DOCKET 50-350

KEWAUNEE NUCLEAR POWER PLANT

CYCLE 9

STARTUP REPORT

JUNE 1983

Wisconsin Public
Service Corporation
Green Bay, Wisconsin
Date 7/15/83

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1.0 INTRODUCTION, SUMMARY, AND CONCLUSION

1.1 Introduction

This report presents the results of the physics tests performed for Kewaunee Cycle 9. 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 8-9 refueling, 36 of the 121 fuel assemblies in the core were replaced with fresh assemblies of Exxon Design(5), enriched to 3.4 w/o U235. The Cycle 9 core consists of the following regions of fuel:

Region	Vendor	Initial U235 W/O	Number of Previous Duty Cycles	Number of Assemblies
1	W	2.2	1	1
2	W	3.0	1	4
4	W	3.3	3	4
6	W	3.1	3	4
8	ENC	3.2	2	8
8	ENC	3.2	2	4
8	ENC	3.2	3	8
9	ENC	3.2	2	16
10	ENC	3.2	1	36
11	ENC	3.4	0	36(FEED)

The core loading pattern, burnup per assembly, and previous core position are shown in Figure 1.1.

On May 11, 1983 at 2030 hours, initial criticality was achieved on the Cycle 9 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, Bank A in, 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 HZP, no xenon through power escalation to 100% 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 9.

1.3 Conclusion

The startup testing of Kewaunee's Cycle 9 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

BOL CYCLE 9 PHYSICS TEST

Test	Date Completed	Time Completed	Plant Conditions
Control Rod Operability Test	5/05/83	1600	Cold SD
Hot Rod Drops	5/09/83	0024	HZP
RPI Calibrations	5/11/83	1100	HZP
Initial Criticality	5/11/83	2030	HZP
Low Power Flux Map 902	5/12/83	0422	HZP
Reactivity Computer Checkout	5/12/83	2028	HZP
ARO Endpoint	5/12/83	2255	HZP
Bank C Worth (Dilution)	5/12/83	2330	HZP
Bank C In-ORO Endpoint	5/13/83	0306	HZP
Bank A In-ORO Endpoint	5/13/83	0600	HZP
Bank A Worth (Boration)	5/13/83	2015	HZP
ARO Endpoint	5/13/83	2030	HZP
ITC Determination	5/13/83	2212	HZP
Power Ascension Flux Map 903	5/14/83	1720	25%
Power Ascension Flux Map 904	5/16/83	0839	40%
Incore/Excore Calibration Flux Map 905	5/19/83	1529	75%
Incore/Excore Calibration Flux Map 906	5/20/83	0821	75%
Incore/Excore Calibration Flux Map 907	5/20/83	1328	75%
Incore/Excore Calibration Flux Map 908	5/20/83	1614	75%
Incore/Excore Calibration Flux Map 909	5/21/83	0833	75%
Power Ascension Flux Map 910	5/23/83	0855	87%
Power Ascension Flux Map 911	5/24/83	0845	100%
Power Ascension Flux Map 912	6/02/83	1415	100%

LOOP B — LOOP A

LOOP B — LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						C6 8 26.92	11 0.00	C8 8 26.96					
B				K10 10 11.98	11 0.00	L8 10 11.62	M7 10 7.02	L6 10 11.65	11 0.00	K4 10 11.95			
C			I9 4 29.43	11 0.00	E8 8 24.12	11 0.00	D7 9 19.60	11 0.00	E6 8 24.19	11 0.00	I5 4 29.37		
D		J11 10 11.94	11 0.00	F7 8 24.44	11 0.00	L4 9 18.24	I10 10 13.03	L10 9 18.16	11 0.00	G8 8 24.37	11 0.00	J3 10 11.96	
E		11 0.00	H5 8 24.12	11 0.00	L7 2 24.56	B5 10 10.04	E7 6 28.63	B9 10 10.04	G2 2 24.50	11 0.00	H9 8 24.03	11 0.00	
F	F3 8 26.96	H12 10 11.60	11 0.00	D12 9 18.18	E2 10 10.04	C3 9 20.59	E10 10 13.05	C11 9 20.57	E12 10 10.05	D2 9 18.16	11 0.00	H2 10 11.61	F11 8 26.96
G	11 0.00	G13 10 7.06	G4 9 19.65	D9 10 13.05	G5 6 28.53	D5 10 13.08	G11 1 18.17	J9 10 13.03	G9 6 28.51	J5 10 13.06	G10 9 19.72	G1 10 7.04	11 0.00
H	H3 8 26.96	F12 10 11.57	11 0.00	J12 9 18.16	I2 10 10.01	K3 9 20.67	I4 10 13.03	K11 9 20.60	I12 10 10.08	J2 9 18.24	11 0.00	F2 10 11.65	H11 8 26.96
I		11 0.00	F5 8 24.12	11 0.00	G12 2 24.49	L5 10 10.07	I7 6 28.56	L9 10 9.99	B7 2 24.54	11 0.00	F9 8 24.06	11 0.00	
J		D11 10 11.95	11 0.00	G6 8 24.40	11 0.00	B4 9 18.22	E4 10 13.07	B10 9 18.19	11 0.00	H7 8 24.39	11 0.00	D3 10 11.95	
K			E9 4 29.28	11 0.00	I8 8 24.11	11 0.00	J7 9 19.60	11 0.00	I6 8 24.16	11 0.00	E5 4 29.26		
L				C10 10 11.95	11 0.00	B8 10 11.62	A7 10 7.06	B6 10 11.61	11 0.00	C4 10 11.98			
M						K6 8 26.95	11 0.00	K8 8 26.95					

Legend (each box): PREVIOUS LOCATION / REGION / BURNUP(=1000MWD/MTU)

KEWAUNEE CYCLE 9
CORE LOADING MAP

FIGURE 1.1

2.0 RCCA MEASUREMENTS

2.1 RCCA Drop Time Measurements

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

2.2 RCCA Bank Measurements

During Cycle 9 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 Cycle 9 reference bank was determined by measurement to be control Bank A. Although the reference bank was predicted to be Bank C, they differed in calculated worth by only 5%. This calculational difference plus the measured to calculated difference resulted in the 10% review criteria on the reference bank to be exceeded by 0.2%.

As required by the startup test program (4) and by WPS design verification procedures, a documented review was performed. The measurements and calculations were examined in light of the startup test results.

The power distribution measurements exhibited a small radial in-out disagreement from calculations, as can be seen by close examination of figure 5.1. The measured power distribution indicates slightly more power is produced on the core periphery than was predicted, which would influence control rod worths. The calculated reference bank was shifted from control Bank C to control Bank A, by adjusting the calculated radial power distribution to eliminate the measured to predicted in-out differences. The re-analysis values are presented in Table 2.2 along with the originally predicted values.

The re-analysis resulted in meeting the review criteria for the reference bank with no impact on the total inferred rod worth. The acceptance criteria was met before and after re-analysis.

The results of this review were presented to the plant operations and review committee (PORC) along with all other Cycle 9 startup physics test results during meeting #83-57, item 83-366.

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% margin is allowed in the calculation of rod worth in these shutdown margin analyses. Since the measured rod worths resulted in less than a 10% difference from predicted values, the analysis in Table 2.3 is conservative and no additional evaluations were required.

TABLE 2.1

KEWAUNEE CYCLE 9

RCCA DROP TIME MEASUREMENTS

HOT ZERO POWER

	All Fuel	Westinghouse Fuel	Exxon Fuel
Average Dashpot Delta T (Sec)	1.283	1.350	1.281
Standard Deviation	0.025	0.000	0.022
Average Rod Bottom Delta T (Sec)	1.806	1.783	1.807
Standard Deviation	0.038	0.000	0.038

TABLE 2.2

KEWAUNEE CYCLE 9

RCCA BANK WORTH SUMMARY

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Predicted Worth (PCM)	Difference (PCM)	Percent Difference
D	897.0	865.0	+32.0	+3.7
C	891.0	931.0*	-40.3	-4.3
B	726.3	761.0	-34.7	-4.6
A	974.5	884.0	+90.5	+10.2
SA	621.3	585.0	+36.3	+6.2
SB	629.2	585.0	+44.2	+7.6
Total	4739.3	4611.0	+128.3	+2.8

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Re-analysis Worth (PCM)	Difference (PCM)	Percent Difference
D	897.0	882.0	+15.0	+1.7
C	891.0	904.0	-13.0	-1.4
B	726.3	753.0	-27.0	-3.6
A	974.5	913.0*	+61.0	+6.7
SA	621.3	579.0	+42.0	+7.2
SB	629.2	579.0	+50.0	+8.6
Total	4739.3	4610.0	+128.0	+2.8

* Calculated Reference Bank

FIG. 2.1

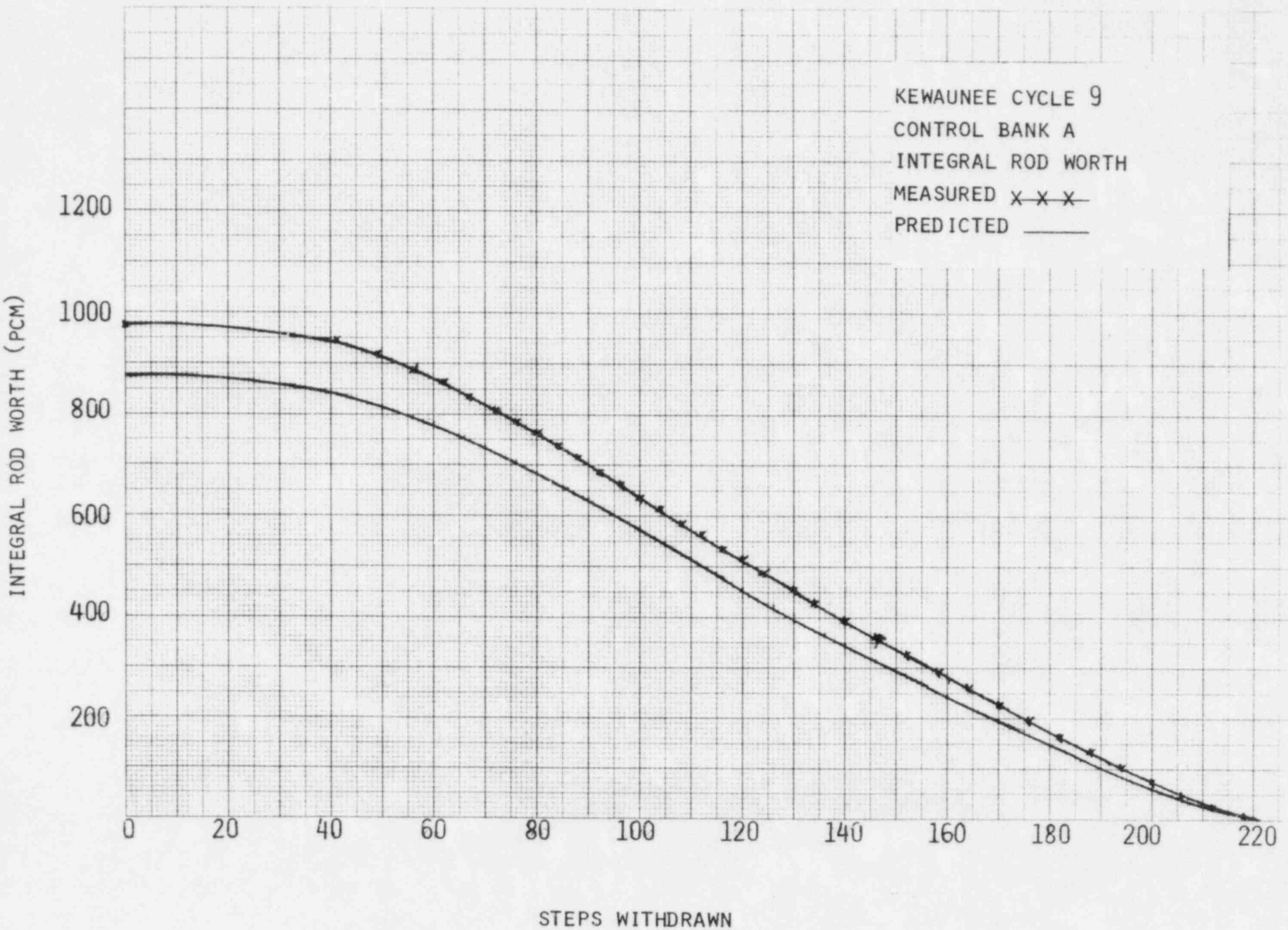
KEWAUNEE CYCLE 9
CONTROL BANK A
INTEGRAL ROD WORTH
MEASURED X X X
PREDICTED ———
INTEGRAL ROD WORTH (PCM)
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180
200
220
STEPS WITHDRAWN

FIG. 2.2

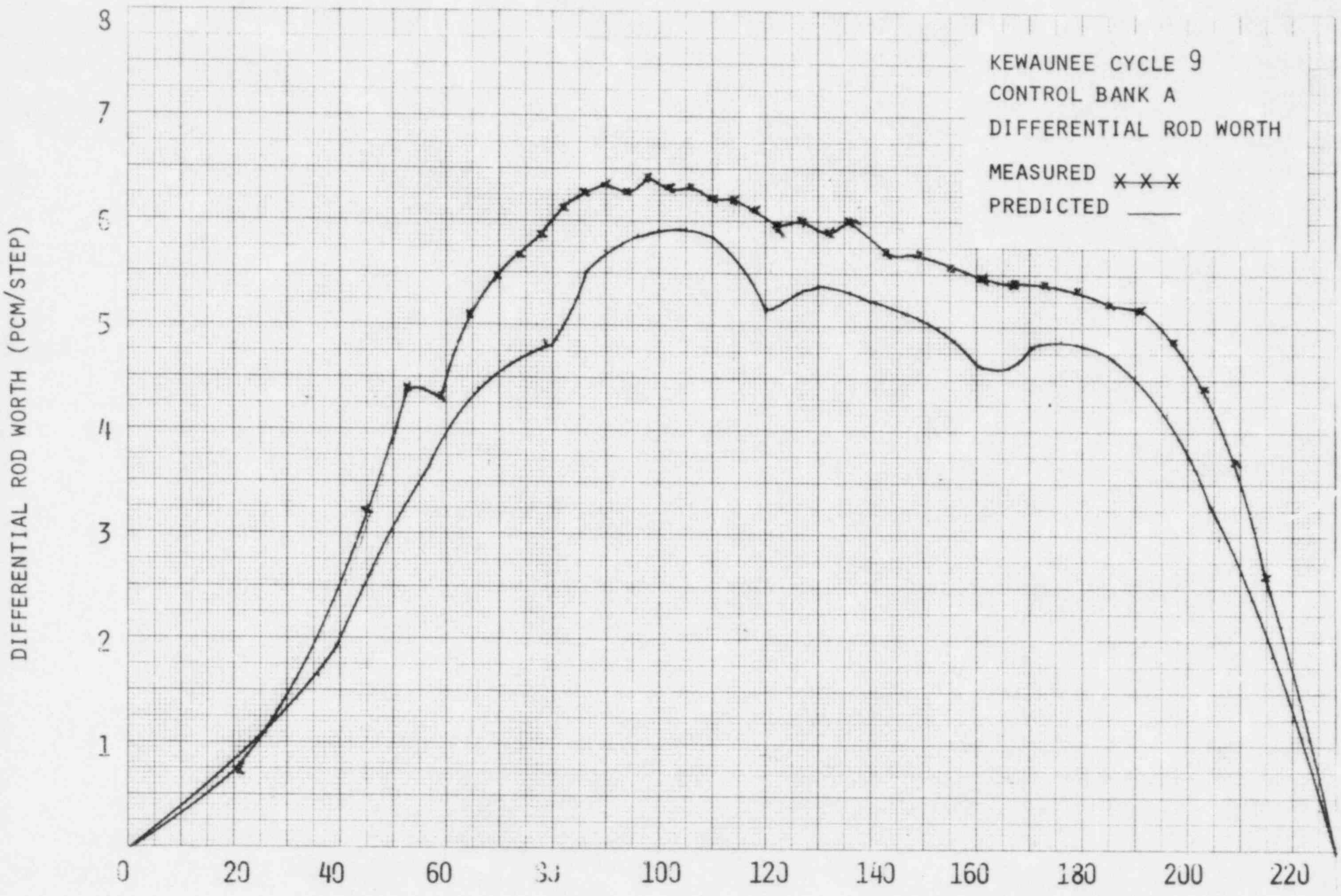
KEWAUNEE CYCLE 9
CONTROL BANK A
DIFFERENTIAL ROD WORTH
MEASURED X X X
PREDICTED ——
DIFFERENTIAL ROD WORTH (PCM/STEP)
STEPS WITHDRAWN
0
20
40
60
100
120
140
160
180
200
220
1
2
3
4
5
6
7
8

TABLE 2.3

KEWAUNEE CYCLE 9

MINIMUM SHUTDOWN MARGIN ANALYSIS

RCCA Bank Worths (PCM)	BOC	EOC
N	6228	6909
N-1	5400	6158
Less 10 Percent	540	616
Sub Total	4860	5542
Total Requirements		
(Including Uncertainties)	2360	3172
Shutdown Margin	2500	2370
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 just critical boron concentration was determined 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 -43 PPM difference for the measured all rods out endpoint, a -41 PPM difference under the "Bank A In" configuration, and a -42 PPM difference under the "Bank C In" configuration. The acceptance criteria 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. The boron concentration change shows good agreement. The differential boron worth shows poor agreement due to the difference between

measured and predicted reference bank worth discussed in section 2.2.1. No acceptance criteria is applied to these comparisons.

3.3 Boron Letdown

The measured boron concentration data for the first few days 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 9

RCCA BANK ENDPOINT MEASUREMENTS

RCCA Bank Configuration	Measured Endpoint(PPM)	WPS Predicted Endpoint(PPM)	Difference (PPM)
All Rods Out	1214	1257	-43
Bank A In	1112	1153	-41
Bank C In	1103	1145	-42

TABLE 3.2

KEWAUNEE CYCLE 9

DIFFERENTIAL BORON WORTH

RCCA Bank Configuration	CB Change Measured (PPM)	CB Change Predicted (PPM)	Percent Difference
ARO to A Bank In	102	104	-1.9

RCCA Bank Configuration	Measured Boron Worth (PCM/PPM)	Predicted Boron Worth (PCM/PPM)	Percent Difference
ARO/A Bank In	-9.6	-8.5	+12.9

5-11-83 THROUGH 6-14-83

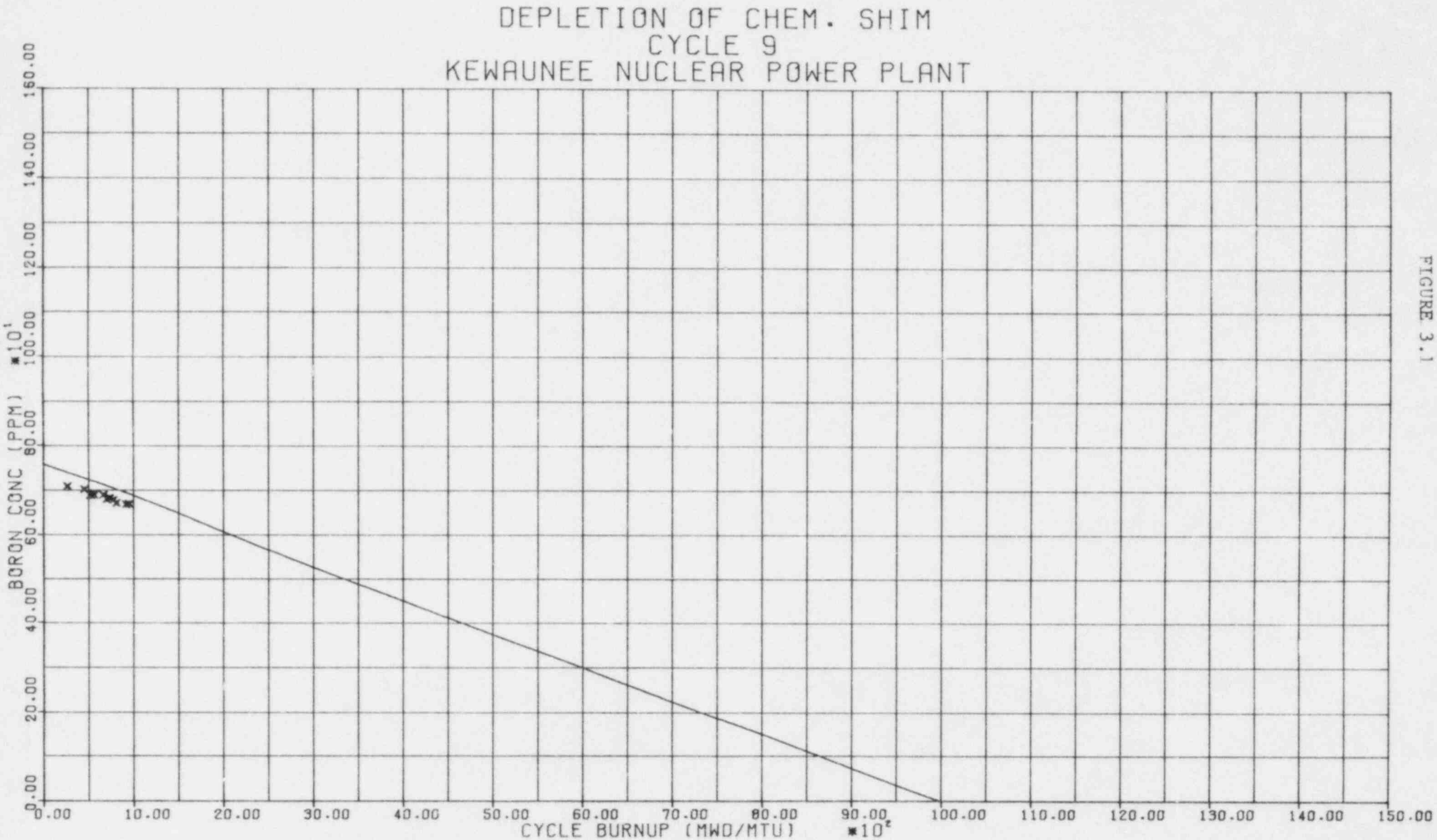

FIGURE 3.1

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 A slightly in, all other RCCA banks full out, with a boron concentration of 1209 PPM for both the heatup and cool-down. These conditions approximate the HZP, all rods out core condition which yields the least 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 9

ISOTHERMAL TEMPERATURE COEFFICIENT

Cooldown

Tave Start	546.6 Degrees F
Tave End	532.0 Degrees F
Bank A	192 Steps
Boron Concentration	1209 PPM

Measured ITC (PCM/Deg F)	WPS Predicted ITC (PCM/Deg F)	Difference (PCM/Deg F)
-8.9	-6.6	-2.3

Heat Up

Tave Start	532.0 Degrees F
Tave End	537.4 Degrees F
Bank A	206 Steps
Boron Concentration	1209 PPM

Measured ITC (PCM/Deg F)	WPS Predicted ITC (PCM/Deg F)	Difference (PCM/Deg F)
-7.6	-6.0	-1.6

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 (except for low power) (4).

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

The review criteria for the INCORE calculated quadrant power are that the quadrant tilt is less than 4% at low power physics test conditions and less than 2% 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 9. Flux map 901 conditions were zero power, but not included in the table. Only 22 thimbles were recorded and mapping was terminated because of a brief opening of a steam generator safety valve. Flux map 902 was recorded as the hot zero power flux map.

Table 5.2 identifies flux map peak FDHN and minimum margin FQN. This table addresses acceptance criteria by verifying that technical specifications limits are not exceeded. The Cycle 9 flux maps met all acceptance criteria.

Table 5.3 addresses the established review criteria for the flux maps. All review criteria were met except the review criterion of 'standard deviation of the percent difference between measured and predicted reaction rate integrals' for flux map 902. The failure to meet this review criterion was reviewed by PORC (meeting 83-57, item 83-366).

It was concluded that exceeding the review criterion was not caused by a model or core loading anomaly. The reason the review criterion was not met is due to small absolute differences on the core periphery (H-1 & A-8) which are

calculated as large percent differences between measured and predicted. These large percent differences are heavily weighted in the standard deviation calculation. Figure 5.1 shows the measured and predicted reaction rate integrals for the 35 measured core locations and the percent differences between measured and predicted.

The graphic displays of power distributions measured for representative flux maps are exhibited in Figures 5.2 through 5.6.

TABLE 5.1

FLUX MAP CHRONOLOGY AND REACTOR CHARACTERISTICS

Map	Date-Time	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MWD/MTU
902	5/12/83-0422	0	0	1205	194	0
903	5/14/83-1720	25	0	1196	195	0
904	5/16/83-0838	40	63% EQ.	956	182	0
905	5/19/83-1529	75	EQ.	797	221	95
906	5/20/83-0821	75	EQ.	791	211	95
907	5/20/83-1328	75	EQ.	791	198	95
908	5/20/83-1614	75	EQ.	791	187	95
909	5/21/83-0833	75	EQ.	791	163	95
910	5/23/83-0855	87	EQ.	765	216	193
911	5/24/83-0845	100	EQ.	736	228	229

TABLE 5.2

VERIFICATION OF ACCEPTANCE CRITERIA

Flux Map	Core Location	FQN	Limit
902	K-10ED,19	2.65	4.28
903	D-11DJ,20	2.38	4.29
904	D-11DJ,24	2.25	4.34
905	K-04JD,23	2.06	2.89
906	C-10EK,33	2.08	2.95
907	K-04JD,36	2.15	2.87
908	K-04JD,37	2.20	2.88
909	C-10EK,36	2.27	2.87
910	K-04JD,24	2.03	2.49
911	K-04JD,34	2.04	2.[illegible]

Flux Map	Core Location	FDHN	Limit
902	K-10ED	1.56	1.70
903	D-11DJ	1.55	1.70
904	C-10EK	1.54	1.70
905	K-04JD	1.50	1.63
906	K-04JD	1.50	1.63
907	K-04JD	1.51	1.62
908	K-04JD	1.52	1.62
909	K-04JD	1.52	1.62
910	K-04JD	1.50	1.59
911	K-04JD	1.49	1.55

FQN and FDHN include appropriate uncertainties and penalties.

Limit on FQN is a function of Core Power, Axial Location, and Fuel 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
902	4.9	5.5 (d)	2.0
903	4.7	3.1	1.6
904	3.9	3.1	1.2
905	4.3	2.9	1.0
906	4.0	2.8	0.9
907	4.0	2.8	0.9
908	3.8	2.8	0.9
909	3.8	2.9	0.9
910	2.5	2.8	0.8
911	5.1	2.8	0.7

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

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

(c) Percent Maximum Quadrant Tilt from normalized calculated quadrant powers. Review criteria is 4% at low power, 2% at equilibrium power.

(d) Review criterion exceeded.

	1	2	3	4	5	6	7	8	9	10	11	12	13
A								0.447 0.371 20.49					
B						0.976 0.924 5.63							
C			0.444 0.479 -7.31					1.115 1.080 3.24	1.039 1.040 -0.10		0.499 0.504 -0.99		
D					1.050 1.091 -3.76		1.268 1.260 0.63						
E		0.834 0.837 -0.36				1.270 1.281 -0.86				1.104 1.087 1.56			
F					1.261 1.280 -1.48			1.256 1.265 -0.71				1.005 0.953 5.46	
G		1.045 1.070 -2.34		1.237 1.260 -1.83		1.251 1.275 -1.88			1.136 1.157 -1.82		1.179 1.152 2.34		0.682 0.643 6.07
H	0.429 0.371 15.63		1.060 1.080 -1.85					1.254 1.261 -0.56		1.242 1.232 0.81			
I					1.098 1.151 -4.60		1.139 1.157 -1.56				1.018 1.042 -2.30		
J			1.027 1.096 -6.30					1.233 1.232 0.08		1.058 1.071 -1.21		0.000 0.000 0.00	
K				1.037 1.091 -4.95			1.159 1.152 0.61						
L				0.551 0.519 6.17					0.917 0.890 3.03				
M							0.679 0.643 5.60						

LOOP B (upper left), LOOP A (upper right), LOOP B (lower left), LOOP A (lower right); 0° marker at right of row G

Legend (cell lines, top to bottom):
- CALCULATED R.R.I
- PREDICTED R.R.I
- PERCENT DIFFERENCE

F.M. 902 CALC./PRED.
REACTION RATE INTEG.

δ=5.47

FIGURE 5.1

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.361 0.342 5.47	0.768 0.679 13.16	0.412 0.342 20.43					
B				0.489 0.528 -7.34	0.994 0.943 5.47	1.021 0.968 5.47	1.257 1.147 9.58	1.045 0.968 7.89	1.014 0.943 7.63	0.525 0.528 -0.62			
C			0.448 0.483 -7.34	1.138 1.206 -5.62	0.974 0.967 0.70	1.130 1.121 0.78	1.169 1.135 2.97	1.135 1.121 1.24	0.980 0.967 1.39	1.198 1.206 -0.63	0.478 0.483 -1.12		
D		0.508 0.528 -3.77	1.158 1.206 -3.95	0.962 1.018 -5.53	1.097 1.125 -2.50	1.198 1.215 -1.42	1.328 1.317 0.85	1.229 1.215 1.17	1.141 1.125 1.45	1.019 1.018 0.10	1.208 1.206 0.14	0.522 0.528 -1.12	
E		0.939 0.943 -0.39	0.963 0.967 -0.39	1.094 1.125 -2.72	1.086 1.110 -2.13	1.286 1.305 -1.46	1.097 1.102 -0.43	1.302 1.305 -0.20	1.114 1.110 0.35	1.142 1.125 1.47	0.999 0.967 3.37	0.993 0.943 5.36	
F	0.337 0.342 -1.43	0.955 0.969 -1.45	1.104 1.122 -1.61	1.193 1.215 -1.79	1.284 1.305 -1.61	1.219 1.237 -1.50	1.297 1.313 -1.22	1.221 1.237 -1.33	1.299 1.305 -0.46	1.222 1.215 0.62	1.156 1.122 3.06	1.013 0.969 4.54	0.361 0.342 5.61
G	0.723 0.679 6.54	1.185 1.147 3.32	1.111 1.135 -2.15	1.292 1.317 -1.87	1.083 1.103 -1.83	1.290 1.313 -1.78	1.050 1.062 -1.14	1.298 1.313 -1.13	1.095 1.103 -0.73	1.322 1.317 0.35	1.166 1.135 2.74	1.198 1.147 4.49	0.717 0.679 5.63
H	0.367 0.342 7.33	1.005 0.969 3.69	1.098 1.122 -2.14	1.180 1.215 -2.86	1.267 1.305 -2.89	1.203 1.237 -2.73	1.295 1.313 -1.39	1.220 1.237 -1.36	1.297 1.305 -0.61	1.212 1.215 -0.29	1.124 1.122 0.18	0.987 0.969 1.91	0.362 0.342 5.84
I		0.965 0.943 2.34	0.926 0.967 -4.22	1.076 1.125 -4.38	1.058 1.110 -4.69	1.264 1.305 -3.16	1.093 1.102 -0.82	1.295 1.305 -0.77	1.106 1.110 -0.32	1.114 1.125 -1.00	0.956 0.967 -1.09	0.920 0.943 -2.38	
J		0.494 0.528 -6.43	1.136 1.206 -5.78	0.963 1.018 -5.38	1.070 1.125 -4.85	1.192 1.215 -1.93	1.312 1.317 -0.38	1.211 1.215 -0.36	1.117 1.125 -0.68	1.000 1.018 -1.80	1.184 1.206 -1.85	0.516 0.528 -2.38	
K			0.474 0.483 -1.86	1.184 1.206 -1.79	0.971 0.967 0.47	1.127 1.121 0.52	1.138 1.135 0.26	1.134 1.121 1.12	0.972 0.967 0.57	1.215 1.206 0.75	0.477 0.483 -1.32		
L				0.533 0.528 0.95	0.950 0.943 0.74	0.998 0.968 3.02	1.182 1.147 3.02	0.997 0.968 2.98	0.970 0.943 2.93	0.544 0.528 2.93			
M						0.361 0.342 5.50	0.716 0.679 5.50	0.357 0.342 4.24					

LOOP B (upper left), LOOP A (upper right), LOOP B (lower left), LOOP A (lower right), 0°

Legend (each box):
- MEASURED FDHN
- PREDICTED FDHN
- PERCENT DIFFERENCE

FLUX MAP 902

δ = 3.95

FIGURE 5.2

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.369 0.359 2.73	0.744 0.699 6.36	0.394 0.359 9.81					
B				0.520 0.539 -3.56	0.974 0.948 2.72	1.006 0.980 2.72	1.216 1.154 5.36	1.030 0.980 5.13	0.996 0.948 5.03	0.548 0.539 1.56			
C			0.475 0.493 -3.57	1.169 1.194 -2.12	0.982 0.972 1.01	1.126 1.125 0.05	1.156 1.140 1.42	1.140 1.125 1.30	0.998 0.972 2.68	1.212 1.194 1.55	0.499 0.493 1.30		
D		0.536 0.539 -0.63	1.185 1.194 -0.78	0.997 1.018 -2.04	1.112 1.124 -1.08	1.189 1.206 -1.43	1.300 1.302 -0.12	1.220 1.206 1.14	1.153 1.124 2.59	1.036 1.018 1.82	1.215 1.194 1.80	0.546 0.539 1.30	
E		0.969 0.948 2.15	0.993 0.972 2.15	1.109 1.124 -1.33	1.090 1.106 -1.42	1.267 1.287 -1.59	1.082 1.096 -1.28	1.273 1.287 -1.06	1.119 1.106 1.14	1.150 1.124 2.33	0.998 0.972 2.67	0.977 0.948 3.03	
F	0.358 0.359 -0.25	0.978 0.980 -0.24	1.109 1.125 -1.40	1.170 1.205 -2.86	1.253 1.287 -2.67	1.190 1.219 -2.37	1.268 1.290 -1.70	1.206 1.219 -1.03	1.287 1.287 -0.01	1.206 1.205 0.07	1.145 1.125 1.74	1.008 0.980 2.82	0.374 0.359 4.26
G	0.707 0.699 1.09	1.163 1.154 0.77	1.104 1.140 -3.16	1.264 1.302 -2.93	1.063 1.097 -3.06	1.254 1.290 -2.81	1.039 1.052 -1.26	1.280 1.290 -0.78	1.093 1.097 -0.40	1.297 1.302 -0.39	1.154 1.140 1.24	1.186 1.154 2.80	0.730 0.699 4.35
H	0.364 0.359 1.39	0.991 0.980 1.09	1.090 1.125 -3.16	1.164 1.205 -3.37	1.243 1.287 -3.39	1.190 1.219 -2.40	1.272 1.290 -1.38	1.208 1.219 -0.92	1.282 1.287 -0.39	1.201 1.205 -0.35	1.127 1.125 0.14	0.996 0.980 1.62	0.379 0.359 5.46
I		0.962 0.948 1.45	0.954 0.972 -1.85	1.096 1.124 -2.46	1.072 1.106 -3.05	1.263 1.287 -1.85	1.096 1.096 -0.03	1.287 1.287 0.02	1.101 1.106 -0.46	1.113 1.124 -1.01	0.963 0.972 -0.98	0.944 0.948 -0.50	
J		0.529 0.539 -1.85	1.178 1.194 -1.31	0.999 1.018 -1.84	1.103 1.124 -1.89	1.186 1.206 -1.63	1.298 1.302 -0.33	1.203 1.206 -0.27	1.108 1.124 -1.38	0.996 1.018 -2.16	1.170 1.194 -2.03	0.537 0.539 -0.50	
K			0.490 0.493 -0.71	1.186 1.194 -0.68	0.971 0.972 -0.13	1.112 1.125 -1.16	1.137 1.140 -0.25	1.140 1.125 1.36	0.979 0.972 0.67	1.199 1.194 0.39	0.475 0.493 -3.57		
L				0.539 0.539 -0.09	0.947 0.948 -0.11	0.994 0.980 1.51	1.171 1.154 1.51	1.005 0.980 2.55	0.991 0.948 4.52	0.564 0.539 4.52			
M						0.374 0.359 4.15	0.728 0.699 4.16	0.374 0.359 4.35					

LOOP B — LOOP A — LOOP B — LOOP A — 0°

Legend (each cell, top to bottom): MEASURED FDHN / PREDICTED FDHN / PERCENT DIFFERENCE

FLUX MAP 903

δ=2.46

FIGURE 5.3

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.377 0.365 3.15	0.749 0.706 6.02	0.397 0.365 8.76					
B				0.523 0.549 -4.70	0.986 0.956 3.14	1.010 0.979 3.15	1.208 1.146 5.39	1.026 0.979 4.81	1.000 0.956 4.69	0.550 0.549 0.22			
C			0.478 0.502 -4.70	1.163 1.200 -3.07	0.985 0.977 0.83	1.111 1.109 0.17	1.137 1.114 2.03	1.126 1.109 1.55	1.003 0.977 2.67	1.203 1.200 0.22	0.498 0.502 -0.72		
D		0.544 0.549 -0.93	1.187 1.200 -1.11	0.994 1.025 -2.98	1.106 1.119 -1.15	1.184 1.199 -1.22	1.295 1.288 0.57	1.216 1.199 1.38	1.147 1.119 2.48	1.033 1.025 0.82	1.207 1.200 0.58	0.545 0.549 -0.71	
E		0.981 0.956 2.66	1.003 0.977 2.65	1.103 1.119 -1.41	1.096 1.110 -1.24	1.269 1.285 -1.26	1.087 1.100 -1.23	1.267 1.285 -1.59	1.114 1.110 0.32	1.141 1.119 1.95	0.995 0.977 1.92	0.974 0.956 1.90	
F	0.367 0.365 0.41	0.983 0.979 0.41	1.101 1.109 -0.72	1.172 1.199 -2.22	1.258 1.285 -2.11	1.200 1.223 -1.86	1.269 1.293 -1.82	1.206 1.223 -1.41	1.281 1.285 -0.33	1.199 1.199 -0.01	1.121 1.109 1.06	1.004 0.979 2.52	0.380 0.365 4.13
G	0.716 0.706 1.42	1.160 1.146 1.23	1.101 1.114 -1.12	1.274 1.288 -1.12	1.073 1.101 -2.54	1.262 1.293 -2.41	1.047 1.067 -1.89	1.276 1.293 -1.29	1.092 1.101 -0.84	1.282 1.288 -0.48	1.120 1.114 0.56	1.175 1.146 2.56	0.737 0.706 4.33
H	0.371 0.365 1.70	0.993 0.979 1.42	1.098 1.109 -0.97	1.180 1.199 -1.62	1.244 1.285 -3.18	1.192 1.223 -2.56	1.270 1.293 -1.75	1.208 1.223 -1.19	1.277 1.285 -0.62	1.191 1.199 -0.67	1.104 1.109 -0.50	0.993 0.979 1.43	0.388 0.365 6.35
I		0.972 0.956 1.72	0.979 0.977 0.27	1.108 1.119 -1.00	1.073 1.110 -3.38	1.256 1.285 -2.23	1.092 1.100 -0.68	1.277 1.285 -0.65	1.100 1.110 -0.94	1.103 1.119 -1.44	0.963 0.977 -1.44	0.942 0.956 -1.46	
J		0.544 0.549 -0.89	1.193 1.200 -0.55	1.010 1.025 -1.44	1.099 1.119 -1.81	1.175 1.199 -1.96	1.278 1.288 -0.78	1.190 1.199 -0.73	1.101 1.119 -1.65	0.999 1.025 [illegible]	1.170 1.200 -2.46	0.541 0.549 -1.46	
K			0.504 0.502 0.40	1.205 1.200 0.43	0.987 0.977 1.05	1.093 1.109 -1.42	1.106 1.114 -0.69	1.116 1.109 0.65	0.977 0.977 0.07	1.198 1.200 -0.14	0.485 0.502 -3.45		
L				0.555 0.549 1.17	0.966 0.956 1.12	1.003 0.979 2.42	1.174 1.146 2.43	1.006 0.979 2.73	0.987 0.956 3.32	0.567 0.549 3.32			
M						0.388 0.365 6.22	0.750 0.706 6.23	0.383 0.365 4.82					

LOOP B (B–C, left) · LOOP A (B–C, right) · LOOP B (K, left) · LOOP A (K, right) · 0° (at row G, right)

Legend (each box): MEASURED FDHN / PREDICTED FDHN / PERCENT DIFFERENCE

FLUX MAP 904

δ=2.45

FIGURE 5.4

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.392 0.380 3.03	0.768 0.724 5.96	0.413 0.380 8.73					
B				0.530 0.548 -3.30	0.977 0.948 3.04	1.020 0.990 3.03	1.228 1.170 4.92	1.032 0.990 4.18	0.987 0.948 4.06	0.548 0.548 0.07			
C			0.483 0.500 -3.30	1.138 1.165 -2.34	0.981 0.974 0.79	1.122 1.121 0.07	1.199 1.182 1.47	1.130 1.121 0.82	0.991 0.974 1.77	1.166 1.165 0.06	0.497 0.500 -0.46		
D		0.547 0.548 -0.07	1.162 1.165 -0.24	0.987 1.010 -2.29	1.089 1.104 -1.37	1.180 1.197 -1.45	1.297 1.298 -0.08	1.205 1.197 0.69	1.122 1.104 1.62	1.015 1.010 0.47	1.169 1.165 0.36	0.545 0.548 -0.46	
E		0.976 0.948 2.97	1.003 0.974 2.98	1.088 1.104 -1.47	1.089 1.105 -1.44	1.252 1.271 -1.49	1.089 1.104 -1.39	1.253 1.271 -1.38	1.106 1.105 0.07	1.118 1.104 1.22	0.989 0.974 1.60	0.967 0.948 1.99	
F	0.382 0.380 0.42	0.995 0.991 0.41	1.126 1.121 0.41	1.178 1.197 -1.60	1.246 1.271 -2.00	1.189 1.213 -2.02	1.254 1.278 -1.85	1.199 1.213 -1.14	1.271 1.271 0.02	1.199 1.197 0.15	1.129 1.121 0.74	1.011 0.991 2.05	0.394 0.380 3.55
G	0.732 0.725 1.04	1.179 1.170 0.79	1.175 1.182 -0.63	1.293 1.298 -0.37	1.079 1.105 -2.33	1.248 1.279 -2.39	1.052 1.070 -1.66	1.267 1.279 -0.94	1.101 1.105 -0.39	1.296 1.298 -0.13	1.188 1.182 0.48	1.194 1.170 2.06	0.751 0.725 3.70
H	0.385 0.380 1.32	1.000 0.991 0.97	1.115 1.121 -0.51	1.178 1.197 -1.58	1.225 1.271 -3.60	1.170 1.213 -3.57	1.254 1.278 -1.86	1.204 1.213 -0.73	1.271 1.271 -0.02	1.191 1.197 -0.47	1.115 1.121 -0.54	1.000 0.991 0.94	0.400 0.380 5.13
I		0.964 0.948 1.69	0.978 0.974 0.43	1.091 1.104 -1.14	1.060 1.105 -4.11	1.219 1.271 -4.11	1.102 1.104 -0.19	1.269 1.271 -0.19	1.095 1.105 -0.90	1.087 1.104 -1.52	0.959 0.974 -1.51	0.935 0.948 -1.34	
J		0.548 0.548 0.02	1.171 1.165 0.49	1.000 1.010 -0.96	1.086 1.104 -1.59	1.167 1.197 -2.51	1.294 1.298 -0.29	1.194 1.197 -0.23	1.084 1.104 -1.78	0.982 1.010 -2.73	1.134 1.165 -2.62	0.541 0.548 -1.33	
K			0.505 0.500 1.12	1.179 1.165 1.16	0.990 0.974 1.69	1.111 1.121 -0.93	1.178 1.182 -0.35	1.131 1.121 0.93	0.974 0.974 0.03	1.161 1.165 -0.30	0.480 0.500 -3.90		
L				0.557 0.548 1.75	0.964 0.948 1.72	1.010 0.990 1.99	1.193 1.170 2.00	1.015 0.990 2.50	0.981 0.948 3.47	0.567 0.548 3.47			
M						0.399 0.380 4.89	0.760 0.724 4.90	0.396 0.380 4.21					

LOOP B (upper left) — LOOP A (upper right) — LOOP B (lower left) — LOOP A (lower right)

Legend (each box): MEASURED FDHN / PREDICTED FDHN / PERCENT DIFFERENCE

FLUX MAP 905

δ=2.26

FIGURE 5.5

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.400 0.387 3.49	0.775 0.730 6.12	0.420 0.387 8.63					
B				0.537 0.553 -2.87	0.981 0.948 3.48	1.025 0.990 3.48	1.222 1.164 4.97	1.030 0.990 4.03	0.985 0.948 3.91	0.550 0.553 -0.52			
C			0.490 0.505 -2.89	1.129 1.157 -2.43	0.983 0.977 0.69	1.122 1.121 0.10	1.197 1.178 1.63	1.130 1.121 0.78	0.992 0.977 1.60	1.151 1.157 -0.52	0.498 0.505 -1.48		
D		0.556 0.553 0.49	1.161 1.157 0.32	0.988 1.012 -2.40	1.090 1.106 -1.46	1.177 1.194 -1.40	1.292 1.290 0.12	1.202 1.194 0.66	1.122 1.106 1.41	1.012 1.012 -0.01	1.154 1.157 -0.29	0.545 0.553 -1.48	
E		0.983 0.948 3.68	1.013 0.977 3.68	1.091 1.106 -1.39	1.095 1.109 -1.22	1.251 1.267 -1.24	1.097 1.107 -0.94	1.255 1.267 -0.96	1.111 1.109 0.22	1.116 1.106 0.95	0.987 0.977 1.01	0.959 0.948 1.09	
F	0.391 0.387 1.09	1.002 0.991 1.08	1.119 1.121 -0.17	1.172 1.193 -1.74	1.246 1.267 -1.62	1.195 1.211 -1.33	1.258 1.274 -1.22	1.195 1.211 -1.35	1.259 1.267 -0.66	1.185 1.193 -0.65	1.126 1.121 0.44	1.008 0.991 1.75	0.399 0.387 3.02
G	0.737 0.730 0.92	1.172 1.164 0.70	1.164 1.178 -1.16	1.277 1.290 -1.04	1.087 1.108 -1.92	1.253 1.274 -1.62	1.063 1.075 -1.10	1.260 1.274 -1.08	1.100 1.108 -0.69	1.281 1.290 -0.71	1.182 1.178 0.34	1.185 1.164 1.80	0.753 0.730 3.19
H	0.391 0.387 1.14	0.999 0.991 0.84	1.109 1.121 -1.05	1.170 1.193 -1.89	1.230 1.267 -2.91	1.180 1.211 -2.58	1.255 1.274 -1.47	1.194 1.211 -1.41	1.259 1.267 -0.62	1.183 1.193 -0.85	1.116 1.121 -0.48	1.000 0.991 0.91	0.406 0.387 4.96
I		0.960 0.948 1.19	0.978 0.977 0.12	1.092 1.106 -1.22	1.067 1.109 -3.75	1.232 1.267 -2.75	1.101 1.107 -0.59	1.260 1.267 -0.51	1.102 1.109 -0.60	1.090 1.106 -1.40	0.963 0.977 -1.40	0.933 0.948 -1.56	
J		0.551 0.553 -0.42	1.162 1.157 0.45	1.003 1.012 -0.85	1.093 1.106 -1.20	1.168 1.194 -2.19	1.280 1.290 -0.74	1.186 1.194 -0.66	1.090 1.106 -1.41	0.986 1.012 -2.57	1.128 1.157 -2.49	0.544 0.553 -1.55	
K			0.511 0.505 1.15	1.171 1.157 1.20	0.996 0.977 1.95	1.109 1.121 -1.11	1.174 1.178 -0.31	1.133 1.121 1.06	0.980 0.977 0.39	1.158 1.157 0.10	0.488 0.505 -3.43		
L				0.564 0.553 1.99	0.967 0.948 1.96	1.009 0.990 1.87	1.186 1.164 1.86	1.015 0.990 2.52	0.984 0.948 3.79	0.574 0.553 3.78			
M						0.405 0.387 4.81	0.765 0.730 4.81	0.404 0.387 4.32					

LOOP B (at B1 and K2); LOOP A (at B13 and K13); 0° (at G13)

Legend (box): ← MEASURED FDHN / ← PREDICTED FDHN / ← PERCENT DIFFERENCE

FLUX MAP 911

δ = 2.20

FIGURE 5.6

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, 200 and 228 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 bistable trip setpoint is checked.

The calibration was performed satisfactorily during the Cycle 9 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 9 startup (4). Several flux maps were performed over a range of axial offsets at approximately 75% 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 Kewaunee Cycle IX," Wisconsin Public Service Corporation, February, 1983.

(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.

(4) "Reactor Test Program, Kewaunee Nuclear Power Plant," Wisconsin Public Service Corporation, May, 1979. (Revised April 14, 1980)

(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.

NRC-83-137

WISCONSIN PUBLIC SERVICE CORPORATION

Public Service

P.O. Box 1200, Green Bay, Wisconsin 54305

July 15, 1983

Director of Nuclear Reactor Regulation
Attention: Mr. S. A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Varga:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Cycle 9 Startup Report

In accordance with our practice of reporting the results of physics tests, we hereby submit 40 copies of the Kewaunee Nuclear Plant Cycle 9 Startup Report.

Very truly yours,

Carl W. Giesler

C. W. Giesler
Vice President - Nuclear Power

js

cc - Mr. Robert Nelson, US NRC
US NRC, c/o Document Management Branch
Washington, D.C. 20555

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