ENCLOSURE

PALO VERDE NUCLEAR GENERATING STATION

UNIT 1 CYCLE 5 STARTUP REPORT

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Introduction

The Palo Verde Unit 1 Cycle 5 Core is designed for a burnup of 437 Effective Full Power Days (EFPD). The core loading is detailed in the following table (Core Map on page 8).

Assembly Designation	Number of Assemblies	Fuel Rods per Assembly	Nominal Enrichment	Shims per Assembly	Batch Average Exposure Gwd/T
G3	48	168 52	3.75 3.30	16	0
G2	24	168 52	4.03 3.30	16	0
G1	12	180 52	4.03 3.75	4	0
G0	8	184 52	4.03 3.75	0	0
F5	32	172 52	4.03 3.50	12	21.785
F4	16	168 52	4.03 3.50	16	21.332
F3	8	176 52	3.80 3.50	8	20.907
F2	4	172 52	3.80 3.50	12	22.172
F1	24	180 52	3.80 3.50	4	18.647
F0	4	184 52	4.03 3.80	0	12.997
E6	8	168 52	4.03 3.70	16	32.539
E4	16	168 52	3.90 3.60	16	37.105
E2	4	168 52	3.90 3.60	16	30.506
E1	8	168 52	4.03 3.90	16	35.106
E0	24	184 52	4.03 3.90	0	27.557
B1	1	208 12	2.78 1.92	16	18.462

The Cycle 5 core makes use of a low-leakage fuel management scheme, in which previously burned assemblies are placed on the core periphery. The majority of the fresh Batch G fuel is located throughout the interior of the core where they are mixed with previously burned fuel to minimize power peaking.

Initial criticality for Cycle 5 was declared at 04:04 on November 24, 1993. Low Power Physics Testing began at 05:00 on November 24, 1993 and ended at 00:57 on November 25,1993. Power Ascension Testing began at 23:35 on November 27, 1993 and concluded at 12:00 on December 5, 1993.

The testing evolution is controlled by two procedures 72PY-9RX01 "Low Power Physics Testing" and 72PA-9ZZ07 "Reload Power Ascension Test."

The tests performed under the control of 72PY-9RX01 are:

All Rods Out (ARO), Hot Zero Power (HZP), Critical Boron Concentration

Isothermal Temperature Coefficient Measurement

Rod Swap Testing

Inverse Boron Worth Measurement.

The tests performed under the control of 72PA-9ZZ07 are:

Radial Power Distribution - 20% Rated Thermal Power (RTP)

Radial Power Distribution - 70% RTP

Axial Power Distribution - 70% RTP

Radial Power Distribution - 100% RTP

Axial Power Distribution - 100% RTP

Hot Full Power, ARO, Critical Boron Concentration.

Test Criteria

The following acceptance criteria apply to each of the tests performed during Low Power Physics Testing and Power Ascension:

Critical Boron Concentration (HZP)	± 100 ppm of predicted
Isothermal Temperature Coefficient Measurement	± 3 pcm/°F of predicted
CEA Testing	
Reference Group	± 10% of predicted
Test Group(s)	± 15% or ± 100 pcm of predicted
Total Worth	± 10% of predicted
Inverse Boron Worth	± 15%
Radial Power Distribution - 20%	± 10% of predicted
Radial Power Distribution - 70%	± 0.1 RPD units
	< 0.05 RMS
Peaking Factors - 70%	± 10% of predicted
Radial Power Distribution - 100%	± 0.1 RPD units
	< 0.05 RMS
Peaking Factors - 100%	± 10% of predicted
Critical Boron Concentration (HFP)	± 50 ppm

Low Power Physics Testing

All Rods Out (ARO) Critical Boron Concentration (CBC)

This test is performed by obtaining an RCS Boron Sample at equilibrium conditions near ARO (CEA Group 5 ~130" W/D) and adjusting this concentration for the reactivity worth of withdrawing Group 5 to ARO. The measured RCS concentration was 1557ppm which was adjusted to 1558 ppm. The Design HZP ARO CBC is 1556 ppm. This value was within the acceptance criteria.

Isothermal Temperature Coefficient (ITC)

This test is performed by raising and lowering the RCS Temperature and measuring the associated changes with Core Reactivity. The measured ITC with Group 5 at approximately 139" W/D was -1.28 pcm/°F. The prediction forDesign ITC was -1.32 pcm/°F and was corrected to test

conditions. The corrected Design ITC was -1.37 pcm/°F. The measured ITC met the acceptance criteria and satisfied the surveillance requirement of Technical Specification 4.1.1.3

Rod Worth Measurements

The Rod Swap Measurement method was utilized to test the worth of ALL Shutdown and Regulating CEA Groups. The basic technique associated with Rod Swap is measuring one Group through the Boration/ Dilution method (Reference Group) and then swapping it with each of the remaining Groups (Test Groups). The results are summarized in the following table:

Test Group(s)	Measured Position	Adjusted Position	Measured Worth	Design Worth	Percent Difference
Grp 5, SD A(20)	94.00	99.56	-610.8	-578.2	-5.33
Grp 2, 4	109.50	109.37	-667.7	-647.6	-3.01
SD B(9)	109.50	110.24	-670.4	-645.0	-3.79
SD A(16), SD B(19)	114.75	114.60	-692.6	-657.4	-5.09
Grp 1	116.25	116.33	-700.8	-666.7	-4.88
SD B(10)	108.25	108.22	-659.1	-647.5	-1.76
SD A(3)	95.50	95.36	-584.7	-575.5	-1.58
SD B(6)	126.77	126.52	-744.1	-720.2	-3.20
SD A(21)	96.47	95.81	-587.5	-576.0	-1.96
SD B(7)	126.02	125.38	-741.6	-720.8	-2.82
Reference Group (Grp 3)			-782.5	-778.0	-0.58
Total Worth			-7441.8	-7212.9	-3.08

All test results met the acceptance criteria.

Inverse Boron Worth

The Inverse Boron Worth (IBW) is determined by obtaining the measured worth of the CEA Reference Group (Group 3) from Rod Swap Testing and the change in Boron Concentration to get the Reference Group Diluted to the Lower Electrical Limit. The measured IBW was 125.23 ppm/%ΔK/K. The design IBW was 123.3 ppm/%ΔK/K. The acceptance criteria was met.

Power Ascension Testing

Flux Symmetry Verification - 20% RTP

This test is performed by obtaining a flux map from the Fixed Incore Detector System and processing this information with CECOR. The output from CECOR yields a full core map of Relative Power Density. The maximum deviation obtained was 8.626% and the minimum deviation was -5.455%. The acceptance criteria for this test was met.

Core Power Distribution Verification - 70% RTP

This test is performed by obtaining a flux map from the Fixed Incore Detector System and processing this information with CECOR. The output from CECOR yields a full core map of Relative Power Density. The maximum deviation obtained was 0.0587. The Root Mean Square (RMS) deviation was -0.0159. All acceptance criteria for the Radial Power Distribution were met.

The second portion of testing at 70% includes the verification of the Axial Power Distribution. This involves a comparison of the Axial Shape through 51 nodes with predicted, and a RMS evaluation. Both of these measurements were found to exceed the acceptance criteria. The Axial Deviation was -0.1055 ($\pm$ 0.1) and the RMS was 0.0628 ($\pm$0.05). After discussions with ABB/CE it was determined that the Predictions provided did not model the End of Cycle (EOC) 4 adequately. At EOC-4 there was an extensive coastdown performed involving both power reductions and temperature reductions. The model used to predict Cycle 5 values did not include this coastdown.

ABB/CE delivered new predictions for 70% RTP and 98% RTP which properly modelled EOC-4. The data collected at 70% RTP was re-evaluated. The maximum deviation on the Axial Power Distribution was -0.0769 and the RMS was 0.0233. All acceptance criteria for this measurement were met.

Peaking factor comparisons (percent difference from predictions) were as follows: F_{xy} -0.359%, F_r 0.208%, F_z 0.110%, and F_q -1.596%. All parameters met the acceptance criteria.

Core Power Distribution Verification - 100% RTP

This test is performed by obtaining a flux map from the Fixed Incore Detector System and processing this information with CECOR. The output from CECOR yields a full core map of Relative Power Density. The maximum deviation obtained was 0.0697 and the minimum deviation was 0.0149. All acceptance criteria for this measurement were met.

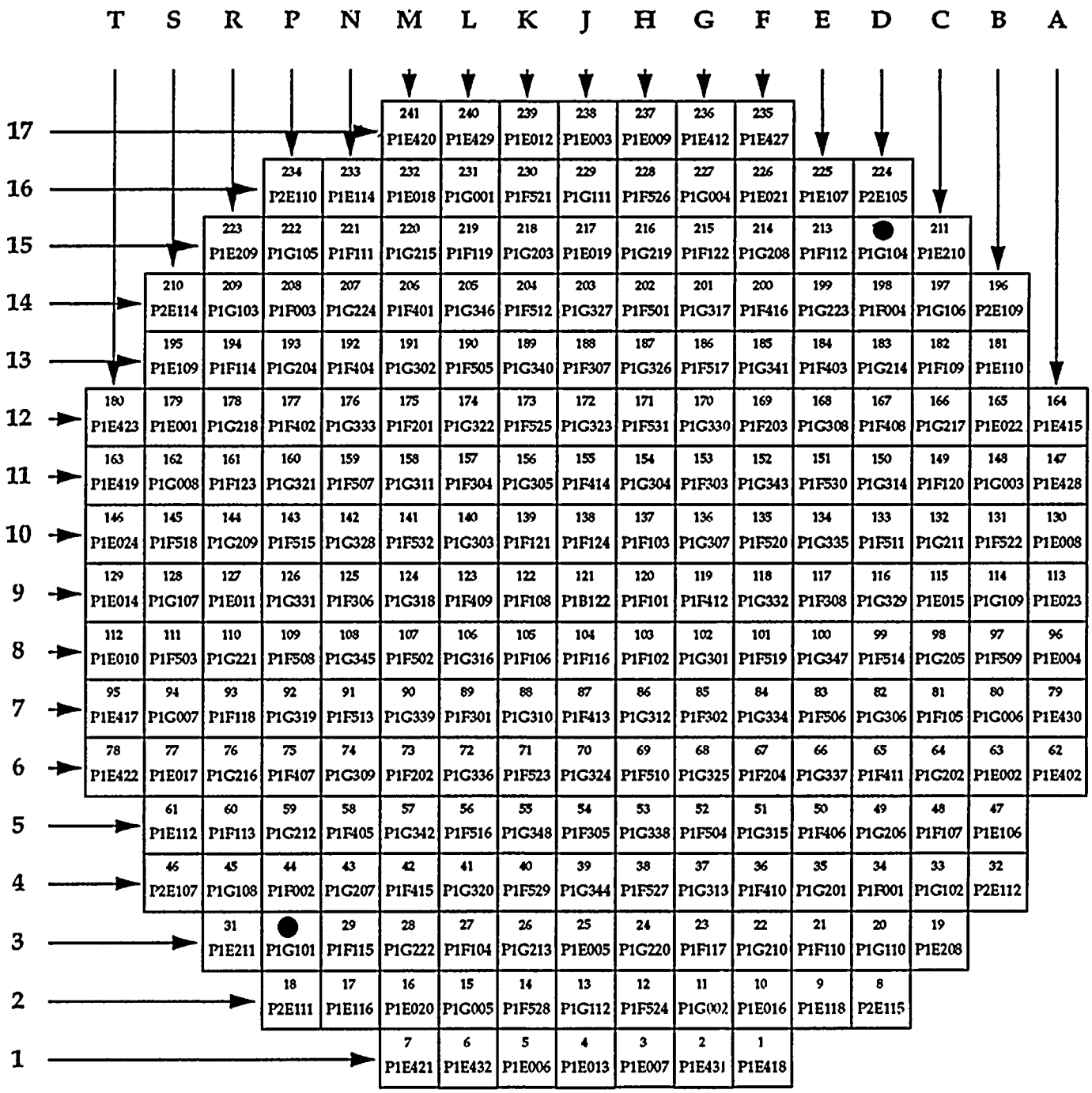
The second portion of testing at 98% RTP includes the verification of the Axial Power Distribution. This involves a comparison of the Axial Shape through 51 nodes with predicted, and a Root Mean Square evaluation. The Axial Deviation was -0.0901 (± 0.1) and the RMS was 0.0315 (±0.05). All acceptance criteria for this measurement were met.

Peaking factor comparisons (percent difference from predictions) were as follows: F_{xy} -1.147%, F_r -0.072%, F_z 1.746%, and F_q -1.231%. All parameters met the acceptance criteria.

Critical Boron Concentration - 100% RTP

This test is performed at ARO HFP equilibrium conditions. A RCS Sample is taken and corrected to the nominal conditions which the prediction was calculated. The measured RCS concentration was 1019 ppm which was adjusted to 1013 ppm. The Design HZP ARO CBC was 1052 ppm. The measured value was within the acceptance criteria.

Cycle 5 Core Load Map



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