CATEGORY 1

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9903110109 DOC.DATE: ~~99/02/17~~ NOTARIZED: NO DOCKET #
FACIL:50-305 Kewaunee Nuclear Power Plant, Wisconsin Public Servic 05000305
AUTH.NAME AUTHOR AFFILIATION
MARCHI,M.L. Wisconsin Public Service Corp.
RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: "Kewaunee NPP Cycle 23 Startup Rept." With 990301 ltr.

DISTRIBUTION CODE: IE26D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 40
TITLE: Startup Report/Refueling Report (per Tech Specs)

NOTES:

	RECIPIENT	COPIES		RECIPIENT	COPIES	
	ID CODE/NAME	LTTR	ENCL	ID CODE/NAME	LTTR	ENCL
	PD3-3 PD	1	1	LONG,W	1	1
INTERNAL:	ACRS	1	1	FILE CENTER	1	1
	NRR/DSSA/SRXB/B	1	1	RGN3 FILE 01	1	1
EXTERNAL:	NOAC	1	1	NRC PDR	1	1

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE. TO HAVE YOUR NAME OR ORGANIZATION REMOVED FROM DISTRIBUTION LISTS OR REDUCE THE NUMBER OF COPIES RECEIVED BY YOU OR YOUR ORGANIZATION, CONTACT THE DOCUMENT CONTROL DESK (DCD) ON EXTENSION 415-2083

TOTAL NUMBER OF COPIES REQUIRED: LTTR 8 ENCL 8

CATEGORY 1 DOCUMENT

NRC-99-015

Public Service

Wisconsin Public Service Corporation
(a subsidiary of WPS Resources Corporation)
700 North Adams Street
P.O. Box 19002
Green Bay, WI 54307-9002

March 1, 1999

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

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Cycle 23 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 23 Startup Report.

Sincerely,

Mark L. Marchi
Vice President-Nuclear

MJT/jmf

Enc.

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

IE26

KEWAUNEE NUCLEAR POWER PLANT

CYCLE 23
STARTUP REPORT
FEBRUARY 1999

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

DOCKET 50-305

KEWAUNEE NUCLEAR POWER PLANT

STARTUP REPORT

CYCLE 23

February 1999

WISCONSIN PUBLIC SERVICE CORPORATION

GREEN BAY, WISCONSIN

KEWAUNEE NUCLEAR POWER PLANT

STARTUP REPORT

CYCLE 23

FEBRUARY 1999

Prepared By: J. J. ______________________ Date: 2-10-99
Nuclear Fuel Engineer

Prepared By: Thomas R ______________________ Date: 2-10-99
Senior Nuclear Fuel Technician

Reviewed By: Michael S Ronski ______________________ Date: 2.11.99
Lead Plant Reactor Engineer

Reviewed By: J T Holly ______________________ Date: 2-10-99
Nuclear Fuel Analysis Supervisor

Reviewed By: ______________________ Date: 2/10/99
Manager-Nuclear Fuel

Reviewed By: Tom G Webb ______________________ Date: 2.17.99
Nuclear Licensing Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION, SUMMARY, AND CONCLUSION

1.1 Introduction

This report presents the results of the physics tests performed during startup of Kewaunee Cycle 23. 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).

The reactor core consists of 121 fuel assemblies of 14 x 14 design. The core loading pattern, assembly identification, and burnable absorber configurations for Cycle 23 are presented in Figure 1.1.

Twenty-four (24) new Siemens Power Corporation (SPC) heavy assemblies containing UO_2 rods enriched to 4.5 w/o U235 and twenty (20) SPC heavy assemblies containing UO_2 rods enriched to 4.1 w/o U235 will reside with 61 partially depleted SPC standard assemblies and 16 partially depleted SPC heavy assemblies. The SPC heavy assemblies contain approximately 405 KgU (per assembly) versus approximately 378 KgU in the SPC standard fuel design. Table 1.1 displays the core breakdown by region, enrichment, number of previous duty cycles, fuel rod design, and grid design.

On November 25, 1998, at 2340 hours, initial criticality was achieved on the Cycle 23 core. The schedule of physics tests and measurements is outlined in Table 1.2.

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). The reactivity comparison was made to the reference bank, Control Bank A, 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 Control Bank A inserted 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 satisfies the 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 full power equilibrium xenon. The results indicate compliance with Technical Specification limits (5) and are presented in Section 5. Section 6 discusses the various calibrations performed during the startup of Cycle 23.

1.3 Conclusion

The startup testing of Kewaunee's Cycle 23 core verified that the reactor core has been properly loaded and the core characteristics satisfy the Technical Specifications (5) and are consistent with the parameters used in the design and safety analysis (1).

TABLE 1.1

Fuel Characteristics

Region	**Region Identifier**	**Initial U02 Rod W/O U235 (Gad Load)**	**Number of Previous Duty Cycles**	**Cycle 23 Assemblies**	**Fuel Rod Design**	**Grid Design**
20	W	3.4	2	1	Standard	Bi-M(1)
22	Z	3.7	3	8	Standard	Bi-M(1)
23	A	3.8	2	4	Standard	Bi-M(1)
23	A	4.1	2	12	Standard	Bi-M(1)
23	A	4.1	2	8	Heavy	HTP(2)
24	B	4.1	1	24	Standard	HTP(2)
24	B	4.5	1	12	Standard	HTP(2)
24	B	4.5 (4 rods - 4%)	1	8	Heavy	HTP(2)
25	C	4.1 (8 rods - 8%)	0	8	Heavy	HTP(2)
25	C	4.1 (12 rods - 8%)	0	12	Heavy	HTP(2)
25	C	4.5 (4 rods - 4%)	0	8	Heavy	HTP(2)
25	C	4.5 (8 rods - 4%)	0	8	Heavy	HTP(2)
25	C	4.5 (8 rods - 8%)	0	8	Heavy	HTP(2)

(1) Bi-M denotes the SPC bi-metallic grid design.

(2) HTP denotes the SPC High Thermal Performance grid design.

TABLE 1.2

BOC Physics Test

Test	Date Completed	Time Completed	Plant Conditions
Control Rod Operability Test	11/23/98	1100	Cold SD
Hot Rod Drops	11/24/98	2330	HSD
RPI Calibrations	11/25/98	0415	HSD
Initial Criticality	11/25/98	2340	HZP
Reactivity Computer Checkout	11/26/98	0530	HZP
ARO Endpoint	11/26/98	0530	HZP
Bank A Worth (Dilution)	11/26/98	0815	HZP
ITC Determination	11/26/98	0815	HZP
Power Ascension Flux Map 2301	11/27/98	1258	23%
Power Ascension Flux Map 2302	12/01/98	1342	37%
Power Ascension Flux Map 2303	12/04/98	1359	72%
Power Ascension Flux Map 2304	12/07/98	1036	91%
Power Ascension Flux Map 2305	12/14/98	1140	94%

FIGURE 1.1
Core Loading Map

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						Z23 3.7	A77 4.1	Z20 3.7					
B				B68 4.1	C71 4.5 4GAD4	C89 4.5 8GAD8	B84 4.5	C90 4.5 8GAD8	C78 4.5 4GAD4	B58 4.1			
C			B73 4.1	C81 4.5 8GAD4	B79 4.5	B94 4.5 4GAD4	C60 4.1 12GAD8	B89 4.5 4GAD4	B78 4.5	C95 4.5 8GAD4	B56 4.1		
D		B51 4.1	C85 4.5 8GAD4	A62 3.8	C56 4.1 8GAD8	A91 4.1	A81 4.1	A96 4.1	C57 4.1 8GAD8	A56 3.8	C86 4.5 8GAD4	B66 4.1	
E		C76 4.5 4GAD4	B75 4.5	C52 4.1 8GAD8	A72 4.1	C70 4.1 12GAD8	B63 4.1	C67 4.1 12GAD8	A88 4.1	C53 4.1 8GAD8	B81 4.5	C74 4.5 4GAD4	
F	Z21 3.7	C93 4.5 8GAD8	B87 4.5 4GAD4	A94 4.1	C66 4.1 12GAD8	B67 4.1	B69 4.1	B64 4.1	C64 4.1 12GAD8	A95 4.1	B93 4.5 4GAD4	C92 4.5 8GAD8	Z19 3.7
G	A85 4.1	B86 4.5	C61 4.1 12GAD8	A80 4.1	B52 4.1	B62 4.1	W29 3.4	B53 4.1	B54 4.1	A90 4.1	C62 4.1 12GAD8	B85 4.5	A83 4.1
H	Z18 3.7	C94 4.5 8GAD8	B90 4.5 4GAD4	A97 4.1	C68 4.1 12GAD8	B70 4.1	B65 4.1	B60 4.1	C69 4.1 12GAD8	A92 4.1	B88 4.5 4GAD4	C91 4.5 8GAD8	Z28 3.7
I		C77 4.5 4GAD4	B83 4.5	C58 4.1 8GAD8	A89 4.1	C63 4.1 12GAD8	B55 4.1	C65 4.1 12GAD8	A74 4.1	C55 4.1 8GAD8	B76 4.5	C75 4.5 4GAD4	
J		B72 4.1	C84 4.5 8GAD4	A65 3.8	C54 4.1 8GAD8	A98 4.1	A79 4.1	A93 4.1	C51 4.1 8GAD8	A69 3.8	C96 4.5 8GAD4	B71 4.1	
K			B61 4.1	C80 4.5 8GAD4	B82 4.5	B92 4.5 4GAD4	C59 4.1 12GAD8	B91 4.5 4GAD4	B77 4.5	C79 4.5 8GAD4	B74 4.1		
L				B57 4.1	C73 4.5 4GAD4	C88 4.5 8GAD8	B80 4.5	C87 4.5 8GAD8	C72 4.5 4GAD4	B59 4.1			
M						Z17 3.7	A84 4.1	Z15 3.7					

CYCLE TWENTY-THREE

ASSEMBLY ID
INITIAL ENRICHMENT
GADOLINIA LOADING

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 23 startup the reactivity of the reference bank, Control Bank A, 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, Control Bank A, measured during dilution differed from the WPSC predicted Control Bank A worth by 132.3 pcm or 12.4 percent. This difference exceeds the review criteria of 10% for reference bank worth. A review of the rod worth difference was performed and the results were presented to the Plant Operations

Review Committee (PORC) on December 7, 1998, at PORC me[illegible]ng number 98129. PORC concurred with the results of the review and approved plant ascension to full power. A comparison of the measured to predicted reference bank integral and differential worth is presented in Figures 2.1 and 2.2

Rod swap results for the remaining banks are presented in Table 2.2. The measured-to-predicted total rod worth difference is 5.9 percent which is within the acceptance criteria of 10.0 percent. All individual remaining 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 total 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 23

RCCA Drop Time Measurements

Hot Zero Power

Average Dashpot Delta T (Seconds)	1.251
Standard Deviation	0.025
Average Rod Bottom Delta T (Seconds)	1.717
Standard Deviation	0.031

TABLE 2.2

Kewaunee Cycle 23

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	840.6	800.0	40.6	5.1
C	796.9	761.0	35.9	4.7
B	447.5	454.0	-6.5	-1.4
A*	1198.3	1066.0	132.3	12.4
SA	873.0	839.0	34.0	4.1
SB	883.2	839.0	44.2	5.3
Total	5039.5	4759.0	280.5	5.9

* Reference bank

TABLE 2.3

Kewaunee Cycle 23

Minimum Shutdown Margin Analysis

RCCA Bank Worths (PCM)	BOC	EOC
N	6579	6551
N-1	5741	5707
Less 10 Percent	574	571
Sub Total	5167	5136
Total Requirements (Including Uncertainties)	2367	2906
Shutdown Margin	2800	2230
Required Shutdown Margin	1000	2000

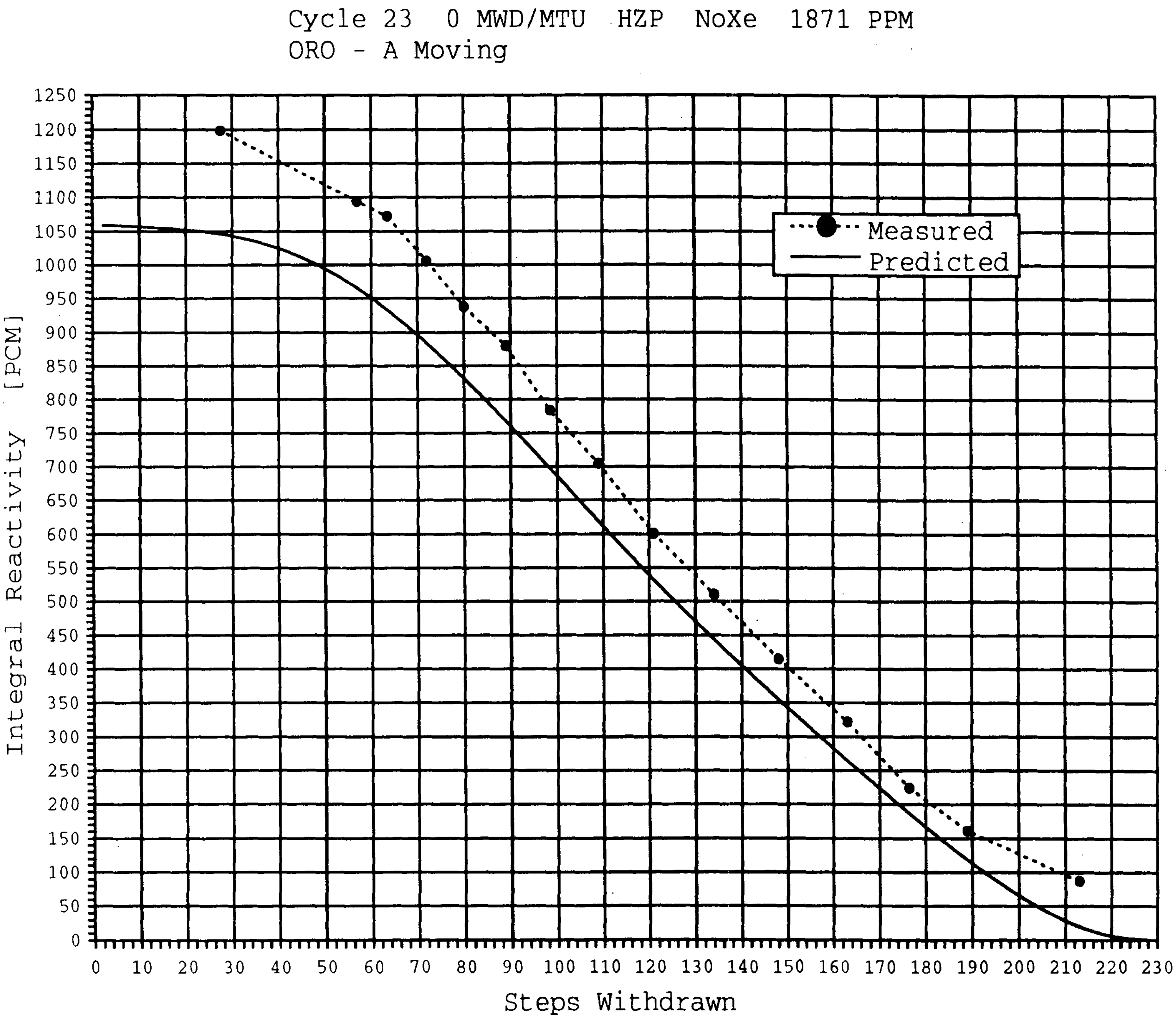

Figure 2.1

RCCA Control Bank A Integral Worth

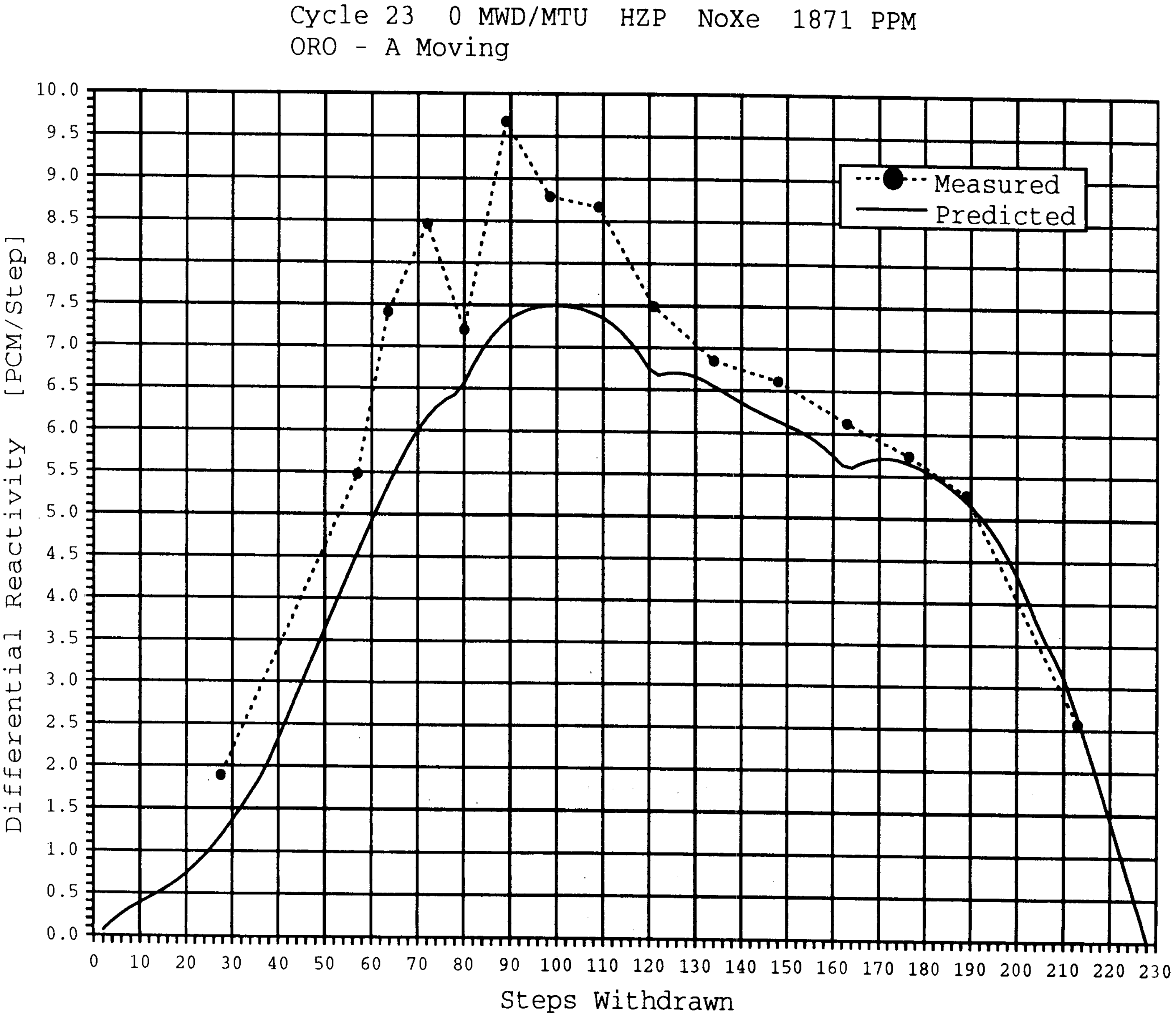

Figure 2.2
RCCA Control Bank A Differential Worth

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 -21 ppm and -26 ppm for the ARO and Control Bank A In conditions, 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 is calculated by dividing the worth of control Bank A 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 23

RCCA Bank Endpoint Measurements

RCCA Bank Configuration	Measured Endpoint (PPM)	WPS Predicted Endpoint (PPM)	Difference (PPM)
All Rods Out	1927	1948	-21
Bank A In	1768	1794	-26

TABLE 3.2

Kewaunee Cycle 23

Differential Boron Worth

RCCA Bank Configuration	CB Change Measured (PPM)	CB Change Predicted (PPM)	Percent Difference
ARO to A Bank In	159	154	3.2

RCCA Bank Configuration	Measured Boron Worth (PCM/PPM)	Predicted Boron Worth (PCM/PPM)	Difference (PCM/PPM)
ARO/A Bank In	-7.5	-6.9	-0.6

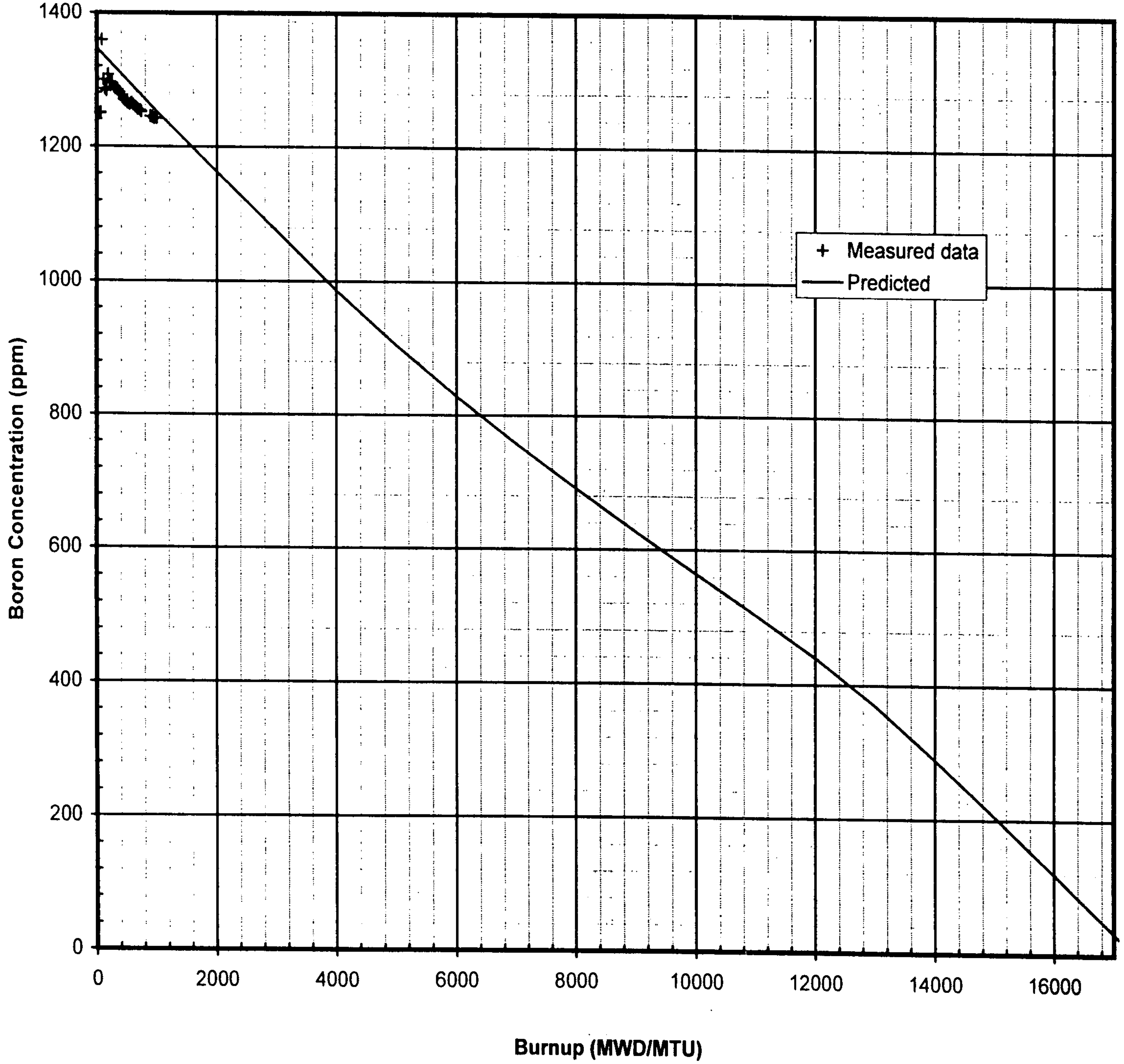

Figure 3.1
Boron Concentration vs.
Burnup
Cycle 23 HFP ARO EqXe

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 change, reactivity change, and the temperature coefficient were obtained from the reactivity computer temperature coefficient analysis results.

Core conditions at the time of the measurement were Bank D slightly inserted, all other RCCA banks full out, with a boron concentration of 1914 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 23

Isothermal Temperature Coefficient

Cooldown

Tave Start - 547.3°F

Tave End - 543.9°F

Bank D - 189 Steps

Boron Concentration - 1914 PPM

Measured ITC (PCM/°F)	WPSC Predicted ITC (PCM/°F)	Difference (PCM/°F)
-3.53	-4.75	1.22

Heat Up

Tave Start - 543.9°F

Tave End - 547.5°F

Bank D - 189 Steps

Boron Concentration - 1914 PPM

Measured ITC (PCM/°F)	WPSC Predicted ITC (PCM/°F)	Difference (PCM/°F)
-4.61	-4.75	0.14

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 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 23. Power generation is limited to approximately 95% of full power because of steam generator tube plugging, but is projected to reach approximately 97% of full power after the feedwater heater bypass is opened.

Comparisons of measured to predicted power distributions for the flux maps are exhibited in Figures 5.1 through 5.5.

Table 5.2 identifies flux map peak FDHN and minimum margin FQEQ for SPC heavy fuel. Table 5.3 identifies flux map peak FDHN and minimum margin FQEQ for SPC standard fuel. These tables address acceptance criteria by verifying that technical specification limits are not exceeded. The Cycle 23 flux maps met all acceptance criteria.

Table 5.4 addresses the established review criteria for the flux maps. All review criteria were met for all the Cycle 23 flux maps.

TABLE 5.1

Flux Map Chronology and Reactor Characteristics

Map	Date	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MDW/MTU
2301	11/27/98	23	EQ.	1816	153	0
2302	12/01/98	37	EQ.	1549	165	54
2303	12/04/98	72	EQ.	1494	192	113
2304	12/07/98	91	EQ.	1401	204	189
2305	12/14/98	94	EQ.	1306	230	424

TABLE 5.2

Verification of Acceptance Criteria for SPC Heavy Fuel

Flux Map	Core Location	FDHN	Limit
2301	H-2 (ML)	1.63	1.79*
2302	H-2 (ML)	1.60	1.74*
2303	F-12 (BC)	1.57	1.80
2304	F-12 (BC)	1.56	1.73
2305	F-12 (BC)	1.56	1.72

Flux Map	Core Location	FQEQ	Limit
2301	F-12 (BC), 30	2.80	4.55*
2302	K-6 (JK), 29	2.52	4.49*
2303	F-12 (BC), 30	2.30	3.23
2304	F-12 (BC), 34	2.21	2.56
2305	F-12 (BC), 32	2.14	2.45

FDHN and FQEQ include appropriate uncertainties and penalties.

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

Limit on FDHN is a function of core power.

* - Flux maps 2301 and 2302 applied the more conservative SPC standard fuel limits to both SPC standard and SPC heavy fuel.

TABLE 5.3

Verification of Acceptance Criteria for SPC Standard Fuel

Flux Map	Core Location	FDHN	Limit
2301	H-2 (ML)*	1.63	1.79
2302	H-2 (ML)*	1.60	1.74
2303	E-11 (KJ)	1.50	1.64
2304	E-11 (KJ)	1.49	1.58
2305	E-11 (KJ)	1.49	1.57

Flux Map	Core Location	FQEQ	Limit
2301	F-12 (BC), 30*	2.80	4.55
2302	K-6 (JK), 29*	2.52	4.49
2303	E-11 (KJ), 30	2.16	3.14
2304	E-11 (KJ), 30	2.08	2.48
2305	E-11 (KJ), 35	2.04	2.38

FDHN and FQEQ include appropriate uncertainties and penalties.

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

Limit on FDHN is a function of core power.

* - Flux maps 2301 and 2302 were analyzed assuming the more conservative SPC standard fuel limits for the entire core. Although the assemblies in core locations H-2, F-12, and K-6 are SPC heavy assemblies, they had the highest FDHN and FQEQ values for the entire core. Therefore, all of the SPC standard assemblies also met the SPC standard fuel limits.

TABLE 5.4

Verification of Review Criteria

Flux Map	(a) Maximum Percent Difference	(b) Standard Deviation	(c) Percent Maximum Quadrant Tilt
2301	3.9	2.4	0.9
2302	2.5	2.3	0.7
2303	2.2	1.8	0.4
2304	1.7	1.9	0.4
2305	1.2	1.9	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 2301

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.294 0.293 0.444	0.403 0.399 0.827	0.296 0.293 1.162					
B				0.524 0.530 -1.095	1.104 1.099 0.446	1.171 1.166 0.446	1.042 1.043 -0.105	1.161 1.166 -0.395	1.095 1.099 -0.391	0.524 0.530 -1.020			
C			0.539 0.545 -1.100	1.169 1.165 0.300	1.366 1.351 1.118	1.363 1.354 0.672	1.166 1.153 -0.535	1.339 1.354 -1.145	1.325 1.351 -1.954	1.153 1.165 -1.021	0.540 0.545 -1.027		
D		0.524 0.527 -0.588	1.153 1.160 -0.612	0.976 0.972 0.381	1.312 1.308 0.298	1.031 1.030 0.049	0.977 0.988 -1.123	1.019 1.030 -1.068	1.299 1.308 -0.726	0.970 0.972 -0.247	1.157 1.160 -0.284	0.522 0.527 -1.025	
E		1.093 1.094 -0.110	1.340 1.341 -0.112	1.306 1.302 0.294	0.865 0.868 -0.288	1.149 1.153 -0.312	1.004 1.084 -1.808	1.129 1.153 -2.090	0.854 0.868 -1.636	1.308 1.302 0.492	1.359 1.341 1.342	1.118 1.094 2.230	
F	0.295 0.291 1.167	1.173 1.159 1.173	1.374 1.350 1.778	1.038 1.029 0.904	1.145 1.154 -0.815	1.058 1.080 -2.056	1.027 1.068 -2.977	1.037 1.080 -3.991	1.125 1.154 -2.556	1.023 1.029 -0.632	1.370 1.350 1.481	1.181 1.159 1.855	0.297 0.291 1.922
G	0.414 0.398 4.075	1.004 1.039 2.387	1.177 1.160 1.474	0.991 0.987 0.426	1.079 1.085 -0.590	1.033 1.059 -2.474	0.762 0.791 -3.628	1.019 1.059 -3.815	1.046 1.085 -3.685	0.970 0.987 -1.733	1.165 1.160 0.448	1.058 1.039 1.829	0.405 0.398 1.887
H	0.304 0.291 4.221	1.187 1.159 2.381	1.368 1.350 1.326	1.039 1.029 0.991	1.151 1.154 -0.295	1.046 1.080 -2.991	1.025 1.068 -3.129	1.044 1.080 -3.333	1.114 1.154 -3.449	1.016 1.029 -1.293	1.346 1.350 -0.267	1.173 1.159 1.199	0.296 0.291 1.613
I		1.125 1.094 2.797	1.359 1.341 1.350	1.320 1.302 1.344	0.847 0.868 -2.408	1.125 1.153 -2.411	1.059 1.084 -2.334	1.126 1.153 -2.333	0.847 0.868 -2.454	1.286 1.302 -1.229	1.337 1.341 -0.336	1.103 1.094 0.814	
J		0.546 0.527 3.681	1.195 1.160 2.963	1.000 0.972 2.912	1.336 1.308 2.164	1.005 1.030 -2.417	0.971 0.988 -1.771	1.012 1.030 -1.718	1.293 1.308 -1.139	0.975 0.972 0.329	1.170 1.160 0.819	0.532 0.527 0.854	
K			0.555 0.645 1.705	1.184 1.165 1.648	1.361 1.351 0.703	1.383 1.354 2.164	1.150 1.163 -1.144	1.358 1.354 0.310	1.356 1.351 0.385	1.186 1.165 1.820	0.552 0.545 1.302		
L				0.533 0.530 0.566	1.106 1.099 0.628	1.218 1.166 4.443	1.089 1.043 4.439	1.202 1.166 3.096	1.119 1.099 1.820	0.539 0.530 1.832			
M						0.306 0.293 4.443	0.417 0.399 4.434	0.302 0.293 3.178					

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

STANDARD DEVIATION = 1.96

Figure 5.2

Power Distribution for Flux Map 2302

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.295 0.297 -0.642	0.412 0.407 1.031	0.305 0.297 2.795					
B				0.526 0.529 -0.567	1.073 1.082 -0.850	1.141 1.151 -0.851	1.039 1.044 -0.469	1.142 1.151 -0.808	1.073 1.082 -0.841	0.522 0.529 -1.267			
C			0.642 0.545 -0.569	1.154 1.149 0.461	1.338 1.333 0.375	1.353 1.344 0.677	1.170 1.181 -0.923	1.325 1.344 -1.406	1.299 1.333 -2.573	1.135 1.149 -1.271	0.542 0.545 -0.605		
D		0.527 0.527 0.114	1.146 1.145 0.079	0.976 0.971 0.525	1.296 1.297 -0.069	1.039 1.036 0.319	0.995 1.006 -1.123	1.023 1.036 -1.274	1.283 1.297 -1.064	0.970 0.971 -0.103	1.153 1.145 0.690	0.523 0.527 -0.608	
E		1.086 1.078 0.761	1.334 1.324 0.763	1.295 1.291 0.325	0.873 0.877 -0.433	1.160 1.161 -0.069	1.086 1.103 -1.550	1.144 1.161 -1.401	0.869 0.877 -0.969	1.318 1.291 2.060	1.349 1.324 1.888	1.097 1.078 1.707	
F	0.300 0.296 1.182	1.160 1.146 1.178	1.362 1.341 1.536	1.043 1.036 0.685	1.153 1.163 -0.911	1.079 1.101 -1.971	1.052 1.085 -3.087	1.059 1.101 -3.823	1.141 1.163 -1.909	1.035 1.036 -0.068	1.363 1.341 1.596	1.173 1.146 2.321	0.305 0.296 3.041
G	0.417 0.406 2.785	1.058 1.041 1.623	1.192 1.179 1.060	1.009 1.005 0.368	1.098 1.104 -0.571	1.064 1.086 -2.062	0.792 0.821 -3.581	1.046 1.086 -3.711	1.070 1.104 -3.125	0.993 1.005 -1.214	1.185 1.179 0.509	1.066 1.041 2.353	0.419 0.406 3.130
H	0.305 0.296 2.872	1.165 1.146 1.623	1.364 1.341 0.962	1.044 1.036 0.801	1.158 1.163 -0.413	1.076 1.101 -2.307	1.056 1.085 -2.709	1.070 1.101 -2.870	1.131 1.163 -2.760	1.024 1.036 -1.129	1.336 1.341 -0.353	1.164 1.146 1.518	0.309 0.296 4.324
I		1.100 1.078 1.985	1.338 1.324 1.020	1.304 1.291 1.015	0.854 0.877 -1.528	1.143 1.161 -1.533	1.079 1.103 -2.104	1.135 1.161 -2.231	0.858 0.877 -2.155	1.278 1.291 -1.053	1.318 1.324 -0.430	1.079 1.078 0.046	
J		0.541 0.527 2.678	1.168 1.145 2.000	0.990 0.971 1.946	1.313 1.297 1.218	1.036 1.036 0.029	1.001 1.006 -0.507	1.030 1.036 -0.589	1.276 1.297 -1.604	0.964 0.971 -0.783	1.146 1.145 0.044	0.527 0.527 0.133	
K			0.553 0.545 1.376	1.164 1.149 1.331	1.343 1.333 0.720	1.365 1.344 1.577	1.183 1.181 0.127	1.353 1.344 0.847	1.337 1.333 0.270	1.172 1.149 2.028	0.550 0.545 0.881		
L				0.533 0.529 0.681	1.090 1.082 0.693	1.184 1.151 2.876	1.074 1.044 2.673	1.161 1.151 2.580	1.104 1.082 2.024	0.640 0.529 2.042			
M						0.309 0.297 4.175	0.424 0.407 4.174	0.306 0.297 3.131					

☐	MEASURED FDHN PREDICTED FDHN PERCENT DIFFERENCE

STANDARD DEVIATION = 1.76

Figure 5.3

Power Distribution for Flux Map 2303

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.305 0.306 -0.163	0.426 0.423 0.781	0.311 0.306 1.667					
B				0.526 0.530 -0.717	1.066 1.062 -0.169	1.140 1.142 -0.166	1.053 1.056 -0.294	1.137 1.142 -0.402	1.057 1.062 -0.490	0.525 0.530 -0.887			
C			0.542 0.546 -0.714	1.136 1.128 0.745	1.322 1.308 1.078	1.352 1.339 0.993	1.223 1.280 -0.537	1.328 1.339 -0.814	1.288 1.308 -1.408	1.118 1.128 -0.878	0.641 0.546 -1.007		
D		0.526 0.528 -0.265	1.121 1.124 -0.276	0.975 0.967 0.817	1.285 1.278 0.556	1.052 1.046 0.574	1.022 1.031 -0.044	1.039 1.046 -0.717	1.274 1.278 -0.282	0.969 0.967 0.207	1.131 1.124 0.578	0.522 0.528 -1.023	
E		1.061 1.059 0.179	1.301 1.299 0.185	1.282 1.273 0.707	0.885 0.885 -0.011	1.156 1.104 0.140	1.103 1.116 -1.138	1.151 1.104 -1.082	0.882 0.885 -0.294	1.302 1.273 2.255	1.326 1.299 2.079	1.079 1.059 1.889	
F	0.308 0.305 0.820	1.146 1.137 0.827	1.353 1.337 1.212	1.052 1.046 0.574	1.157 1.160 -0.815	1.093 1.112 -1.736	1.072 1.999 -2.466	1.078 1.112 -3.076	1.150 1.166 -1.304	1.648 1.046 0.210	1.362 1.337 1.862	1.156 1.137 1.662	0.310 0.305 1.738
G	0.432 0.422 2.372	1.070 1.054 1.556	1.242 1.228 1.124	1.035 1.030 0.456	1.110 1.117 -0.600	1.078 1.100 -1.973	0.818 0.843 -3.000	1.066 1.100 -3.100	1.085 1.117 -2.910	1.016 1.030 -1.330	1.233 1.228 0.423	1.071 1.064 1.041	0.429 0.422 1.708
H	0.313 0.305 2.459	1.155 1.137 1.566	1.351 1.337 1.055	1.056 1.046 0.956	1.160 1.166 -0.400	1.085 1.112 -2.473	1.070 1.099 -2.675	1.091 1.112 -2.797	1.133 1.166 -2.804	1.036 1.046 -0.966	1.335 1.337 -0.150	1.150 1.137 1.135	0.310 0.305 1.574
I		1.077 1.059 1.681	1.311 1.299 0.885	1.284 1.273 0.688	0.867 0.885 -2.012	1.141 1.104 -2.010	1.092 1.116 -2.159	1.139 1.104 -2.165	0.865 0.885 -2.260	1.261 1.273 -0.956	1.292 1.299 -0.562	1.061 1.059 0.208	
J		0.537 0.528 1.838	1.142 1.124 1.628	0.982 0.967 1.614	1.296 1.278 1.401	1.042 1.046 -0.363	1.024 1.031 -0.708	1.038 1.946 -0.746	1.260 1.278 -1.385	0.970 0.967 0.362	1.126 1.124 0.205	0.529 0.528 0.190	
K			0.551 0.646 0.879	1.138 1.128 0.869	1.313 1.308 0.405	1.356 1.339 1.262	1.231 1.230 0.057	1.347 1.339 0.560	1.312 1.308 0.283	1.149 1.128 1.044	0.646 0.546 0.055		
L				0.532 0.630 0.321	1.066 1.062 0.358	1.162 1.142 1.725	1.074 1.050 1.723	1.162 1.142 1.760	1.082 1.062 1.846	0.540 0.530 1.849			
M						0.313 0.306 2.158	0.432 0.423 2.176	0.312 0.306 2.027					

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

STANDARD DEVIATION = 1.41

Figure 5.4

Power Distribution for Flux Map 2304

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.311 0.310 0.129	0.434 0.431 0.767	0.315 0.310 1.385					
B				0.526 0.531 -0.885	1.052 1.051 0.114	1.134 1.133 0.115	1.057 1.059 -0.189	1.130 1.133 -0.238	1.049 1.051 -0.228	0.529 0.531 -0.358			
C			0.543 0.546 -0.895	1.120 1.117 0.278	1.305 1.294 0.827	1.341 1.332 0.608	1.239 1.245 -0.498	1.324 1.332 -0.661	1.281 1.294 -0.974	1.113 1.117 -0.358	0.344 0.546 -0.712		
D		0.528 0.529 -0.208	1.110 1.113 -0.243	0.970 0.967 0.341	1.273 1.270 0.213	1.054 1.051 0.238	1.035 1.044 -0.872	1.045 1.051 -0.533	1.272 1.270 0.181	0.973 0.967 0.662	1.123 1.113 0.898	0.525 0.529 -0.718	
E		1.053 1.648 0.429	1.293 1.287 0.427	1.269 1.265 0.292	0.890 0.892 -0.236	1.168 1.169 -0.103	1.109 1.126 -1.501	1.149 1.169 -1.711	0.887 0.892 -0.516	1.298 1.265 2.601	1.316 1.287 2.284	1.069 1.046 1.950	
F	0.312 0.310 0.840	1.139 1.129 0.650	1.343 1.331 0.887	1.051 1.051 0.038	1.157 1.170 -1.111	1.102 1.122 -1.809	1.082 1.113 -2.803	1.083 1.122 -3.476	1.153 1.170 -1.496	1.056 1.051 0.428	1.358 1.331 2.059	1.146 1.129 1.541	0.314 0.310 1.453
G	0.437 0.429 1.653	1.069 1.057 1.154	1.252 1.244 0.043	1.643 1.043 -0.019	1.115 1.127 -1.065	1.090 1.114 -2.172	0.832 0.861 -3.460	1.076 1.114 -3.411	1.093 1.127 -3.061	1.031 1.043 -1.141	1.252 1.244 0.603	1.073 1.057 1.514	0.435 0.429 1.398
H	0.316 0.310 1.938	1.142 1.129 1.143	1.339 1.331 0.586	1.055 1.051 0.333	1.157 1.170 -1.145	1.091 1.122 -2.736	1.080 1.113 -2.929	1.089 1.122 -2.906	1.137 1.170 -2.812	1.044 1.051 -0.657	1.334 1.331 0.225	1.148 1.129 1.205	0.313 0.310 0.937
I		1.066 1.048 1.669	1.304 1.287 1.290	1.281 1.265 1.289	0.872 0.892 -2.209	1.143 1.169 -2.216	1.100 1.126 -2.336	1.142 1.169 -2.344	0.871 0.892 -2.277	1.259 1.265 -0.490	1.285 1.287 -0.194	1.054 1.048 0.601	
J		0.544 0.529 2.874	1.141 1.113 2.552	0.991 0.967 2.514	1.298 1.270 2.173	1.046 1.051 -0.504	1.035 1.044 -0.824	1.042 1.051 -0.866	1.251 1.270 -1.480	0.977 0.967 1.024	1.120 1.113 0.602	0.532 0.529 0.567	
K			0.555 0.546 1.351	1.132 1.117 1.325	1.302 1.294 0.587	1.348 1.332 1.201	1.245 1.245 -0.024	1.341 1.332 0.668	1.300 1.294 0.495	1.143 1.117 2.355	0.649 0.648 0.183		
L				0.533 0.631 0.452	1.056 1.051 0.504	1.148 1.133 1.306	1.073 1.059 1.303	1.152 1.133 1.668	1.076 1.051 2.360	0.643 0.531 2.354			
M						0.315 0.310 1.418	0.437 0.431 1.417	0.316 0.310 1.869					

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

STANDARD DEVIATION = 1.48

Figure 5.5

Power Distribution for Flux Map 2305

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.315 0.313 0.871	0.440 0.435 1.148	0.318 0.313 1.598					
B				0.526 0.530 -0.793	1.050 1.043 0.662	1.135 1.128 0.656	1.065 1.063 0.169	1.126 1.128 -0.142	1.042 1.043 -0.144	0.528 0.530 -0.321			
C			0.540 0.547 -0.804	1.117 1.110 0.049	1.305 1.287 1.438	1.546 1.332 1.021	1.259 1.263 -0.301	1.323 1.332 -0.853	1.275 1.287 -0.964	1.106 1.110 -0.324	0.645 0.547 -0.384		
D		0.526 0.528 -0.303	1.103 1.107 -0.325	0.972 0.965 0.725	1.274 1.284 0.815	1.060 1.054 0.531	1.046 1.053 -0.712	1.048 1.054 -0.607	1.265 1.284 0.063	0.970 0.965 0.549	1.117 1.107 0.885	0.526 0.528 -0.379	
E		1.042 1.046 0.173	1.282 1.280 0.180	1.269 1.260 0.738	0.896 0.894 0.224	1.172 1.170 0.188	1.115 1.131 -1.406	1.149 1.170 -1.821	0.888 0.894 -0.705	1.288 1.260 2.207	1.312 1.280 2.500	1.069 1.040 2.798	
F	0.314 0.312 0.577	1.131 1.124 0.596	1.339 1.330 0.677	1.055 1.054 0.066	1.162 1.172 -0.836	1.111 1.127 -1.420	1.091 1.119 -2.460	1.090 1.127 -3.327	1.154 1.172 -1.510	1.056 1.054 0.351	1.359 1.330 2.203	1.144 1.124 1.762	0.318 0.312 1.762
G	0.442 0.434 1.642	1.073 1.061 1.084	1.268 1.262 0.483	1.052 1.052 -0.038	1.122 1.132 -0.883	1.100 1.120 -1.821	0.840 0.870 -3.472	1.091 1.120 -3.491	1.097 1.132 -3.101	1.041 1.052 -1.085	1.273 1.262 0.850	1.079 1.061 1.697	0.442 0.434 1.658
H	0.318 0.312 1.922	1.136 1.124 1.094	1.336 1.330 0.429	1.056 1.054 0.209	1.161 1.172 -0.904	1.095 1.127 -2.866	1.083 1.119 -3.226	1.090 1.127 -3.274	1.138 1.172 -2.893	1.046 1.054 -0.607	1.333 1.330 0.216	1.137 1.124 1.112	0.314 0.312 0.705
I		1.057 1.040 1.644	1.295 1.280 1.141	1.274 1.260 1.135	0.867 0.894 -2.976	1.135 1.170 -2.975	1.098 1.131 -2.882	1.136 1.170 -2.863	0.871 0.894 -2.539	1.254 1.260 -0.460	1.277 1.280 -0.242	1.045 1.040 0.490	
J		0.542 0.528 2.652	1.135 1.107 2.565	0.990 0.965 2.560	1.295 1.264 2.476	1.023 1.054 -2.979	1.028 1.053 -2.355	1.030 1.054 -2.306	1.242 1.204 -1.733	0.975 0.965 1.036	1.113 1.107 0.497	0.630 0.528 0.455	
K			0.555 0.547 1.499	1.127 1.110 1.495	1.299 1.287 0.932	1.365 1.332 2.478	1.241 1.263 -1.734	1.337 1.332 0.345	1.293 1.287 0.458	1.138 1.110 2.505	0.547 0.547 -0.037		
L				0.534 0.630 0.793	1.052 1.043 0.044	1.147 1.128 1.676	1.081 1.063 1.675	1.152 1.128 2.101	1.069 1.843 2.502	0.843 0.530 2.510			
M						0.318 0.313 1.662	0.443 0.435 1.677	0.319 0.313 2.077					

☐ MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

STANDARD DEVIATION = 1.64

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 23 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 23 startup (4). A flux map was performed at approximately 70 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 23," Wisconsin Public Service Corporation, September 1998.

(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 (Revision 6, May 19, 1997)

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