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March 4, 1999

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

Re: St. Lucie Unit 2
Docket 50-389
Cycle 11 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 11 is hereby submitted.

Should you have any questions, please contact us.

Very truly yours,

J. A. Stall
Vice President
St. Lucie Plant

JAS/RLD

Enclosure: St. Lucie Unit 2, Cycle 11 Reactor Startup Physics Testing Report; March 2, 1999

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, St. Lucie Plant

IE26

ST. LUCIE UNIT 2
CYCLE 11

STARTUP TEST REPORT

(D/RE/930584-R0)

ST. LUCIE UNIT 2, CYCLE 11
REACTOR STARTUP PHYSICS
TESTING REPORT

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St. Lucie Unit 2, Cycle 11
Startup Physics Testing Report

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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 11 refueling. The Startup testing verifies 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.

This Cycle 11 Startup Report is being submitted in accordance with Technical Specification 6.9.1.1 because:

A. Fuel design changes were made, introducing the "Value Added" pellet, the Guardian Grid and consequently eliminating long lower end-caps

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

II. Cycle 11 Fuel Design

The Cycle 11 reload consists entirely of fuel manufactured by Asea Brown Boveri – Combustion Engineering (ABB-CE). The 217 assemblies of the Cycle 11 core are comprised of fuel from four batches. Of these, 64 are fresh batch N assemblies, 64 are once-burned batch M assemblies, 84 are twice-burned batch L assemblies and 5 are thrice-burned batch K assemblies.

The Region N assemblies consist of non-gadolinia fuel rods (4.1 to 4.45 w/o U_{235} enriched) and Gadolinia (UO_2 -GD_2 O_3) bearing fuel rods (Gadolinia burnable absorber fuel rods, 4 or 8 w/o gadolinia homogeneously dispersed in a 2.2 to 2.55 w/o U_{235} enriched carrier).

The mechanical design of the Region N fuel assemblies differs from Regions M, L and K in the following ways:

1) The bottom grid is the laser welded "Guardian" grid. The Guardian grid incorporates debris stopping features. The other fuel batches employ TIG welded lower grids.

2) The fuel rod lower endcaps were changed from the long lower endcap design to a shorter design which works with the new Guardian grid. This effectively shifted the active fuel 1.14 inches down relative to the other fuel assembly regions.

3) The upper pellet stack spacer disc which separates the top fuel pellet from the upper plenum spring was deleted.

4) The Plenum spring design was modified to accommodate the longer plenum size.

5) The fuel rod pellet diameter was increased by 0.0005 inches, pellet dish volume decreased by 69%, and the pellet theoretical density was increased from 95.25% to 95.4%.

6) The top spacer grid incorporates backup arches in all interior cells as opposed to only the peripheral cells of previous fuel assembly designs.

7) The upper end fitting flow and hold-down plates were slightly thickened. The spring force was increased for the fuel assembly upper end fitting springs

PC/M 98016 adressed the mechanical, thermal hydraulic and neutronic impact of the region N fuel design changes. Evaluations performed by FPL and ABB-CE found the operational impact of the fuel design changes to be acceptable. There was no safety impact due to the fuel design changes. Subsequent Low Power Physics, Power Ascension and Shape Annealing Factor (SAF) testing substantiated the conclusions of the evaluations.

II. Cycle 11 Fuel Design (continued)

No fuel handling issues were noted due to the Region N fuel assembly upper end fitting changes mentioned above. The impact of the upper end fitting changes had been evaluated by FPL prior to the fuel receipt. This was accomplished by field testing an available Region N design upper end fitting with a PSL 2 new fuel grapple.

The entire Cycle 11 core consists of debris resistant fuel (long lower end-cap or Guardian grid). The Cycle 11 loading pattern is similar to Cycle 10. Cycle 11 employs a low-leakage fuel management scheme and is 90 degrees rotationally symmetric.

The Cycle 11 core map is represented in Figure 1. The assembly serial numbers and control element assembly (CEA) serial numbers are given for each core location.

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 2.29 seconds with maximum and minimum times of 2.92 seconds and 0.90 seconds, respectively. All drop times were within the 3.1 second maximum requirement of Technical Specification 3.1.3.4. In addition the CEA drop time distribution requirements for scram shape (average drop time ≤2.77 seconds and maximum drop time ≤3.07 seconds) specified in the reload PC/M 98016 (Reference 6) were satisfied.

IV. Approach to Criticality

The approach to criticality involved diluting from a sub-critical boron concentration of 1660 ppm to a predicted critical boron concentration of 1441 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 1 summarizes the dilution rates and times, as well as beginning and ending boron concentrations.

Initial criticality for St. Lucie Unit 2, Cycle 11, was achieved on December 12, 1998 at 06:29 with CEA group 5 at 60 inches withdrawn and all other CEAs at the all-rods-out (ARO) position. The actual critical concentration was observed to be 1473 ppm.

V. Zero Power Physics Testing

To ensure that the operating characteristics of the Cycle 11 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 98016 (Reference 6). Satisfactory agreement was obtained.

The measurement of the all-rods-out (ARO) critical boron concentration was performed. The measured value was 1524.9 ppm which compared favorably with the design value of 1491 ppm (Reference 2). This was within the acceptance limits of $\pm$ 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 –1.630 pcm/°F which fell well within the acceptance criteria of $\pm$ 2.0 pcm/°F of the design MTC of -1.938 pcm/°F (corrected). This satisfies Unit 2 Technical Specification 3.1.1.4 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 2. 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 $\pm$100 pcm of its corresponding design CEA worths, whichever is greater and,

2) The measure 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.

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 25%, 50%, and greater than 98% rated thermal power.

A summary of the flux maps at the 25%, 50% and 98% power levels is provided in figures 4, 5 & 6. These flux maps are used for comparing the measured power distribution with the predicted power distribution. For the purposes of the power ascension, the acceptance criteria requires the RMS value of the power deviation be less than or equal to 5%. In addition, for the 25% and 98% plateaus, the individual assembly powers should be within 10% of the predicted power (both) and the relative power density (RPD) should be within 0.1 RPD units of predicted for the 25% power case. These criteria were satisfied.

A Shape Annealing Factor (reference 5) test was performed in conjunction with the power ascension (reference 3). This test was necessitated by the replacement of the Reactor Protection System Channel "D" the Linear Power Range Detector and the change in the active fuel stack height introduced with the Region N fuel. The measured Shape Annealing Factors were installed in the Linear Power Range Detector instrument circuits as required by the reload PC/M 98016 (Reference 6).

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.

VII. Summary

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

VIII. References

1) *"Initial Criticality,"* Pre-Operational Procedure 2-3200088

2) *"Reload Startup Physics Testing,"* Pre-Operational Procedure·3200091

3) *"Reactor Engineering Power Ascension Program,"* Pre-Operational Procedure 3200092

4) St. Lucie Unit 2 Technical Specifications.

5) "*Shape Annealing Factor Test*," Pre-Operational Test Procedure 3200093

6) St. Lucie Unit 2 Cycle 11 Reload PC/M #98016

St. Lucie Unit 2, Cycle 11
Startup Physics Testing Report

FIGURE 1
CYCLE 11 CORE LOADING PATTERN

N ↑

	Y	X	W	V	T	S	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
21								L41		L97		L76		L47							
20					L66	M04	M24		N15 28		M48		N18 10		M26	M10	L84				
19				L86	N20 55	M45	N35 23		L04		M35 200		L06		N40 34	M54	N26 15	L62			
18			L65	N29 201	L59	N02 111	L32		N42 114		L11		N48 4		L22	N04 78	L93	N30 202	L88		
17		L82	N27 43	L91	N09 73	L50	M62 118		L29		M06 29		L27		M32 119	L80	N10 107	L61	N14 8	L68	
16		M11	M52	N05 112	L78	N49 19	M58		N54 113		K78		N56 51		M68	N34 5	L52	N06 115	M44	M01	
15, 14	L45	M27	N52 17	L20	M33 105	M69	M39 203		L55		N57 33		L73		M41 204	M55	M59 104	L34	N36 100	M21	L43
13, 12	L74	N28 101	L07	N45 32	L25	N62 75	L71		M81 21		M63		M83		L57	N63 6	L31	N46 1	L01	N16 25	L94
11, 10	L95	M49	M38 205	L12	M07 67	K79	N53 30		M66		K73 70		M65		N64 44	K80	M08 60	L13	M37 206	M50	L75
9, 8	L42	N23 63	L02	N43 53	L30	N55 18	L56		M84		M64		M82 109		L70	N60 116	L24	N44 72	L08	N24 13	L44
7		M22	N39 122	L35	M60 110	M56	M42 207		L72		N61 52		L54		M40 208	M70	M34 108	L21	N41 121	M28	
6		M02	M43	N07 71	L53	N33 16	M67		N58 14		K77		N59 64		M57	N47 9	L79	N01 12	M51	M12	
5		L69	N21 120	L60	N11 20	L81	M31 102		L26		M05 31		L28		M61 103	L51	N12 41	L90	N22 7	L83	
4			L89	N31 209	L92	N08 76	L23		N38 27		L10		N37 22		L33	N03 117	L58	N32 210	L64		
3				L63	N17 3	M53	N51 74		L05		M36 211		L03		N50 11	M46	N19 79	L87			
2					L85	M09	M25		N13 69		M47		N25 26		M23	M03	L67				
1								L46		L77		L96		L40							

Assembly Serial # XXX
Insert Serial # ##

FIGURE 2. WIDE RANGE CHANNEL B BORON DILUTION

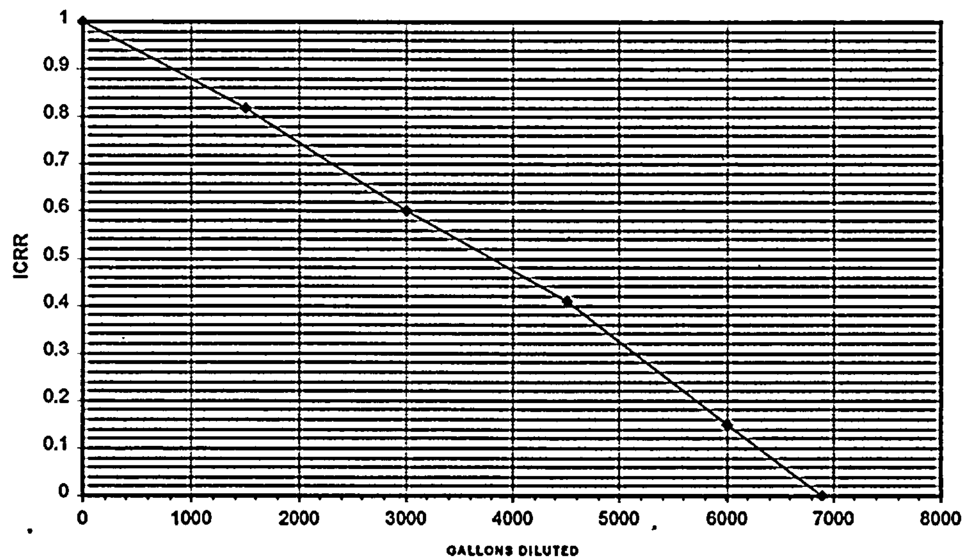


FIGURE 3. WIDE RANGE CHANNEL D BORON DILUTION

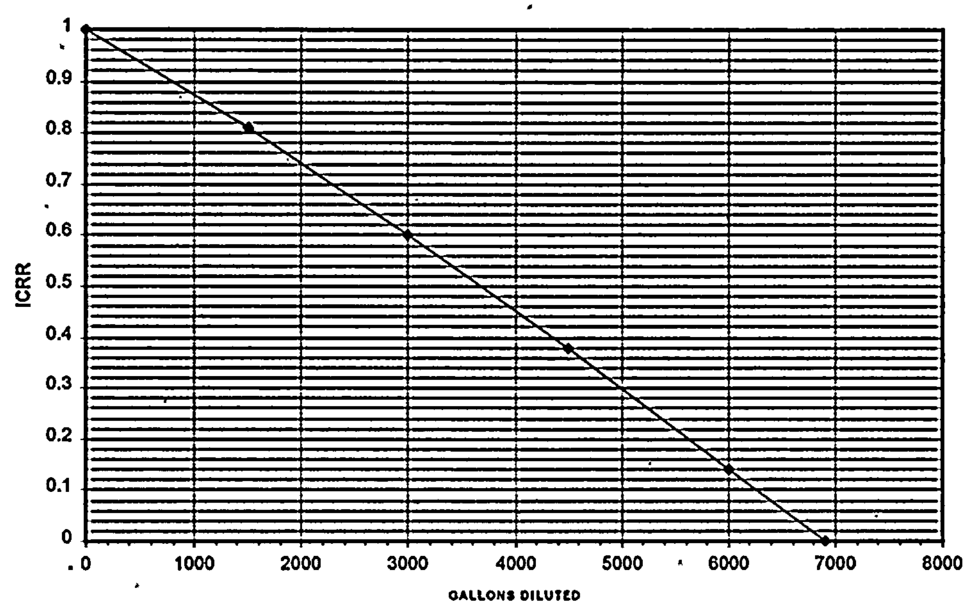
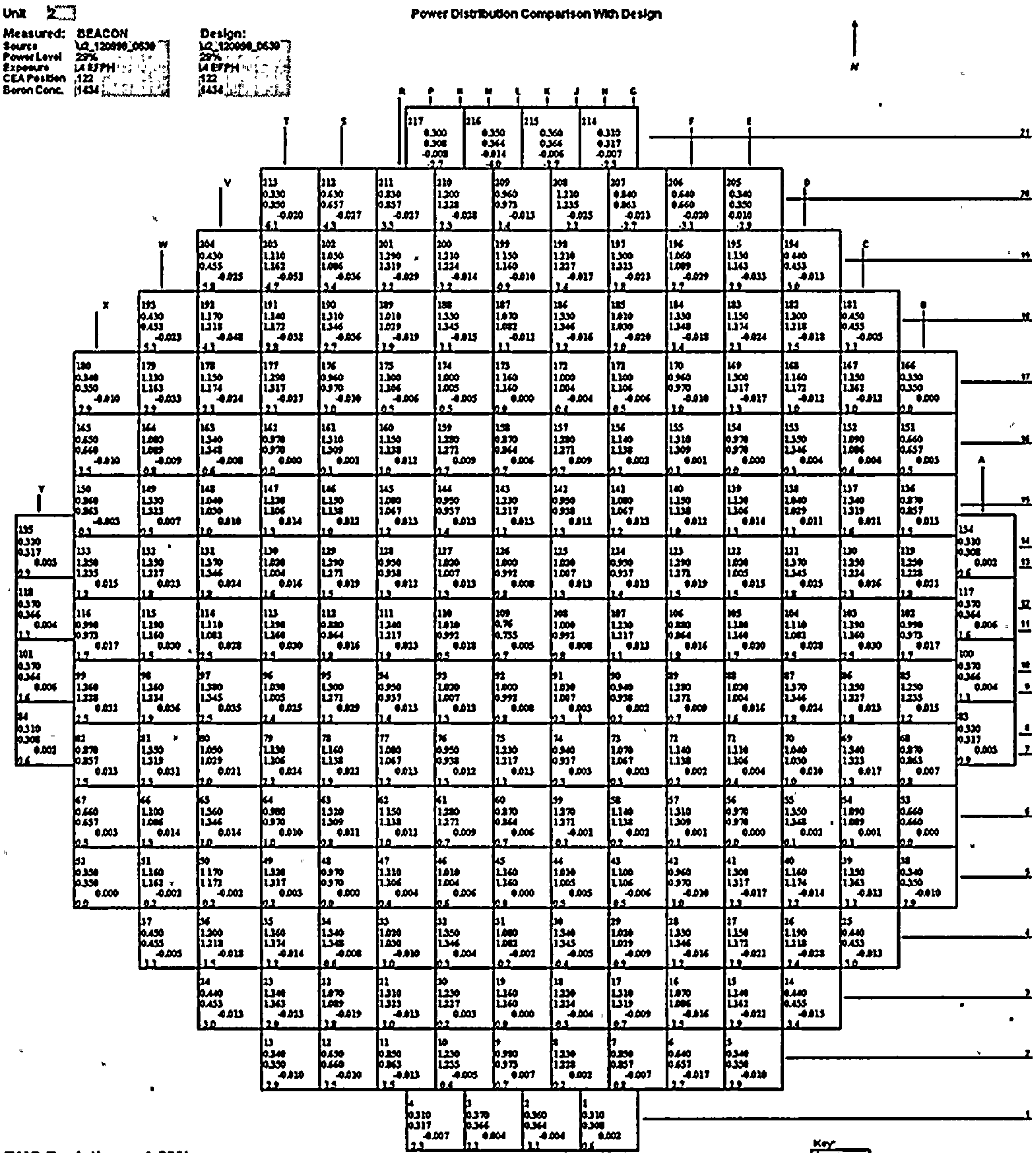


Figure 4

POWER DISTRIBUTION COMPARISON WITH DESIGN – 25% POWER

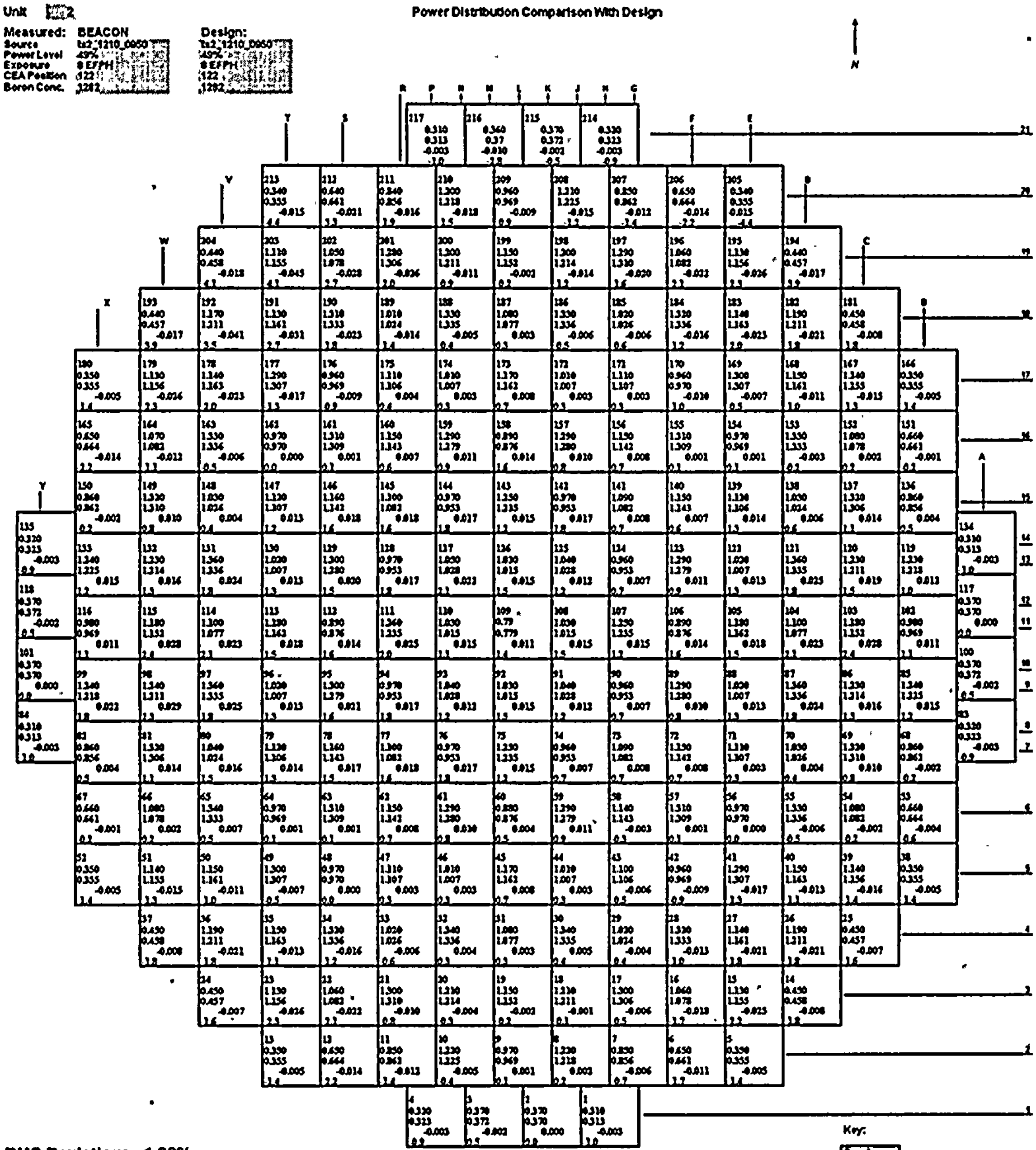


RMS Deviation: 1.63%

The incore detection system is operable per Appendix 1, RMS deviation should be less than or equal to 5.0% and meet the requirements of 4.7.1 if performed at the 25 and 95 percent power test plateaus during the power ascension test program.

Figure 5

POWER DISTRIBUTION COMPARISON WITH DESIGN – 50% POWER

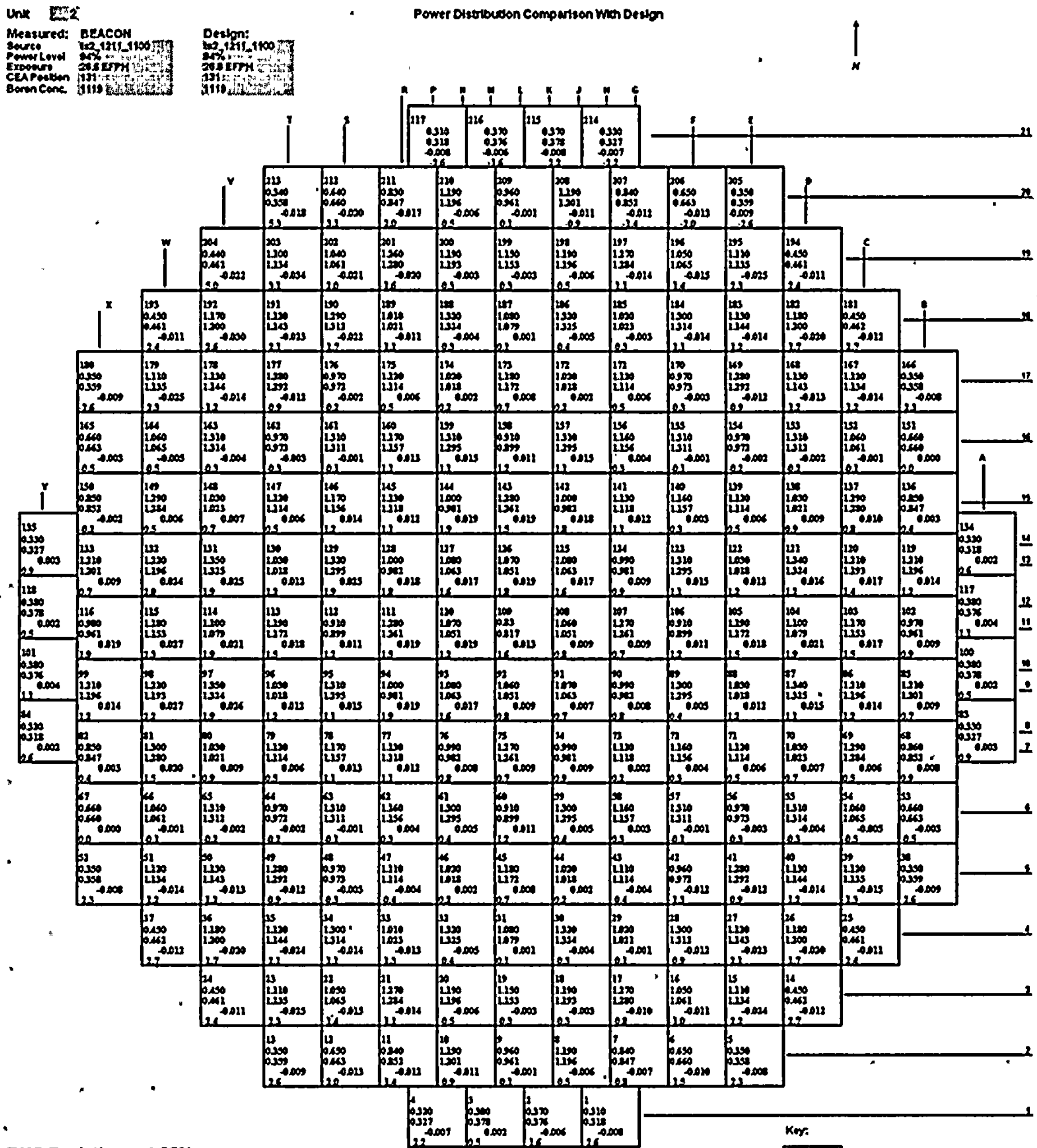


RMS Deviation: 1.39%

The incore detection system is operable per Appendix 1, RMS deviation should be less than or equal to 5.0% and meet the requirements of 4.7.1 if performed at the 25 and 95 percent power test plateaus during the power ascension test program.

Figure 6

POWER DISTRIBUTION COMPARISON WITH DESIGN – 98% POWER



RMS Deviation: 1.25%

The incore detection system is operable per Appendix 1, RMS deviation should be less than or equal to 5.0% and meet the requirements of 4.7.1 if performed at the 25 and 98 percent power test plateaus during the power ascension test program.

Table 1
Approach to Criticality

Dilution Rate	Initial Boron Concentration	Final Boron Concentration	Dilution Time (minutes)
132 gpm	1660	1591	21
88 gpm	1591	1491	70
44 gpm	1491	1473	75

Table 2
CEA Group Worth Summary

CEA Group	Measured Worth (pcm)	Design * Worth (pcm)	Percent Difference
Reference Group B	2140.69	2070.00	-3.30
A	1427.65	1417	-0.75
1&2	1724.48	1691	-1.94
3,4&5	1762	1712	-2.84
Total	7054.84	6890	-2.34

*Reference 2

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