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Kewaunee Nuclear Power Plant
Operated by Nuclear Management Company, LLC

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Cycle 27 Startup Report

In accordance with our practice of reporting the results of physics tests, enclosed is the Kewaunee Nuclear Power Plant Cycle 27 Startup Report.

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Enclosure (1)

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ENCLOSURE 1
CYCLE 27 STARTUP REPORT

INTRODUCTION

This report presents the results of the physics tests performed during startup of the Kewaunee Nuclear Power Plant (KNPP) Cycle 27. The core design and reload safety evaluation were performed by Westinghouse using approved methods. The results of the physics tests were compared to analytical results to confirm calculated safety margins. No corrective actions were required.

FUEL ASSEMBLIES

The KNPP reactor core consists of 121 fuel assemblies of 14 x 14 design:

- Forty-four (44) new Westinghouse 422V+ fuel assemblies containing UO_2 rods. Thirty-six (36) are enriched to 4.6 weight percent U^{235}, and eight (8) are enriched to 4.92 weight percent U^{235}.
- Forty-four (44) partially depleted Westinghouse 422V+ fuel assemblies.
- One (1) Westinghouse 422V+ fuel assembly containing UO_2 rods enriched to 3.3 weight percent U^{235}.
- Thirty-two (32) partially depleted FRA-ANP heavy fuel assemblies.

RCCA BANK MEASUREMENTS

During Cycle 27 startup the worth of all control rods were measured using the reactivity computer using the Westinghouse Dynamic Rod Worth methodology. The table below provides a summary of the RCCA Worth data:

RCCA Bank	Measured Worth (PCM)	Predicted Worth (PCM)	Difference (PCM)	Percent Difference
A	855.8	857.3	-1.5	-0.2
B	582.1	574.9	7.2	1.3
C	770.9	729.7	41.2	5.6
D	762.8	733.0	29.8	4.1
SA	577.9	566.9	11.0	1.9
SB	590.1	563.1	27.0	4.8
TOTAL	**4139.6**	**4024.9**	**114.7**	**2.8**

SHUTDOWN MARGIN EVALUATION

Prior to power escalation a shutdown margin evaluation was made to verify the existence of core shutdown capability. The minimum shutdown margins at beginning of cycle (BOC) and at end of cycle (EOC) are presented in the Table below:

RCCA Bank Worths (PCM)	BOC	EOC
N	4672	6620
N-1 (Worst Stuck Rod)	3960	5430
Less 10.0 Percent	400	540
Sub Total	3560	4890
Total Requirements (Including Uncertainties)	1950	3270
Shutdown Margin	**1610**	**1620**
Required Shutdown Margin	**1542**	**1542**

A 10.0 percent uncertainty in the calculation of total rod worth is accounted for in the shutdown margin analyses. Since the measured total rod worth result is within the acceptable range compared to the predicted value, the analysis is conservative and no additional evaluations are required.

BORON ENDPOINTS AND BORON WORTH MEASUREMENTS

1. Boron Endpoints

Criticality was achieved by dilution with Bank D near All Rods Out (ARO). Boron concentration was allowed to stabilize. The critical boron concentration for the ARO core configuration was then determined by boron endpoint measurement. The results indicated a measured to predicted difference of 21 PPM for the ARO core condition. The acceptance criterion on the ARO boron endpoint is ±100 PPM; thus, the boron endpoint comparison is considered acceptable. The table below summarizes the RCCA Bank Endpoint measurements:

RCCA Bank Configuration	Measured Endpoint (PPM)	Predicted Endpoint (PPM)	Difference (PPM)
All Rods Out	2225	2204	21

2. Differential Boron Worth

The differential boron worth was not calculated for Cycle 27. The reference bank was not measured by dilution. Dynamic Rod Worth Measurements is being used to determine rod worths. There is no requirement or acceptance criterion for determination of the Differential Boron Worth. The boron endpoint measurement described above is adequate to determine if the differential boron worth assumption in the model is accurate.

ISOTHERMAL TEMPERATURE COEFFICIENT

The measurement of the isothermal temperature coefficient was accomplished by monitoring reactivity while cooling down and heating up the reactor by manual control of the steam dump valves. The temperature change, reactivity change, and the temperature coefficient were obtained from the reactivity computer temperature coefficient analysis results.

Core conditions at the time of the measurement were Bank D slightly inserted, all other RCCA banks full out. These conditions approximate the Hot Zero Power (HZP), ARO core condition, which yields the most conservative (least negative) isothermal temperature coefficient measurement. The review criterion of ± 3 PCM/°F was met. The Isothermal Temperature Coefficient (ITC) data is presented below:

Cooldown

T_{ave}	545.3 °F
Bank D	190 Steps
Boron	2214 ppm

Measured ITC (PCM/°F)	Predicted ITC (PCM/°F)	Difference (PCM/°F)
-2.03	-2.69	0.66

Heat Up

T_{ave}	546.7 °F
Bank D	190 Steps
Boron	2214 ppm

Measured ITC (PCM/°F)	Predicted ITC (PCM/°F)	Difference (PCM/°F)
-2.58	-2.69	0.11

POWER DISTRIBUTION

1. Summary of Power Distribution Criteria

Power distribution predictions are verified through data recorded using the incore detector system and processed through the *INCORE* computer code. The computer code calculates Hot Channel Factors Under Equilibrium Conditions (F_Q^{EQ}) and Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$), which are limited by technical specifications. These parameters are defined as the acceptance criteria on a flux map.

The review criterion for measurement is that the percent differences of the normalized reaction rate integrals of symmetric thimbles do not exceed 10 percent at low power physics test conditions and 6 percent at equilibrium conditions.

The review criterion for the prediction is that the standard deviation of the percent differences between measured and predicted reaction rate integrals does not exceed 5 percent.

The review criteria for the INCORE calculated quadrant powers are that the quadrant tilt is less than 4 percent at low power physics test conditions and less than 2 percent at equilibrium conditions.

A summary of the review criteria is presented in Table 1.

2. Power Distribution Measurements

Comparisons of measured to predicted power distributions for the flux maps are exhibited in the Tables below.

- Table 2 contains the startup and flux map chronology.
- Table 3 identifies flux map peak $F_{\Delta H}^N$ and minimum margin F_Q^{EQ} for Westinghouse 422V+ fuel.

These tables address acceptance criteria by verifying that technical specification limits are not exceeded. The Cycle 27 startup flux maps met all acceptance criteria.

Table 1

Verification of Review Criteria

Flux Map	(a) Maximum Percent Difference	(b) Standard Deviation	(c) Percent Max. Quadrant Tilt
2701	2.9	2.29	1.28
2702	3.6	2.09	1.41
2703	3.4	2.76	1.73
2704	3.5	2.29	1.58
2705	2.8	2.35	1.44

(a) Maximum Percent Difference between symmetric thimbles for measured reaction rate integrals. From *INCORE* edit C-DRR, maximum positive value. Review criterion is 10 percent at low power. Review criterion is 6 percent at equilibrium power.

(b) Standard Deviation of the percent difference between measured and predicted reaction rate integrals. From *INCORE* edit C-DRR at the bottom. Review criterion is 5 percent.

(c) Percent Maximum Quadrant Tilt from normalized calculated quadrant powers. From *INCORE* edit E-SUM, maximum positive value. Review criteria are 4 percent at low power and 2 percent at equilibrium power.

Table 2

Flux Map Chronology and Reactor Characteristics

Map	Date	Percent Power	Xenon	Boron PPM	D Rods Steps	Exposure MDW/MTU
2701	12/05/04	28.9	EQ	1927	154	15
2702	12/07/04	48.4	EQ	1729	163	40
2703	12/11/04	89.4	EQ	1669	209	147
2704	12/15/04	100.0	EQ	1506	226	262
2705	12/16/04	99.9	EQ	1485	226	349

Table 3

Verification of Acceptance Criteria for Westinghouse 422V+ Fuel

Flux Map	Core Location	FDHN	Limit
2701	I-11 (DE)	1.61	2.06
2702	I-11 (DE)	1.60	1.96
2703	L-7 (JD)	1.59	1.75
2704	L-7 (JD)	1.59	1.70
2705	L-7 (JD)	1.59	1.70

Flux Map	Core Location	FQEQ	Limit
2701	G-12 (DE), 26	2.33	4.56
2702	L-7 (JD), 26	2.29	4.56
2703	L-7 (XX), 23	2.07	2.52
2704	L-7 (XX), 36	2.11	2.30
2705	L-7 (XX), 37	2.10	2.30