KEWAUNEE NUCLEAR POWER PLANT

CYCLE 8
STARTUP REPORT

JULY, 1982

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CYCLE 8

STARTUP REPORT

JUNE 1982

Wisconsin Public Service
Corporation
Green Bay, Wisconsin
Date 6/15/82

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1.0 INTRODUCTION, SUMMARY, AND CONCLUSIONS

1.1 Introduction

This report presents the results of the physics tests performed for Kewaunee Cycle 8. 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 7-8 refueling, 36 of the 121 fuel assemblies in the core were replaced with fresh assemblies of Exxon Design(5), enriched to 3.2 w/o U235. The Cycle 8 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	5
4	W	3.3	4	8
6	W	3.1	3	8
7	ENC	3.2	2	12
8	ENC	3.2	1	4
8	ENC	3.2	2	16
9	ENC	3.2	1	32
10	ENC	3.2	0	36(FEED)

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

On May 20, 1982 at 1806 HRS., initial criticality was achieved on the Cycle 8 core. The schedule of physics tests and measurements is outlined in Table 1.1.

1.2 Summary

RCCA measurements are shown in Section 2. All RCCA drop time measurements were within Technical Specification Limits. RCCA bank worths were measured using the rod swap reactivity comparison technique previously described (4,6). The reactivity comparison was made to the reference bank, Bank C, which was measured using the 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 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 8.

1.3 Conclusion

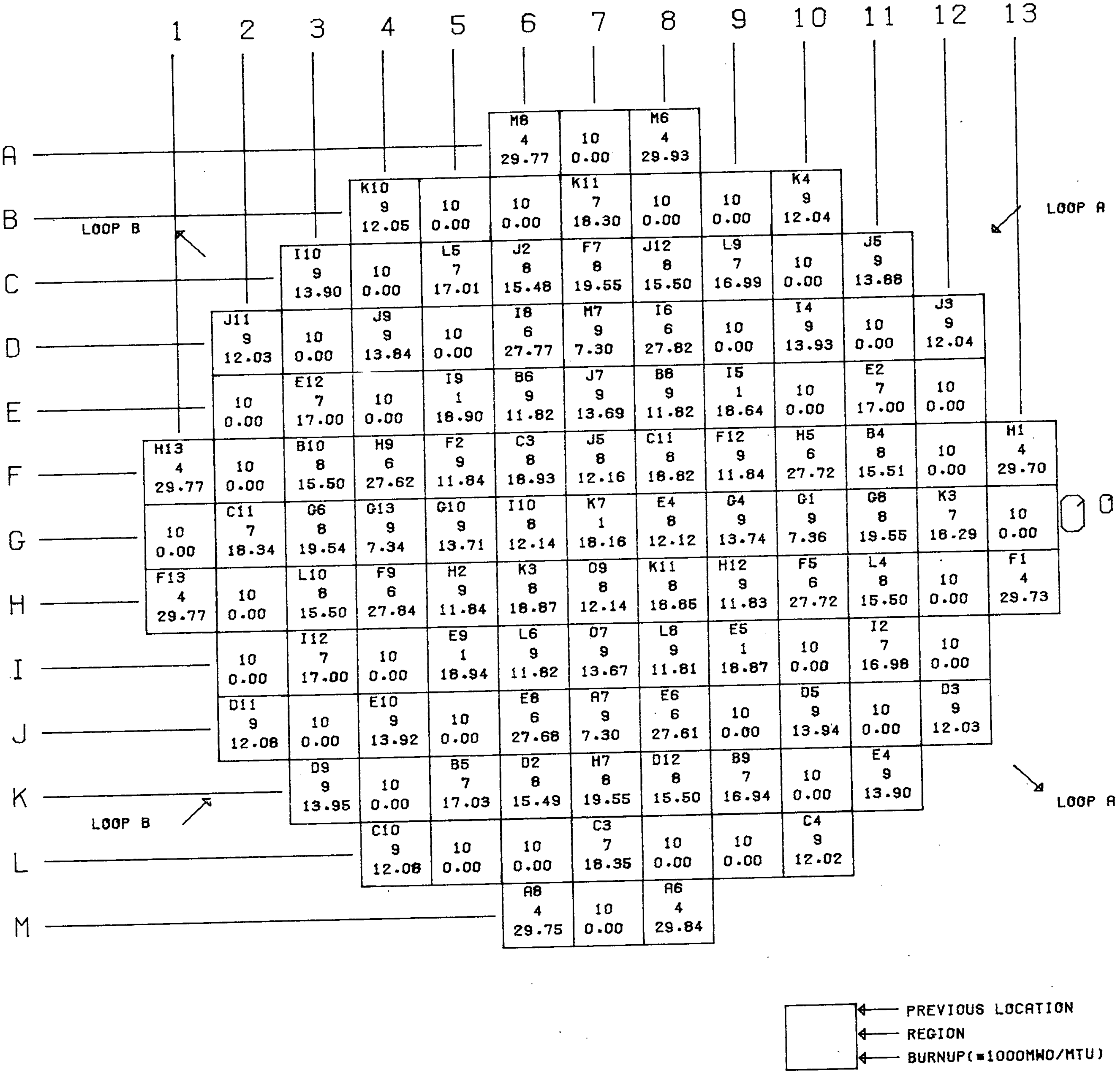
The startup testing of Kewaunee's Cycle 8 core verified that the reactor core has been properly loaded and the core characteristics satisfy the Technical Specifications (7) and are consistent with the parameters used in the design and safety analysis (1).

TABLE 1.1

KEWAUNEE NUCLEAR POWER PLANT

BOL CYCLE 8 PHYSICS TEST

Test	Date Completed	Time Completed	Plant Conditions
Control Rod Operability Test	5/16/82	1100	200-F/400#
RPI Calibrations	5/19/82	1745	HZP
Hot Rod Drops	5/20/82	1040	HZP
Initial Criticality	5/20/82	1806	HZP
Low Power Flux Map 410	5/21/82	0539	HZP
Reactivity Computer Checkout	5/21/82	0935	HZP
MTC Determination	5/21/82	1120	HZP
Boron Endpoint - ARO	5/21/82	1150	HZP
Bank C Worth (Dilution)	5/22/82	1345	HZP
Boron Endpoint - C in	5/21/82	1430	HZP
Rod Swap	5/21/82	2240	HZP
Bank C Worth (Boration)	5/21/82	2315	HZP
Bank C Worth (Dilution)	5/21/82	0105	HZP
Bank C Worth (Boration)	5/22/82	0325	HZP
Power Ascension Flux Map 411	5/23/82	0118	29%
Power Ascension Flux Map 412	5/25/82	0956	43%
Incore/Excore Calibration Flux Map 413	5/27/82	0811	77%
Incore/Excore Calibration Flux Map 414	5/27/82	1128	77%
Incore/Excore Calibration Flux Map 415	5/27/82	1442	77%
Incore/Excore Calibration Flux Map 416	5/27/82	1734	77%
Incore/Excore Calibration Flux Map 417	5/27/82	2256	77%
Power Ascension Flux Map 418	6/1/82	0829	88%
Power Ascension Flux Map 419	6/2/82	1353	100%
Power Ascension Flux Map 420	6/4/82	0852	100%



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						M8 4 29.77	10 0.00	M6 4 29.93					
B				K10 9 12.05	10 0.00	10 0.00	K11 7 18.30	10 0.00	10 0.00	K4 9 12.04			
C			I10 9 13.90	10 0.00	L5 7 17.01	J2 8 15.48	F7 8 19.55	J12 8 15.50	L9 7 16.99	10 0.00	J5 9 13.88		
D		J11 9 12.03	10 0.00	J9 9 13.84	10 0.00	I8 6 27.77	M7 9 7.30	I6 6 27.82	10 0.00	I4 9 13.93	10 0.00	J3 9 12.04	
E		10 0.00	E12 7 17.00	10 0.00	I9 1 18.90	B6 9 11.82	J7 9 13.69	B8 9 11.82	I5 1 18.64	10 0.00	E2 7 17.00	10 0.00	
F	H13 4 29.77	10 0.00	B10 8 15.50	H9 6 27.62	F2 9 11.84	C3 8 18.93	J5 8 12.16	C11 8 18.82	F12 9 11.84	H5 6 27.72	B4 8 15.51	10 0.00	H1 4 29.70
G	10 0.00	C11 7 18.34	G6 8 19.54	G13 9 7.34	G10 9 13.71	I10 8 12.14	K7 1 18.16	E4 8 12.12	G4 9 13.74	G1 9 7.36	G8 8 19.55	K3 7 18.29	10 0.00
H	F13 4 29.77	10 0.00	L10 8 15.50	F9 6 27.84	H2 9 11.84	K3 8 18.87	G9 8 12.14	K11 8 18.85	H12 9 11.83	F5 6 27.72	L4 8 15.50	10 0.00	F1 4 29.73
I		10 0.00	I12 7 17.00	10 0.00	E9 1 18.94	L6 9 11.82	G7 9 13.67	L8 9 11.81	E5 1 18.87	10 0.00	I2 7 16.98	10 0.00	
J		D11 9 12.08	10 0.00	E10 9 13.92	10 0.00	E8 6 27.68	A7 9 7.30	E6 6 27.61	10 0.00	D5 9 13.94	10 0.00	D3 9 12.03	
K			D9 9 13.95	10 0.00	B5 7 17.03	D2 8 15.49	H7 8 19.55	D12 8 15.50	B9 7 16.94	10 0.00	E4 9 13.90		
L				C10 9 12.08	10 0.00	10 0.00	C3 7 18.35	10 0.00	10 0.00	C4 9 12.02			
M						A8 4 29.75	10 0.00	A6 4 29.84					

KEWAUNEE CYCLE 8
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 8 startup the reactivity of the reference bank (Bank C) 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. This method allows design verification of all the RCCA bank reactivity worths in a much shorter period of time than the boration/dilution method.

2.2.1 Rod Swap Results

The cycle 8 reference bank was determined to be Bank C. The measurement of the reference bank was repeated due to testing difficulties; (a) a flat plateau (a flux range over which the reactivity computer demonstrates that reactivity is independent of flux) could not be clearly established, and (b) reactor trips, caused by a defective lot of fuses in the control rod drive system, were encountered during the test. As a result, there was difficulty in evaluating the reference bank worth by reactivity computer; some measurements met the review criteria, others did not.

The rod swap results were presented to the Plant Operations and Review Committee (PORC Meeting 82-55, item 82-291). The committee reviewed the reactivity computer results as well as corroborating data regarding rod worths.
The boron endpoint data presented in Table 3.1 provides a second measure of reference bank worth. The difference in the measured to predicted boron concentration change is only 5%. Further verification of the calculated rodworth adequacy can be found in the rodswap critical data displayed in Table 2.2. The measured critical positions of the reference bank were within a few steps of the predicted heights.

The committee recommended that the two smallest reference bank rod worth measurements be averaged, and used for the rodswap evaluation. Although these results are somewhat poorer than past experience, all review and acceptance criteria were met. The results of predicted to measured bank worth comparisons for the reference bank are presented in Figures 2.1 and 2.2. The average integral worth comparison is within the 10% review criterion for the reference bank. The remaining bank worths were inferred by reactivity swaps with the reference bank and the results are displayed in Table 2.3. Since the measured to predicted comparison of total bank worth was -9.3%, which is within the ±10% acceptance criterion, no further measurements or calculations were performed.

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 2.4. 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 2.4 is conservative and no additional evaluation is necessary.

TABLE 2.1

KEWAUNEE CYCLE 8

RCCA DROP TIME MEASUREMENTS

HOT ZERO POWER

	All Fuel	Westinghouse Fuel	Exxon Fuel
Average Dashpot Delta T (Sec)	1.286	1.338	1.284
Standard Deviation	0.028	0.000	0.027
Average Rod Bottom Delta T (Sec)	1.786	1.778	1.787
Standard Deviation	0.034	0.000	0.034

TABLE 2.2

RODSWAP CRITICAL DATA

Measured Ref. Bank Height (Steps)	Predicted Ref. Bank Height (Steps)	Boron Conc.(ppm)	Core Configuration
202	197	1245	A-IN, ORO
142	142	1247	B-IN, ORO
147	151	1242	D-IN, ORO
139	129	1250*	Sa-IN, ORO
139	129	1250*	Sb-IN, ORO

* Boron Conc. adjusted after reactor trip

TABLE 2.3
KEWAUNEE CYCLE 8
RCCA BANK WORTH SUMMARY

Rod Swap Method RCCA Bank	Measured Worth (PCM)	WPS Predicted Worth (PCM)	Difference PCM	Percent Difference
D	611.0	719.0	-108.0	-15.0
C	965.7	1068.0	-102.3	- 9.6
B	647.1	733.0	-85.9	-11.7
A	881.2	947.0	-65.8	- 6.9
SA	599.7	640.0	-40.3	- 6.3
SB	601.8	640.0	-38.2	- 6.0
Total	4306.5	4747.0	-440.5	- 9.3

FIG. 2.1

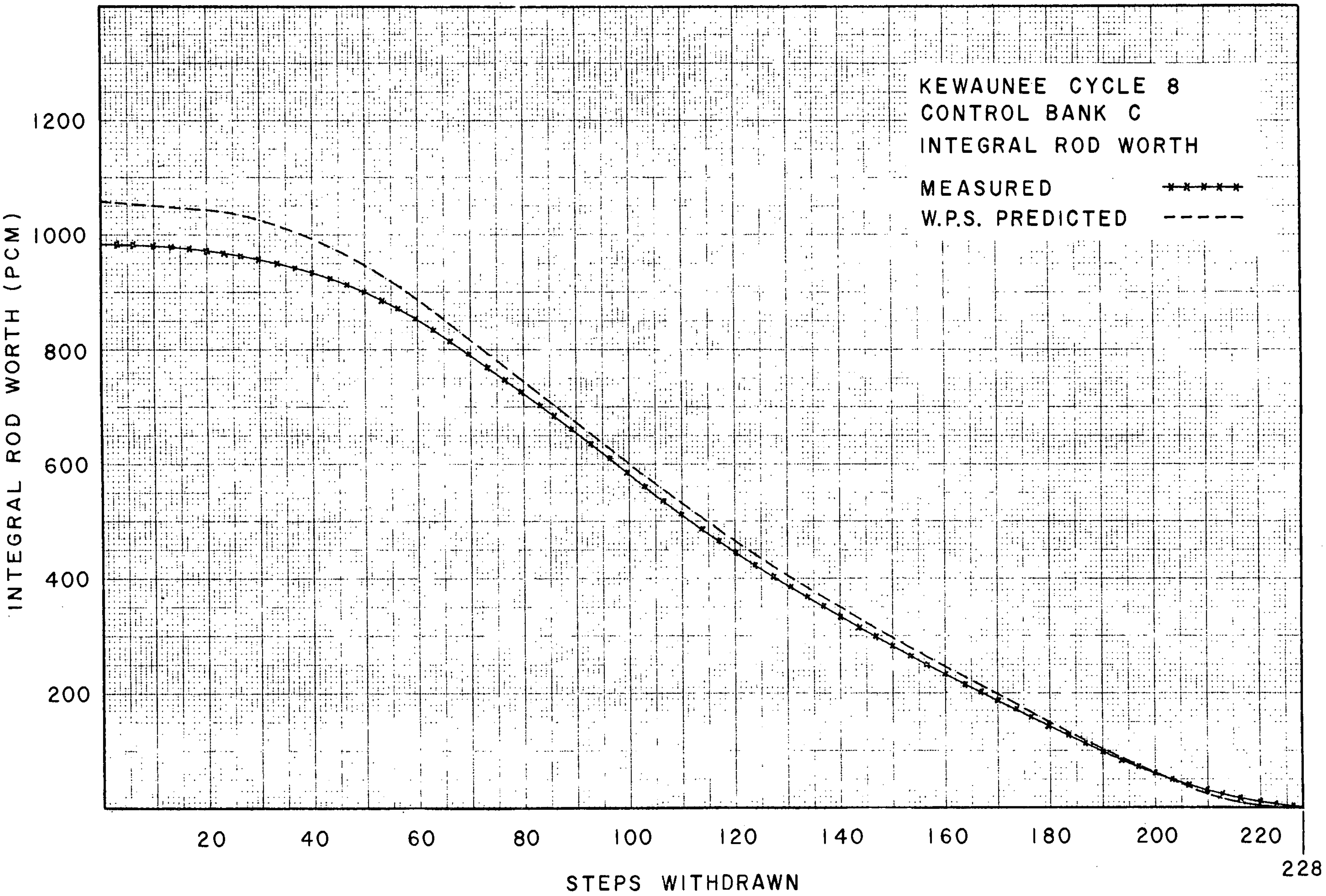

KEWAUNEE CYCLE 8
CONTROL BANK C
INTEGRAL ROD WORTH
MEASURED
W.P.S. PREDICTED
INTEGRAL ROD WORTH (PCM)
1200
1000
800
600
400
200
20
40
60
80
100
120
140
160
180
200
220
228
STEPS WITHDRAWN

FIG. 2.2

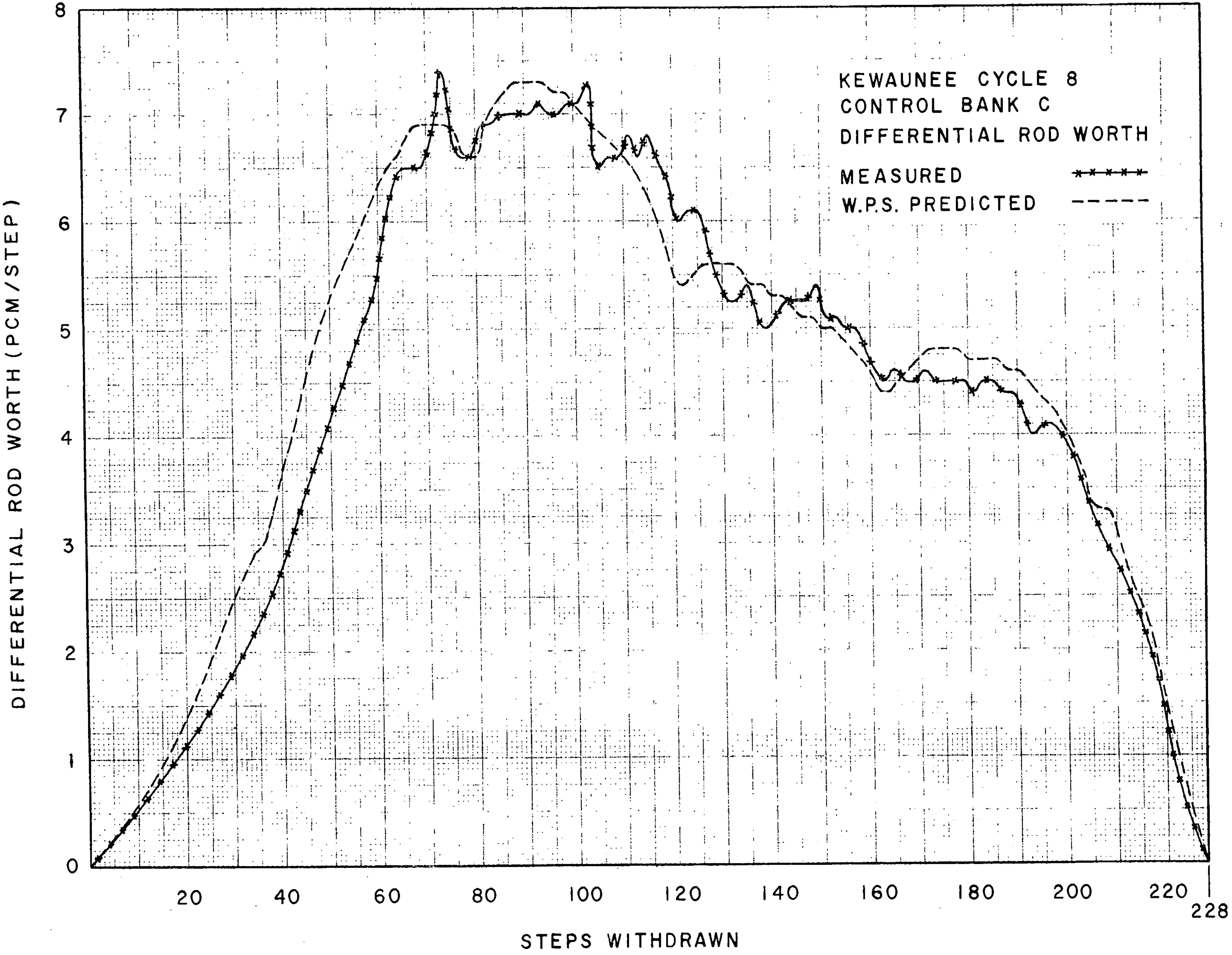

KEWAUNEE CYCLE 8
CONTROL BANK C
DIFFERENTIAL ROD WORTH
MEASURED
W.P.S. PREDICTED
DIFFERENTIAL ROD WORTH (PCM/STEP)
0
1
2
3
4
5
6
7
8
20
40
60
80
100
120
140
160
180
200
220
228
STEPS WITHDRAWN

TABLE 2.4

KEWAUNEE CYCLE 8

MINIMUM SHUTDOWN MARGIN ANALYSIS

	BOC	EOC
RCCA Bank Worths (PCM)		
N	6593	7020
N-1	5586	6023
Less 10 Percent	559	602
Sub Total	5027	5421
Total Requirements (Including Uncertainties)	2144	2875
Shutdown Margin	2883	2546
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 C 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 -4 PPM difference for the measured all rods out endpoint and a -10 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 C 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 8

RCCA BANK ENDPOINT MEASUREMENTS

RCCA Bank Configuration	Measured Endpoint (PPM)	WPS Predicted Endpoint(PPM)	Difference (PPM)
All Rods Out	1370	1374	-4
Bank C In	1245	1255	-10

TABLE 3.2

KEWAUNEE CYCLE 8

DIFFERENTIAL BORON WORTH

RCCA Bank Configuration	CB Change Measured (PPM)	CB Change Predicted (PPM)	Percent Difference
ARO to C Bank In	125	119	5.0

RCCA Bank Configuration	Measured Boron Worth (PCM/PPM)	Predicted Boron Worth (PCM/PPM)	Percent Difference
ARO/C Bank In	-7.7	-9.0	-14.4

6-02-82 THROUGH 6-30-8

DEPLETION OF CHEM. SHIM
CYCLE 8
KEWAUNEE NUCLEAR POWER PLANT

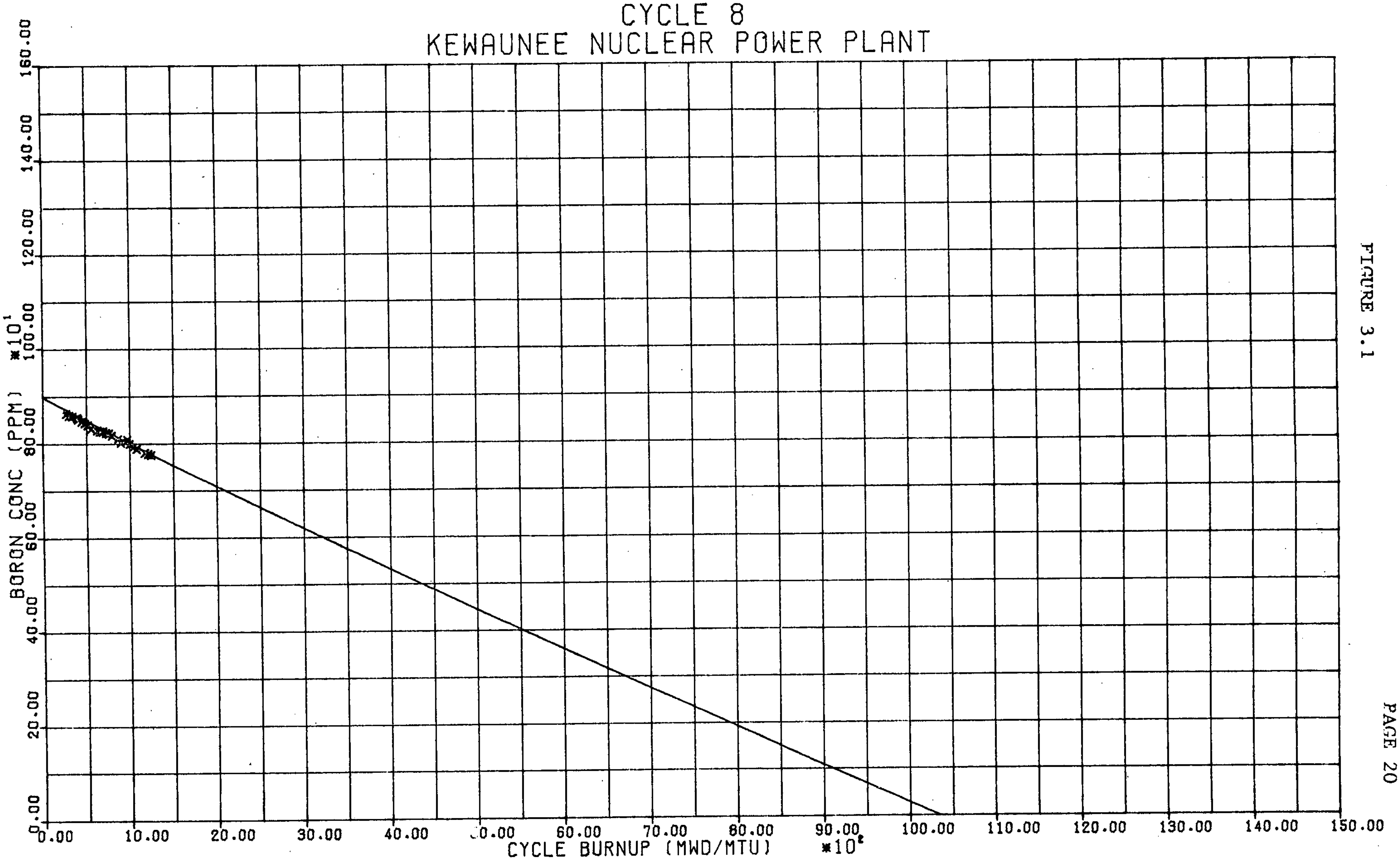


FIGURE 3.1

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 D slightly in, all other RCCA banks full out, with a boron concentration of 1359 PPM for both the heatup and cooldown. 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/Degree F was met.

TABLE 4.1

KEWAUNEE CYCLE 8

ISOTHERMAL TEMPERATURE COEFFICIENT

Cooldown

Tave Start	546.6 Degrees F
Tave End	536.6 Degrees F
Bank D	186 Steps
Boron Concentration	1359 PPM

Measured ITC (PCM/DEG F)	WPS Predicted ITC (PCM/DEG F)	Difference (PCM/DEG F)
-4.9	-5.6	0.7

Heat Up

Tave Start	543.7 Degrees F
Tave End	549.1 Degrees F
Bank D	186 Steps
Boron Concentration	1359 PPM

Measured ITC (PCM/DEG F)	WPS Predicted ITC (PCM/DEG F)	Difference (PCM/DEG F)
-3.7	-6.5	2.8

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 5% at low power physics test conditions and 3% 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 5% 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 8.

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 8 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 'maximum measured difference in symmetric thimbles.' The failure to meet this review criterion was reviewed by PORC (meeting 82-57, item 82-303; meeting 82-57, item 82-304; meeting 82-59, item 82-308; and meeting 82-71, item 82-378).

The review criterion, maximum measured difference in symmetric thimbles less than 3 per cent, was established based on historical data which indicated that symmetric locations generally do not exceed a measured difference greater than 3 percent. The intent was to minimize the impact of incore detector measurement error. Occasionally failed detectors, poor data, or input errors occur. These errors, as well as any gross core anomalies, can be easily distinguished when data is examined against this review criterion.

The Cycle 8 flux maps were compared to the extensive historical data base maintained by WPS. The results of these reviews indicate that although the criterion of 3% was exceeded, there are no significant differences between the symmetric pairs of thimble measurements of previous cycles. The conclusion is that no core anomaly exists.

A graphic display of percent difference in symmetric locations is provided for the eight symmetric pairs in Figures 5.1 through 5.8. This data begins with Cycle 7 startup (flux map 365) and includes Cycle 7 and the startup of Cycle 8.

The graphic displays of power distributions measured for representative flux maps are exhibited in Figures 5.9 through 5.13.

TABLE 5.1

FLUX MAP CHRONOLOGY AND REACTOR CHARACTERISTICS

Map	Date-Time	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MWD/MTU
410	5/21/82-0539	0	0.0	1364	189	0
411	5/23/82-0118	29	0.0	1350	189	0
412	5/25/82-0956	43	0.0	1077	189	15
413	5/27/82-0811	77	EQ.	998	228	62
414	5/27/82-1128	77	EQ.	942	200	65
415	5/27/82-1442	77	EQ.	941	185	66
416	5/27/82-1734	77	EQ.	935	167	70
417	5/27/82-2256	77	EQ.	938	228	72
418	6/01/82-0829	88	EQ.	895	211	199
419	6/02/82-1353	100	EQ.	878	228	221
420	6/04/82-0852	100	EQ.	861	228	293

TABLE 5.2

VERIFICATION OF ACCEPTANCE CRITERIA

Flux Map	Core Location	FQN	Limit
410	H-12DK,19	2.69	4.28
411	L-06ED,22	2.37	4.31
412	H-12DJ,23	2.21	4.33
413	B-08JK,26	2.09	2.85
414	B-08JK,33	2.18	2.89
415	B-08JK,35	2.26	2.88
416	L-06ED,41	2.39	2.88
417	B-08JK,19	2.15	2.79
418	B-08JK,33	2.09	2.51
419	B-08JK,33	2.08	2.21
420	B-08JK,32	2.06	2.22

Flux Map	Core Location	FDHN	Limit
410	D-11DK	1.58	1.70
411	F-07KC	1.52	1.70
412	B-08JK	1.53	1.70
413	L-08JD	1.51	1.62
414	B-08JK	1.51	1.62
415	B-08JK	1.51	1.62
416	B-08JK	1.50	1.62
417	B-08JK	1.51	1.62
418	B-08JK	1.50	1.59
419	B-08JK	1.50	1.55
420	B-08JK	1.50	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

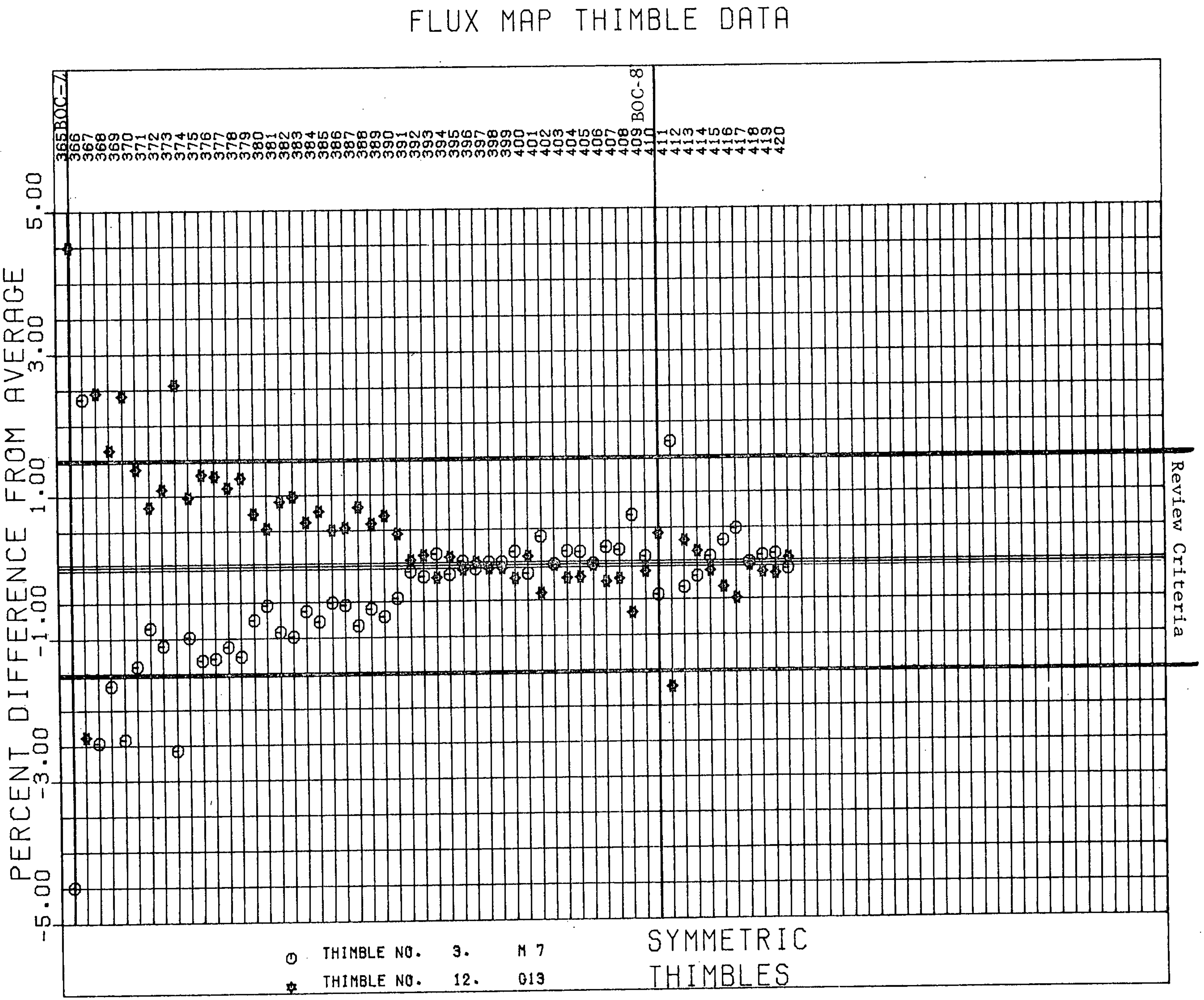
VERIFICATION OF REVIEW CRITERIA

Flux Map	(a) Maximum Percent Difference	(b) Standard Deviation	(c) Maximum Quadrant Tilt
410	9.0	4.1	2.7
411	6.9	2.7	1.6
412	6.0	3.1	1.4
413	6.2	3.3	1.3
414	6.0	3.0	1.4
415	6.0	3.1	1.4
416	6.0	3.0	1.3
417	6.1	3.0	1.4
418	5.8	2.4	1.1
419	6.0	2.4	1.0
420	5.9	2.4	1.1

(a) Maximum Percent Difference between symmetric thimbles for measured reaction rate integrals. Review criteria is 5% at low power. Review criteria is 3% 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 5% at low power, 2% at equilibrium power.


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
BOC-7
BOC-8
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
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400
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407
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410
411
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413
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416
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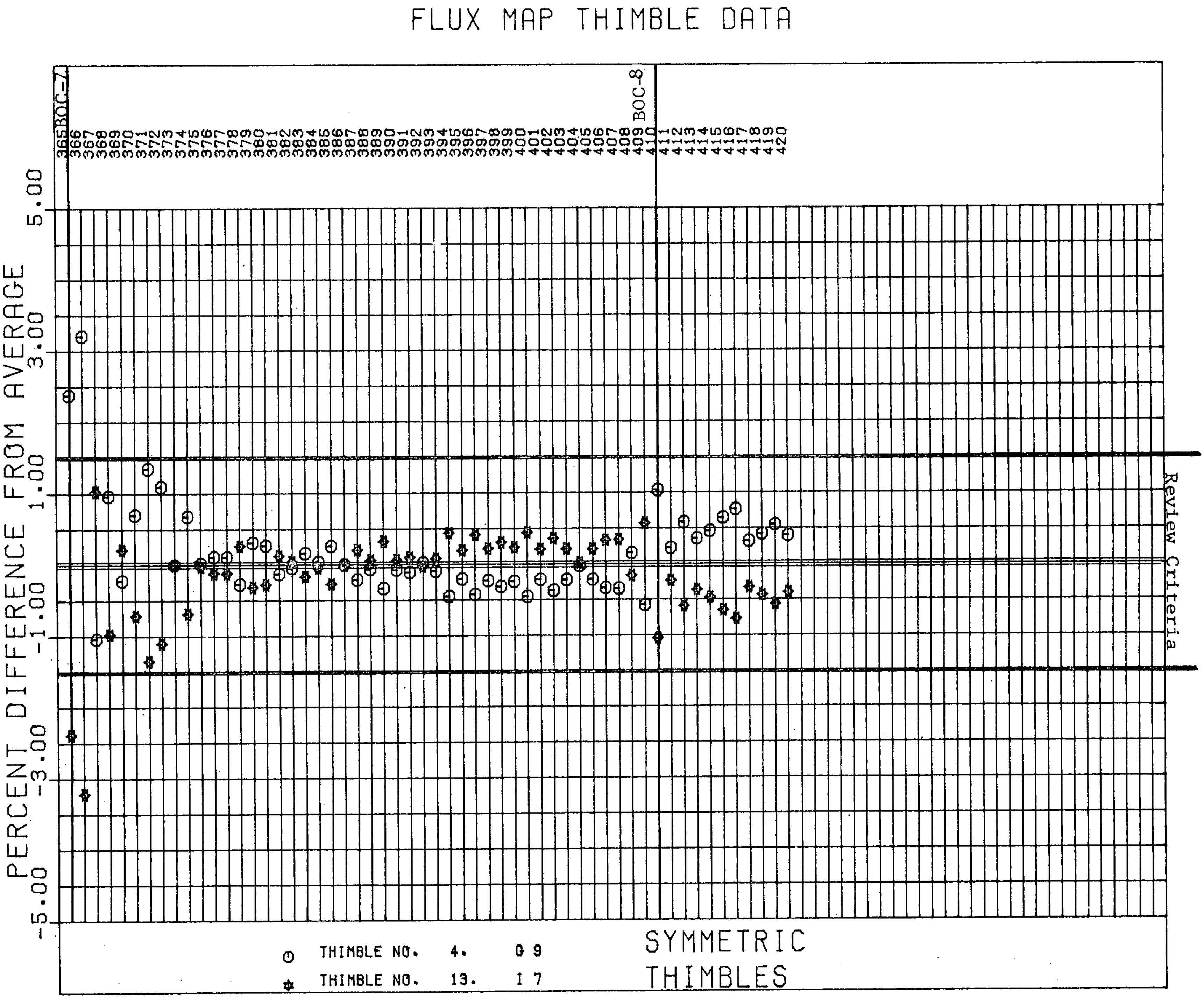
418
419
420
Review Criteria
SYMMETRIC THIMBLES
THIMBLE NO. 3. M 7
THIMBLE NO. 12. 013

FIGURE 5.1


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
365BOC-7
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
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389
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396
397
398
399
400
401
402
403
404
405
406
407
408
409 BOC-8
410
411
412
413
414
415
416
417
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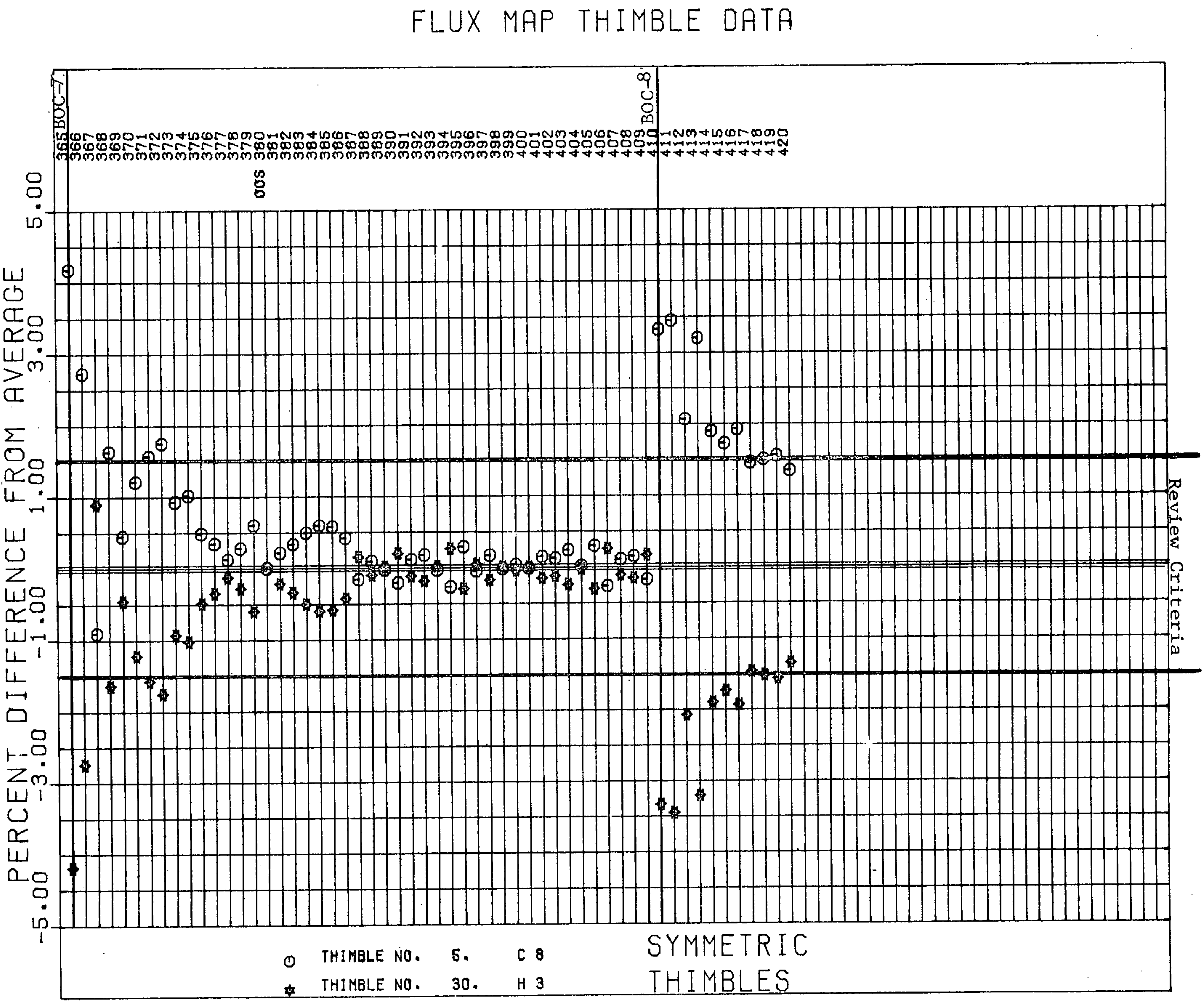
420
Review Criteria
THIMBLE NO. 4. O 9
THIMBLE NO. 13. I 7
SYMMETRIC
THIMBLES

FIGURE 5.2


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
365
BOC-7
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
OOS
381
382
383
384
385
386
387
388
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391
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393
394
395
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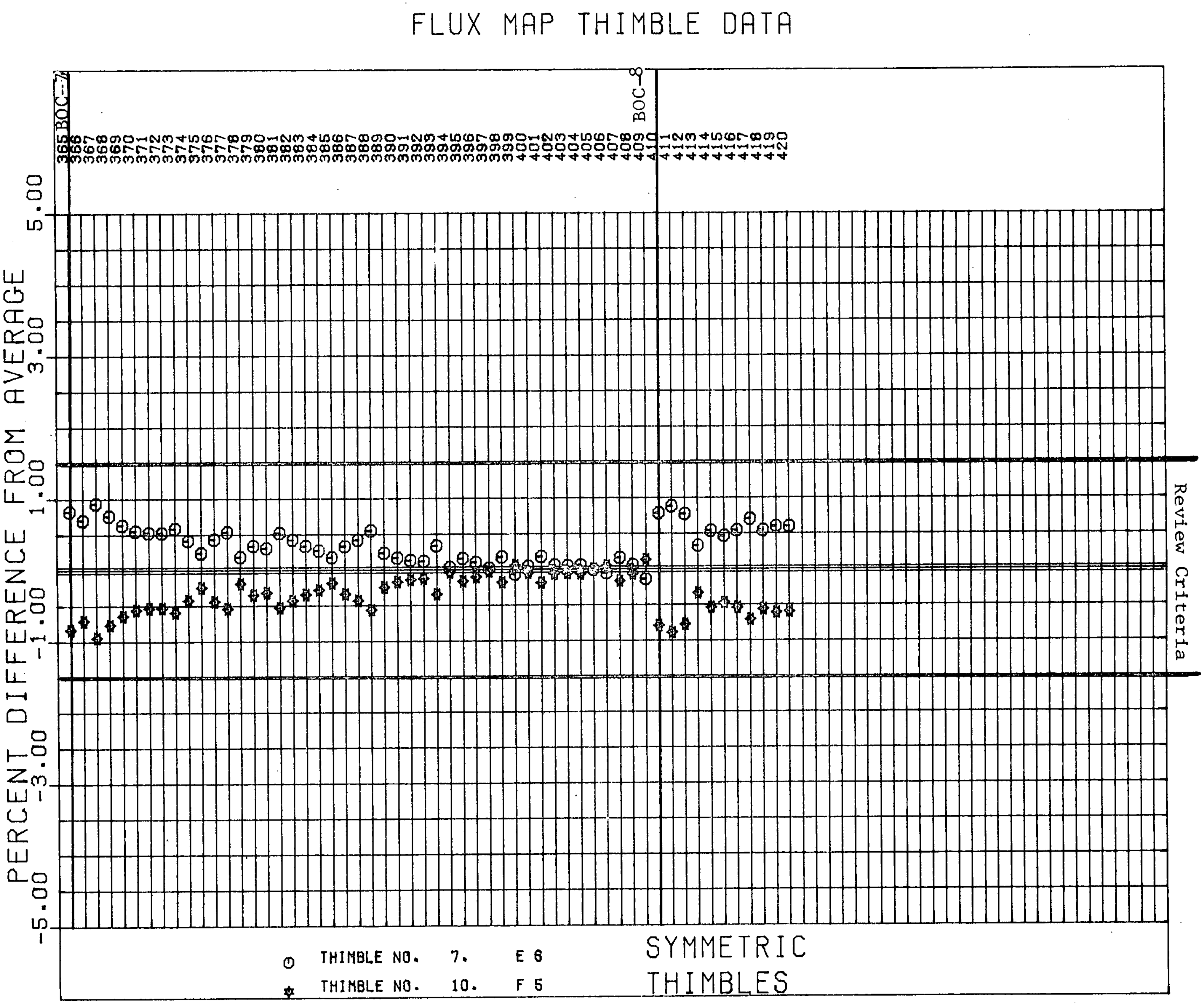
397
398
399
400
401
402
403
404
405
406
407
408
409
410
BOC-8
411
412
413
414
415
416
417
418
419
420
Review Criteria
ⴲ THIMBLE NO. 5. C 8
✡ THIMBLE NO. 30. H 3
SYMMETRIC THIMBLES

FIGURE 5.3


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
BOC-7
BOC-8
365
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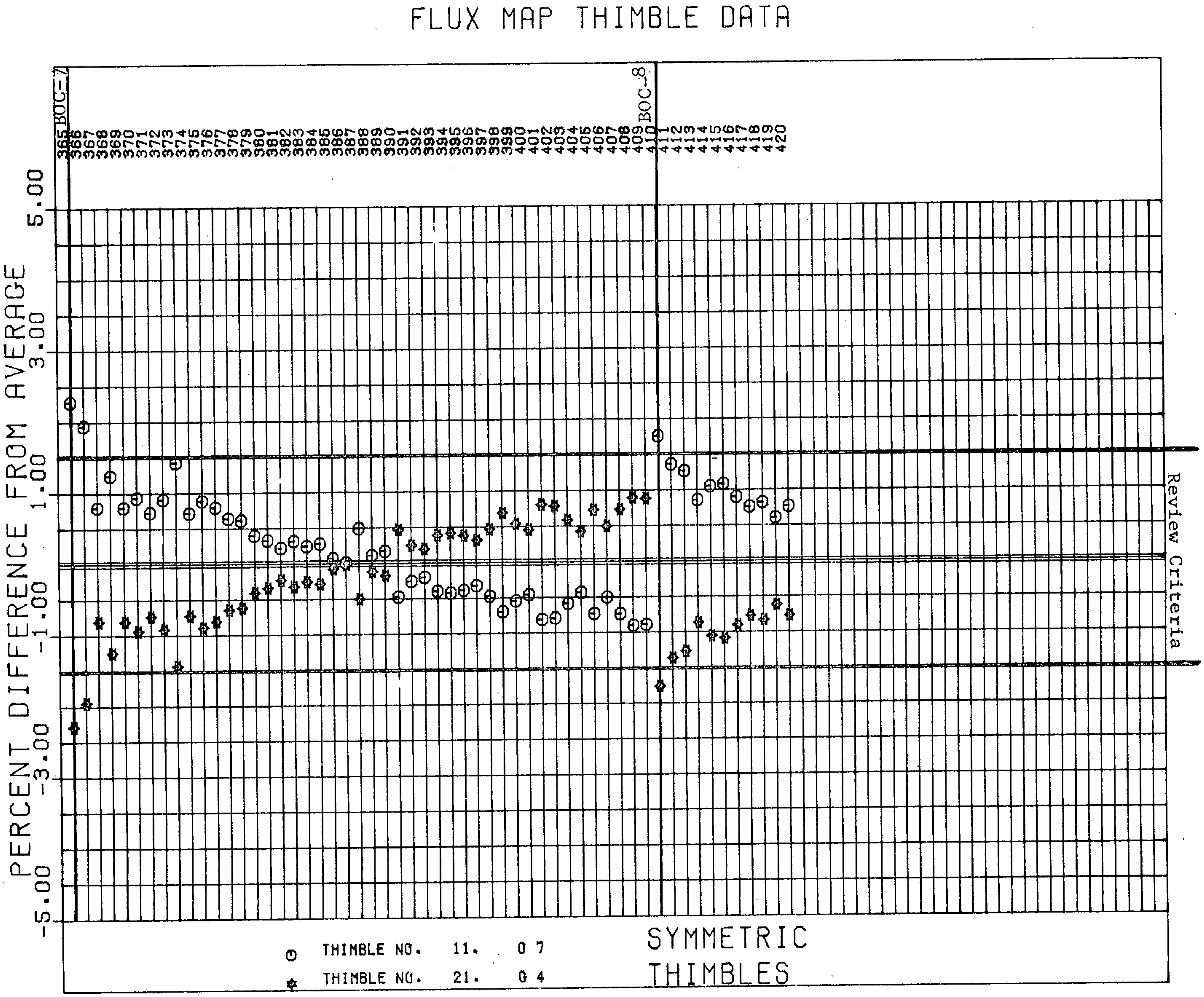
Review Criteria
THIMBLE NO. 7. E 6
THIMBLE NO. 10. F 5
SYMMETRIC THIMBLES

FIGURE 5.4


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
365 BOC-7
366
367
368
369
370
371
372
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409 BOC-8
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Review Criteria
SYMMETRIC THIMBLES
THIMBLE NO. 11. 0 7
THIMBLE NO. 21. 0 4

FIGURE 5.5

FLUX MAP THIMBLE DATA

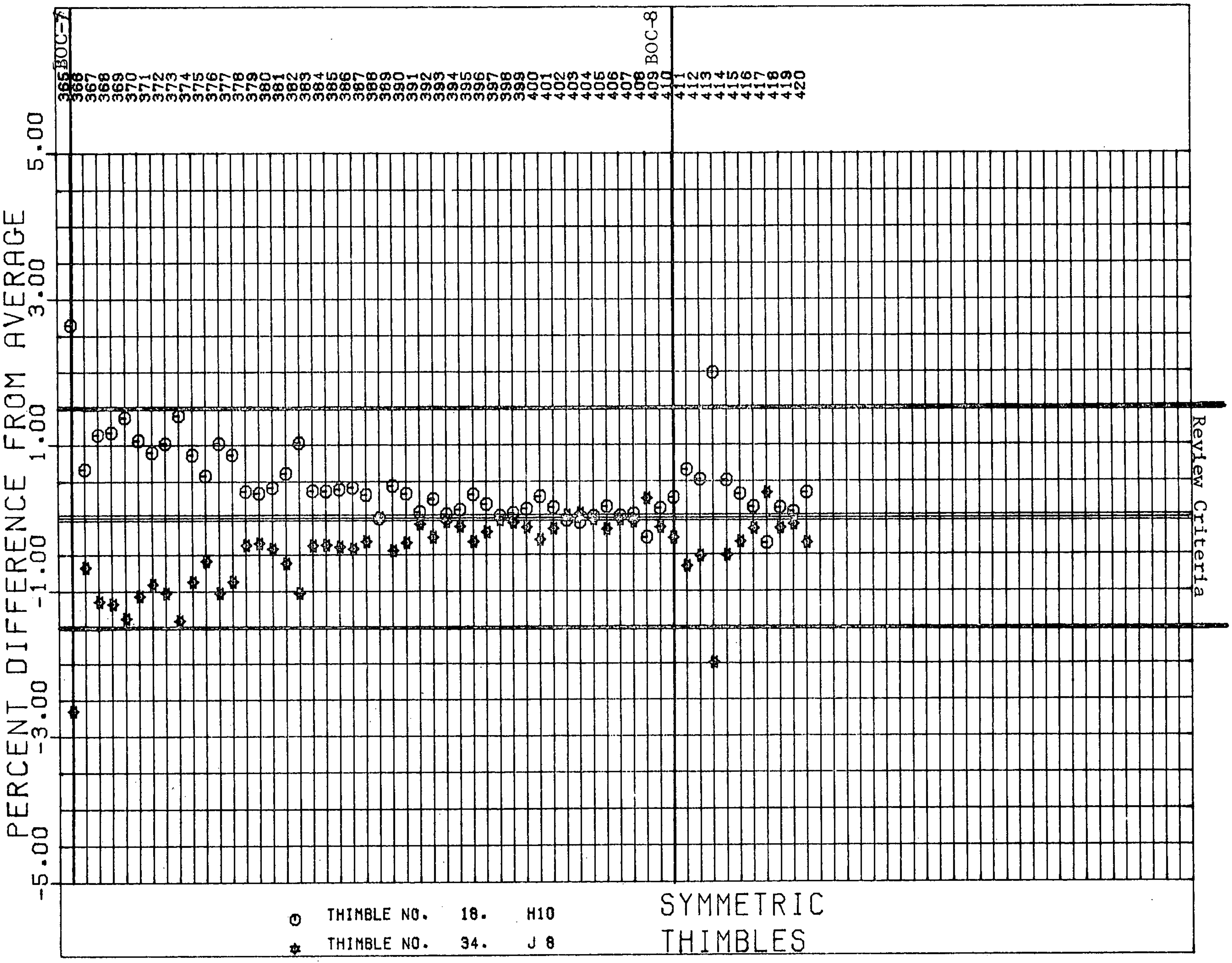


FIGURE 5.6

FLUX MAP THIMBLE DATA

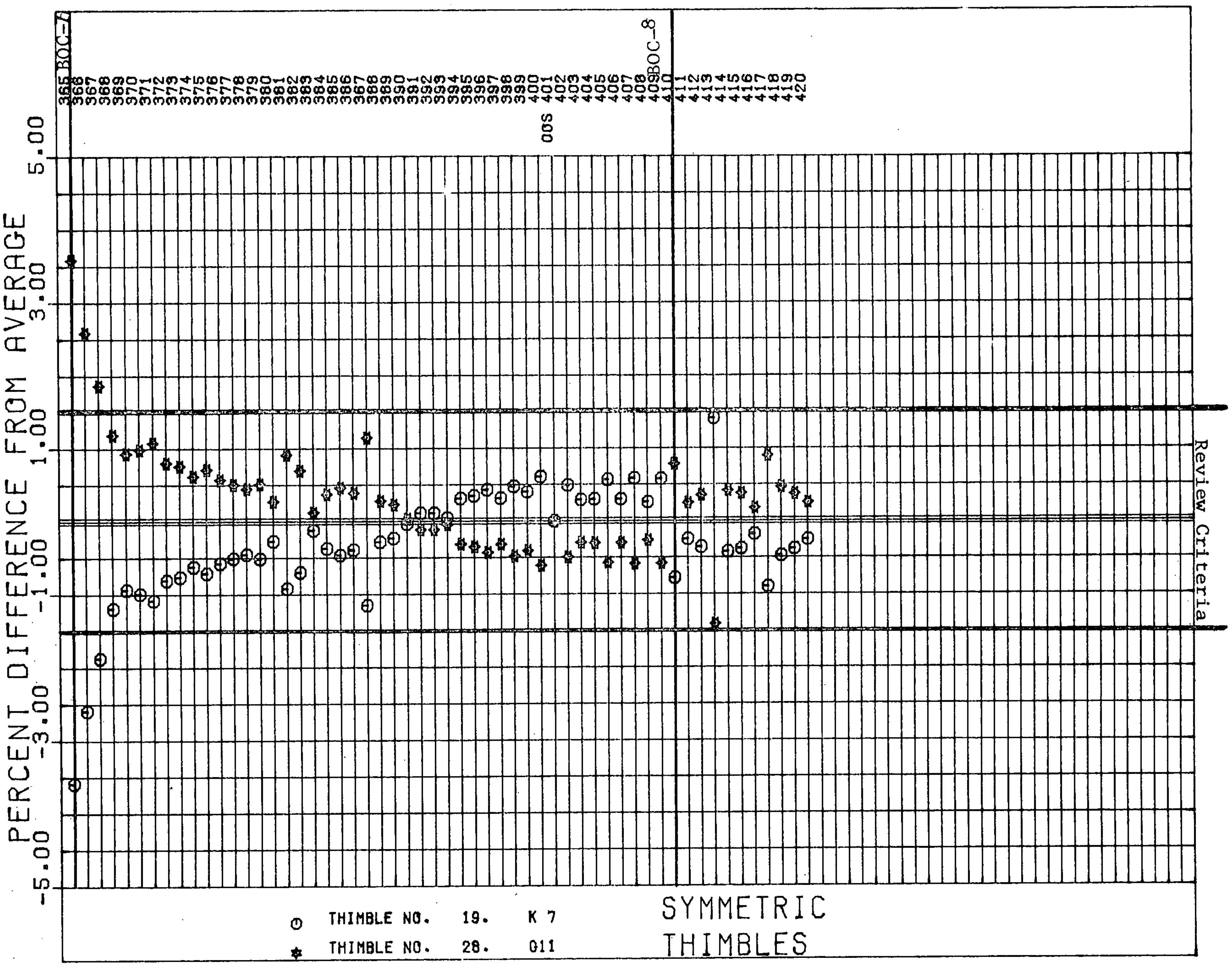
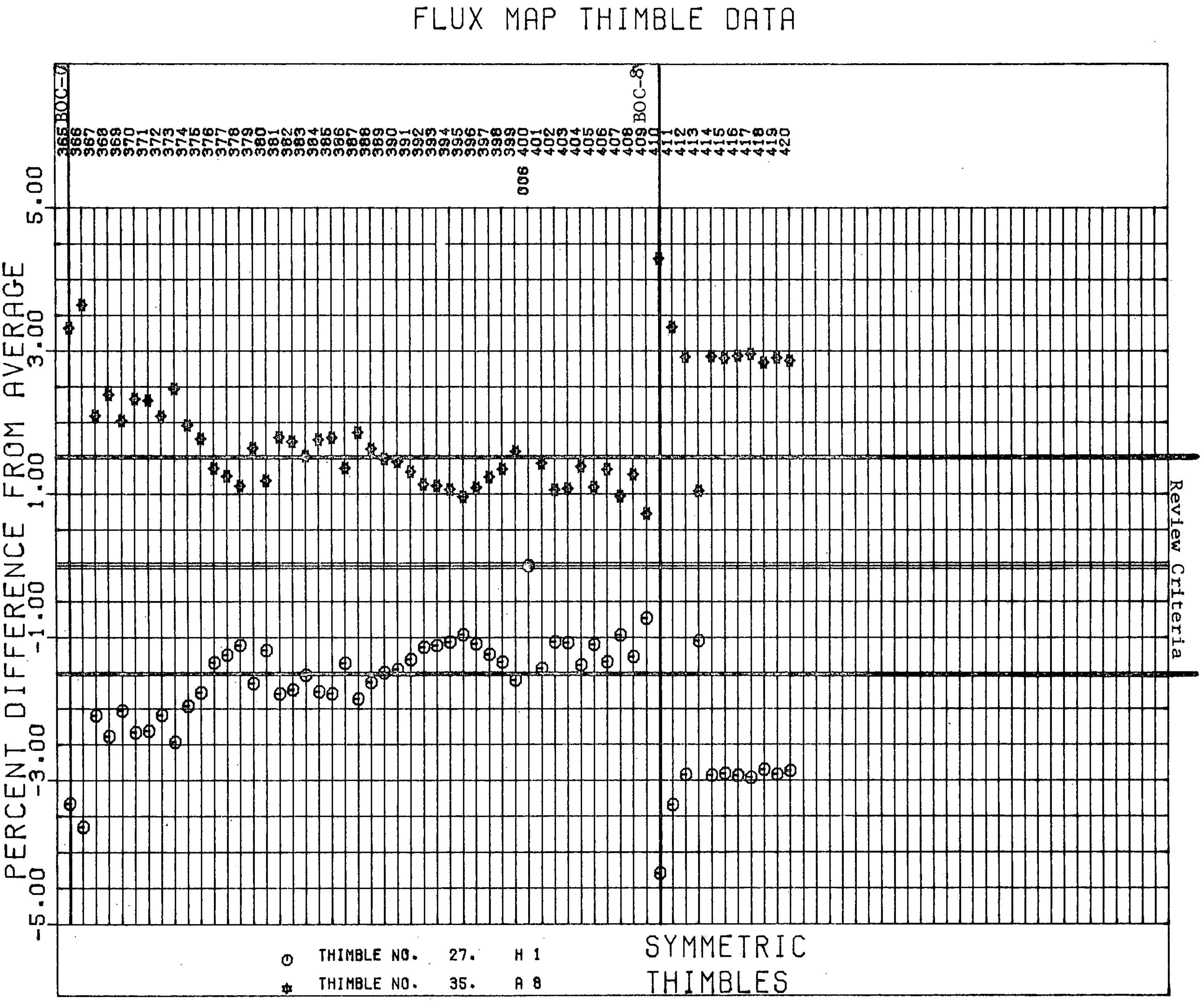


FIGURE 5.7


FLUX MAP THIMBLE DATA
PERCENT DIFFERENCE FROM AVERAGE
5.00
3.00
1.00
-1.00
-3.00
-5.00
BOC-7
BOC-8
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Review Criteria
THIMBLE NO. 27. H 1
THIMBLE NO. 35. A 8
SYMMETRIC THIMBLES

FIGURE 5.8

LOOP B

LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.335 0.345 -3.07	0.595 0.587 1.35	0.364 0.345 5.56					
B				0.528 0.532 -0.71	0.933 0.963 -3.08	1.132 1.168 -3.08	0.951 0.929 2.39	1.223 1.168 4.71	1.008 0.963 4.67	0.561 0.532 5.51			
C			0.595 0.600 -0.72	1.172 1.173 -0.09	1.075 1.088 -1.20	1.069 1.075 -0.57	0.998 0.988 1.01	1.110 1.075 3.27	1.134 1.088 4.23	1.238 1.173 5.52	0.644 0.600 7.42		
D		0.517 0.531 -2.62	1.142 1.172 -2.53	1.223 1.224 -0.06	1.134 1.139 -0.48	0.964 0.965 -0.08	1.233 1.217 1.36	0.995 0.965 3.15	1.194 1.139 4.82	1.293 1.224 5.67	1.251 1.172 6.71	0.570 0.531 7.42	
E		0.920 0.962 -4.42	1.038 1.086 -4.41	1.123 1.138 -1.29	0.932 0.946 -1.44	1.281 1.292 -0.88	1.343 1.361 -1.29	1.277 1.292 -1.18	0.960 0.946 1.53	1.206 1.138 5.96	1.118 1.086 2.91	0.960 0.962 -0.27	
F	0.316 0.344 -8.28	1.068 1.164 -8.29	1.005 1.073 -6.30	0.937 0.964 -2.76	1.244 1.290 -3.56	1.243 1.295 -3.98	1.321 1.376 -3.97	1.271 1.295 -1.85	1.300 1.290 0.75	0.999 0.964 3.63	1.111 1.073 3.56	1.196 1.164 2.79	0.351 0.344 1.92
G	0.543 0.587 -7.52	0.871 0.926 -5.94	0.933 0.986 -5.37	1.185 1.214 -2.38	1.301 1.358 -4.20	1.302 1.375 -5.27	1.031 1.075 -4.11	1.350 1.375 -1.82	1.356 1.358 -0.13	1.254 1.214 3.27	1.019 0.986 3.39	0.954 0.926 2.98	0.599 0.587 2.10
H	0.320 0.344 -7.11	1.099 1.164 -5.54	1.018 1.073 -5.15	0.947 0.964 -1.75	1.245 1.290 -3.51	1.248 1.295 -3.66	1.324 1.376 -3.80	1.274 1.295 -1.64	1.302 1.290 0.89	0.995 0.964 3.24	1.119 1.073 4.31	1.211 1.164 4.01	0.358 0.344 4.07
I		0.933 0.962 -3.05	1.052 1.086 -3.13	1.110 1.138 -2.48	0.934 0.946 -1.23	1.268 1.292 -1.89	1.358 1.361 -0.21	1.291 1.292 -0.06	0.963 0.946 1.88	1.168 1.136 2.66	1.115 1.086 2.68	0.990 0.962 2.84	
J		0.507 0.531 -4.61	1.133 1.172 -3.34	1.192 1.224 -2.58	1.122 1.139 -1.53	0.963 0.965 -0.16	1.238 1.217 1.70	0.982 0.965 1.85	1.165 1.139 2.26	1.241 1.224 1.42	1.190 1.172 1.53	0.546 0.531 2.84	
K			0.589 0.600 -1.72	1.154 1.173 -1.62	1.085 1.088 -0.23	1.110 1.075 3.28	1.025 0.988 3.75	1.110 1.075 3.29	1.113 1.088 2.25	1.187 1.173 1.20	0.601 0.600 0.23		
L				0.531 0.532 -0.09	0.961 0.963 -0.16	1.206 1.168 3.23	0.959 0.929 3.23	1.202 1.168 2.89	0.984 0.963 2.23	0.544 0.532 2.24			
M						0.356 0.345 3.19	0.606 0.587 3.17	0.355 0.345 2.72					

LOOP B

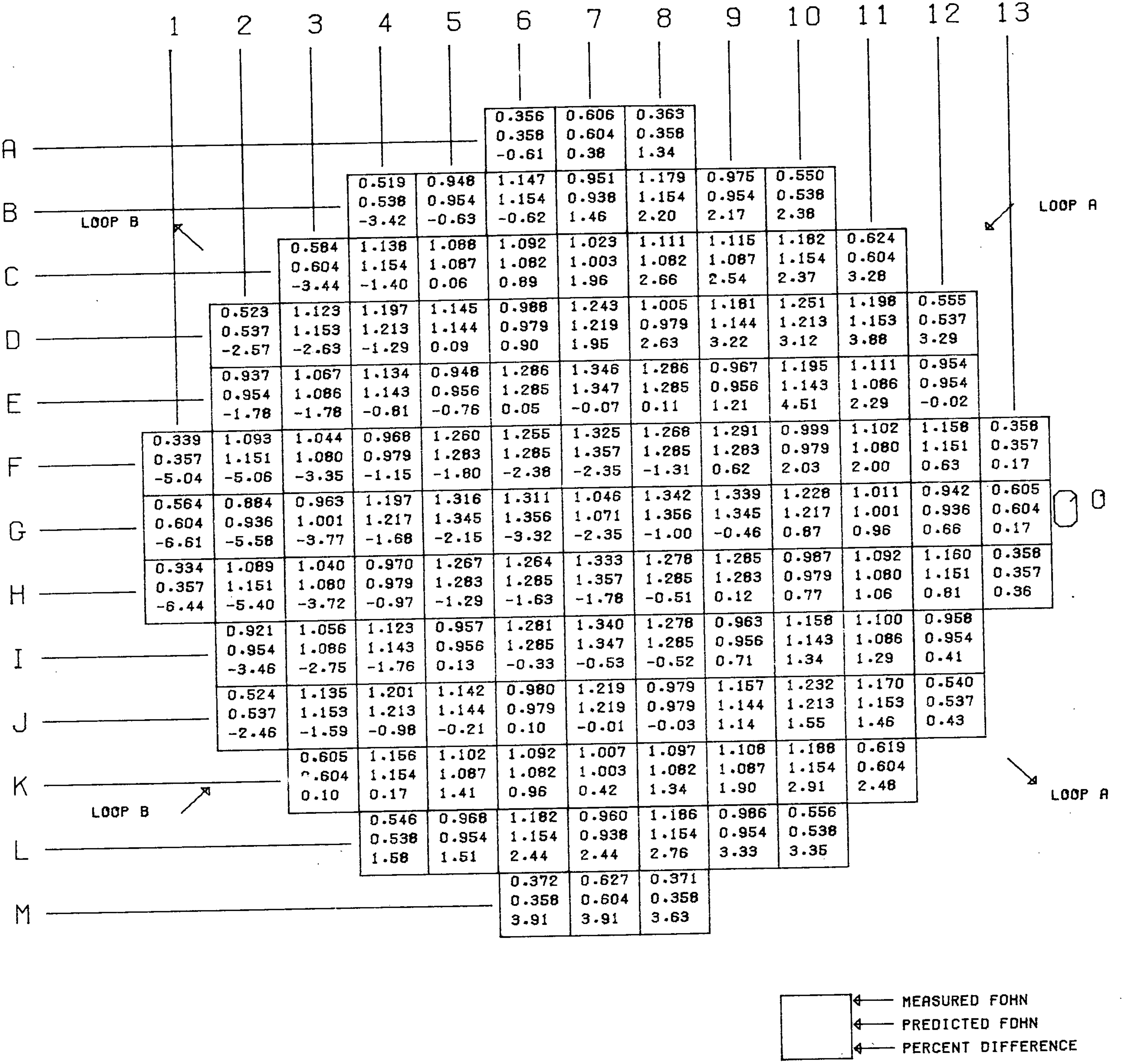
LOOP A

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 410

δ = 3.50

FIGURE 5.9



	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.356 0.358 -0.61	0.606 0.604 0.38	0.363 0.358 1.34					
B				0.519 0.538 -3.42	0.948 0.954 -0.63	1.147 1.154 -0.62	0.951 0.938 1.46	1.179 1.154 2.20	0.975 0.954 2.17	0.550 0.538 2.38			
C			0.584 0.604 -3.44	1.138 1.154 -1.40	1.088 1.087 0.06	1.092 1.082 0.89	1.023 1.003 1.96	1.111 1.082 2.66	1.115 1.087 2.54	1.182 1.154 2.37	0.624 0.604 3.28		
D		0.523 0.537 -2.57	1.123 1.153 -2.63	1.197 1.213 -1.29	1.145 1.144 0.09	0.988 0.979 0.90	1.243 1.219 1.95	1.005 0.979 2.63	1.181 1.144 3.22	1.251 1.213 3.12	1.198 1.153 3.88	0.555 0.537 3.29	
E		0.937 0.954 -1.78	1.067 1.086 -1.78	1.134 1.143 -0.81	0.948 0.956 -0.76	1.286 1.285 0.05	1.346 1.347 -0.07	1.286 1.285 0.11	0.967 0.956 1.21	1.195 1.143 4.51	1.111 1.086 2.29	0.954 0.954 -0.02	
F	0.339 0.357 -5.04	1.093 1.151 -5.06	1.044 1.080 -3.35	0.968 0.979 -1.15	1.260 1.283 -1.80	1.255 1.285 -2.38	1.325 1.357 -2.35	1.268 1.285 -1.31	1.291 1.283 0.62	0.999 0.979 2.03	1.102 1.080 2.00	1.158 1.151 0.63	0.358 0.357 0.17
G	0.564 0.604 -6.61	0.884 0.936 -5.58	0.963 1.001 -3.77	1.197 1.217 -1.68	1.316 1.345 -2.15	1.311 1.356 -3.32	1.046 1.071 -2.35	1.342 1.356 -1.00	1.339 1.345 -0.46	1.228 1.217 0.87	1.011 1.001 0.96	0.942 0.936 0.66	0.605 0.604 0.17
H	0.334 0.357 -6.44	1.089 1.151 -5.40	1.040 1.080 -3.72	0.970 0.979 -0.97	1.267 1.283 -1.29	1.264 1.285 -1.63	1.333 1.357 -1.78	1.278 1.285 -0.51	1.285 1.283 0.12	0.987 0.979 0.77	1.092 1.080 1.06	1.160 1.151 0.81	0.358 0.357 0.36
I		0.921 0.954 -3.46	1.056 1.086 -2.75	1.123 1.143 -1.76	0.957 0.956 0.13	1.281 1.285 -0.33	1.340 1.347 -0.53	1.278 1.285 -0.52	0.963 0.956 0.71	1.158 1.143 1.34	1.100 1.086 1.29	0.958 0.954 0.41	
J		0.524 0.537 -2.46	1.135 1.153 -1.59	1.201 1.213 -0.98	1.142 1.144 -0.21	0.980 0.979 0.10	1.219 1.219 -0.01	0.979 0.979 -0.03	1.157 1.144 1.14	1.232 1.213 1.55	1.170 1.153 1.46	0.540 0.537 0.43	
K			0.605 ᐢ.604 0.10	1.156 1.154 0.17	1.102 1.087 1.41	1.092 1.082 0.96	1.007 1.003 0.42	1.097 1.082 1.34	1.108 1.087 1.90	1.188 1.154 2.91	0.619 0.604 2.48		
L				0.546 0.538 1.58	0.968 0.954 1.51	1.182 1.154 2.44	0.960 0.938 2.44	1.186 1.154 2.76	0.986 0.954 3.33	0.556 0.538 3.35			
M						0.372 0.358 3.91	0.627 0.604 3.91	0.371 0.358 3.63					

FLUX MAP 411

δ=2.31

FIGURE 5.10

LOOP B

LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.366 0.367 -0.27	0.631 0.619 2.07	0.383 0.367 4.30					
B				0.538 0.543 -0.81	0.959 0.962 -0.29	1.160 1.163 -0.29	0.971 0.949 2.29	1.200 1.163 3.19	0.992 0.962 3.15	0.559 0.543 3.08			
C			0.600 0.605 -0.81	1.152 1.146 0.54	1.097 1.088 0.86	1.097 1.087 0.86	1.022 1.009 1.25	1.110 1.087 2.12	1.116 1.088 2.59	1.181 1.146 3.06	0.629 0.605 3.87		
D		0.543 0.542 0.07	1.146 1.146 0.02	1.210 1.203 0.62	1.139 1.136 0.24	0.984 0.980 0.38	1.216 1.207 0.74	1.001 0.980 2.06	1.177 1.136 3.61	1.251 1.203 3.96	1.200 1.146 4.74	0.563 0.542 3.87	
E		0.970 0.962 0.89	1.097 1.087 0.89	1.128 1.135 -0.65	0.952 0.962 -1.04	1.270 1.277 -0.58	1.306 1.330 -1.78	1.253 1.277 -1.92	0.968 0.962 0.64	1.199 1.135 5.66	1.120 1.087 2.99	0.964 0.962 0.22	
F	0.352 0.366 -3.96	1.114 1.160 -3.97	1.052 1.085 -3.10	0.957 0.980 -2.32	1.236 1.275 -3.07	1.228 1.274 -3.62	1.285 1.340 -4.10	1.232 1.274 -3.31	1.271 1.275 -0.34	0.991 0.980 1.13	1.103 1.085 1.64	1.171 1.160 0.93	0.373 0.366 1.83
G	0.587 0.619 -5.07	0.909 0.948 -4.02	0.970 1.007 -3.72	1.183 1.205 -1.86	1.282 1.328 -3.49	1.277 1.339 -4.64	1.020 1.069 -4.60	1.296 1.339 -3.23	1.307 1.328 -1.59	1.209 1.205 0.29	1.016 1.007 0.83	0.957 0.948 0.97	0.631 0.619 1.96
H	0.349 0.366 -4.75	1.117 1.160 -3.72	1.046 1.085 -3.57	0.969 0.980 -1.17	1.240 1.275 -2.73	1.231 1.274 -3.34	1.286 1.340 -4.00	1.239 1.274 -2.72	1.268 1.275 -0.56	0.986 0.980 0.64	1.099 1.085 1.26	1.175 1.160 1.30	0.379 0.366 3.41
I		0.955 0.962 -0.75	1.082 1.087 -0.43	1.128 1.135 -0.66	0.951 0.962 -1.09	1.251 1.277 -2.05	1.311 1.330 -1.45	1.260 1.277 -1.35	0.967 0.962 0.61	1.153 1.135 1.57	1.104 1.087 1.55	0.974 0.962 1.22	
J		0.543 0.542 0.18	1.159 1.146 1.13	1.209 1.203 0.48	1.142 1.136 0.55	0.962 0.980 -1.90	1.198 1.207 -0.79	0.974 0.980 -0.61	1.150 1.136 1.21	1.211 1.203 0.66	1.154 1.146 0.71	0.549 0.542 1.22	
K			0.616 C 305 1.80	1.167 1.146 1.85	1.116 1.088 2.61	1.070 1.087 -1.59	1.011 1.009 0.16	1.105 1.087 1.68	1.114 1.088 2.35	1.172 1.146 2.30	0.607 0.605 0.21		
L				0.557 0.543 2.63	0.987 0.962 2.62	1.170 1.163 0.61	0.955 0.949 0.61	1.186 1.163 1.96	1.005 0.962 4.50	0.567 0.543 4.51			
M						0.377 0.367 2.81	0.636 0.619 2.81	0.381 0.367 3.65					

LOOP B

LOOP A

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 412

δ=2.43

FIGURE 5.11

LOOP B

LOOP A

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.384 0.376 2.02	0.643 0.631 1.90	0.383 0.376 1.81					
B				0.526 0.542 -2.86	0.968 0.949 2.00	1.177 1.154 2.01	0.990 0.968 2.27	1.184 1.154 2.55	0.973 0.949 2.55	0.562 0.542 3.82			
C			0.584 0.601 -2.86	1.117 1.119 -0.17	1.106 1.081 2.32	1.123 1.103 1.79	1.090 1.069 1.92	1.128 1.103 2.25	1.113 1.081 2.91	1.162 1.119 3.82	0.630 0.601 4.83		
D		0.540 0.541 -0.13	1.115 1.118 -0.28	1.180 1.180 -0.03	1.135 1.128 0.58	0.999 0.994 0.50	1.229 1.221 0.65	1.016 0.994 2.18	1.170 1.128 3.71	1.231 1.180 4.34	1.175 1.118 5.07	0.567 0.541 4.82	
E		0.973 0.950 2.43	1.107 1.081 2.43	1.129 1.128 0.08	0.964 0.969 -0.57	1.267 1.271 -0.31	1.288 1.322 -2.60	1.231 1.271 -3.19	0.963 0.969 -0.61	1.188 1.128 5.33	1.125 1.081 4.03	0.975 0.950 2.67	
F	0.366 0.376 -2.63	1.120 1.151 -2.66	1.079 1.101 -2.04	0.977 0.994 -1.65	1.238 1.270 -2.51	1.228 1.267 -3.07	1.267 1.328 -4.59	1.210 1.267 -4.49	1.255 1.270 -1.17	0.994 0.994 0.04	1.116 1.101 1.34	1.164 1.151 1.09	0.388 0.376 3.35
G	0.606 0.631 -3.87	0.929 0.967 -3.91	1.025 1.067 -3.93	1.194 1.220 -2.11	1.285 1.321 -2.74	1.278 1.328 -3.79	1.025 1.075 -4.63	1.281 1.328 -3.55	1.295 1.321 -2.00	1.208 1.220 -0.95	1.070 1.067 0.25	0.976 0.967 0.98	0.652 0.631 3.41
H	0.363 0.376 -3.54	1.109 1.151 -3.67	1.058 1.101 -3.89	0.976 0.994 -1.79	1.241 1.270 -2.31	1.230 1.267 -2.92	1.286 1.328 -3.15	1.240 1.267 -2.11	1.265 1.270 -0.41	0.986 0.994 -0.74	1.094 1.101 -0.64	1.149 1.151 -0.15	0.391 0.376 3.99
I		0.945 0.950 -0.46	1.074 1.081 -0.66	1.118 1.128 -0.86	0.957 0.969 -1.25	1.247 1.271 -1.88	1.295 1.322 -2.06	1.245 1.271 -2.03	0.968 0.969 -0.06	1.138 1.128 0.87	1.090 1.081 0.78	0.943 0.950 -0.74	
J		0.552 0.541 1.92	1.132 1.118 1.23	1.185 1.180 0.40	1.123 1.128 -0.43	0.978 0.994 -1.61	1.201 1.221 -1.68	0.977 0.994 -1.67	1.124 1.128 -0.34	1.181 1.180 0.09	1.118 1.118 0.03	0.537 0.541 -0.72	
K			0.613 0.601 2.08	1.142 1.119 2.03	1.104 1.081 2.14	1.091 1.103 -1.06	1.056 1.069 -1.25	1.113 1.103 0.88	1.099 1.081 1.64	1.153 1.119 3.02	0.606 0.601 0.80		
L				0.554 0.542 2.31	0.970 0.949 2.22	1.169 1.154 1.32	0.981 0.968 1.32	1.186 1.154 2.72	1.000 0.949 5.35	0.571 0.542 5.37			
M						0.390 0.376 3.69	0.654 0.631 3.69	0.393 0.376 4.52					

LOOP B

LOOP A

MEASURED FDHN
PREDICTED FDHN
PERCENT DIFFERENCE

FLUX MAP 413

δ=2.56

FIGURE 5.12

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						0.385 0.385 -0.08	0.651 0.642 1.43	0.396 0.385 2.86					
B				0.547 0.549 -0.29	0.950 0.951 -0.07	1.149 1.150 -0.07	0.987 0.972 1.52	1.177 1.150 2.31	0.973 0.951 2.31	0.563 0.549 2.51			
C			0.606 0.606 -0.28	1.123 1.116 0.62	1.091 1.083 0.77	1.112 1.103 0.85	1.082 1.071 0.99	1.122 1.103 1.75	1.105 1.083 2.06	1.144 1.116 2.51	0.625 0.608 2.80		
D		0.550 0.549 0.24	1.117 1.115 0.22	1.184 1.176 0.66	1.136 1.131 0.46	1.005 0.998 0.61	1.224 1.215 0.74	1.016 0.998 1.73	1.160 1.131 2.57	1.210 1.176 2.90	1.151 1.115 3.20	0.564 0.549 2.79	
E		0.958 0.951 0.74	1.090 1.082 0.74	1.128 1.130 -0.20	0.973 0.977 -0.41	1.261 1.262 -0.06	1.297 1.307 -0.78	1.251 1.262 -0.85	0.962 0.977 0.55	1.171 1.130 3.64	1.102 1.082 1.82	0.951 0.951 -0.07	
F	0.368 0.384 -4.16	1.100 1.148 -4.16	1.071 1.102 -2.85	0.987 0.998 -1.10	1.240 1.261 -1.67	1.229 1.256 -2.13	1.281 1.312 -2.39	1.233 1.256 -1.85	1.261 1.261 -0.02	1.005 0.998 0.61	1.110 1.102 0.76	1.148 1.146 -0.02	0.386 0.384 0.52
G	0.605 0.642 -5.82	0.928 0.971 -4.41	1.033 1.069 -3.32	1.202 1.213 -0.93	1.280 1.305 -1.94	1.275 1.312 -2.85	1.047 1.073 -2.47	1.292 1.312 -1.53	1.296 1.305 -0.70	1.212 1.213 -0.04	1.070 1.069 0.13	0.971 0.971 -0.01	0.646 0.642 0.58
H	0.363 0.384 -5.54	1.101 1.148 -4.11	1.067 1.102 -3.17	0.992 0.998 -0.63	1.241 1.261 -1.58	1.230 1.256 -2.10	1.284 1.312 -2.10	1.241 1.256 -1.20	1.261 1.261 -0.02	1.002 0.998 0.36	1.109 1.102 0.67	1.153 1.148 0.44	0.389 0.384 1.12
I		0.941 0.951 -1.05	1.079 1.082 -0.28	1.124 1.130 -0.50	0.968 0.977 -0.91	1.245 1.282 -1.32	1.299 1.307 -0.64	1.255 1.262 -0.56	0.982 0.977 0.51	1.142 1.130 1.11	1.094 1.082 1.12	0.964 0.951 1.30	
J		0.550 0.549 0.18	1.128 1.115 1.19	1.183 1.176 0.58	1.139 1.131 0.70	0.984 0.998 -1.44	1.206 1.215 -0.77	0.992 0.998 -0.66	1.138 1.131 0.65	1.184 1.176 0.71	1.123 1.115 0.76	0.556 0.549 1.31	
K			0.618 0.608 1.70	1.136 1.116 1.77	1.110 1.063 2.47	1.085 1.103 -1.67	1.067 1.071 -0.41	1.111 1.103 0.68	1.098 1.083 1.36	1.132 1.116 1.43	0.609 0.608 0.21		
L				0.563 0.549 2.48	0.975 0.951 2.48	1.146 1.150 -0.31	0.969 0.972 -0.32	1.158 1.150 0.73	0.977 0.951 2.69	0.564 0.549 2.70			
M						0.389 0.385 1.01	0.648 0.642 1.03	0.392 0.385 1.84					

LOOP B

LOOP A

LOOP B

LOOP A

0 0

☐ ← MEASURED FDHN
← PREDICTED FDHN
← PERCENT DIFFERENCE

FLUX MAP 420

$\delta = 1.82$

FIGURE 5.13

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 8 startup; no problems or abnormalities were encountered and site procedure acceptance criteria were met. At full power an adjustment was made to all 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 8 startup (4). Several flux maps were performed over a range of axial offsets at approximately 77% 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 VIII," Wisconsin Public Service Corporation, February, 1982.

(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.