DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION

UNIT 2

CYCLE 6

STARTUP PHYSICS TEST REPORT

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BEAVER VALLEY POWER STATION

Cycle 6 Startup Test Report

INTRODUCTION:

Beaver Valley Unit 2 was shutdown on March 24, 1995, for its fifth refueling outage. During the outage, 68 of 157 fuel assemblies were replaced with a split batch of 56 fuel assemblies of 3.60 weight percent (w/o) enrichment and 12 assemblies of 4.20 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 of each fuel rod. Many of the fuel pellets within the fuel rods of the fresh fuel assemblies have a coating of zirconium diboride (a neutron absorber). Rods with this coating are known as Integral Fuel Burnable Absorber (IFBA) rods and are used for power shaping and to reduce the initial critical boron concentration.

This report describes the startup test program applicable for the Cycle 6 reload core design verification for Beaver Valley, Unit 2. This testing program consisted of the following measurements conducted from May 7, 1995, through May 19, 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 46% and 99% reactor power.

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

TEST SUMMARIES:

2BVT 1.1.1, "Control Rod Drop Time Measurements"

PURPOSE:

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

TEST DESCRIPTION:

A single RCCA bank containing 8 RCCAs is withdrawn to the full-out position (231 steps). Computer-based rod drop test equipment is connected to the digital rod position indication system of each control rod in the bank. Test leads are connected between the computer and the reactor trip breaker contacts. The reactor trip breakers are opened and the drop timing data for each rod in the bank is obtained by the computer. 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 computer generated timing traces. During the test, the reactor trip breaker contact signal was found to occur before stationary gripper voltage decay. As a result, the drop time was conservatively taken to be measured between opening of the reactor trip breaker contact and entry of the control rod into the dashpot region.

RESULTS:

The test commenced at 0147 hours on May 7, 1995, and was completed at 0930 hours. The drop times of all 48 rods were within the BVPS Unit 2 Technical Specification 3.1.3.4 requirement of $\leq$ 2.7 seconds to dashpot entry. Figure 1 shows the drop times for each rod. The slowest drop time was 1.501 seconds for rod B-6 while the fastest drop time was 1.346 seconds for rod H-6.

2RST-2.1, "Initial Approach to Criticality After Refueling"

PURPOSE:

The purpose of this test is 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 for criticality were established on May 8, 1995, at 1423 hours with shutdown banks fully withdrawn, control banks fully inserted, reactor coolant system (RCS) boron concentration at 1470 ppm, RCS temperature at 547.8°F and RCS pressure at 2230 psig.

The control banks were withdrawn in normal sequence while pausing periodically to monitor inverse count rate ratio (ICRR). At 1633 hours, criticality was achieved with Control Bank D at 133 steps.

Following the recording of criticality data, flux was increased toward nuclear heat. Nuclear heat was observed at 3.22×10^{-7} amps as indicated on the reactimeter. This corresponds to approximately 1.0×10^{-6} amps and 1.0×10^{-6} 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, 27 pcm and 50 pcm as indicated by the reactimeter. Calculated reactivity and theoretical reactivity were compared for the measured doubling time corresponding to each reactivity insertion.

2RST-2.1, "Initial Approach to Criticality After Refueling", was completed at 2106 hours on May 8, 1995.

RESULTS:

The all rods out (ARO) critical boron concentration corrected for rod position was calculated to be 1522 ppm which was within the acceptance criteria range of 1450 to 1550 ppm.

The LPPTB was set at 5.12×10^{-9} amps to 1.02×10^{-7} amps based on a nuclear heating point of 3.22×10^{-7} amps and a background current reading of 5.12×10^{-10} amps for Power Range Detector N44.

The measured errors for the reactimeter were -0.18%, -1.09% and -3.95%, which were within the acceptance criteria of ± 4%.

2RST-2.2, "Core Design Check Test"

PURPOSE:

The purpose of this test is 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 is 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 2RST-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 1529.7 ppm, which was within the acceptance criteria of 1450 to 1550 ppm.

RESULTS: (Continued)

Boron Endpoint: (Continued)

The reference control bank B-in (CBB-in) critical boron concentration difference was measured to be 185.4 ppm, which was within the acceptance criteria of 154.8 to 189.2 ppm.

Temperature Coefficient:

The average ARO, HZP isothermal temperature coefficient (ITC) was determined to be -3.62 pcm/°F which was within the acceptance criteria of -2.66 to -6.66 pcm/°F.

The difference between the measured ITC (-3.62 pcm/°F) and the predicted design value of the doppler coefficient (-1.74 pcm/°F) equals the moderator temperature coefficient (MTC). The MTC was calculated to be -1.88 pcm/°F. This value meets the requirements of BVPS Unit 2 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 7.18 pcm/ppm. This value was within the acceptance criteria of 6.55 to 8.87 pcm/ppm.

RCC Bank Worths:

The boron dilution method of control rod worth measurement was used to determine the worth of control bank B (CBB). CBB was then used to determine the worths of the remaining control and shutdown banks relative to CBB using the rod swap methodology. 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 -3.95%, which was within the ± 4% acceptance criteria.

RESULTS: (Continued)

30 Percent Power Symmetry Check:

A full-core flux map was performed on May 12, 1995, at approximately 29% reactor power with Control Bank D at 178 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. The measured values were within the acceptance criteria.

46 Percent Power Flux Map and Incore/Excore Calibration:

On May 13, 1995, 2RST-2.3, "Nuclear Power Range Calibration", was performed at approximately 46% power. One full-core and six quarter-core flux maps were obtained at various axial offsets to obtain data for the calibration of the excore detectors and to verify core peaking factors. The results of the full-core flux map are shown in Table 2. The measured peaking factors were within the acceptance criteria.

100 Percent Power Flux Map:

On May 19, 1995, a full-core flux map was performed at 99% 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. The map showed that the incore/excore calibration performed at 46% power was acceptable. 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 2, Cycle 6.

TABLE 1

CONTROL ROD BANK WORTHS

Bank	Measured Value (pcm)	Predicted Value (pcm)	Error	Acceptance Criteria
CBD	902.40	992	- 9.03%	± 15%
CBC	746.32	815	- 8.43%	± 15%
CBB*	1330.91	1339	- 0.60%	± 10%
CBA	478.86	493	-14.14 pcm	± 100 pcm
SBB	809.77	869	- 6.82%	± 15%
SBA	1218.79	1282	- 4.93%	± 15%
Total Worth	5487.04	5790	- 5.23%	± 10%

* Reference Bank for Rod Swap

TABLE 2

FULL CORE FLUX MAPS

Parameters	FM20601 29% Power	FM20602 46% Power	FM20609 99% Power	Acceptance Criteria
Quadrant Tilt	1.0087	-	--	≤ 1.02 for 29% map
Maximum Deviation from Predicted Assembly Powers	5.8%	6.4%	4.3%	± 10% for Predicted Relative Power > .9
				Tech. Spec.:
F delta H	-	1.5829	1.5168	≤ 1.8835 for 46% ≤ 1.6273 for 99%
				Tech. Spec.:
Fxy	-	1.6897	1.6470	≤ 1.9398 for 46% ≤ 1.7553 for 99% Fxy(RTP) = 1.75

FIGURE 1

Unit 2 Cycle 6 HFF Rod Drops

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2						1.456 1.959		1.429 1.898		1.414 1.907					
3							1.372 1.820		1.406 1.906						
4				1.409 1.872		1.390 1.874				1.400 1.895		1.436 1.929			
5					1.377 1.851						1.406 1.866				
6		1.404 1.872		1.388 1.843		1.366 1.819		1.346 1.821		1.364 1.812		1.371 1.841		1.501 1.989	
7			1.352 1.864				1.357 1.807		1.351 1.792				1.395 1.845		
8		1.376 1.833				1.360 1.816				1.359 1.833				1.462 1.935	
9			1.393 1.868				1.362 1.803		1.361 1.829				1.375 1.846		
10		1.424 1.866		1.392 1.854		1.385 1.860		1.360 1.804		1.376 1.836		1.369 1.830		1.432 1.905	
11					1.368 1.834						1.409 1.865				
12				1.409 1.868		1.404 1.891				1.432 1.902		1.392 1.854			
13							1.358 1.823		1.377 1.884						
14						1.476 1.977		1.421 1.869		1.414 1.891					
15															

Average Drop Time = 1.395 sec.
Fastest Drop Time = 1.346 sec.
Slowest Drop Time = 1.501 sec.

X.XX	Breaker "Opening" to dashpot entry - sec. (Tech. Spec. requirement)
X.XX	Breaker "Opening" to dashpot bottom - sec.

REFERENCE BANK DIFFERENTIAL ROD WORTH; CBB

PREDICTED AND MEASURED
UNIT 2 CYCLE 6

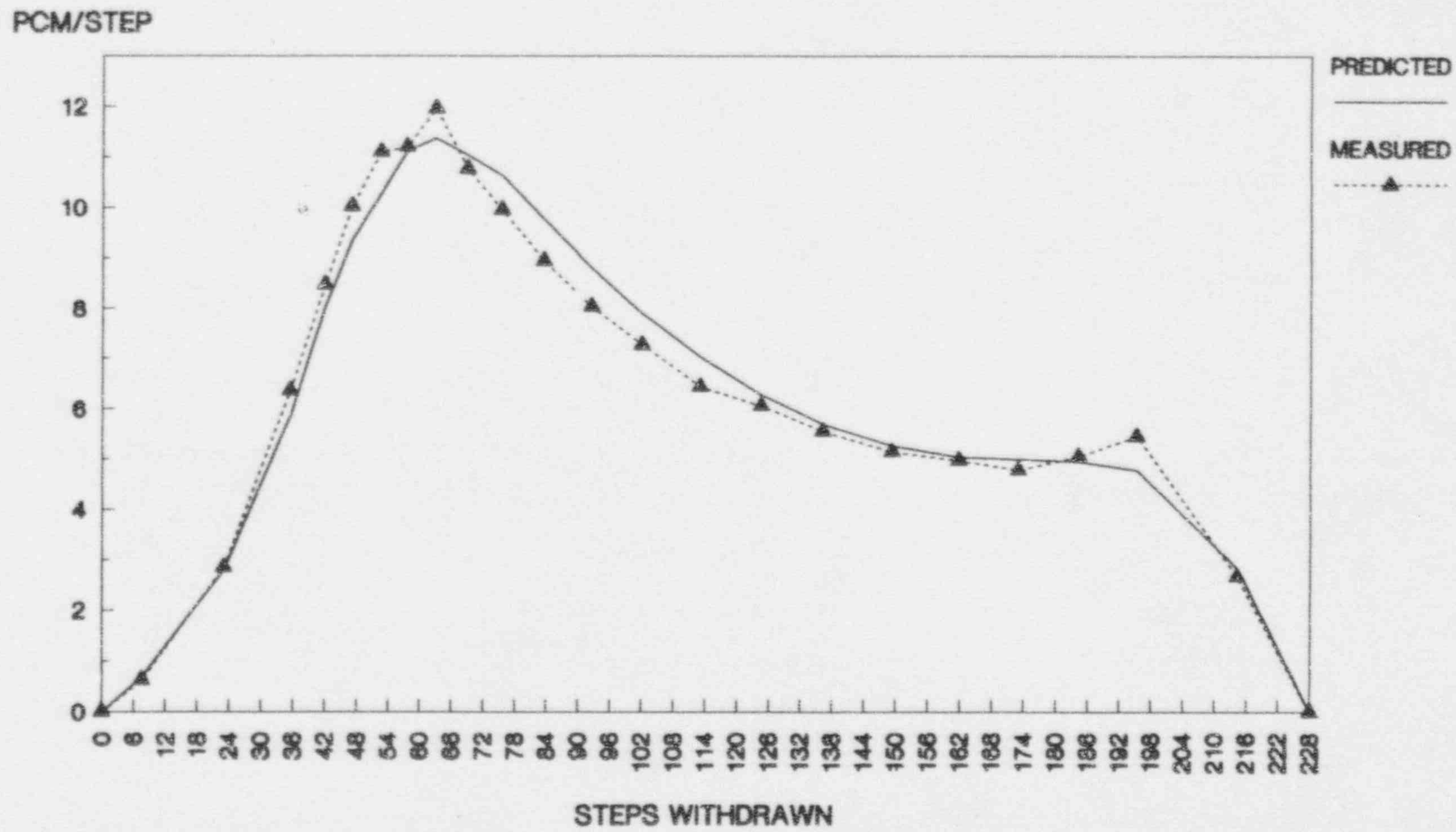

FIGURE 2

REFERENCE BANK INTEGRAL ROD WORTH; CBB

PREDICTED AND MEASURED

UNIT 2 CYCLE 6

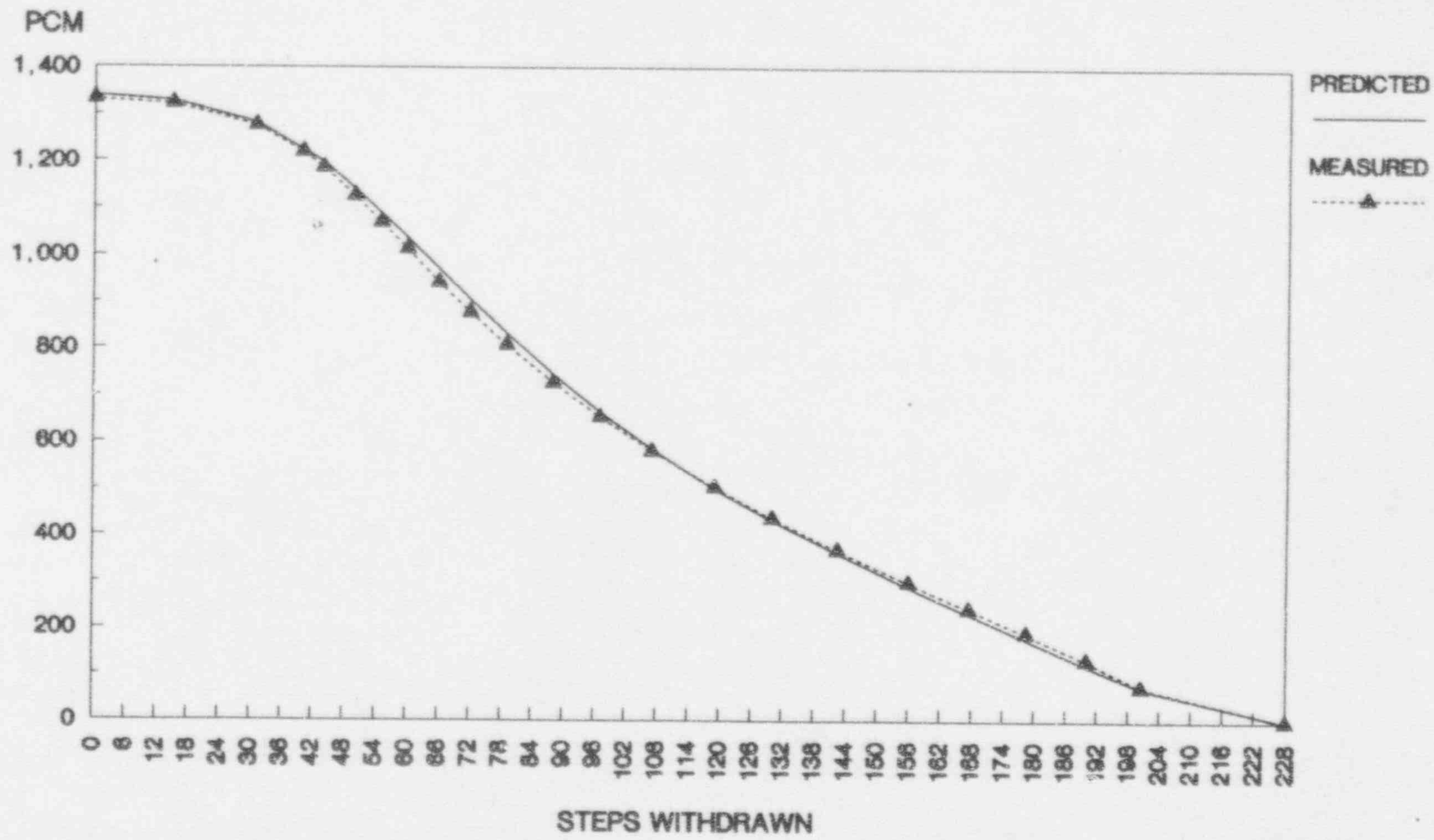

FIGURE 3