DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION

UNIT 1

CYCLE 11

STARTUP PHYSICS TEST REPORT

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BEAVER VALLEY POWER STATION

Cycle 11 Startup Test Report

INTRODUCTION:

Beaver Valley Unit 1 was shutdown on January 3, 1995, for its tenth refueling outage. During the outage, 52 of 157 fuel assemblies were replaced with a split batch of 24 fuel assemblies of 3.62 w/o enrichment and 28 assemblies of 4.01 w/o enrichment. The fresh fuel rods are based on the Westinghouse Vantage 5 Hybrid (V5H) design which is characterized by the use of zircaloy grids with natural uranium in the top and bottom six inches. Assemblies with integral fuel burnable absorbers (IFBA) have arrangements of 32, 64, 104 or 128 rods with boride-coated pellets in the central 120 inches. A region of unpoisoned fuel six inches in length is found between the natural uranium and the boride-coated fuel in these IFBA fuel assemblies. All fresh assemblies in Cycle 11 have rotated grids to reduce fuel assembly vibration. Additionally, 20 assemblies utilize Damper Rod Assembly (DRA) inserts. These inserts are intended to reduce fuel assembly vibration in V5H fuel manufactured without rotated grids. The Cycle 11 core also contains eight Peripheral Power Suppression Assembly inserts (PPSAs). These inserts contain Hafnium rodlets to reduce local neutron leakage to the reactor vessel.

This report describes the startup test program applicable for the Cycle 11 reload core design verification for BVPS, Unit 1. This testing program consisted of the following measurements conducted from March 2, 1995, through March 24, 1995:

1. Control rod drop time
2. Initial criticality
3. Boron endpoints
4. Temperature coefficient
5. Control bank worths
6. Reactimeter checks
7. 30% power symmetry check
8. Incore/Excore cross-calibration
9. Power distribution measurements at 72%, 89% and 100% reactor power.

The results of these startup tests are summarized in this report and comparisons are made to predicted design values and applicable BVPS technical specification requirements.

TEST SUMMARIES:

1BVT 1.1.1, "Control Rod Drop Time Measurements"

PURPOSE:

The purpose of this test was to determine a drop time for each full-length rod cluster control assembly (RCCA) with the reactor coolant system (RCS) in hot standby, Tavg ≥ 541°F, and full RCS flow.

TEST DESCRIPTION:

A single RCCA bank is withdrawn to the full-out position (231 steps). A recorder is connected to the analog rod position indication system primary coil of each control rod in the bank. Test leads are then connected to the reactor trip breaker contacts. The reactor trip breakers are opened and the drop traces for each rod in the bank are obtained on the recorder. Each of the 48 rod cluster assemblies are tested in this manner and the times are determined from the opening of the reactor trip breaker contacts to dashpot entry on the recorder traces. These times are then adjusted for the measured difference between the opening of the reactor trip breaker contacts and the decay of the stationary gripper voltage. This provides a rod drop time consistent with the technical specification requirement for timing between the start of stationary gripper voltage decay and entry into the dashpot.

RESULTS:

The test commenced at 1240 hours on March 2, 1995, and was completed at 0545 hours on March 3, 1995. The drop times of the 48 rods were well within the BVPS Unit 1 Technical Specification 3.1.3.4 requirement of ≤ 2.7 seconds to dashpot entry. Figure 1 shows the drop times for each rod. The slowest drop time was 1.35 seconds for rod B-6 while the fastest drop time was 1.18 seconds for rods G-9 and J-7.

1RST-2.1, "Initial Approach to Criticality After Refueling"

PURPOSE:

The purpose of this test was to: (1) achieve initial criticality; (2) determine the point at which nuclear heat occurs and establish the low power physics testing band (LPPTB); and (3) verify the proper calibration of the reactimeter.

TEST DESCRIPTION:

Initial conditions were established on March 5, 1995, at 1928 hours with shutdown banks fully withdrawn, control banks fully inserted, RCS boron concentration at 1259 ppm, RCS temperature at 546.1°F and RCS pressure at 2234 psig.

The control banks were withdrawn in normal sequence while pausing periodically to monitor inverse count rate ratio (ICRR). At 2206 hours, criticality was achieved with Control Bank D at 131 steps.

Following the recording of criticality data, flux was increased toward nuclear heat. Nuclear heat was observed at 4.8×10^{-7} amps as indicated on the reactimeter. This corresponds to approximately 1.0×10^{-6} amps and 6.0×10^{-7} amps on Intermediate Range Detectors N35 and N36, respectively.

A reactimeter operational checkout was then performed using the reactor with positive reactivity insertions of 17 pcm, 38 pcm and 52 pcm as indicated by the reactimeter. Calculated reactivity and theoretical reactivity were compared for the measured doubling time corresponding to each reactivity insertion.

1RST-2.1, "Initial Approach to Criticality After Refueling", was completed at 0920 hours on March 7, 1995.

RESULTS:

The all rods out (ARO) critical boron concentration corrected for rod position was calculated to be 1340 ppm which was within the acceptance criteria range of 1254 to 1354 ppm.

The LPPTB was set at 9.30×10^{-9} amps to 1.52×10^{-7} amps based on a nuclear heating point of 4.8×10^{-7} amps and a background current reading of 9.3×10^{-10} amps for Power Range Detector N44.

The measured errors for the reactimeter were -3.12%, -3.62% and -1.54%, which were within the acceptance criteria of ± 4%.

1RST-2.2, "Core Design Check Test"

PURPOSE:

The purpose of this test was to verify the reactor core design from hot zero power (HZP) to 100 percent reactor power, and to perform the initial incore/excore cross-calibration.

TEST DESCRIPTION:

The test was divided into five parts:

Section A covered low power physics testing. These tests are performed in the low power physics testing band at less than 5% reactor power. They include the following measurements:

- boron endpoints,
- isothermal temperature coefficient,
- differential boron worth,
- boron dilution worth of the reference bank, control bank B (CBB),
- and rod swap bank worths.

Section B involved performing a full-core flux map prior to exceeding 30% reactor power to verify core symmetry and proper core loading.

Section C required a full-core flux map to be obtained prior to exceeding 75% reactor power to ensure the measured peaking factors were within their applicable technical specification limits.

Section D required an incore/excore calibration between 45% and 90% of rated thermal power. This involved performing procedure 1RST-2.3, "Nuclear Power Range Calibration", in which a series of flux maps are performed at various axial offsets to provide data for nuclear power range calibration and adjustment.

Finally, Section E involved performing a full-core flux map at 100% reactor power. This map served as a calibration check for the incore/excore calibration and verified that the power distribution limits of the technical specifications were not exceeded.

RESULTS:

Boron Endpoint:

The all rods out (ARO) critical boron concentration was measured to be 1335.5 ppm, which was within the acceptance criteria of 1254 to 1354 ppm.

The reference control bank B-in (CBB-in) critical boron concentration difference was measured to be 141.7 ppm, which was within the acceptance criteria of 134.1 to 163.9 ppm.

RESULTS: (Continued)

Temperature Coefficient:

The average ARO, HZP isothermal temperature coefficient (ITC) was determined to be -6.42 pcm/°F which was within the acceptance criteria of -9.12 to -5.12 pcm/°F.

The difference between the measured ITC and the predicted design value of the doppler coefficient (-1.88 pcm/°F) equals the moderator temperature coefficient (MTC) which was calculated to be -4.54 pcm/°F. This value meets the requirements of BVPS Unit 1 Technical Specification 3.1.1.4 which requires the MTC to be between -50 pcm/°F and 0 pcm/°F.

Differential Boron Worth:

The measured differential boron worth was 7.93 pcm/ppm. This value was within the acceptance criteria of 6.78 to 9.18 pcm/ppm.

RCC Bank Worths:

The boron dilution method of control rod worth measurement was used to determine the worth of the reference bank for rod swap, CBB. The worths of the remaining control and shutdown banks were obtained relative to CBB. The measured worth, predicted worth, percent difference for each control rod bank and total worth of all control rod banks are listed in Table 1. Figures 2 and 3 provide a graphical representation of differential and integral rod worth, respectively, for CBB. The measured values were within the acceptance criteria for this test as listed in Table 1.

Reactimeter:

The reactimeter was checked prior to low power physics testing (LPPT) and at the conclusion of LPPT using an internal doubling time test. In addition, the reactimeter was checked using the reactor following initial criticality. The highest measured error was -3.62%, which was within the ± 4% acceptance criteria.

30 Percent Power Symmetry Check:

A full-core flux map was performed on March 10, 1995, at approximately 29% reactor power with Control Bank D at 167 steps withdrawn to determine the initial flux distribution in the core. Table 2 lists the values of incore quadrant tilt and maximum deviation from predicted assembly powers for this flux map.

RESULTS: (Continued)

72 Percent Power Flux Map and Incore/Excore Calibration:

On March 13 and 14, 1995, 1RST-2.3, "Nuclear Power Range Calibration", was performed at approximately 72% power. One full-core and seven quarter-core flux maps were obtained at various axial offsets to calibrate the excore detectors and verify core peaking factors. The results of the full-core flux map are shown in Table 2.

The measured values were within the acceptance criteria. The measured Fxy corrected for uncertainties was 1.7029 for the 72% flux map. Technical Specifications require this value be less than Fxy(RTP) (1.69) and Fxy(LIM) (1.7843 for 72% power). The measured Fxy was less than Fxy(LIM), however, it exceeded Fxy(RTP). This required an additional power distribution check to be done prior to exceeding 92% power per Technical Specification 4.2.2.2.d.1.

89 Percent Power Flux Map:

On March 16, 1995, a full-core flux map was performed at 89% reactor power. This map was performed to satisfy Technical Specification 4.2.2.2.d.1 surveillance requirements due to the measured Fxy exceeding Fxy(RTP) from analysis of the 72% power flux map.

The measured Fxy including uncertainties was 1.6553 which was below Fxy (RTP) by 2.05% and Fxy (LIM) by 4.12%.

The results of the full-core flux map are shown in Table 2.

100 Percent Power Flux Map:

On March 24, 1995, a full-core flux map was performed at 100% power. This map served as a check for the incore/excore calibration and power distribution limits. The results of the map are listed in Table 2. This map demonstrated that the incore/excore calibration performed at 72% power was satisfactory. Analysis of the power distribution limits showed that Fxy and F delta H were within their respective surveillance limits.

The 100% power flux map marked the completion of the startup physics test program for Beaver Valley Power Station, Unit 1, Cycle 11.

TABLE 1

CONTROL ROD BANK WORTHS

Bank	Measured Value (pcm)	Predicted Value (pcm)	Error	Acceptance Criteria
CBD	1049.39	1110	- 5.46%	± 15%
CBC	1049.43	972	7.97%	± 15%
CBB*	1123.75	1193	-5.80%	± 10%
CBA	275.95	338	-62.05 pcm	± 100 pcm
SBB	895.91	839	6.78%	± 15%
SBA	930.56	1088	-14.47%	± 15%
Total Worth	5325.00	5540	-3.88%	± 10%

* Reference Bank for Rod Swap

TABLE 2

FULL CORE FLUX MAPS

Parameters	MAP1101 29% Power	MAP1102 72% Power	MAP1110 89% Power	MAP1111 100% Power	Acceptance Criteria
Quadrant Tilt	1.0265*	1.0211	1.0177	1.0171	< 1.02 for 29% map or > 1.02 and ≤ 1.04, inform Westinghouse
Maximum Deviation from Predicted Assembly Powers	-10.1%*	-9.5%	-8.8%	-9.0%	± 10% for Predicted Relative Power > .9 or Westinghouse evaluation for continued power ascension.
F delta H	N/A	1.6180	1.5996	1.5864	Tech. Spec.: < 1.7555 for 72% < 1.6724 for 89% < 1.6215 for 100%
Fxy	N/A	1.7029	1.6553	1.6383	Tech. Spec.: < 1.7843 for 72% < 1.7264 for 89% < 1.6910 for 100% Fxy(RTP) = 1.69

* Westinghouse was informed and following review, concurrence was received to continue power ascension.

FIGURE 1

Unit 1 Cycle 11 HFF Rod Drops

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2						1.25 1.71		1.22 1.75		1.23 1.77					
3							1.21 1.71		1.21 1.71						
4				1.22 1.73		1.21 1.70				1.21 1.71		1.22 1.75			
5					1.20 1.72						1.21 1.74				
6		1.22 1.70		1.21 1.71		1.21 1.73		1.22 1.76		1.23 1.73		1.21 1.75		1.35 1.83	
7			1.19 1.66				1.18 1.71		1.19 1.66				1.21 1.75		
8		1.23 1.81				1.21 1.72				1.20 1.74				1.30 1.82	
9			1.20 1.70				1.19 1.70		1.18 1.66				1.20 1.66		
10		1.21 1.71		1.21 1.83		1.22 1.74		1.21 1.75		1.21 1.72		1.21 1.71		1.29 1.79	
11					1.22 1.74						1.22 1.74				
12				1.22 1.78		1.21 1.72				1.21 1.71		1.21 1.80			
13							1.21 1.73		1.20 1.70						
14						1.31 1.84		1.23 1.75		1.25 1.81					
15															

Average Drop Time = 1.22 sec.
Fastest Drop Time = 1.18 sec.
Slowest Drop Time = 1.35 sec.

X.XX	Breaker "Opening" to dashpot entry - sec.
X.XX	Breaker "Opening" to dashpot bottom - sec.

REFERENCE BANK DIFFERENTIAL ROD WORTH; CBB

PREDICTED AND MEASURED

UNIT 1 CYCLE 11

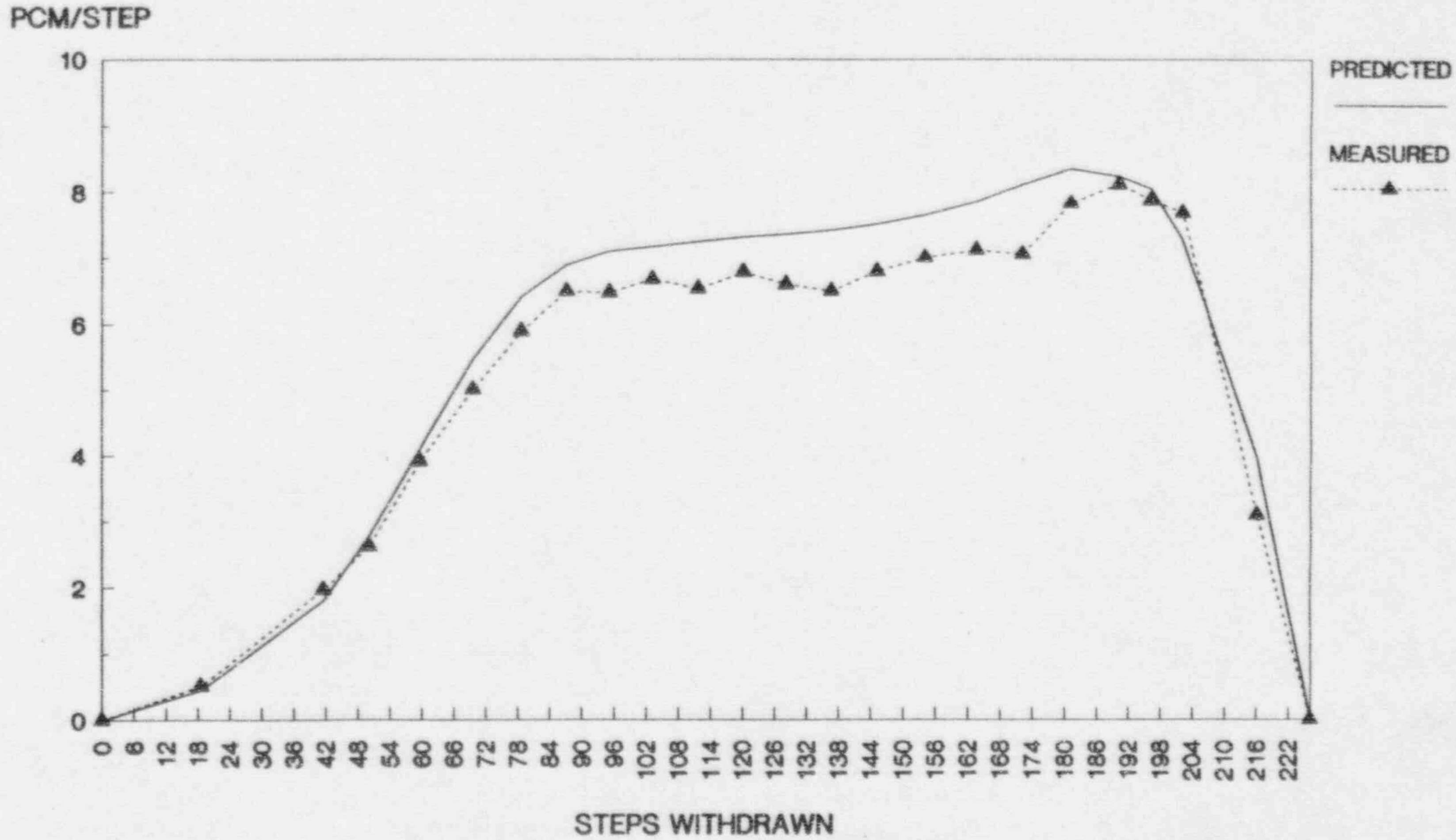
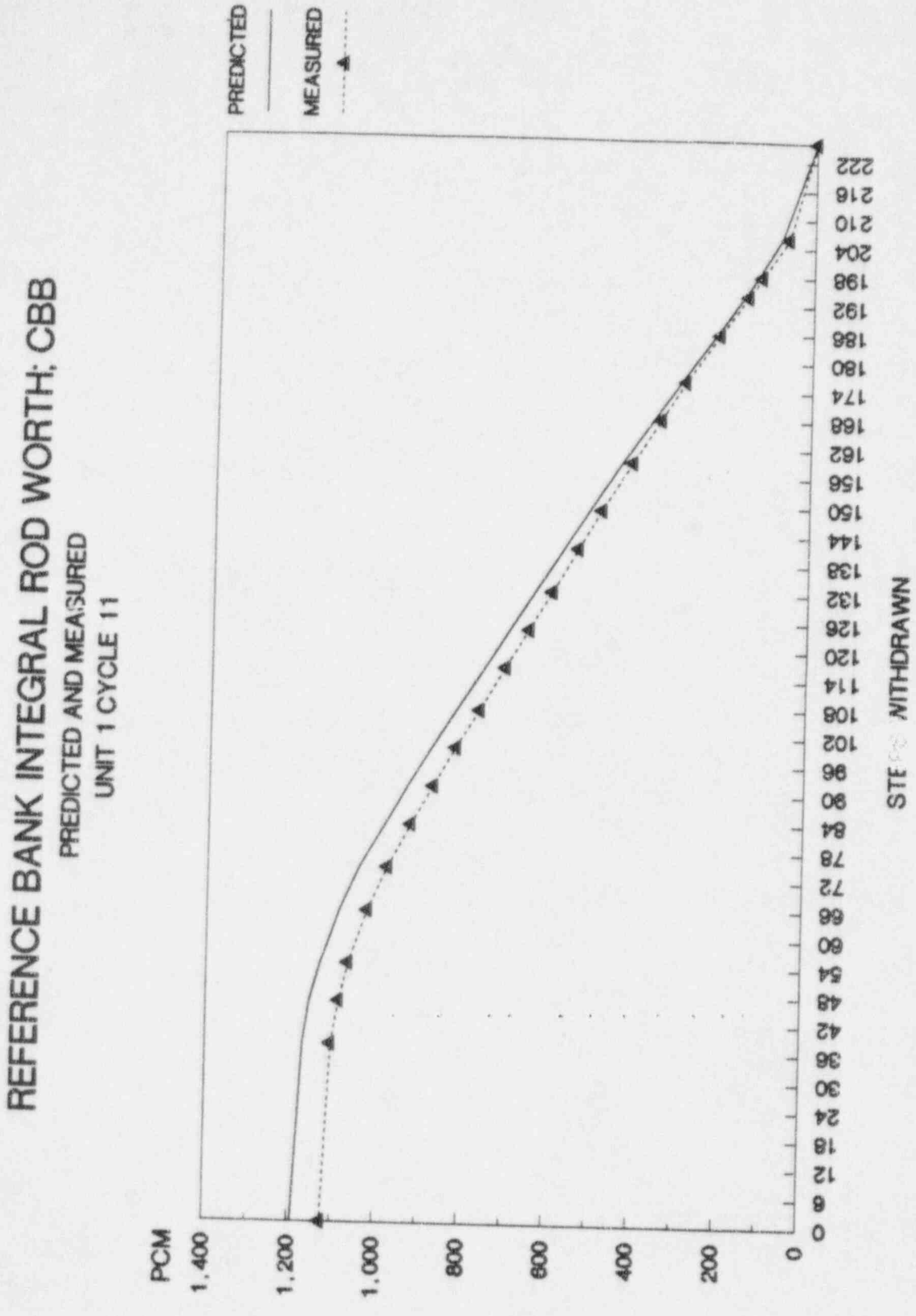


FIGURE 2

FIGURE 3


REFERENCE BANK INTEGRAL ROD WORTH; CBB
PREDICTED AND MEASURED
UNIT 1 CYCLE 11
PREDICTED
MEASURED
PCM
STEPS WITHDRAWN