COMMONWEALTH EDISON COMPANY

ZION GENERATING STATION

DOCKET NO. 50-295

LICENSE NO. DPR-39

UNIT 1 CYCLE 6

ROD SWAP REPORT

June 1981

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Non-proprietary Version

2353N

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1.0 INTRODUCTION

At 0600 hours on April 16, 1981 Zion Unit 1 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 first 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 95% 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

[ ]

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 31.5 steps is shown in figure 2. Using this plot, [ ]$^{+a}$ for each bank was then calculated. These values are shown in Table 4.

The values of [ ]$^{+a}$ for 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 [ ]$^{+a}$ 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 95% 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 -4.26%. 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 bank with a predicted worth of > 600 pcm was -7.40% for Control Bank B. For banks having a predicted worth $\leq$ 600 pcm the largest difference was 36.4 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 4533.0 pcm. This value is -5.03% 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 818.5 pcm. This is a -0.8% difference from the integral worth measured during dilution.

4.0 SUMMARY

The Rod Swap Technique for measuring rod worths was utilized for the first time at Zion Station during the Unit 1 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 March 2, 1981 fom W. E. Kortier to W. L. Stiede transmitting rod worth verification-prediction data. ZUP-172.

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	CRr (a)	862		
2	CBC	711	[	±a,C
3	CBB	801		
4	CBA	284		
5	SBD	423		
6	SBC	423		
7	SBB	729		
8	SBA	540	]	]

(a) Reference bank

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

(c) Ratio of integral worth of the reference bank from h_x^P to the fully withdrawn position with and without bank x in the core.

TABLE 7

Zion Unit 1C6

ROD WORTH MEASUREMENT DATA FORM

Test Physics

Testing

Bank or RCCA identification CBD Boration ___ Dilution X

Date 4-16-81 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:	1389	1301
Pressurizer Boron Concentration:	1399	1302
RCS Temperature (Tavg):	548.7°F	547.0

Time	RCC Position (Steps Withdrawn)			Delta H (Δh)	Reactivity (pcm)		
	Initial	Final	Average		Δρ	Δρ/Δh	Σ Δρ
	228.0	214.0	221.00	14.0	18.3	1.31	18.3
	214.0	213.0	213.50	1.0	2.5	2.50	20.8
	213.0	202.0	207.50	11.0	36.5	3.32	57.3
	202.0	192.0	197.00	10.0	43.5	4.35	100.8
	192.0	182.0	187.00	10.0	47.0	4.70	147.8
	182.0	177.0	179.50	5.0	25.0	5.00	172.8
	177.0	169.5	173.25	7.5	34.5	4.60	207.3
	169.5	163.5	166.50	6.0	28.5	4.75	235.8
	163.5	157.5	160.50	6.0	27.0	4.50	262.8
	157.5	152.0	154.75	5.5	28.0	5.09	290.8
	152.0	146.0	149.00	6.0	29.5	4.92	320.3
	146.0	140.0	143.00	6.0	32.0	5.33	352.3
	140.0	134.0	137.00	6.0	28.0	4.67	380.3
	134.0	128.0	131.00	6.0	30.0	5.00	410.3
	128.0	122.0	125.00	6.0	30.0	5.00	440.3
	122.0	116.0	119.00	6.0	29.0	4.83	469.3
	116.0	114.0	115.00	2.0	10.0	5.00	479.3
	114.0	113.5	113.75	0.5	2.0	4.00	481.3

REMARKS BEPs 228 214 #1 18.5

#2 18.0 AVG = 18.3

#3 18.3

TABLE 2 (cont)

Zion Unit IC6

CD WORTH MEASUREMENT DATA FORM

Test Physics

Testing

Bank or RCCA Identification CBD Boration ____ Dilution X

Date 4-16-81 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:	1389	1301
Pressurizer Boron Concentration:	1399	1302
RCS Temperature (Tavg):	548.7	547.0

Time	RCC Position (Steps Withdrawn)			Delta H	Reactivity (pcm)		
	Initial	Final	Average	(Δh)	Δρ	Δρ/Δh	Σ Δρ
	113.5	110.5	112.00	3.0	15.9	5.29	497.2
	110.5	103.5	107.00	7.0	37.2	5.31	534.4
	103.5	98.0	100.75	5.5	29.0	5.30	563.4
	98.0	93.0	95.50	5.0	26.5	5.30	589.9
	93.0	88.0	90.50	5.0	25.5	5.10	615.4
	88.0	83.5	85.75	4.5	22.5	5.00	637.9
	83.5	78.5	81.00	5.0	23.5	4.70	661.4
	78.5	73.0	75.75	5.5	25.2	4.60	686.6
	73.0	67.5	70.25	5.5	23.5	4.30	710.1
	67.5	61.5	64.50	6.0	25.5	4.30	735.6
	61.5	55.0	58.25	6.5	23.0	3.50	758.6
	55.0	46.0	50.50	9.0	24.5	2.70	783.1
	46.0	36.0	41.00	10.0	18.4	1.80	801.5
	36.0	25.0	30.50	11.0	13.8	1 30	815.3
	25.0	6.0	15.50	19.0	10.0	0.50	825.3
	6.0	0.0	3.00	6.0	0.0	0.00	825.3

REMARKS

TABLE 3

Critical Configuration Data

Zion Unit 1

Cycle 6

Date 4/16/81

Time (hrs)	RCC T_{avg} (°F)	RCS Boron Conc. (ppm)	Reference Bank Position (steps)		RCC Bank Positions						
			$(h_x^M)_o$	(h_x^M)	No. 2 (CBC)	No. 3 (CBB)	No. 4 (CBA)	No. 5 (SBD)	No. 6 (SBC)	No. 7 (SBB)	No. 8 (SBA)
12:18	547.1	1306	20		228	228	228	228	228	228	228
12:38	546.8			186.5	0	228	228	228	228	228	228
12:50	546.9		16		228	228	228	228	228	228	228
13:03	546.8			201.5	228	0	228	228	228	228	228
13:17	546.8		15		228	228	228	228	228	228	228
13:26	546.8			99	228	228	0	228	228	228	228
13:38	546.6		13		228	228	228	228	228	228	228
13:49	546.8			123.5	228	228	228	0	228	228	228
13:58	546.8		13		228	228	228	228	228	228	228
14:09	546.9			124	228	228	228	228	0	228	228
14:19	547.0		12		228	228	228	228	228	228	228
14:30	547.3			187	228	228	228	228	228	0	228
14:40	547.2		13		228	228	228	228	228	228	228
14:53	547.5			153	228	228	228	228	228	228	0
15:04	547.5		11		228	228	228	228	228	228	228

TABLE 4

Calculation of $(\Delta\rho_1)_x$

Zion Unit 1

Cycle 6

Date 4/17/81

Bank (x)		$(h_x^M)_o$ (steps)			$(\Delta\rho_1)_x$
No.	Ident.	Initial	Return	Average	(pcm)
2	CBC	20	16	18.0	[ ]+a,c
3	CBB	16	15	15.5	
4	CBA	15	13	14.0	
5	SBD	13	13	13.0	
6	SBB	13	12	12.5	
7	SBB	12	13	12.5	
8	SBA	13	11	12.0	

TABLE 5

Calculation of $a_x(\Delta\rho\,2)_x$

Zion Unit 1

Cycle 6

Date 4/17/81

Bank (x)		n_x^M	$(\Delta\rho\,2)_x$	a_x	$a_x(\Delta\rho\,2)_x$
No.	Ident.	(steps)	(pcm)		(pcm)
2	CBC	186.5	[		+a,c
3	CBB	201.5			
4	CBA	99.0			
5	SBD	125.5			
6	SBC	124.0			
7	SBB	187.0			
8	SBA	153.0	]		]

TABLE 6

Calculation of Inferred Integral Bank Worths

Zion Unit 1

Cycle 6

W_R^M = 825.3 (pcm)

Date 4/17/81

Bank (x)		$(\Delta\rho_1)_x$	$(\Delta\rho_2)_x$	$\alpha_x(\Delta\rho_2)_x$	W_x^I (a)
No.	Ident.	(pcm)	(pcm)	(pcm)	(pcm)
2	CBC	[		] +a,c	695.4
3	CBB				741.7
4	CBA				301.3
5	SBD				393.9
6	SBC				386.6
7	SBB				684.5
8	SBA	]			504.3

(a) [ ] +a,c

TABLE 7

Comparison of Measured/Inferred Bank Worths with Design Predictions

Zion Unit 1

Cycle 6

Date 4/17/81

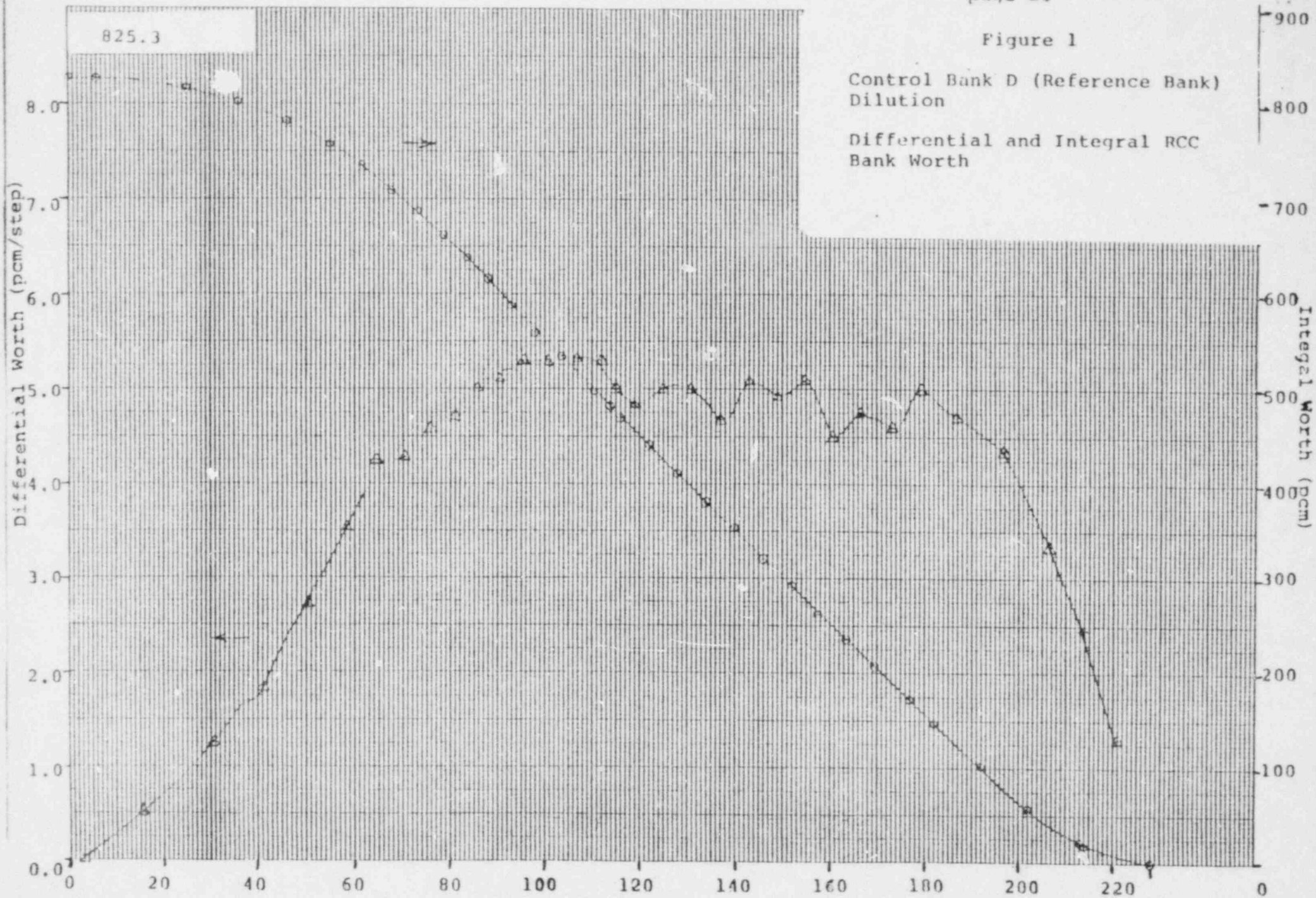
Bank (x)		$W_x^{M/I}$	W_x^P	$(\epsilon_1)_x$
No.	Ident.	(pcm)	(pcm)	(%)
1	CBD	825.3	[	] +a,c
2	CBC	695.4		
3	CBB	741.7		
4	CBA	301.3		
5	SBD	393.9		
6	SBC	386.6		
7	SBB	684.5		
8	SBA	504.3		

$W_x^{M/I}$ (pcm)	W_x^P (pcm)	ϵ_2 (%)
4533.0	[	] +a,c

Figure 1

Control Bank D (Reference Bank)
Dilution

Differential and Integral RCC
Bank Worth



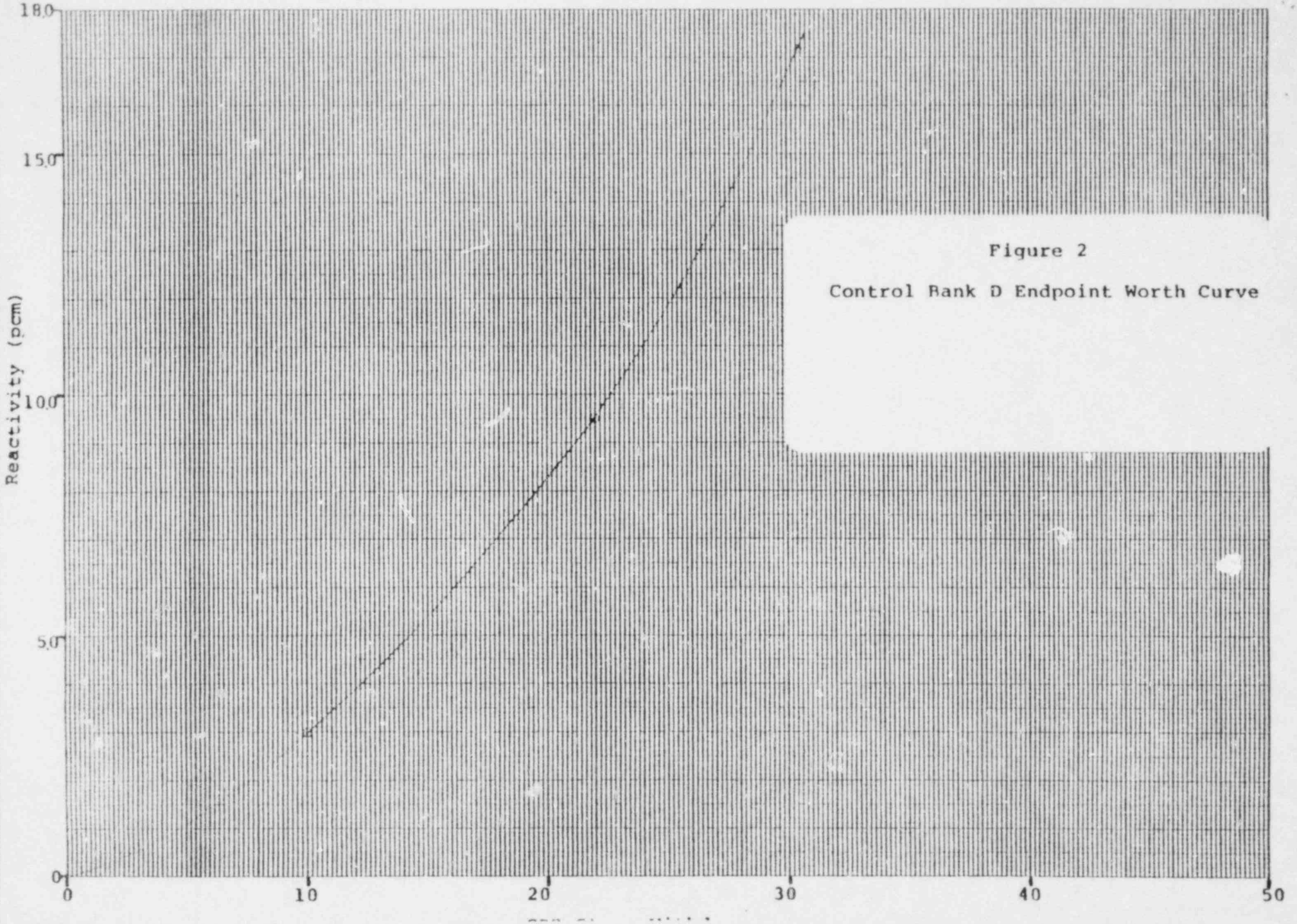


Figure 2

Control Bank D Endpoint Worth Curve