DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION

UNIT 1

CYCLE 7

STARTUP PHYSICS TEST REPORT

March, 1988

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BEAVER VALLEY POWER STATION

Cycle 7 Startup Test Report

INTRODUCTION:

Beaver Valley Unit 1 was shutdown on December 11, 1987 for its Sixth Refueling Outage. During the outage, 72 of 157 fuel assemblies were replaced with a split batch: 48 fuel assemblies of 3.60 w/o enrichment and 24 fuel assemblies of 3.95 w/o enrichment. The fresh fuel rods are based on the standard design with natural uranium in the top and bottom six inches. Assemblies with Integral Fuel Burnable Absorbers (IFBA) have arrangements of 64, 80, or 160 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.

This report describes the startup test program applicable for the Cycle 7 reload core design verification for BVPS, Unit 1. This testing program consisted of the following measurements conducted from February 25, 1988 through March 21, 1988:

1. Control rod drop time
2. Initial criticality
3. Boron endpoints
4. Control bank worths
5. Temperature coefficient
6. Reactivity computer checks
7. 30% power symmetry check
8. Incore/Excore cross-calibration
9. Power distribution measurements at 75%, 90%, 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:

BVT 1.1 - 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 Assembly with the RCS in Hot Standby, Tavg ≥ 541°F, and full RCS flow.

TEST DESCRIPTION:

A single RCCA Bank is withdrawn to the full-out position (228 steps). A visicorder is connected to the detector primary coil and test leads are then inserted at the stationary gripper coil jacks in the power cabinets. The RCCA blown fuse indicator and moving coil fuse are removed. After the visicorder is turned ON, an assembly is dropped by pulling the stationary gripper fuse out. Each of the 48 rod cluster assemblies is tested in this manner and the drop times are determined from the visicorder traces.

RESULTS:

The test was started at 1825 on February 25, 1988 and completed at 0258 on February 26, 1988. The drop times of all 48 rods were well within the BVPS Technical Specification Requirement of < 2.2 seconds, with slowest time being 1.32 seconds for rod B-6 at hot full RCS flow.

BVT 1.7 - 2.2.1, "Initial Approach to Criticality"

PURPOSE:

The purpose of this test was to: (1) achieve initial criticality; (2) determine the point at which nuclear heat occurs and establish the Zero Power Physics Testing Band (ZPPTB); (3) verify the proper calibration of the reactivity computer.

TEST DESCRIPTION:

Initial conditions were established with shutdown banks fully withdrawn, control banks fully inserted, boron concentration 1906 ppm, RCS temperature at 547°F and RCS pressure at 2235 psig on February 28, 1988 at 1614.

The control banks were withdrawn in 50 step intervals until Control Bank D reached 160 steps. An Inverse Count Rate Ratio (ICRR) was taken at each interval. During control rod withdrawal, the ICRR dropped from 1.0 to approximately 0.40.

Dilution to criticality commenced at 1730 at a rate of approximately 1000 pcm/hr. Again, the ICRR was monitored and plotted at 20 minute intervals. At 2127 on February 28, 1988 after 13,419 gallons had been added criticality was achieved.

Following the recording of criticality data, flux was increased toward nuclear heat. Nuclear heat occurred at 6.6×10^{-7} amps as indicated on the reactivity computer.

A reactivity computer operational checkout was then performed using the reactor with positive reactivity insertions of 27 pcm, 38 pcm, and 56 pcm. The doubling times were measured and predicted reactivity compared to measured for each insertion. BVT 1.7 - 2.2.1 was completed at 0622 on February 29, 1988.

RESULTS:

The All Rods Out (ARO) critical boron concentration corrected for rod position was calculated to be 1513 ppm which was outside the acceptance criteria of 1454 ± 50 ppm. Westinghouse was contacted and reviewed the Cycle 7 Reload Safety Analysis Checklist (RSAC) parameters. Based on this review, it was determined that a 59 ppm deviation from the design value would not significantly affect the RSAC analysis since this is within the analyzed boron concentrations, approximately ± 100 ppm. A field revision to the test was written referencing the Westinghouse analysis and approved by the station to change the acceptance criteria to 1454 ± 75 ppm.

The ZPPTB was set at 8.6×10^{-9} amps to 3×10^{-8} amps based on a measured nuclear heating point of 6.6×10^{-7} amps and background current reading of 8.6×10^{-10} amps on the power range detectors.

All the test runs for the reactivity computer were within the acceptance criteria of 4%. The errors for the three test cases were 1.1%, 1.8%, and 1.2%.

BVT 1.7 - 2.2.2, "Core Design Check Test"

PURPOSE:

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

TEST DESCRIPTION:

The test was divided into five parts:

Section A covered zero power physics tests. These tests included boron endpoint measurements, boron dilution worth measurement of the reference bank (CBB), rod swap bank worths, differential boron worth, and an isothermal temperature coefficient measurement.

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

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 50% and 100% of rated thermal power. This involved performing BVT 1.3 - 2.2.3, "Nuclear Power Range Calibration", in which a series of flux maps are run at various axial offsets.

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 1510.8 ppm at 0906 on February 29, 1988, which was outside the acceptance criteria of 1454 ± 50 ppm. Based on the results of BVT 1.7 - 2.2.1, "Initial Approach to Criticality", the ARO critical boron concentration was expected to be outside the ± 50 ppm limit. Westinghouse was contacted during BVT 1.7 - 2.2.1 and reviewed the Cycle 7 RSAC. Based on the Westinghouse reanalysis, a field revision to the test was incorporated to change the acceptance criteria to 1454 ± 75 ppm.

The Control Bank B-in critical boron concentration was measured to be 1345.5 ppm at 1826 on February 29, 1988, which was within the acceptance criteria of 1295 ppm ± 15%.

Temperature Coefficient:

The ARO, HZP Isothermal Temperature Coefficient (ITC) was measured at 1219 on February 29, 1988. The average ITC was determined to be -2.75 pcm/°F which was within the acceptance criteria of -3.54 ± 3 pcm/°F.

Subtracting out the predicted design value of the doppler coefficient (-1.95 pcm/°F) from the measured ITC, the MTC was calculated to be -0.80 pcm/°F. This value meets the requirements of BVPS Technical Specifications which require the MTC to be between -50 pcm/°F and 0 pcm/°F.

Differential Boron Worth:

The measured differential boron worth was 7.73 pcm/ppm. This value was within the acceptance criteria of 8.65 pcm/ppm ± 15%.

RCC Bank Worths:

The boron dilution measurement of the reference bank for rod swap, CBB, was completed at 1758 on February 29, 1988. Following the insertion of CBB, the worths of the remaining control and shutdown banks were obtained relative to CBB on February 29, 1988 between 1850 and 2147. The measured worth, predicted value, and percent difference for each RCC bank and total RCC worth are listed in Table 1. All the measured values were within the acceptance criteria for this test.

Reactivity Computer:

The reactivity computer was checked prior to Low Power Physics Testing (LPPT), every 24 hours during testing, and at the conclusion of LPPT using the exponential generator. In addition, the reactivity computer was checked using the reactor following initial criticality. In all cases, the computer error was within the 4% acceptance criteria, with the highest measured error being 1.8%.

30 Percent Power Symmetry Check:

A full-core flux map was performed on March 4, 1988 at approximately 30% reactor power with CBD at 168 steps to determine the initial flux distribution in the core. Table 2 lists the values for quadrant tilt and maximum deviation from predicted assembly powers for the 30% flux map. All measured values were within the acceptance criteria for the test.

75 Percent Power Flux Map and Incore/Excore Calibration:

On March 6, 1988 BVT 1.3 - 2.2.3, "Nuclear Power Range Calibration", was performed at approximately 75% power. This test involved a full-core and seven quarter-core flux maps 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. All measured values are within the applicable acceptance criteria except Fxy (RTP). The measured Fxy corrected for uncertainties was 1.6632 for the 75% flux map. The Technical Specifications require that this value be less than Fxy (RTP) (1.62) and Fxy (LIM) (1.7017 for 75% power).

The corrected Fxy was less than the power dependent Fxy (LIM) by 2.3%, but exceeded the Fxy (RTP) by 2.7%. Per Technical Specification Requirement 4.2.2.2.d.1, Fxy must be remeasured within 24 hours after exceeding by 20% the power level at which Fxy exceeded Fxy (RTP) or within 31 EFPD, whichever occurs first. Thus, following the 75% flux map, it was decided to perform a flux map at 90% power to remeasure Fxy prior to exceeding 95% reactor power.

90 Percent Power Flux Map:

A full-core flux map was obtained on March 9, 1988 at 90% reactor power. The results of this map are shown in Table 2. Again, all measured values were within the acceptance criteria except Fxy (RTP). The measured Fxy with uncertainties was 1.6277 which was less than Fxy (LIM) by 1.5%, but exceeded Fxy (RTP) by .5%. Although the 90% flux map showed that Fxy was above Fxy (RTP), the plant could proceed to 100% power where the final flux map for the startup testing program was scheduled.

100 Percent Power Flux Map:

On March 21, 1988 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 measured Fxy with uncertainties was 1.5990 which was below Fxy (RTP) by 1.3% and Fxy (LIM) by 1.5%. The results of the map are shown in Table 2.

The 100% flux map marked the completion of the reload startup test program for Beaver Valley Power Station, Unit 1, Cycle 7.

TABLE 1

CONTROL ROD BANK WORTHS

Bank	Measured Value (pcm)	Predicted Value (pcm)	Error (%)	Acceptance Criteria
CBB*	1278.5	1376	-7.1	± 10%
CBD	1001.1	1044	-4.1	± 15%
CBC	742.1	798	-7.0	± 15%
CBA	646.0	660	-2.1	± 15%
SBB	823.4	913	-9.8	± 15%
SBA	1102.3	1185	-7.0	± 15%
Total Worth	5593.4	5976	-6.4	± 10%

* Reference Bank for Rod Swap.

TABLE 2

FULL CORE FLUX MAPS

Parameters	30% Power CBD 168 steps	75% Power CBD 190 steps	90% Power CBD 197 steps	100% Power CBD 223 steps	Acceptance Criteria
Quadrant Tilt	1.0063	1.0064	1.0065	1.0041	≤ 1.02 for power above 50%
Maximum Deviation from Predicted Assembly Powers	5.2%	2.8%	3.5%	3.5%	± 10% for Predicted Power > .9
F delta H	N/A	1.5055	1.4627	1.4510	Tech. Spec.: < 1.6673 for 75% < 1.5978 for 90% < 1.5552 for 100%
Fxy	N/A	1.6632	1.6277	1.5990	Tech. Spec.: < 1.7017 for 75% < 1.6533 for 90% < 1.6236 for 100% Fxy(RTP)=1.62

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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Reference: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Cycle 7 Startup Test Report

Gentlemen:

Attached is a copy of the Cycle 7 Startup Test Report. This report summarizes the results of the startup test program performed during the reload core design verification and is provided in accordance with Technical Specification 6.9.1.3. The test results indicate the measured parameters were within the specified acceptance criteria limits or were otherwise evaluated as being acceptable within the range of analyzed limits. The measured F_{xy} for the 75% and 90% RTP flux maps exceeded the technical specification limit [F_{xy}(RTP) = 1.62], however, when measured in accordance with surveillance requirement 4.2.2.2 at 100% RTP the measured F_{xy} was within the limits.

Therefore, the reload core design has been verified and found acceptable for operation during Cycle 7.

Very truly yours,

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