COMMONWEALTH EDISON COMPANY

ZION GENERATING STATION

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UNIT 2 CYCLE 6

ROD SWAP REPORT

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1.0 INTRODUCTION

At 1300 hours on November 24, 1981 Zion Unit 2 achieved initial criticality for Cycle 6. As part of the Zero Power Physics Program the "Rod Swap Technique" was utilized to measure rod worths. This was the second time at Zion that this technique was used, solely by itself, in determining rod worths.

The results of the rod swap technique were satisfactory. All acceptance and design criteria were met. The total rod worth was measured to be 94% of the total predicted value. This is well within the acceptance criterion that the total rod worth as determined by rod swap be greater than or equal to 90% of the predicted total rod worth.

The detailed results of the rod swap technique are summarized in the following sections.

2.0 ROD SWAP TECHNIQUE

Before the Rod Swap Technique, rod worths were measured utilizing a reactivity computer. This reactivity computer measured the worth of the control rods during a change in the boron concentration of the reactor coolant system. This is a relatively slow process and results in large amounts of water being letdown from the RCS which needs to be processed.

The rod swap technique is simply a method to determine the worth of a bank relative to a "reference" bank. The reference bank is the bank with the highest predicted worth. The method is used in the following manner:

1. The worth of the reference bank is measured using conventional methods (i.e. reactivity computer and boron changes).

2. The worth of the remaining banks is then measured, individually and at a constant boron concentration, by an exchange with the reference bank.

The data from the exchange with the reference bank allows the worth of the remaining banks to be inferred from the measured worth of the reference bank. The inferred worths are calculated using the following formula:

[ ] +a,c

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[ ] +a,c

Westinghouse supplied Zion with predicted worths for each rod bank (Ref 1). These predictions are shown in Table 1.

The acceptance criterion for the Rod Exchange Technique was that the total rod worth as determined by rod exchange must be greater than or equal to 90% of the predicted total rod worth.

The design (review) acceptance criteria was

A. The absolute value of the percent difference between measured and predicted integral worth for the reference bank is $\leq$ 10%.

B. The absolute value of the percent difference between inferred and predicted integral worths for all other banks is $\leq$ 15%. For banks having a predicted integral worth equal to or less than 600 pcm, the absolute difference between the inferred and predicted worth is $\leq$ 100 pcm.

C. The absolute value of the percent difference between the sum of the measured/ inferred bank worths and the sum of the predicted worths is $\leq$ 10%.

3.0 RESULTS

Since Control Bank D was predicted to be the highest worth bank, it was used as the reference bank. The worth of CBD was measured using the reactivity computer and the conventional boron dilution method. The results of this measurement are shown in Table 2. The integral and differential worths for CBD are plotted in Figure 1.

With CBD near the fully inserted position, each bank was then swapped individually with this reference bank. Critical configuration data was recorded for each bank before and after the swap. This data is shown in Table 3.

Using this critical configuration data, the inferred worth (W_x^I) for each bank was then calculated. A plot of the integral worth of CBD from 0 to 30 steps is shown in Figure 2. Using this plot, [ ]$^{+a,c}$ for each bank was then calculated. These values are shown in Table 4.

The values of [ ]$^{+a,c}$ or each bank are shown in Table 5. These values were calculated using the integral and differential rod worths of Table 2 and Figure 1. With the values of [ ]$^{+a,c}$ calculated, the inferred worth of each bank was then computed. These inferred worths are shown in Table 6.

Table 7 shows the comparison of the rod worths as measured by the rod swap technique with the predicted values. All acceptance and design criteria were met.

The total rod worth was measured to be 94% of the total predicted value. This meets the acceptance criterion that the total rod worth as determined by rod swap be greater than or equal to 90% of the predicted total rod worth.

The difference between the measured worth of the reference bank CBD and its predicted worth was -4.22. This is well within the design acceptance criterion that the absolute value of the percent difference between measured and predicted integral worth for the reference bank must be $\leq$ 10%.

The second design acceptance criterion was that the absolute value of the percent difference between inferred and predicted integral worths for all other banks is $\leq$ 15%. For banks having a predicted integral worth equal to or less than 600 pcm, the absolute difference between the inferred and predicted worth is $\leq$ 100 pcm.

As seen in Table 7 the largest percent difference for those banks with a predicted worth of > 600 pcm was -7.58% for Shutdown Bank B. For banks having a predicted worth $\leq$ 600 pcm the largest difference was 36.0 pcm for Shutdown Bank C.

The last design acceptance criterion was that the absolute value of the percent difference between the sum of the measured/ inferred bank worths and the sum of the predicted worths is $\leq$ 10% The total rod worth as measured by rod swap was 4730.6 pcm. This value is -5.99% from the predicted value.

Following the completion of the rod swap the worth of CBD was remeasured while borating it out to the nearly withdrawn position. The integral worth of CBD from this remeasurement was 957.9 pcm. This is a +0.01% difference from the integral worth measured during dilution.

4.0 SUMMARY

The Rod Swap Technique for measuring rod worths was utilized for the second time at Zion Station during the Unit 2 Cycle 6 startup testing program. The results of the technique were very satisfactory with good agreement between measured/ inferred worths and the predicted worths. All acceptance and design acceptance criteria were met.

5.0 REFERENCE

1) Letter dated November 5, 1981 from W. E. Kortier to J. S. Abel entitled "Zion Unit 2 Rod Swap Data". ZUP 2.2.124

TABLE 1

Nuclear Design Predictions for Rod Interchange Measurements

Bank No. (x)	Bank Identity	W_x^P (pcm)	h_x^P (b) (steps)	a_x (c)
1	CBD(a)	[		
2	CBC		[	
3	CBB			
4	CBA			
5	SBD			
6	SBC			
7	SBB			
8	SBA	] +a,c	]	] +a,c

(a) Reference bank

(b) Reference bank critical position after interchange with bank x

(c) [ ] +a,c

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TABLE 2

ROD WORTH MEASUREMENT DATA FORM

Zion Unit 2 Cycle 6 Date 11/24/81

Test Physics Testing

Bank or RCCA Identification CBD Boration ___ Dilution X

Date 11/24/81 Power HZP

Shutdown Bank Positions: A 228 B 228 C 228 D 228

Control Bank Positions: A 228 B 228 C 228 D Moving

	Initial	Final
RCS Boron Concentration:	1301	1197
Pressurizer Boron Concentration:	1292	1199
RCS Temperature (Tavg):	546.5°F	546.6

	RCC Position (Steps Withdrawn)			Delta H	Reactivity (pcm)		
Time	Initial	Final	Average	(Δh)	Δρ	Δρ/Δh	Σ Δρ
1840	228.0	215.5	221.75	12.5	17.3*	1.38	17.3
1844	215.5	204.0	209.75	11.5	42.0	3.65	59.3
1848	204.0	192.5	198.25	11.5	51.3	4.46	110.6
1852	192.5	183.5	188.00	9.0	41.2	4.58	151.8
1855	183.5	174.5	179.00	9.0	40.8	4.53	192.6
1858	174.5	166.0	170.25	8.5	38.5	4.53	231.1
1901	166.0	156.5	161.25	9.5	42.0	4.42	273.1
1904	156.5	146.5	151.50	10.0	48.2	4.82	321.3
1908	146.5	137.0	141.25	9.5	47.5	5.00	368.8
1911	137.0	128.0	132.50	9.0	46.0	5.11	414.8
1914	128.0	119.5	123.75	8.5	42.8	5.03	457.6
1917	119.5	111.5	115.50	8.0	45.0	5.63	502.6
1920	111.5	105.0	108.25	6.5	38.8	5.97	541.4
1923	105.0	98.5	101.75	6.5	39.8	6.12	581.2
1926	98.5	92.0	95.25	6.5	40.8	6.28	622.0
1928	92.0	86.5	89.25	5.5	35.0	6.36	657.0
1931	86.5	79.5	83.00	7.0	43.0	6.14	700.0
1935	79.5	72.5	76.00	7.0	43.0	6.14	743.0

REMARKS * Δρ obtained from BEP with CBD @ 215.5

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TABLE 2 (Continued)

ROD WORTH MEASUREMENT DATA FORM

Zion Unit 2 Cycle 6 Date 11/24/81

Test Physics Testing

Bank or RCCA Identification CBD Boration Dilution X

Date 11/24/81 Power HZP

Shutdown Bank Positions: A 228 B 228 C 228 D 228

Control Bank Positions: A 228 B 228 C 228 D Moving

	Initial	Final
RCS Boron Concentration:	1301	1197
Pressurizer Boron Concentration:	1292	1199
RCS Temperature (Tavg):	546.5°F	546.6

Time	RCC Position (Steps Withdrawn)			Delta H (Δh)	Reactivity (pcm)		
	Initial	Final	Average		Δρ	Δρ/Δh	Σ Δρ
1939	72.5	66.0	71.25	6.5	41.4	6.37	784.4
1944	66.0	59.0	62.50	7.0	40.3	5.76	824.7
1951	59.0	51.0	55.00	8.0	40.0	5.00	864.7
2000	51.0	41.0	46.00	10.0	37.0	3.70	901.7
2012	41.0	35.0	38.00	6.0	16.8	2.80	918.5
2017	35.0	30.5	32.75	4.5	10.3	2.29	928.8
2026	30.5	25.5	28.00	5.0	9.0	1.80	937.8
2036	25.5	19.5	22.00	5.0	8.0	1.60	945.8
*	19.5	0.0	9.75	19.5	12.0	0.62	957.8

REMARKS * From BEP 19.5 → 0 steps = 12 pcm at 0230 11/25/81

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TABLE 3

Critical Configuration Data

Zion Unit 2

Cycle 6

Date 11/25/81

Time (hrs)	RCS T_{avg} (°F)	RCS Boron Conc. (ppm)	Reference Bank Position (steps) $(h_x^M)_o$	Reference Bank Position (steps) (h_x^M)	RCC Bank Positions No. 2 (CBC)	No. 3 (CBB)	No. 4 (CBA)	No. 5 (SBD)	No. 6 (SBC)	No. 7 (SBB)	No. 8 (SBA)
0324	546.2	1197	24.0		228	228	228	228	228	228	228
0342	546.7			175.5	0	228	228	228	228	228	228
0401	547.2		27.0		228	228	228	228	228	228	228
0427	547.7			197.0	228	0	228	228	228	228	228
0440	547.5		28.0		228	228	228	228	228	228	228
0459	546.9			80.5	228	228	0	228	228	228	228
0512	546.8		27.0		228	228	228	228	228	228	228
0530	546.9			106.0	228	228	228	0	228	228	228
0544	547.4		28.0		228	228	228	228	228	228	228
0603	547.5			106.0	228	228	228	228	0	228	228
0617	547.5		29.0		228	228	228	228	228	228	228
0629	547.5			183.0	228	228	228	228	228	0	228
0644	547.6		29.0		228	228	228	228	228	228	228
0657	547.4			105.0	228	228	228	228	228	228	0
0713	547.2	↓	28.5		228	228	228	228	228	228	228

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TABLE 4

Calculation of $[(\Delta\rho_1)_x]^{+a,c}$

Zion Unit 2

Cycle 6

Date 11/25/81

Bank (x)		$(h_x^M)_o$ (steps)			$[\quad]^{+a,c}$
No.	Ident.	Initial	Return	Average	(pcm)
2	CBC	24.0	27.0	25.5	$[\quad]^{+a,c}$
3	CBB	27.0	28.0	27.5	
4	CBA	28.0	27.0	27.5	
5	SBD	27.0	28.0	27.5	
6	SBC	28.0	29.0	28.5	
7	SBB	29.0	29.0	29.0	
8	SBA	29.0	28.5	28.75	

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TABLE 5

Calculation of [ ] +a,c

Zion Unit 2

Cycle 6

Date 11/25/81

Bank (x)		H_X^M	[		] +a,c
No.	Ident.	(steps)	(pcm)		(pcm)
2	CBC	175.5	[		] +a,c
3	CBB	197.0			
4	CBA	80.5			
5	SBD	106.0			
6	SBC	106.0			
7	SBB	183.0			
8	SBA	105.0	[		]

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TABLE 6

Calculation of Inferred Integral Bank Worths

Zion Unit 2

Cycle 6

W_R^M = 957.8 (pcm)

Date 11/25/81

Bank (x)		[ ]	n	[ ] +a,c	W_x^I (a)
No.	Ident.	(pcm)	(pcm)	(pcm)	(pcm)
2	CBC	[			745.7
3	CBB				809.4
4	CBA				282.1
5	SBD				398.9
6	SBC				397.0
7	SBB				765.2
8	SBA	[		] +a,c	374.5

(a) [ ] +a,c

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TABLE 7

Comparison of Measured/Inferred Bank Worths with Design Predictions

Zion Unit 2

Cycle 6

Date 11/25/81

Bank (x)		$w_x^{M/I}$	w_x^P	$(\epsilon_1)_x$
No.	Ident.	(pcm)	(pcm)	(%)
1	CBD	957.8	[redacted]	[redacted] +a,c
2	CBC	745.7		
3	CBB	809.4		
4	CBA	282.1		
5	SBD	398.9		
6	SBC	397.0		
7	SBB	765.2		
8	SBA	374.5		

$\Sigma w_x^{M/I}$ (pcm)	Σw_x^P (pcm)	ϵ_2 (%)
4730.6	[redacted]	[redacted] +a,c

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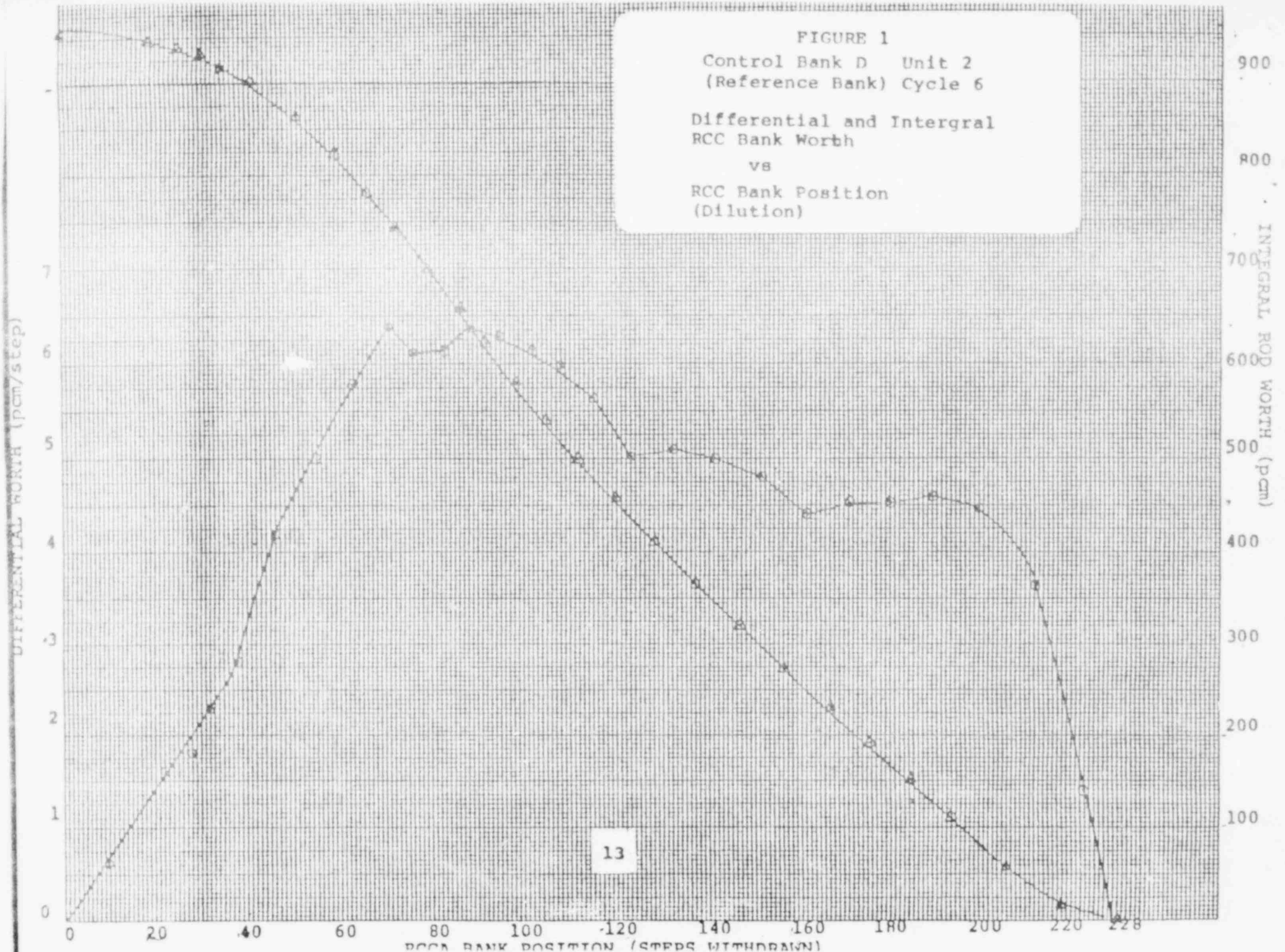
FIGURE 1
Control Bank D Unit 2
(Reference Bank) Cycle 6
Differential and Intergral
RCC Bank Worth
vs
RCC Bank Position
(Dilution)
DIFFERENTIAL WORTH (pcm/step)
INTEGRAL ROD WORTH (pcm)
RCCA BANK POSITION (STEPS WITHDRAWN)
0
20
40
60
80
100
120
140
160
180
200
220
228
100
200
300
400
500
600
700
800
900
1
2
3
4
5
6
7

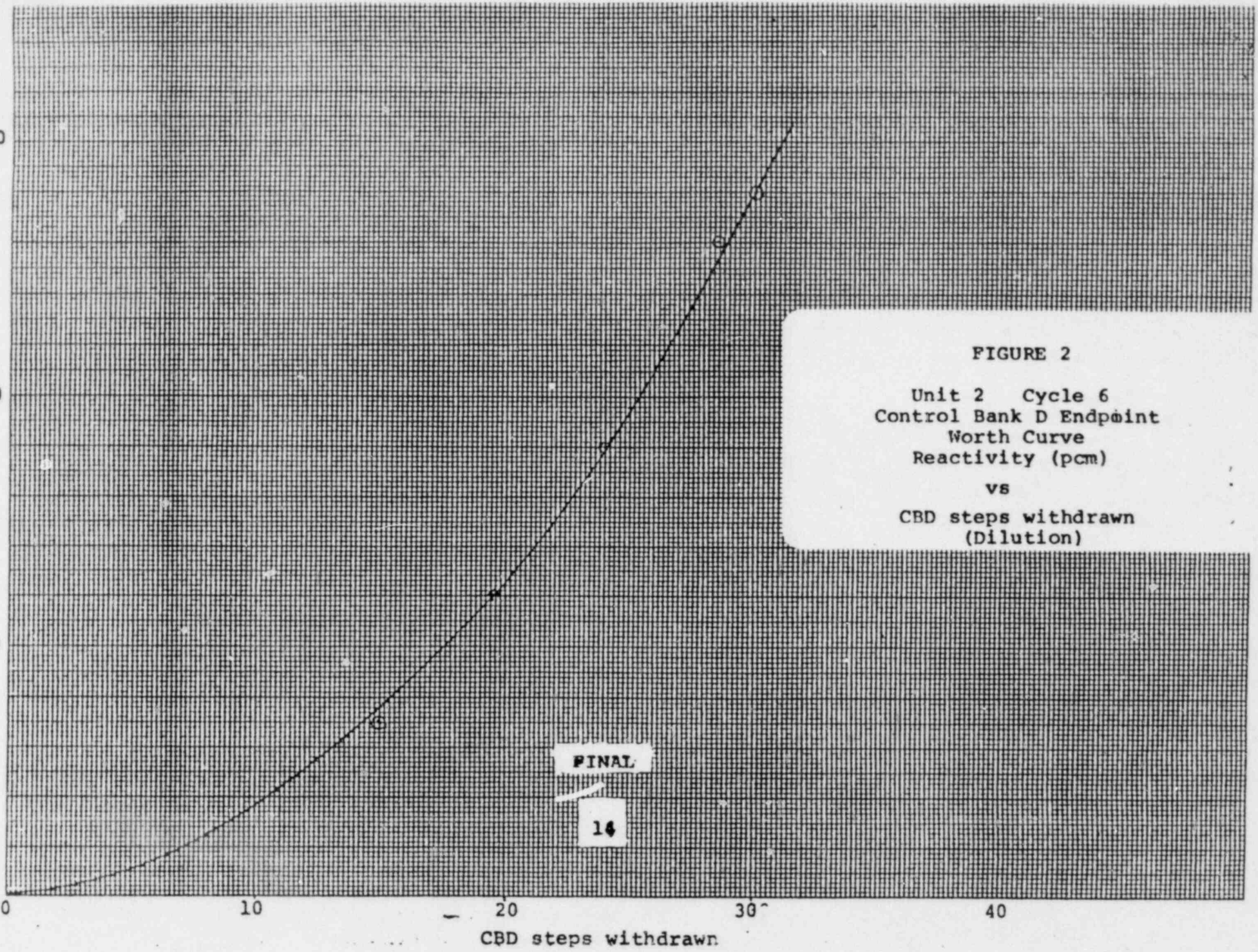

FIGURE 2

Unit 2 Cycle 6
Control Bank D Endpoint
Worth Curve
Reactivity (pcm)

vs

CBD steps withdrawn
(Dilution)