

FLORIDA POWER & LIGHT COMPANY

TURKEY POINT PLANT

UNIT 4 CYCLE V.

STARTUP REPORT

7812140152

Introduction

This report contains an official summary of the Startup Physics Tests, Unit 4 Cycle V. The tests were conducted in accordance with Operating Procedure 0204.5, Nuclear Design Check Tests During Startup Sequence After Refueling.

The testing program commenced on September 27, 1978 with initial criticality and was completed on September 30, 1978.

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1.0 Unit 4 Cycle V

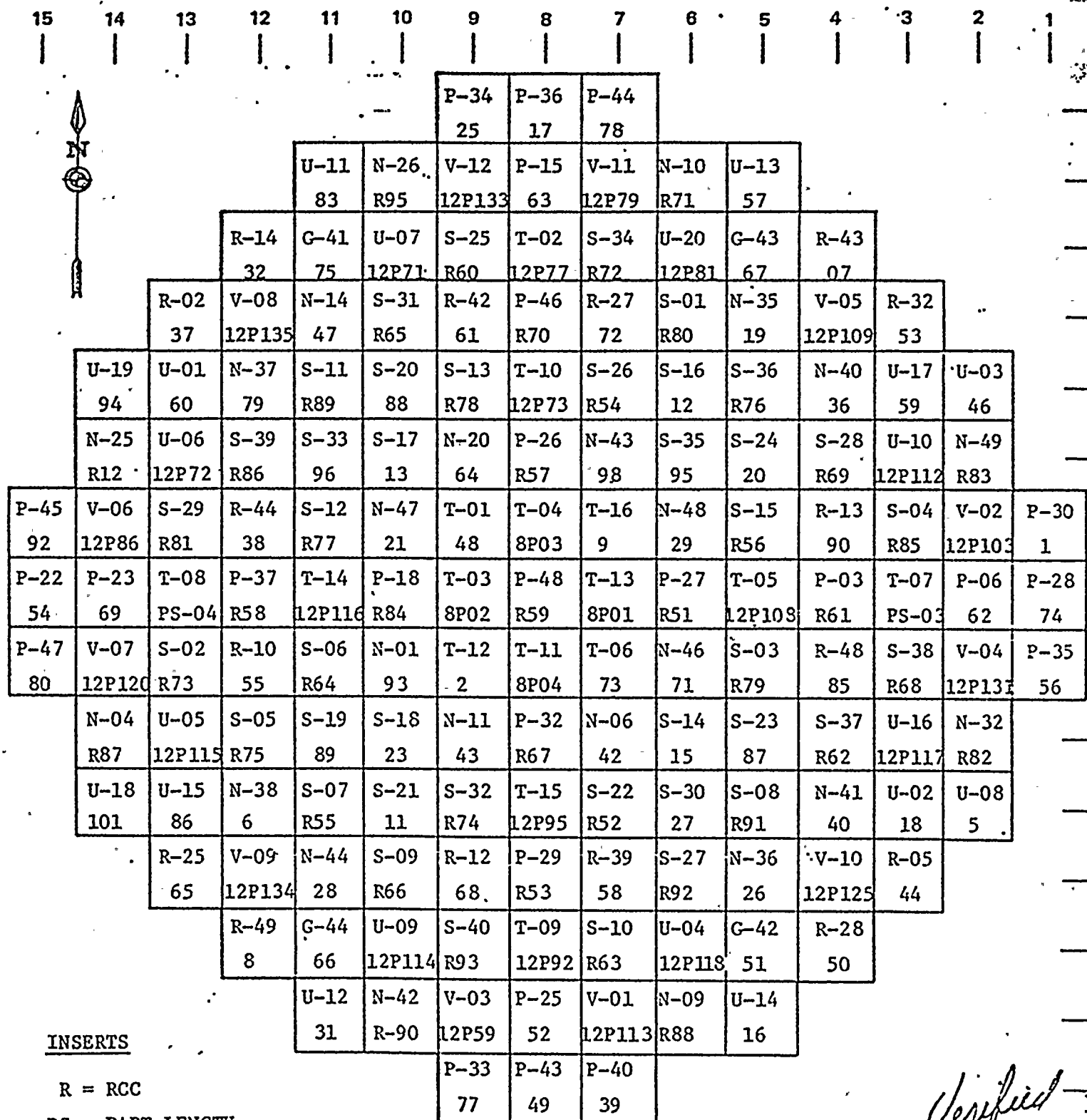
1.1 Loading Pattern

1.2 Rod Pattern

1.3 Rod Drop Times

8/18/78

REACTOR FUEL LOCATION
TURKEY POINT PLANT UNIT NO. 4
CYCLE NO. V



R = RCC

RS = PART LENGTH

BP = POISON

NO LETTER DESIGNATION = THIMBLE PLUG

D = THIMBLE PLUG FOR REMOVABLE ROD ASSEMBLY

PS = PRIMARY SOURCE

Assembly No.

Insert No.

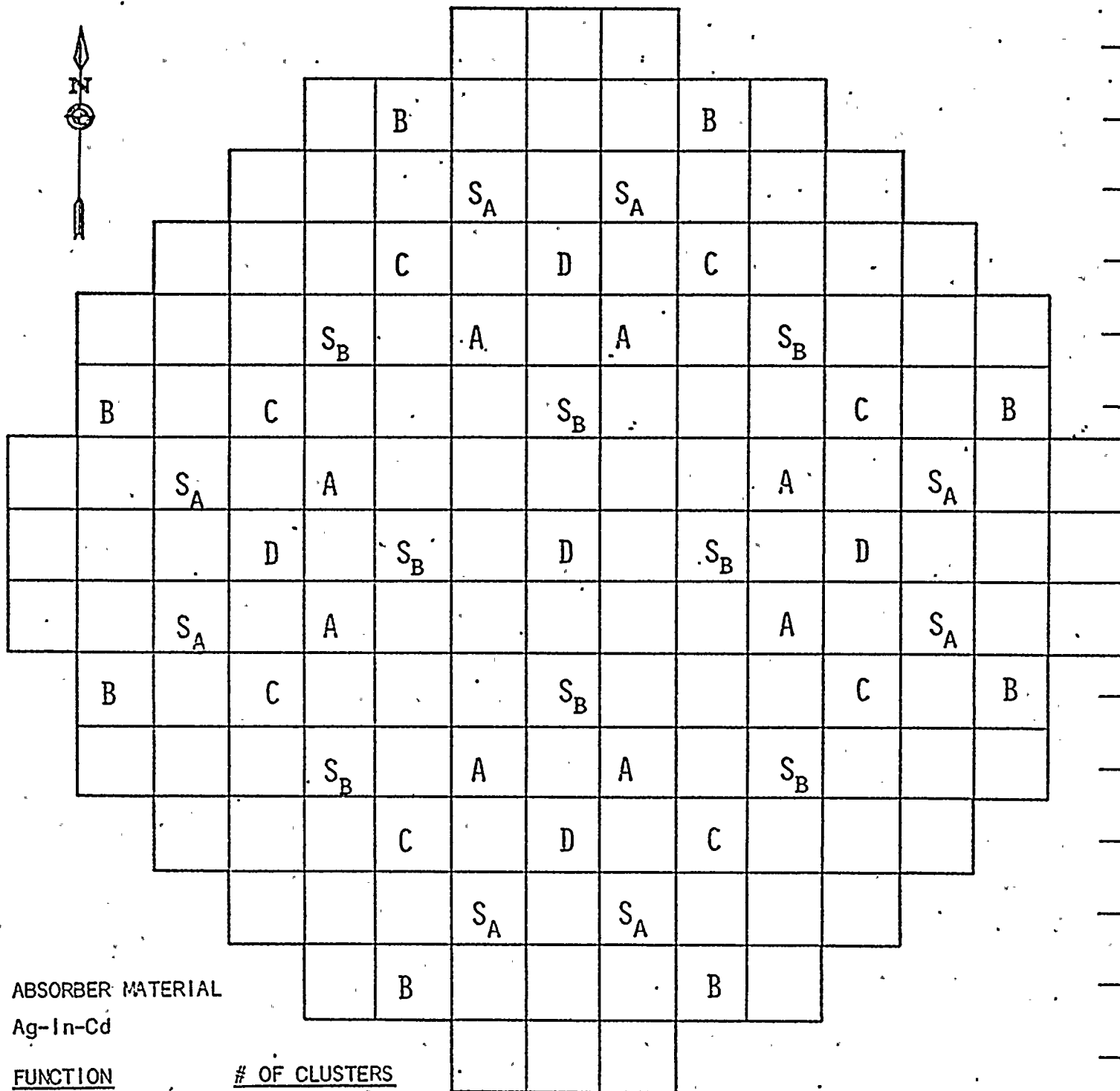
LEGEND

FORM 5445 REV. 11/77

DATE

REACTOR FUEL LOCATION
TURKEY POINT PLANT UNIT NO. 4
CYCLE NO. V

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1



ABSORBER MATERIAL

Ag-In-Cd

FUNCTION

OF CLUSTERS

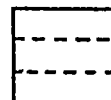
Control Bank D
Control Bank C
Control Bank B
Control Bank A
Shutdown Bank S_B
Shutdown Bank S_A

5
8
8
8
8
8

Assembly No.

Insert No.

LEGEND



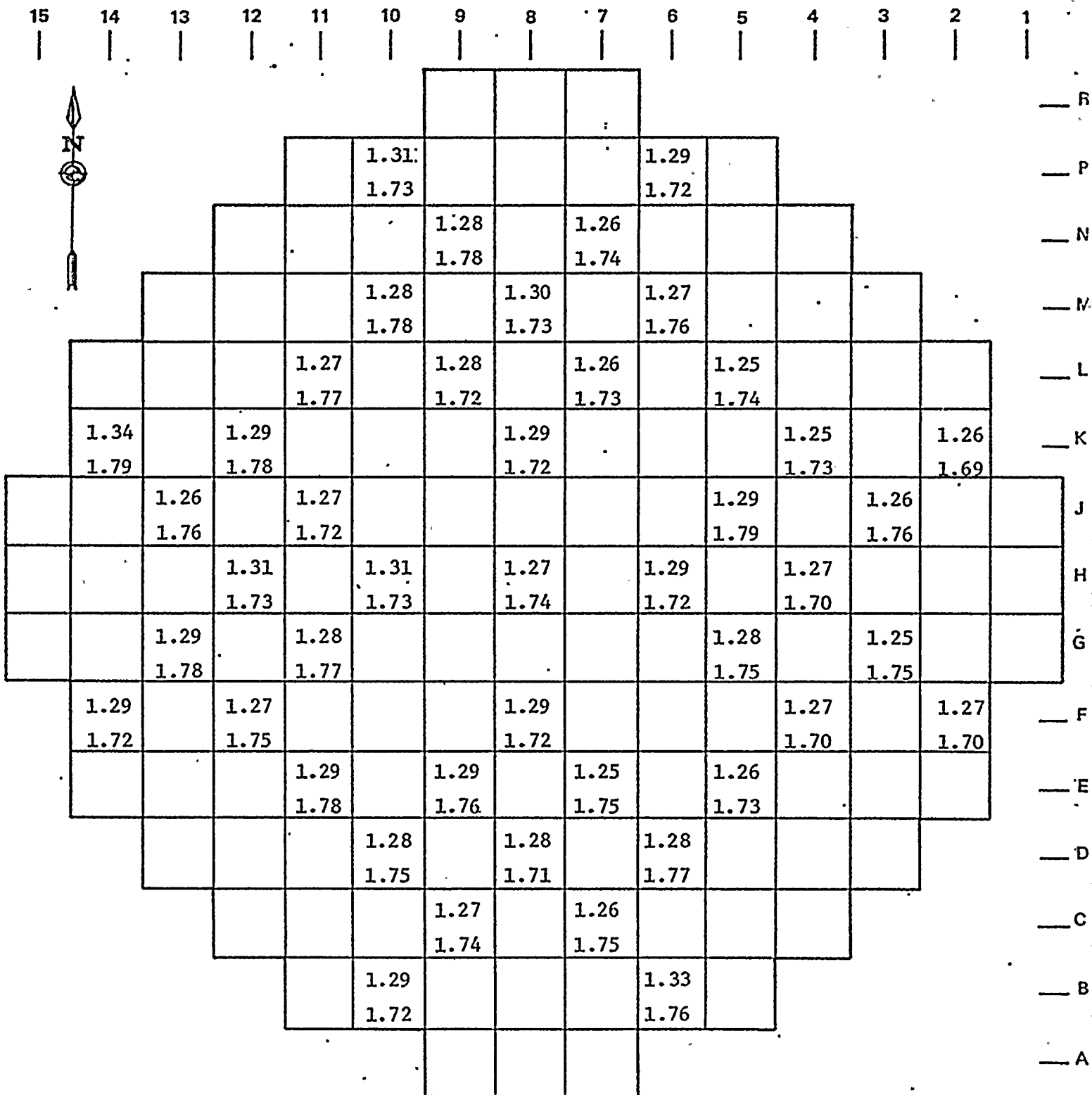
ROD DROPS

The following is a table of rod drops times as measured prior to Unit 4 Startup Physics Tests. The two times given are time to dashpot, a Technical Specification of 1.8 seconds or less, and time to the bottom of the core, which does not have a Technical Specification requirement.

All rods were dropped and met the Technical Specification requirement.

DATE
September 25, 1978

REACTOR FUEL LOCATION
TURKEY POINT PLANT UNIT NO. 4
CYCLE NO. V



Time to Dash. Pot
(sec)
Time to Bottom of
Core (sec)

LEGEND

2.0 Initial Criticality

The approach to criticality began September 27, 1978 at 2140 hours in accordance with Operating Procedure 0204.3, Initial Criticality After Refueling. Criticality was achieved September 28, 1978 at 0800 hours by withdrawing control rods to 193 steps on Bank D and diluting 39,700 gallons of water.

Upon attaining criticality the flux level was increased to 1×10^{-8} amps on the intermediate range to obtain critical data.

Tavg = 547°F

Control Bank = 193 steps

Flux = 1×10^{-8} amps

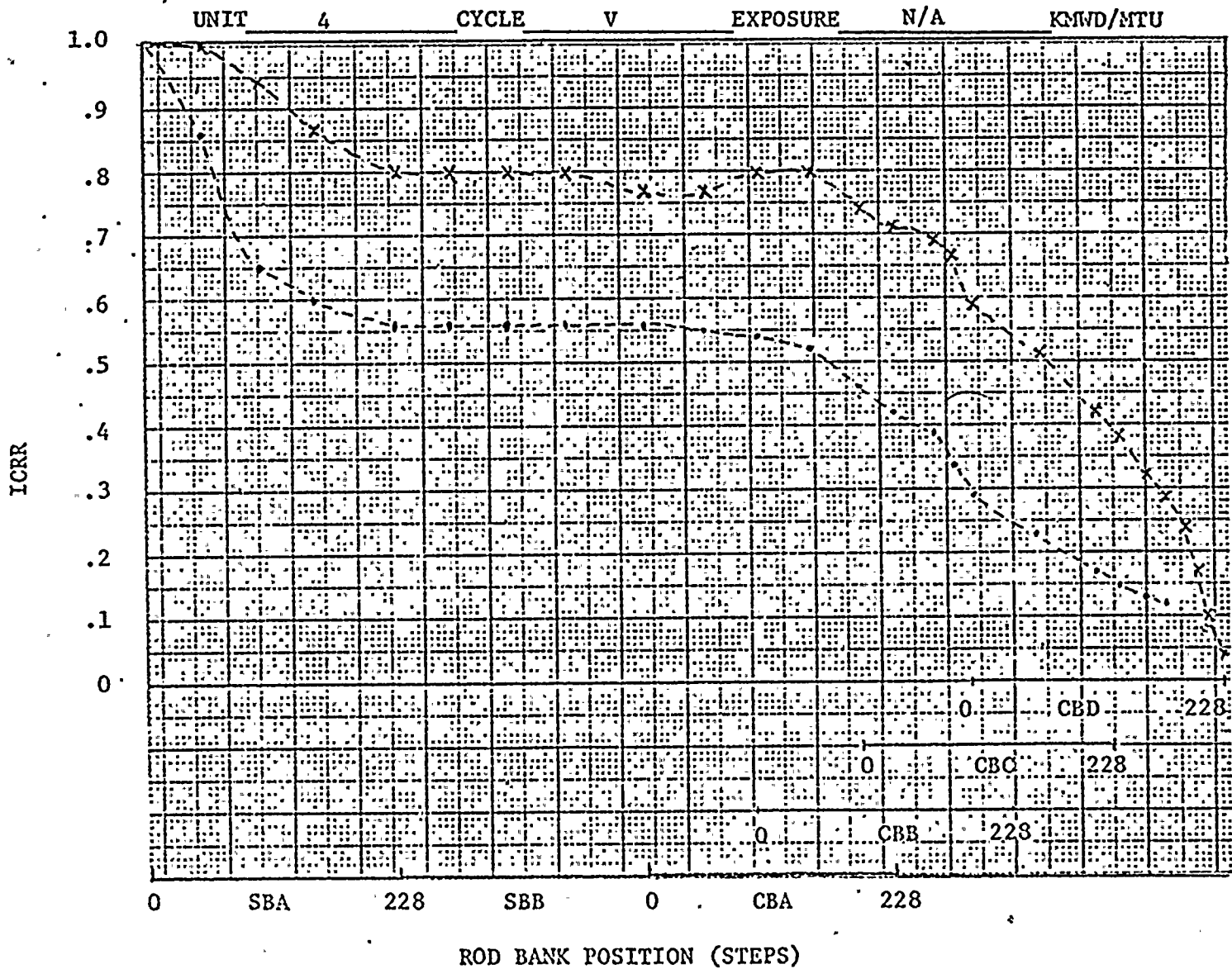
Boron = 775 ppm

The following two graphs are a plot of the ICRR during the approach to criticality.

ICRR VS ROD BANK POSITION

. - N32

x - N35



x - N32

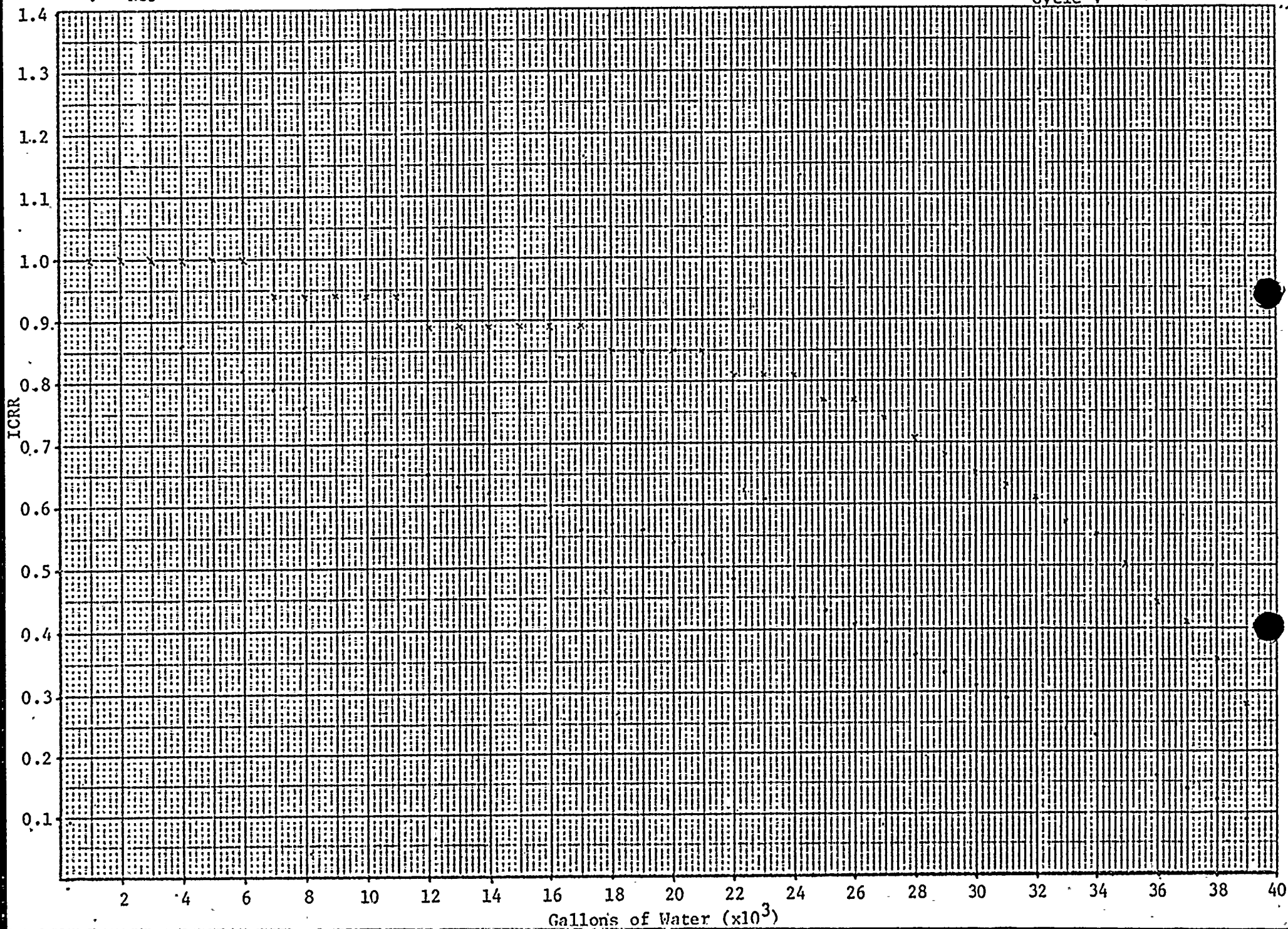
. - N35

ICRR Vs. Dilution

9-28-78

Unit 4

Cycle V



3.0 Summary of Tests

3.1 Nuclear Heating

3.2 Reactivity Vs. Period Check

3.3 Boron Endpoints

3.4 Rod Worths (PPM)

3.5 Rod Worths (PCM)

3.6 Temperature Coefficient

3.1 Nuclear Heating

Nuclear Heating was determined in accordance with Operating Procedure 0204.3, Initial Criticality After Refueling.

Nuclear heating first occurred at:

Kiethly Pico Ammeter = 4.3×10^{-7} amps

N-35 = 3.7×10^{-7} amps

N-36 = 3.3×10^{-7} amps

All physics test were conducted at a flux level at or below 1.0×10^{-7} amps to assure nuclear heating did not occur.

3.2 Reactivity Vs. Period

Reactivity Computer Checkout was done in accordance with Operating Procedure 0204.3, Initial Criticality After Refueling. The results are as follows:

Period (sec)	Reactivity (pcm)	Reactivity (design)	Diff (%)
145.1	36.5	35	+ 1.04
139.9	37.9	37	+ 1.02
111.9	45.2	45	+ 1.00
123.4	42.5	41	+ 3.66
151.4	35.5	34	+ 4.41
128.5	30.0	29	+ 3.4
194.6	20.0	20	0.0

3.3 Boron Endpoints

	<u>Measured</u>	<u>Design Westinghouse</u>
ARO	799	750
D in	725	678
CD in	567	515
DCB in	520	470
DCBA in	359	309

3.4 Rod Worth (PPM)

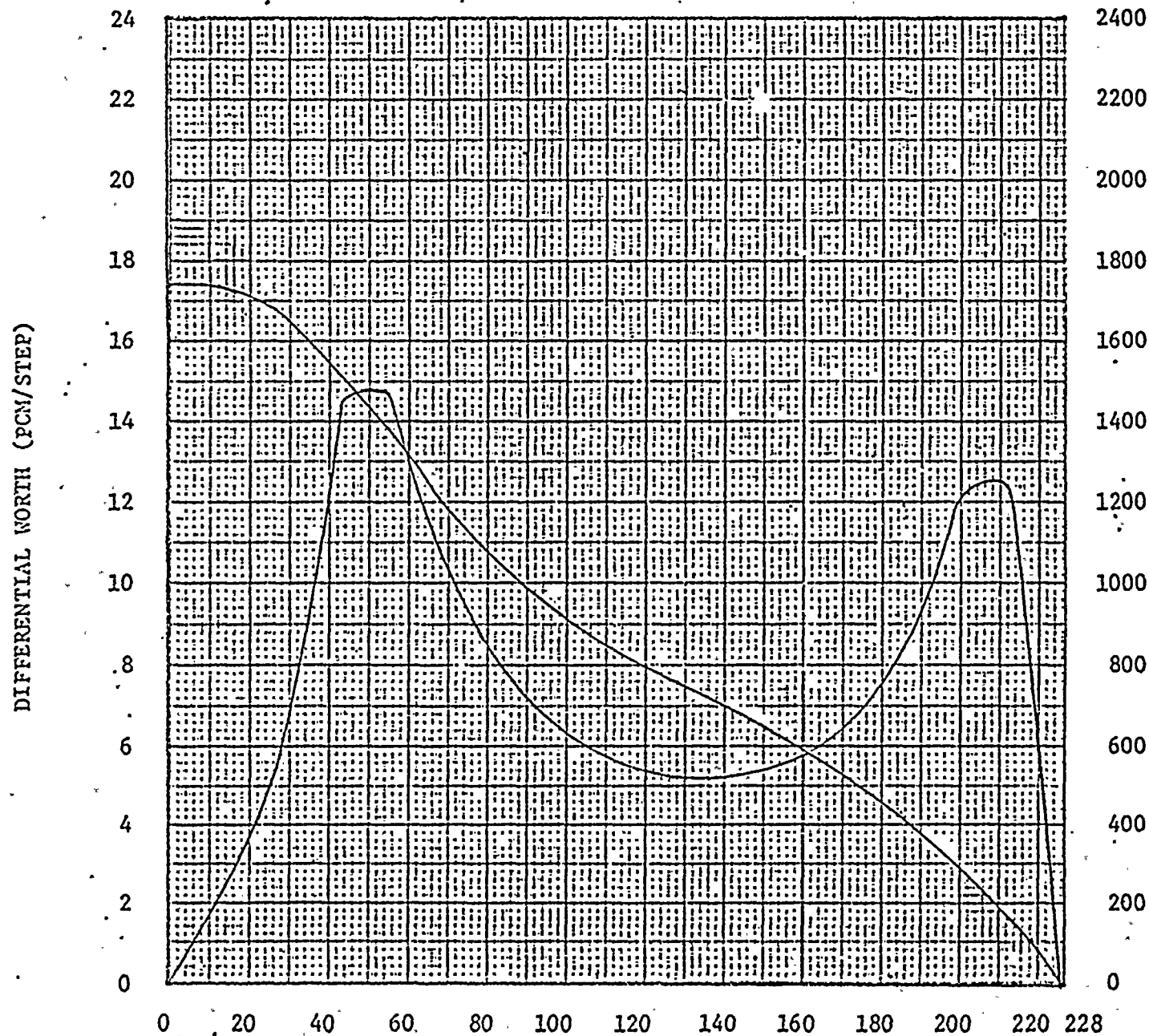
	Measured	Westinghouse	% Diff
D	74	72	-2.7
C	158	163	+3.1
B	47	45	-4.4
A	<u>161</u>	<u>161</u>	<u>0</u>
Total	440	441	+0.22

3.5 Rod Worth (PCM)

	Measured	Westinghouse	% Diff
D	727	762	+4.8
C	1701	1735	+1.9
B	473	487	+2.9
A	<u>1744</u>	<u>1749</u>	<u>+0.3</u>
Total	4645	4733	+1.89



HOT ZERO POWER
DIFFERENTIAL & INTEGRAL BANK WORTH
VS
BANK POSITION



2400

2200

2000

1800

1600

1400

1200

1000

800

600

400

200

0

UNIT 4
CYCLE 5
EXPOSURE 0.0 KMD/MTU
BANK A

BANK POSITIONS

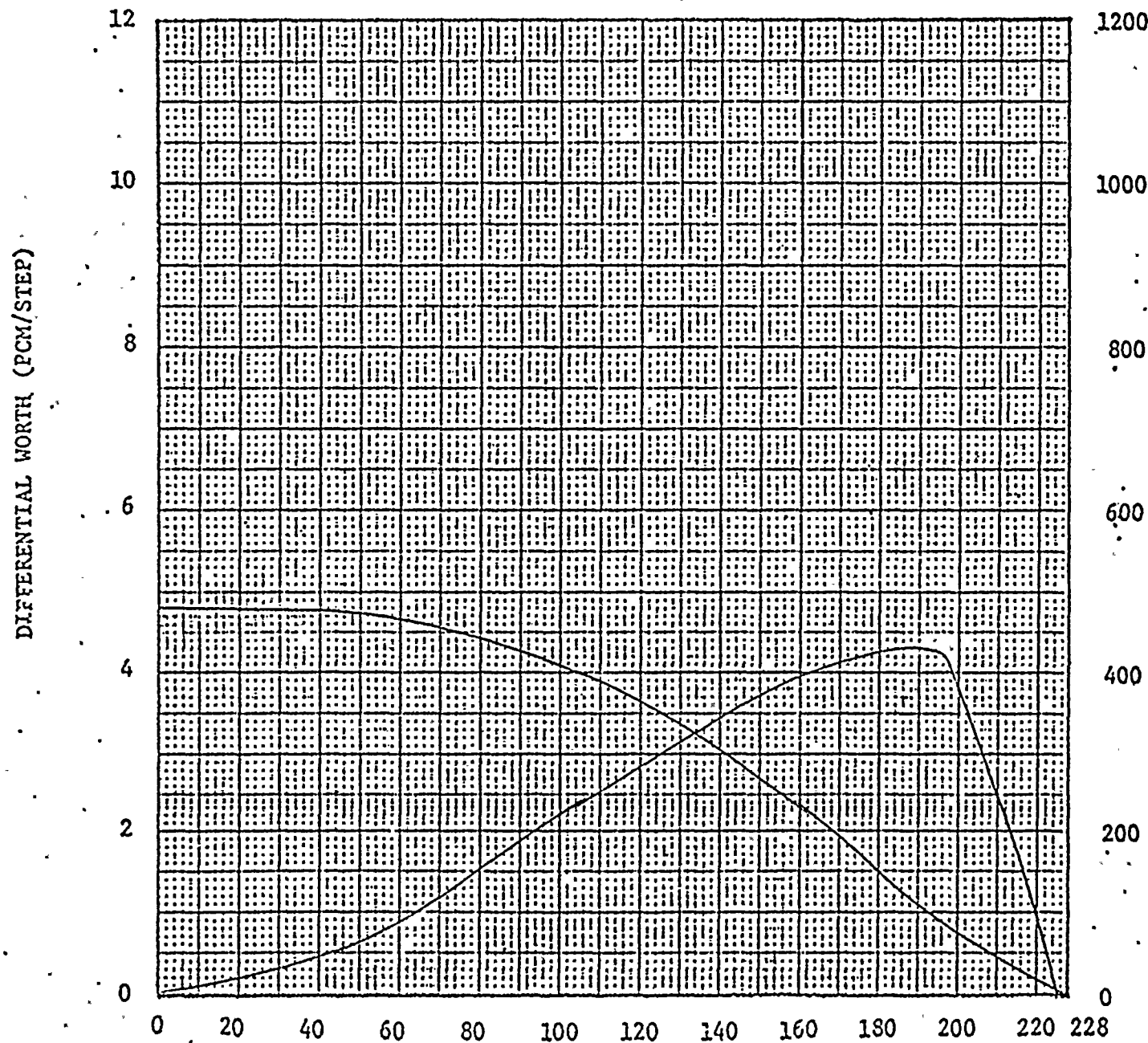
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SDB	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBA	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
CBB	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CBC	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CBD	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
P/L	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

TEST METHOD

DILUTION	<input checked="" type="checkbox"/>
BORATION	<input type="checkbox"/>

INTEGRAL NORTH (PCM)

HOT ZERO POWER
DIFFERENTIAL & INTEGRAL BANK WORTH
VS
BANK POSITION



UNIT 4
CYCLE 5
EXPOSURE 0.0 KMD/MTU
BANK B

BANK POSITIONS

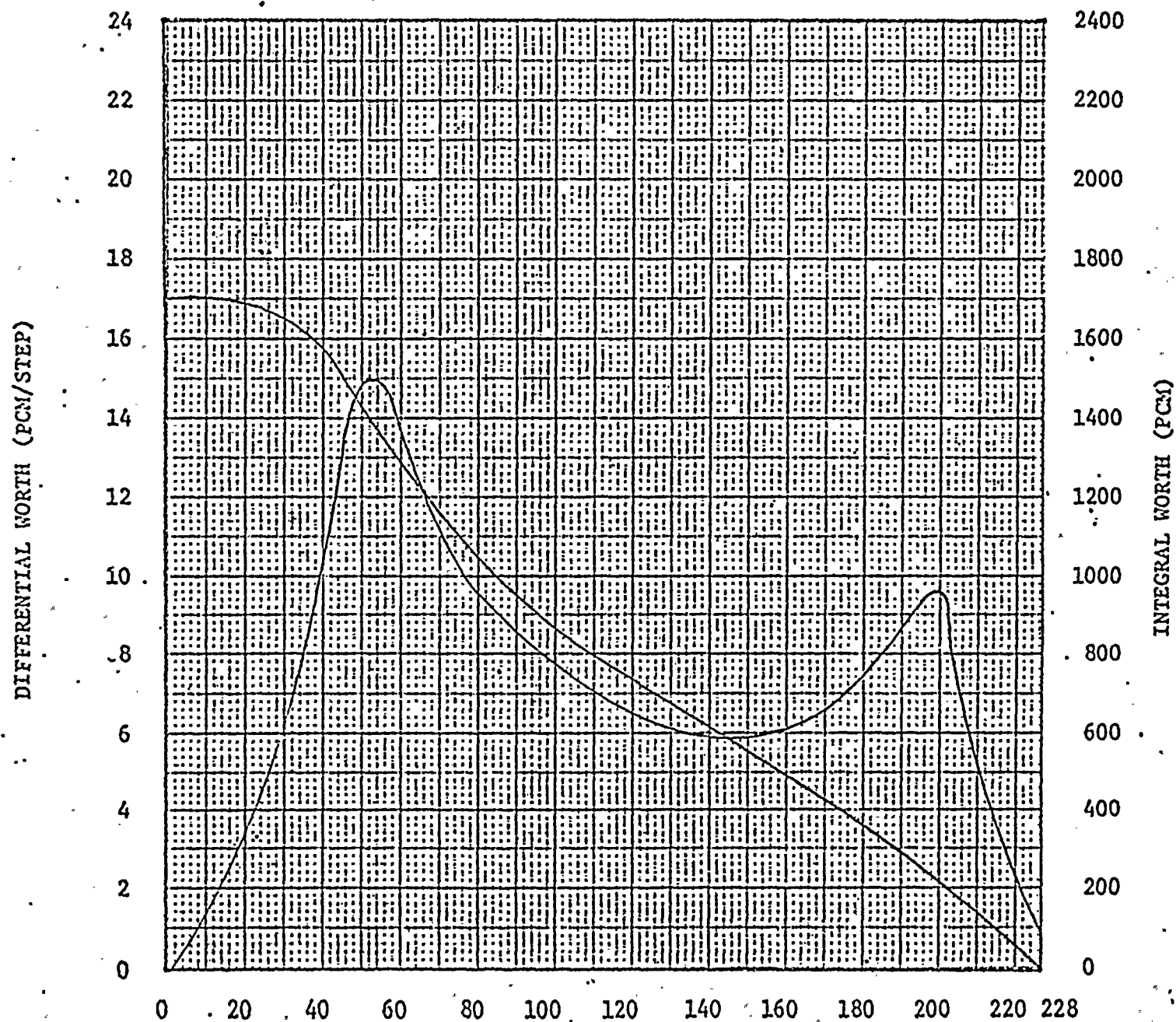
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CBC	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CBD	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
P/L	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

TEST METHOD

DILUTION ☒
BORATION ☐



HOT ZERO POWER DIFFERENTIAL & INTEGRAL BANK WORTH VS BANK POSITION



UNIT : 4
CYCLE 5
EXPOSURE 0.0 KMD/MTU
BANK C

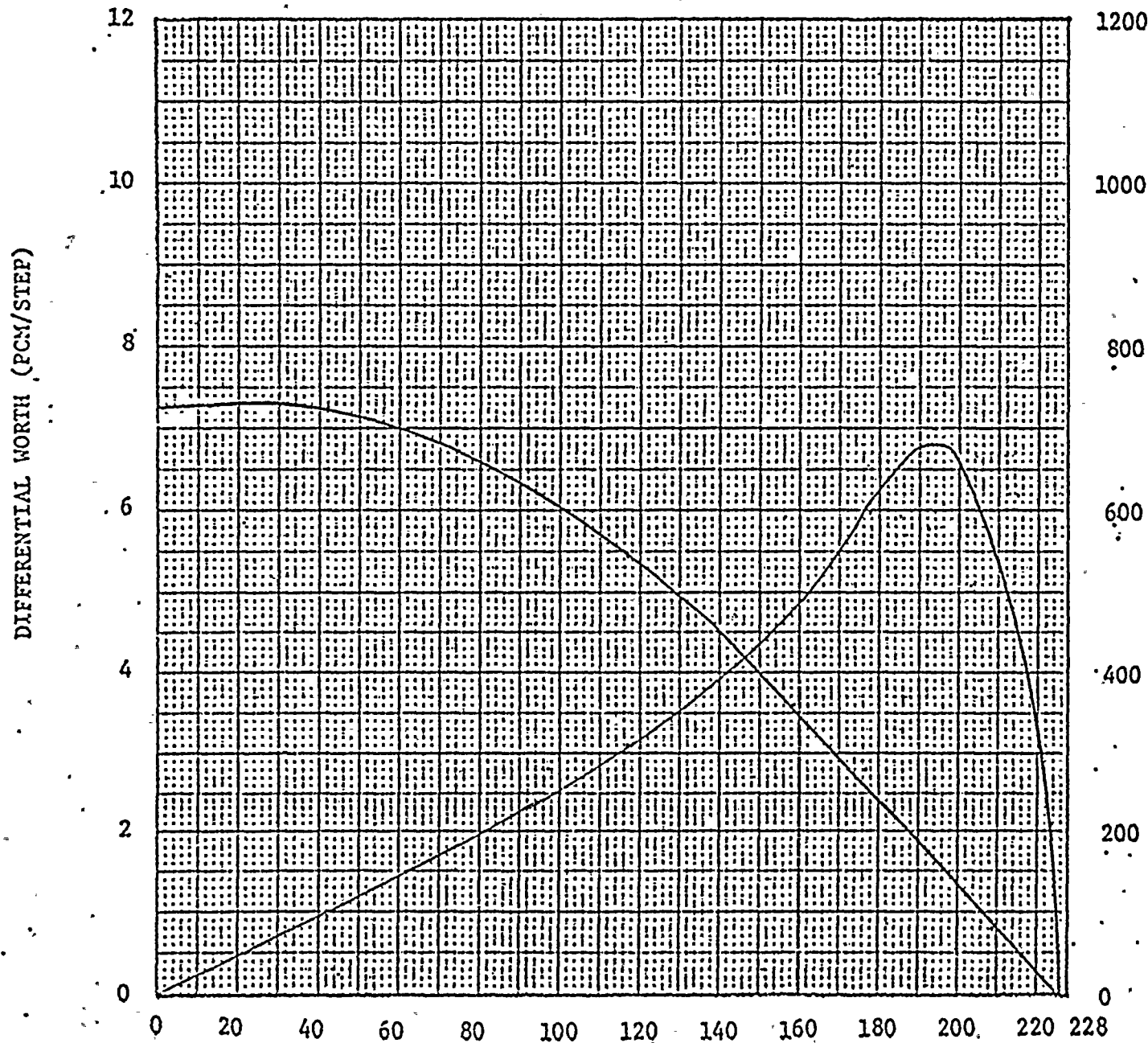
BANK POSITIONS

	OUT	IN	MOVING
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SDB	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBB	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBC	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
CBD	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
P/L	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

TEST METHOD

DILUTION	<input checked="" type="checkbox"/>
BORATION	<input type="checkbox"/>

HOT ZERO POWER
DIFFERENTIAL & INTEGRAL BANK WORTH
VS
BANK POSITION



UNIT 4
CYCLE 5
EXPOSURE 0.0 KMD/MTU
BANK D

BANK POSITIONS

	OUT	IN	MOVING
SDA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
SDB	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBA	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBB	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBC	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CBD	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
P/L	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

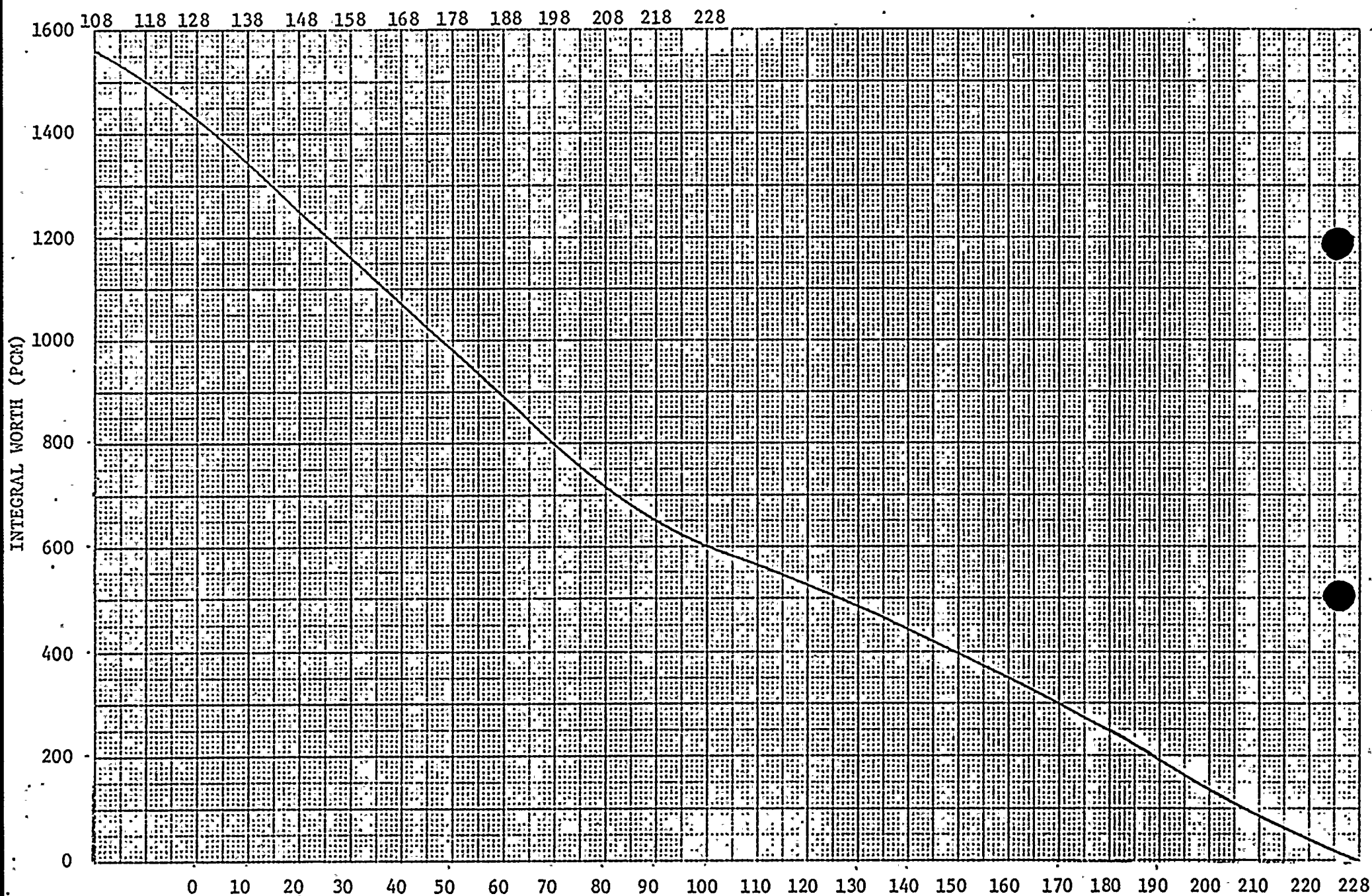
TEST METHOD

DILUTION ☒
BORATION ☐

PTP-4 CYCLE-5
INTEGRAL WORTH IN OVERLAP

ECC SECTION
FIGURE-3
ERK 10/12/78

CONTROL BANK C POSITION (STEPS)



CONTROL BANK D POSITION (STEPS)

Temperature Coefficient

Temperature coefficient was measured in accordance with Operating Procedure 0204.5, Nuclear Design Check Tests During Startup After Refueling.

The measured numbers (in PCM/°F) are:

Isothermal Temperature Coefficient

Rods	Measured	Design Westinghouse
ARO	-7.66	-7.01

Moderator Temperature Coefficient

Rods	Measured	Design Westinghouse
ARO	-5.76	-5.11

Moderator Temperature Coefficient can be defined as Isothermal Temperature Coefficient minus Doppler Coefficient. Doppler Coefficient = -1.9 pcm/°F. Est. from Westinghouse WCAP -9351 was used for all Temperature Coefficients.

4.0 SHUTDOWN MARGIN

The Shutdown Margin was calculated prior to power escalation to verify adequate shutdown capability. For this calculation design, rod worths were reduced by 10% and showed shutdown margin at BOC and EOC. The following is a summary of the results:

	<u>CYCLE 5</u>	
	<u>BOC</u>	<u>EOC</u>
<u>Control Rod Worth (%$\Delta\rho$)</u>		
All Rods Inserted Less Worst Stuck Rod	6.51	6.54
(1) Less 10%	5.86	5.89
<u>Control Rod Requirements (%$\Delta\rho$)</u>		
Reactivity Defects (Doppler, T_{avg} , Void, Redistribution)	2.13	2.70
Rod Insertion Allowance	.50	.50
(2) Total Requirements	2.63	3.20
Shutdown Margin [(1)-(2)] % $\Delta\rho$	3.23	2.69
Required Shutdown Margin (% $\Delta\rho$)	1.36	1.77

5.0 Power Distribution Map

5.1 HZP Flux Map

5.2 30% Flux Map

5.3 98% Flux Map

FLORIDA POWER & LIGHT COMPANY
TURKEY POINT PLANT UNIT 4
OPERATING SUMMARY

R	P	N	H	L	K	J	H	G	F	E	D	C	B	A
0.315	0.353	0.312												
0.321	0.360	0.318												
-1.7	-1.7	-1.8												
0.595	0.628	1.132	0.810	1.123	0.833	0.596								
0.602	0.648	1.151	0.824	1.143	0.836	0.605								
-1.3	-1.8	-1.7	-1.7	-1.9	-2.1	-0.7								
0.454	1.138	1.279	1.184	1.222	1.188	1.283	1.159	0.468						
0.460	1.159	1.311	1.203	1.242	1.201	1.307	1.154	0.459						
-1.3	-1.9	-2.4	-1.5	-1.5	-1.3	-1.1	0.5	2.0						
0.449	1.151	0.978	1.227	1.607	1.329	1.018	1.231	1.304	1.182	0.467				
0.459	1.161	0.997	1.232	1.624	1.647	1.324	1.232	0.995	1.161	0.460				
-2.2	-0.8	-2.1	-0.4	-1.7	-1.7	-0.6	-0.1	0.9	1.8	1.5				
0.584	1.123	1.301	1.321	1.312	1.286	1.299	1.271	1.339	1.175	0.604				
0.609	1.154	0.995	1.264	1.308	1.257	1.255	1.293	1.264	1.339	0.602				
-2.6	-2.6	0.6	4.4	0.9	-1.6	0.7	1.0	0.1	2.2	0.3				
0.629	1.292	1.247	1.321	1.275	0.985	0.991	1.259	1.309	1.351	0.641				
0.636	1.307	1.232	1.298	1.259	0.981	0.963	1.259	1.309	1.311	0.640				
-1.1	-1.1	1.2	1.8	1.2	0.4	3.0	1.5	0.7	1.6	0.1				
0.307	1.144	1.207	1.039	1.278	0.990	1.254	1.122	1.276	0.988	1.265	1.338	1.219	1.152	0.321
0.318	1.145	1.201	1.024	1.254	0.982	1.258	1.106	1.258	0.981	1.257	1.324	1.203	1.151	0.321
-3.4	-0.0	0.5	1.5	2.0	0.8	-0.3	1.4	1.5	0.7	0.9	1.4	0.5	-0.1	0.1
0.347	0.822	1.272	1.071	1.286	0.852	1.102	1.073	1.122	0.972	1.265	1.055	1.245	0.809	0.337
0.360	0.824	1.242	1.047	1.257	0.963	1.105	1.067	1.122	0.963	1.257	1.055	1.245	0.824	0.360
-3.4	-0.3	2.4	2.3	2.3	2.0	-0.4	1.0	1.4	0.9	0.6	1.0	0.8	-1.6	-6.2
0.310	1.152	1.234	1.055	1.305	1.056	1.272	1.125	1.282	0.984	1.245	1.310	1.187	1.095	0.255
0.321	1.151	1.203	1.024	1.257	0.981	1.255	1.106	1.255	0.982	1.254	1.324	1.203	1.145	0.321
-3.4	0.6	2.5	3.0	3.8	2.3	1.1	1.7	1.9	0.2	-0.7	-1.4	-1.2	-4.8	-9.2
0.657	1.345	1.267	1.339	1.285	0.995	0.995	0.998	1.254	1.279	1.265	1.273	0.617		
0.640	1.311	1.232	1.300	1.259	0.982	0.963	0.981	1.259	1.298	1.232	1.307	0.636		
2.6	2.6	2.8	3.0	2.1	1.3	3.4	1.8	-0.4	-1.5	-2.2	-2.5	-3.0		
0.635	1.222	1.035	1.292	1.338	1.304	1.335	1.278	1.247	0.982	1.133	0.582			
0.602	1.160	0.997	1.264	1.293	1.254	1.257	1.286	1.300	1.264	0.995	1.154	0.500		
5.4	5.4	3.8	2.2	2.5	4.0	6.3	2.4	-1.7	-1.4	-1.3	-1.8	-2.9		
0.498	1.233	1.017	1.278	1.069	1.065	1.006	1.194	0.983	1.157	0.458				
0.460	1.161	0.995	1.232	1.024	1.047	1.024	1.232	0.997	1.161	0.459				
8.2	6.2	2.2	3.7	4.3	1.9	1.5	-3.1	-1.3	-0.3	-0.3				
0.472	1.127	1.321	1.195	1.178	1.126	1.240	1.118	0.459						
0.459	1.154	1.307	1.201	1.242	1.203	1.311	1.160	0.460						
2.9	1.1	-0.4	-5.2	-6.2	-5.4	-3.6	-0.3							
0.586	0.607	1.056	0.785	1.050	0.597	0.576								
0.600	0.634	1.145	0.824	1.151	0.640	0.602								
-2.3	-4.6	-7.7	-7.1	-7.5	-5.7	-5.3								
0.289	0.329	0.295												
0.318	0.360	0.321												
-8.9	-8.6	-8.0												
										MEASURED F DELTA H				
										EXPECTED F DELTA H				
										DIFFERENCE				

ROD POSITION

Bank	Location In Steps	Classification
SBA	<u>228</u>	Map No. FM4 V1
SBB	<u>228</u>	Power (%) <u>0</u>
CBA	<u>228</u>	Axial
CBB	<u>228</u>	Offset <u>+46.22</u>
CBC	<u>228</u>	Max $F_{\Delta H}^N$ <u>1.475</u>
CBD	<u>212</u>	Max F_Q^N <u>2.826</u>

**FLORIDA POWER & LIGHT COMPANY
ORKEY POINT PLANT UNIT 4
OPERATING SUMMARY**

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
30.322	30.364	30.329												
30.347	30.391	30.343												
J -7.0J	-7.0J	-4.1J												
30.612	30.655	31.100	30.803	31.114	30.675	30.649								
30.641	30.667	31.131	30.830	31.126	30.664	30.639								
J -4.4J	-1.8J	-2.8J	-3.3J	-1.0J	1.7J	1.6J								
30.479	31.147	31.270	31.149	31.169	31.167	31.311	31.195	30.509						
30.501	31.179	31.289	31.168	31.175	31.166	31.287	31.174	30.500						
J -4.4J	-2.7J	-1.5J	-1.6J	-0.5J	0.1J	1.9J	1.7J	1.6J						
30.495	31.170	31.023	31.232	31.002	30.895	31.004	31.260	31.042	31.265	30.504				
30.500	31.190	31.033	31.233	31.006	30.913	31.007	31.234	31.031	31.190	30.501				
J -1.2J	-1.7J	-0.9J	-0.1J	-0.5J	-2.5J	-0.3J	2.1J	1.6J	1.3J	0.5J				
30.642	31.181	31.034	31.293	31.315	31.271	31.193	31.196	31.275	31.303	31.042	31.179	30.635		
30.639	31.174	31.031	31.283	31.301	31.239	31.206	31.237	31.299	31.283	31.033	31.179	30.641		
J 0.5J	0.5J	0.3J	0.0J	1.1J	2.6J	-1.1J	-3.2J	-1.9J	1.3J	0.9J	-0.0J	-0.9J		
30.670	31.299	31.246	31.317	31.278	30.986	30.953	30.959	31.157	31.273	31.250	31.306	30.676		
30.664	31.287	31.234	31.299	31.271	31.007	30.981	31.008	31.271	31.301	31.233	31.289	30.667		
J 0.9J	0.9J	1.0J	1.4J	0.5J	-1.1J	-2.9J	-4.8J	-6.9J	-2.1J	1.3J	1.3J	1.4J		
30.326	31.131	31.184	31.041	31.298	31.016	31.203	31.041	31.212	30.957	31.209	31.021	31.182	31.170	30.354
30.343	31.126	31.166	31.007	31.237	31.008	31.243	31.073	31.243	31.007	31.239	31.006	31.168	31.131	30.347
J -5.0J	0.5J	1.5J	3.5J	5.0J	1.0J	-3.2J	-3.0J	-2.5J	-5.0J	-2.4J	1.5J	1.2J	3.5J	2.2J
30.372	30.830	31.224	30.962	31.305	31.019	31.037	30.910	31.051	30.950	31.191	30.918	31.166	30.824	30.383
30.371	30.830	31.175	30.916	31.206	30.981	31.073	30.938	31.073	30.981	31.206	30.918	31.175	30.630	30.391
J -5.0J	-0.0J	4.2J	4.7J	8.2J	3.9J	-3.4J	-2.9J	-2.1J	-3.1J	-1.2J	0.0J	-0.8J	-0.7J	-2.0J
30.329	31.144	31.218	31.049	31.266	31.029	31.199	31.050	31.227	31.012	31.248	31.043	31.174	31.101	30.324
30.347	31.131	31.168	31.006	31.239	31.007	31.243	31.073	31.243	31.008	31.237	31.007	31.166	31.126	30.343
J -5.0J	1.1J	4.3J	4.2J	2.1J	2.2J	-3.5J	-2.2J	-1.3J	0.4J	0.9J	3.6J	0.6J	-2.1J	-5.8J
30.694	31.342	31.243	31.268	31.233	30.975	30.979	31.014	31.280	31.332	31.306	31.322	30.661		
30.667	31.289	31.233	31.301	31.271	31.008	30.981	31.007	31.271	31.299	31.234	31.287	30.664		
J 4.1J	4.1J	0.8J	-2.5J	-3.0J	-3.3J	-0.2J	0.7J	0.7J	2.6J	5.8J	2.8J	-0.5J		
30.656	31.206	31.009	31.193	31.244	31.239	31.248	31.272	31.322	31.293	31.071	31.217	30.636		
30.641	31.179	31.033	31.283	31.299	31.237	31.206	31.239	31.301	31.283	31.031	31.174	30.639		
J 2.3J	2.3J	-2.3J	-7.0J	-4.3J	0.2J	3.5J	2.7J	1.7J	0.8J	3.9J	3.6J	-0.4J		
30.504	31.167	30.959	31.207	31.009	30.932	31.036	31.270	31.066	31.252	30.527				
30.501	31.190	31.031	31.234	31.007	30.918	31.006	31.233	31.033	31.190	30.500				
J 0.6J	-2.0J	-7.0J	-2.2J	0.3J	1.5J	2.9J	3.0J	3.2J	5.2J	5.3J				
30.497	31.151	31.276	31.171	31.181	31.187	31.358	31.243	30.528						
30.500	31.174	31.287	31.166	31.175	31.168	31.289	31.179	30.501						
J -0.7J	-2.0J	-0.8J	0.4J	0.5J	1.6J	5.4J	5.4J	5.3J						
30.626	30.639	31.071	30.815	31.117	30.680	30.676								
30.639	30.664	31.126	30.620	31.131	30.667	30.641								
J -2.0J	-3.8J	-4.8J	-1.9J	-1.2J	2.0J	5.4J								
30.318	30.370	30.342												
30.343	30.391	30.347												
J -7.5J	-5.4J	-1.4J												
										MEASURED F DELTA H				
										EXPECTED F DELTA H				
										DIFFERENCE				

ROD POSITION

Bank	Location In Steps	Classification	INCORE	TILTS
SBA	<u>228</u>	Map No. FM4 V2	0.9979	0.9930
SBB	<u>228</u>	Power (%) <u>30</u>		
CBA	<u>228</u>	Axial		
CBB	<u>228</u>	Offset - <u>2.47</u>	0.9934	1.0157
CBC	<u>228</u>	Max F ^N _{ΔH} <u>1.477</u>		
CBD	<u>146</u>	Max F ^N _Q <u>1.794</u>		

R P N M L K J H G F E D C B A

<u>Bank</u>	<u>Location In Steps</u>	<u>Classification</u>	<u>INCORE</u>	<u>TILTS</u>
SBA	<u>228</u>	Map No. FM4 V3	<u>0.9870</u>	<u>1.0055</u>
SBB	<u>228</u>	Power (%) <u>98</u>	<u>1.0050</u>	<u>1.0026</u>
CBA	<u>228</u>	Axial		
CBB	<u>228</u>	Offset - <u>1.35</u>		
CBC	<u>228</u>	Max $F_{\Delta H}^N$ <u>1.449.</u>		
CBD	<u>210</u>	Max F_O^N <u>1.621</u>		

Power Defect

Unit 4 Cycle V

Power defect was measured by taking the difference in boron concentrations between hot zero power, no xenon and hot full power equilibrium xenon conditions, and subtracting out unwanted changes in reactivity such as, xenon, burnup, and rod position.

This method of measuring power defect has many uncertainties because of the errors in boron concentrations.

Because of present operating limits during startup after refueling, it would be impractical to use the reactivity computer. At present, other methods of measuring power defect are being investigated.

The following is a summary of the results:

MEASURED BOL	WESTINGHOUSE	% DIFFERENCE
1591 pcm	1520 pcm	-4.46

