



Florida Power & Light Company, 6501 South Ocean Drive, Jensen Beach, FL 34957

March 13, 2002

L-2002-049
10 CFR 50.36

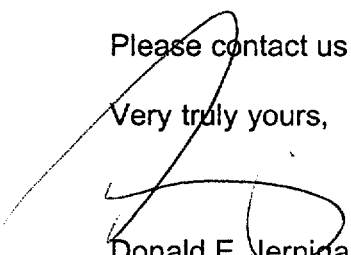
U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Re: St. Lucie Unit 2
Docket No. 50-389
Cycle 13 Startup Physics Testing Report

Pursuant to St. Lucie Unit 2 Technical Specification 6.9.1.1, the enclosed summary report of plant startup and power escalation testing for Cycle 13 is hereby submitted.

Please contact us should you have any questions.

Very truly yours,



Donald E. Vernigan
Vice President
St. Lucie Plant

DEJ/spt

Enclosure: St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

ST. LUCIE UNIT 2

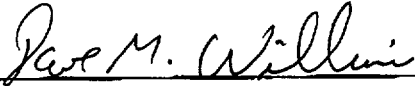
CYCLE 13

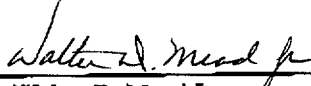


STARTUP PHYSICS

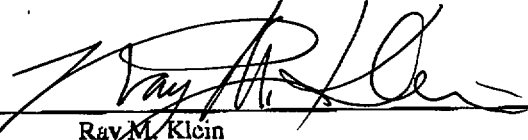
TESTING REPORT

ST. LUCIE UNIT 2, CYCLE 13 REACTOR STARTUP PHYSICS TESTING REPORT

Author  Date 2/20/02
Dave M. Williams
Reactor Engineering, St. Lucie Plant

Reviewed  Date 2/20/02
Walter D. Mead Jr.
Reactor Engineering, St. Lucie Plant

Reviewed  Date 2/20/02
Carl O'Farrill
Nuclear Fuel, ENG

Approved  Date 2/20/02
Ray M. Klein
Acting Reactor Engineering Supervisor, St. Lucie Plant

**St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report**

Table of Contents

<u>Section</u>	<u>Title</u>	<u>Page</u>
I	Introduction	4
II	Cycle 13 Fuel Design	5
III	CEA Drop Time Testing	6
IV	Approach to Criticality	7
V	Zero Power Physics Testing	8
VI	Power Ascension Program	9
VII	Summary	10
VIII	References	11

List of Figures

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Cycle 13 Core Loading Pattern	12
2	Inverse Count Ratio Plot- Channel B	13
3	Inverse Count Ratio Plot- Channel D	13
4	Power Distribution Comparison with Design - 30% Power	14
5	Power Distribution Comparison with Design - 45% Power	15
6	Power Distribution Comparison with Design - 98% Power	16

**St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report**

Table of Contents (cont)

List of Tables

Table	Title	Page
1	Cycle 13 Reload Sub-Batch ID	17
2	Approach to Criticality	18
3	CEA Group Worth Summary	19

St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

I. Introduction

The purpose of this report is to provide a description of the fuel design and core load, and to summarize the startup testing performed at St. Lucie Unit 2 following the Cycle 13 refueling. The startup testing verifies that key core and plant parameters are as predicted. The major parts of this testing program include:

- 1) Initial criticality following refueling,
- 2) Zero power physics testing, and
- 3) Power ascension testing.

The test data satisfied all acceptance criteria and demonstrated general conformance to predicted performance.

St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

II. Cycle 13 Fuel Design

The Cycle 13 reload consists entirely of fuel manufactured by Westinghouse Electric Company (WEC), previously ABB-Combustion Engineering. The Cycle 13 core consists of 68 fresh Region R fuel assemblies, 76 once burned Region P assemblies, 64 twice burned Region N assemblies, 8 twice burned Region K assemblies, and 1 thrice burned Region K assembly. The Region K assemblies are reinserted from the spent fuel pool. The fuel in the Cycle 13 core is arranged in a low leakage pattern similar to the design of the Cycle 12 core. Table 1 provides enrichment information for the Cycle 13 reload sub-batches.

The mechanical design of Region R fuel is essentially the same as that of Region P fuel, and consists of "value-added" fuel pellets and "guardian grid" design, first introduced in Cycle 11. Region R fuel includes some changes necessitated primarily by the transition of the fabrication of fuel rod assemblies from Hematite to the Columbia, S.C. manufacturing facility. The fuel rod design changes include elimination of alumina spacer disc located between the bottom of the fuel stack and the pedestal portion of the lower end cap, changes to the lengths of the end caps, and modifications to the plenum spring. These changes result in a slight increase in the net rod internal void volume, and lowering the active fuel stack by approximately 0.355 inches.

Region R assemblies consist of non-gadolinia enriched UO_2 fuel rods and $\text{UO}_2\text{-Gd}_2\text{O}_3$ gadolinia burnable absorber fuel rods. UO_2 fuel rods have a central zone enrichment of 4.1 and 4.45 w/o U-235, whereas the $\text{UO}_2\text{-Gd}_2\text{O}_3$ rods have a central zone of 4 and 8 w/o Gd_2O_3 dispersed in a 2.2 and 2.6 w/o U-235 carrier. The total Region R burnable absorber requirement for fresh fuel is 656 $\text{UO}_2\text{-Gd}_2\text{O}_3$ rods.

Cycle 13 reload (PC/M 00075) is based on the Reload Process Improvement (RPI) approach, first introduced in Cycle 12. This approach uses a checklist format to assess cycle-specific core designs for compliance with the existing safety analysis. Technical Specifications changes and the safety analyses supporting the implementation of RPI have been previously approved by the NRC in License Amendment #105.

The Cycle 13 core map is represented in Figure 1. The assembly serial numbers and control element assembly (CEA) serial numbers are given for each core location.

St. Lucie Unit 2, Cycle 13

Startup Physics Testing Report

III. CEA Drop Time Testing

Following the core reload and prior to the approach to criticality, CEA drop time testing was performed. The objective of this test is to measure the time of insertion from the fully withdrawn position (upper electrical limit) to the 90% inserted position under hot, full flow conditions. The average CEA drop time was found to be 2.73 seconds with maximum and minimum times of 2.90 seconds and 2.21 seconds, respectively (Reference 7). All drop times were within the 3.1 second requirement of Technical Specification 3.1.3.4 and the reload PC/M 00075 requirements (Reference 6).

St. Lucie Unit 2, Cycle 13

Startup Physics Testing Report

IV. Approach to Criticality

The approach to criticality involved diluting from a non-critical boron concentration of 1785 ppm to a predicted critical boron concentration of 1574 ppm. Inverse Count Rate Ratio (ICRR) plots were maintained during the dilution process using wide range channels B and D. Refer to Figures 2 and 3 for ICRR information. Table 2 summarizes the dilution rates and times, as well as beginning and ending boron concentrations.

Initial criticality for St. Lucie Unit 2, Cycle 13, was achieved on December 21, 2001 at 00:21 with CEA group 5 at 120 inches withdrawn and all other CEAs at the all-rods-out (ARO) position. The actual critical concentration was measured to be 1573 ppm (Reference 1).

St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

V. Zero Power Physics Testing

To ensure that the operating characteristics of the Cycle 13 core were consistent with the design predictions, the following tests were performed:

- 1) Reactivity Computer Checkout;
- 2) All Rods Out Critical Boron Concentration;
- 3) Isothermal Temperature Coefficient Measurement; and
- 4) CEA Group Rod Worth Measurements.

Proper operation of the reactivity computer is ensured by performing the "Reactivity Computer Checkout." This part of the testing determines the appropriate testing range and checks that reactivity changes are being correctly calculated by the reactivity computer's internal algorithms. The testing range is selected such that the signal to noise ratio is maximized and that testing is performed below the point of adding nuclear heat. The reactivity calculation is checked by performing a positive and negative reactor period test through respective introduction of a known amount of positive and negative reactivity. The results of the reactivity computer checkout were compared to the appropriate predictions supplied in the reload PC/M 00075 (Reference 6). Satisfactory agreement was obtained.

The measurement of the all-rods-out (ARO) critical boron concentration was performed. The measured value was 1577 ppm which compared favorably with the design value of 1577 ppm (Reference 2). This was within the acceptance limits of ± 100 PPM.

The measurement of the isothermal temperature coefficient was performed and the resulting moderator temperature coefficient (MTC) was derived. The MTC was determined to be +0.709 pcm/°F which fell well within the acceptance criteria of ± 2.0 pcm/°F of the design MTC of +0.102 pcm/°F (corrected). This satisfies Unit 2 Technical Specification 3.1.1.4a which states that the MTC shall be less positive than 5.0 pcm/°F when reactor power is less than or equal to 70% rated thermal power.

Rod worth measurements were performed using the rod swap methodology. This method involves exchanging a reference group, which is measured by the boration dilution technique, with each of the remaining test groups. A comparison of the measured and design CEA reactivity worths is provided in Table 3. The following acceptance criteria apply to the measurements made:

- 1) The measured value of each test group, or supergroup measured, is within $\pm 15\%$ or ± 100 pcm of its corresponding design CEA worths, whichever is greater and,
- 2) The measured worth of the reference group and the total worth for all the CEA groups measured is within $\pm 10\%$ of the total design worth.

All acceptance criteria were met.

St. Lucie Unit 2, Cycle 13

Startup Physics Testing Report

VI. Power Ascension Program

During power ascension, the fixed incore detector system is utilized to verify that the core is loaded properly and there are no abnormalities occurring in various core parameters (core peaking factors, linear heat rate, and tilt) for power plateaus at 30%, 45%, and greater than 98% rated thermal power. A shape annealing factor (Reference 5) test was performed in conjunction with the power ascension (Reference 3). This test was required due to the replacement of the "A" Linear Range nuclear instrument channel detector.

A summary of the flux maps at the 30%, 45% and 98% power levels is provided in Figures 4, 5 and 6. These flux maps are used for comparing the measured power distribution with the predicted power distribution. For the purposes of power ascension, the acceptance criteria require the root mean square (RMS) value of the power deviation to be less than or equal to 5%. The individual assembly powers should be within 10% of the predicted power for assembly powers greater than or equal to 0.9 (30% and 98% plateaus). In addition, for the 30% plateau the relative power density (RPD) should be within 0.1 RPD units of predicted for assembly powers less than or equal to 0.9. These criteria were satisfied.

Additionally, calorimetric, nuclear, and delta T power calibrations were performed at each power plateau prior to advancing reactor power to the next higher level specified by procedure.

**St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report**

VII. Summary

Compliance with the applicable Unit 2 Technical Specifications was satisfactory and all acceptance criteria were met.

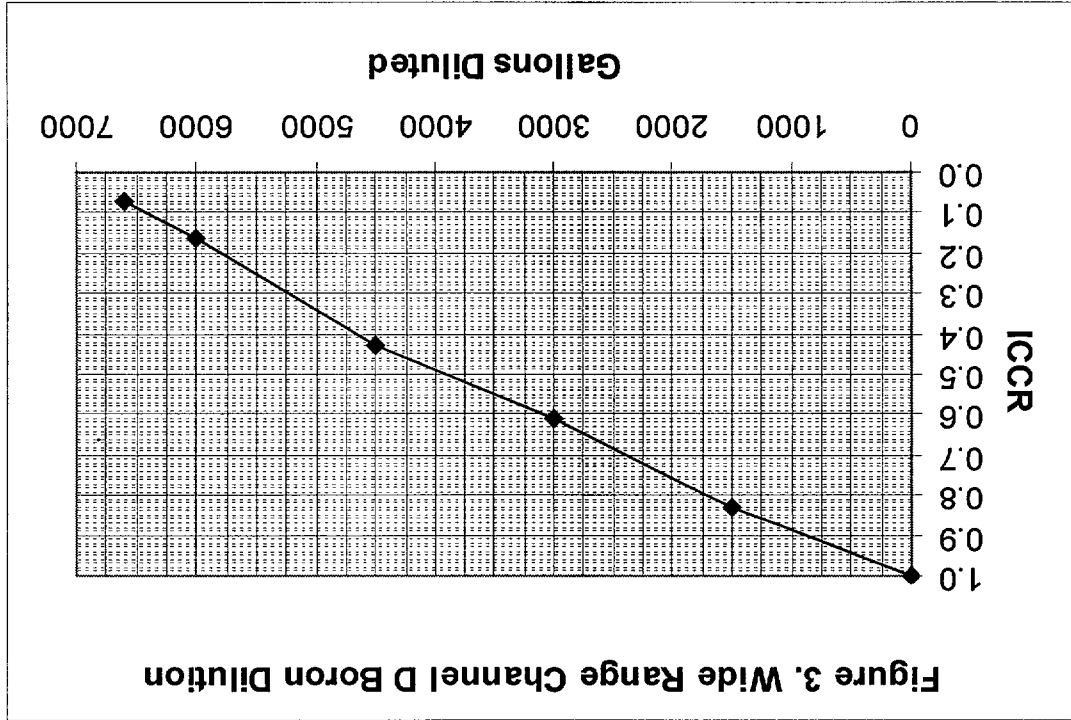
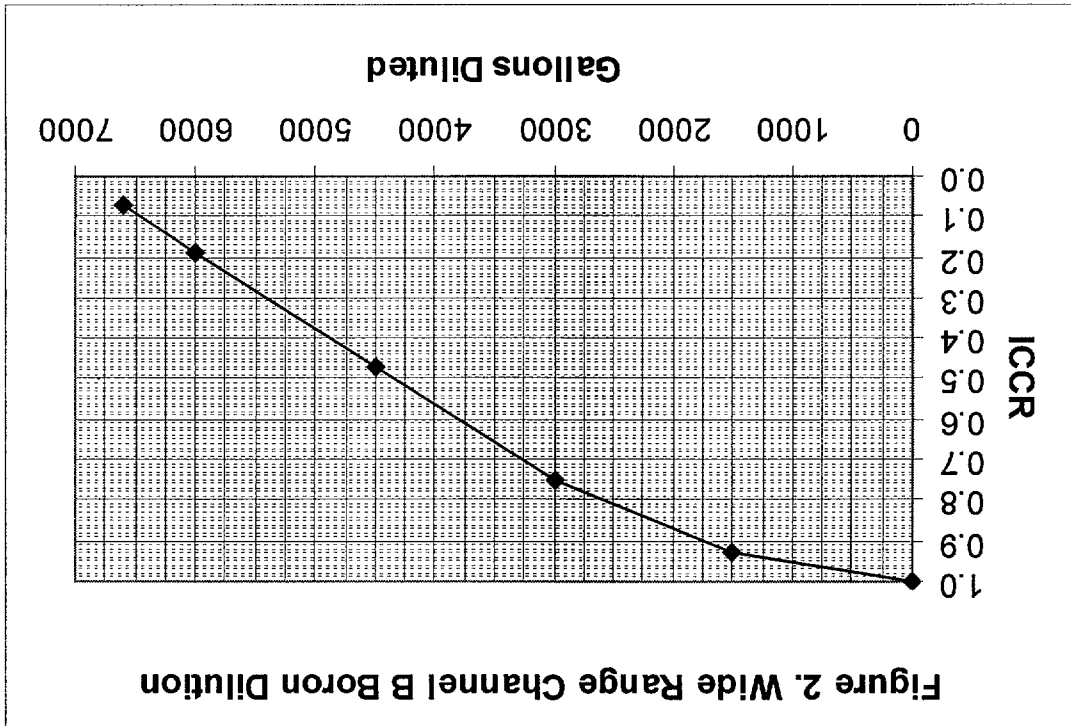
St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report

VIII. References

- 1) *"Initial Criticality,"* Pre-Operational Procedure 2-3200088, Rev. 22.
- 2) *"Reload Startup Physics Testing,"* Pre-Operational Procedure 3200091, Rev. 22
- 3) *"Reactor Engineering Power Ascension Program,"* Pre-Operational Procedure 3200092, Rev. 28.
- 4) St. Lucie Unit 2 Technical Specifications, Amendment 123.
- 5) *"Shape Annealing Factor Test,"* Pre-Operational Test Procedure 3200093, Rev. 10A.
- 6) St. Lucie Unit 2 Cycle 13 Reload PC/M #00075, Rev 1.
- 7) *"Periodic Rod Drop Time and CEA Position Functional Test,"* Operating Procedure 2-0110054, Rev. 19B.

FIGURE 1
CYCLE 13 CORE LOADING PATTERN





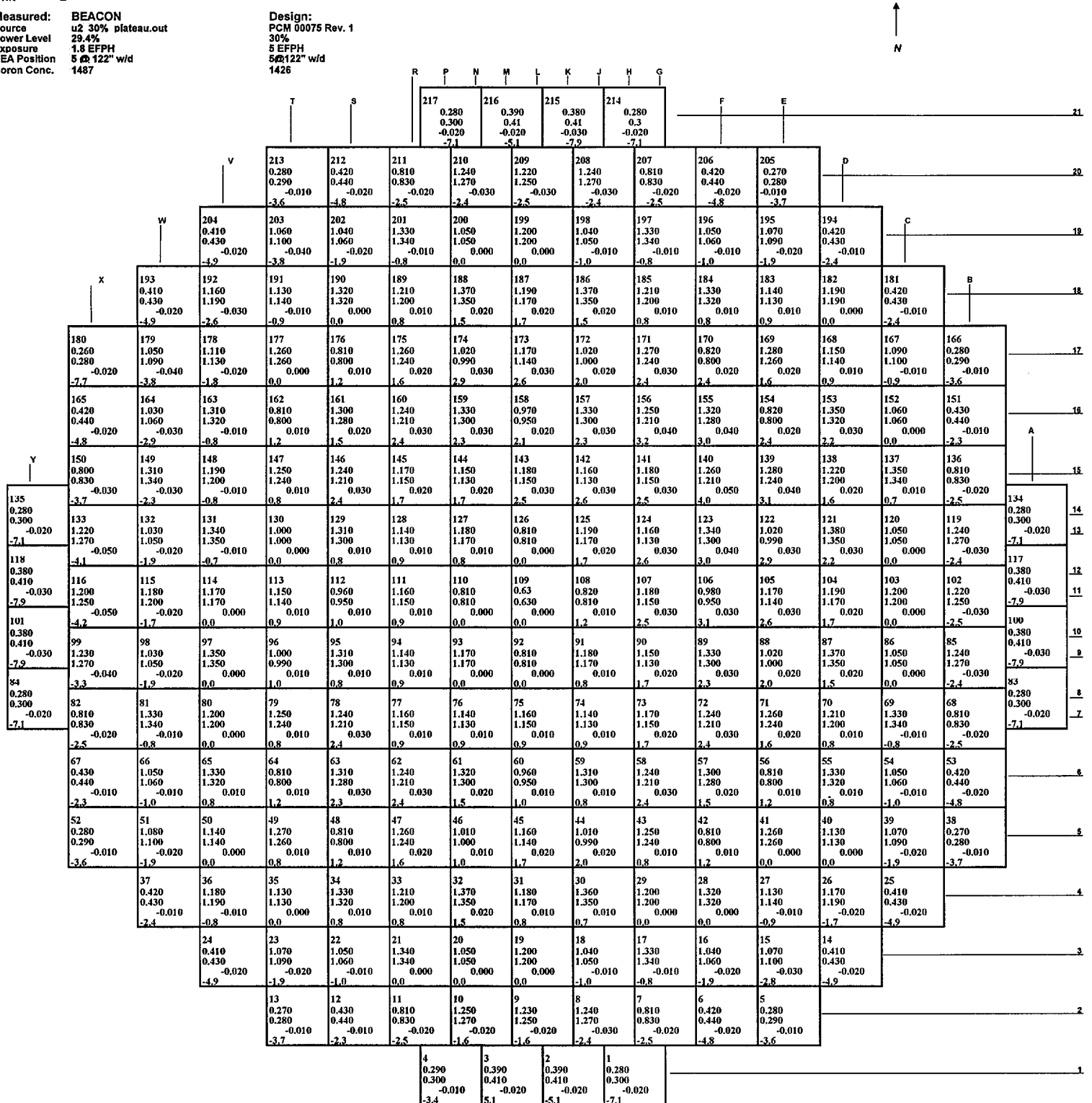
St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

Figure 4
Power Distribution Comparison With Design - 30% Power

Unit 2

Measured: BEACON
Source u2 30% plateau out
Power Level 29.4%
Exposure 1.8 EFPH
CEA Position 5 @ 122" w/d
Boron Conc. 1487

Design: PCM 00075 Rev. 1
30%
5 EFPH
5 @ 122" w/d
1426



Key:

Box #
Measured
Design
Delta
% Diff.

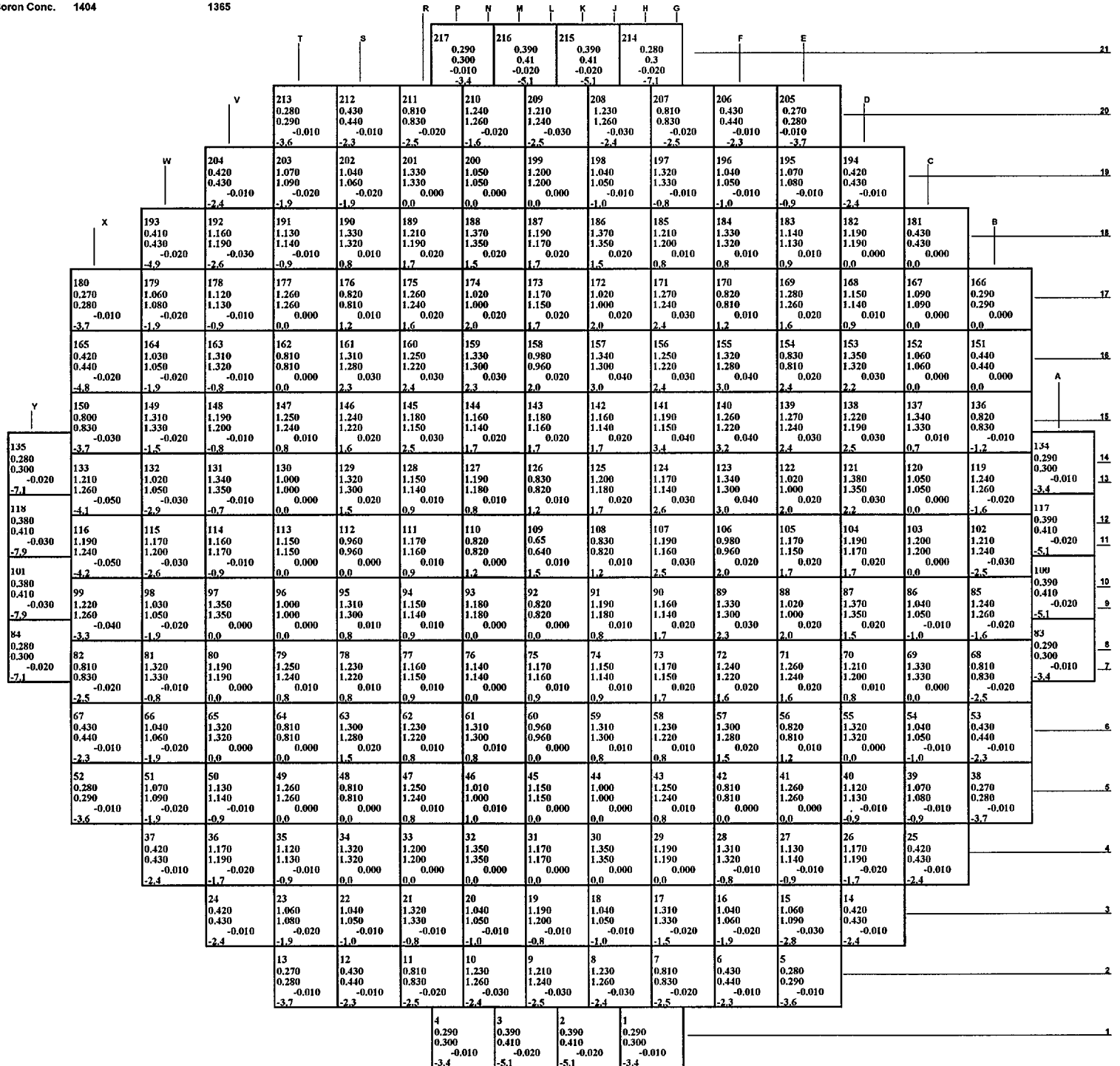
St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

Figure 5
Power Distribution Comparison With Design - 45% Power

Unit 2

Measured: BEACON
Source u2 45% plateau.out
Power Level 45.5%
Exposure 4.2
CEA Position 50122" w/d
Boron Conc. 1404

Design: PCM 00075 Rev. 1
45%
10 EFPH
50122" w/d
1365



Key:

Box #	Measured
Design	Delta
% Diff.	

St. Lucie Unit 2, Cycle 13 Startup Physics Testing Report

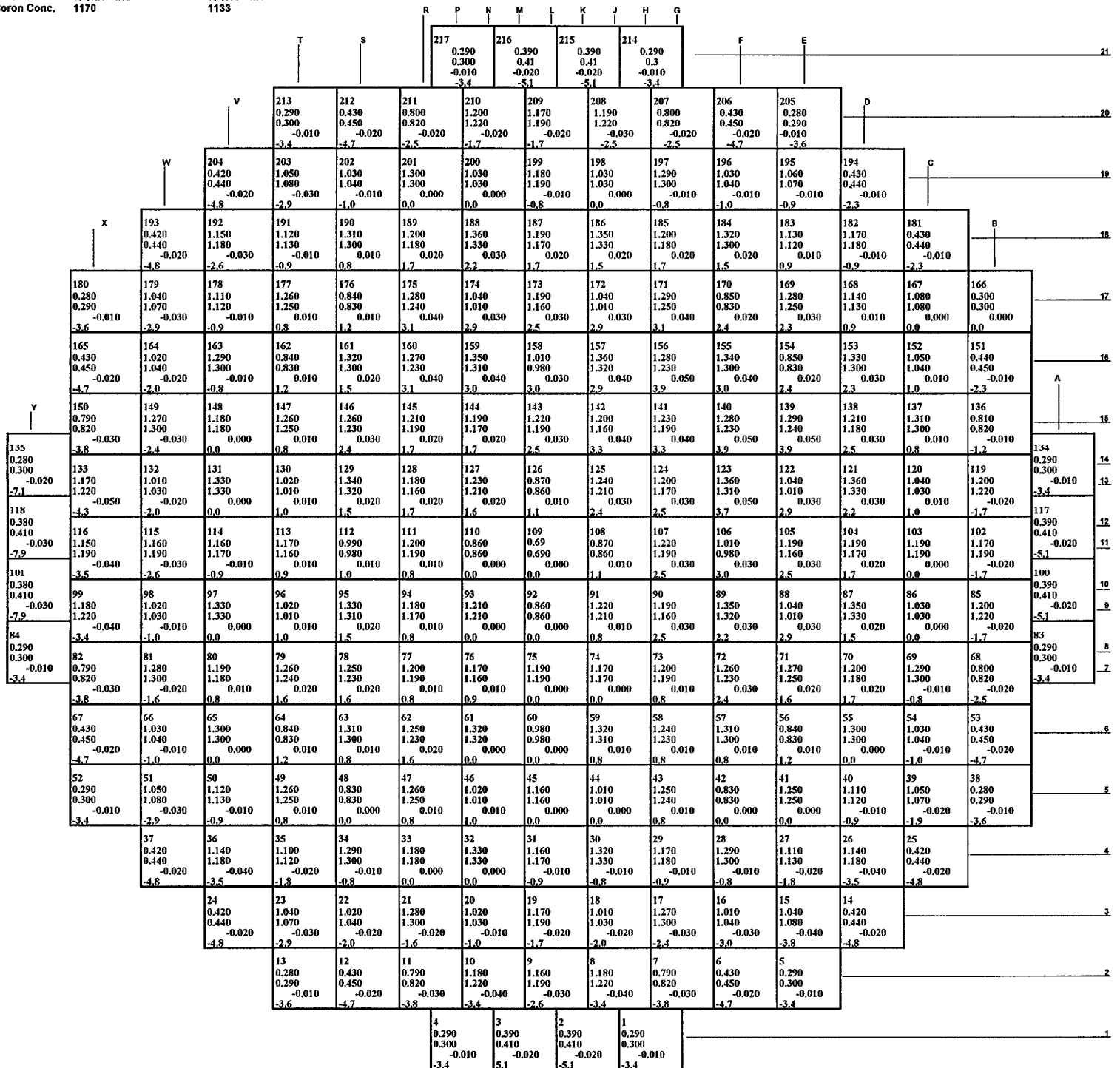
Figure 6

Power Distribution Comparison With Design - 98%

Unit 2

Measured: BEACON
Source u2 98% plateau.out
Power Level 96%
Exposure 71.4
CEA Position 502128" w/d
Boron Conc. 1170

Design: PCM 00075 Rev. 1
100%
80 EFPH
502137" w/d
1133



RMS Deviation: 2.16%

St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report

Table 1
Cycle 13 Reload Sub-Batch ID*

Sub-Batch	Number of Assemblies
KY	1
KX	8
N1	8
N2	4
N3	20
N4	20
N5	12
P1	4
P2	4
P3	24
P4	16
P5	20
P6	8
R1	36
R2	20
R3	12

*Reference 6

St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report

Table 2
Approach to Criticality

Dilution Rate	Initial Boron Concentration	Final Boron Concentration	Approximate Dilution Time (minutes)
132 gpm	1785	1724	15
88 gpm	1724	1624	60
44 gpm	1624	1573	91

St. Lucie Unit 2, Cycle 13
Startup Physics Testing Report

Table 3
CEA Group Worth Summary

CEA Group	Measured Worth (pcm)	Design Worth * (pcm)	Percent Difference
Reference Group B	1965.26	1925	-2.05
3,4&5	1618.36	1534	-5.21
A	1567.00	1484	-5.30
1&2	1591.22	1543	-3.03
Total	6741.84	6486	-3.79

*Reference 6.

Percent difference = (Design - Measured)/(Measured) * 100