87	
K			0.494 0.490 0.69	1.130 1.123 0.67	1.195 1.186 0.76	0.991 1.025 -3.36	1.160 1.177 -1.41	1.022 1.025 -0.33	1.195 1.186 0.74	1.130 1.123 0.62	0.496 0.490 1.24		
L				0.559 0.554 0.85	1.003 0.995 0.80	1.118 1.141 -1.99	0.885 0.903 -1.98	1.132 1.141 -0.76	1.010 0.995 1.56	0.563 0.554 1.55			
M						0.359 0.362 -0.61	0.639 0.643 -0.62	0.363 0.362 0.44					

LOOP B

LOOP

☐ ← MEASURED FDHN
← PREDICTED FDHN
← PERCENT DIFFERENCE

FLUX MAP 1409

δ = 1.10

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 14 startup; no problems or anomalies 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 14 startup (4). Several flux maps were performed over a range of axial offsets at approximately 70 percent power. The incore axial offset to excore axial offset ratio was generated for each detector from the data collected during the mappings. These ratios agreed well with previous results. 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 14," Wisconsin Public Service Corporation, December, 1986.

(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," Wisconsin Public Service Corporation, February, 1979. (Revision 1, February, 1987)

(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.

(8) "Cycle 13 Startup Report", "Wisconsin Public Service Corporation, May, 1987.