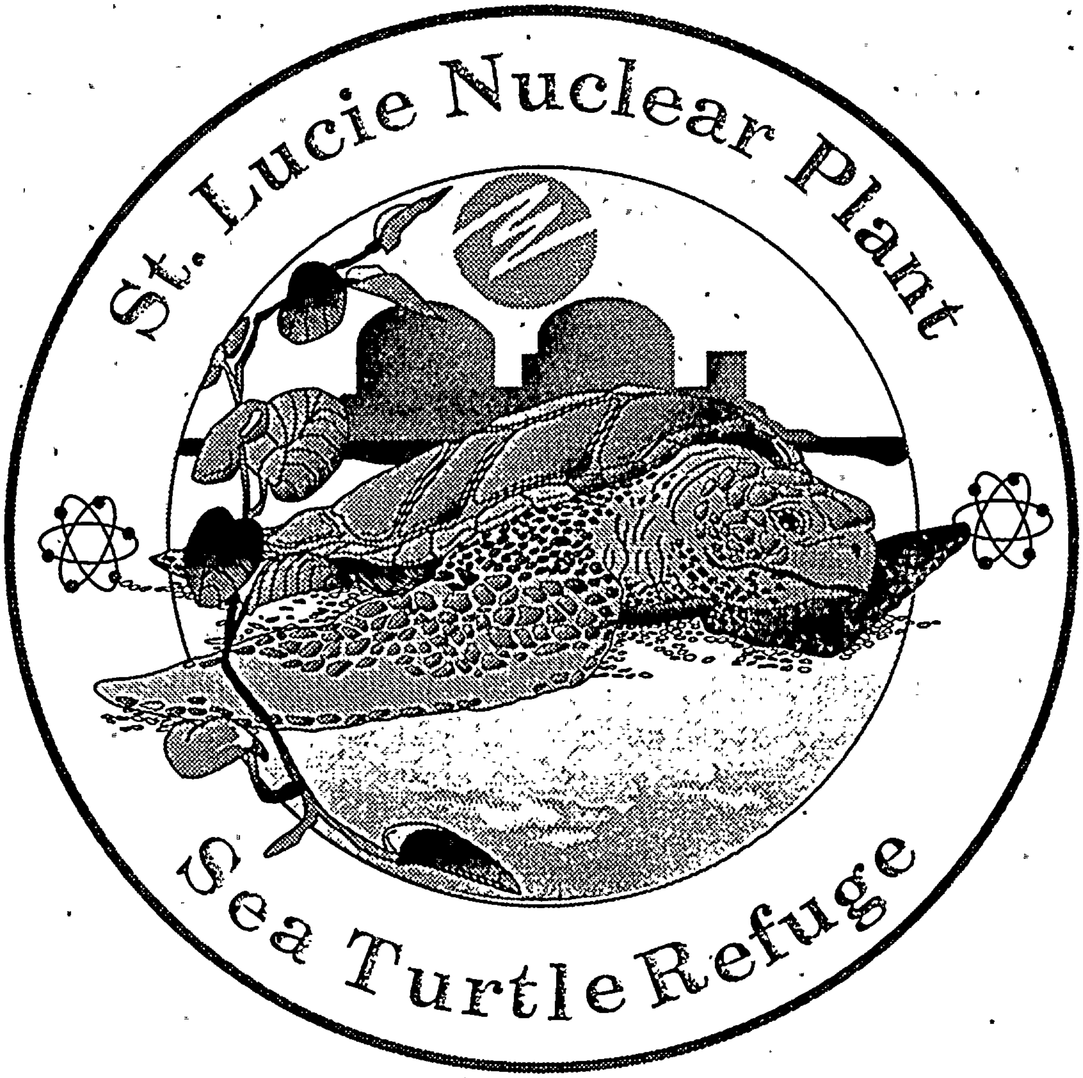
St. Lucie Unit #1,
Cycle 11



Startup Test Report

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I. Introduction

The purpose of this report is to provide a description of the fuel design and core load and a summary of the startup physics testing performed at St. Lucie Unit 1 following the Cycle 11 refueling. Startup physics testing verifies key core parameters are as predicted. The major parts of this testing program are:

1) Initial Criticality following reload,
2) Zero Power Physics Testing and,
3) Power Ascension Testing.

II. Cycle 11 Fuel Design

The Cycle 11 core consists entirely of fuel manufactured by Siemens Nuclear Power Corp.(SNP). The 217 fuel assemblies in the Cycle 11 core are comprised of fuel from four batches. Of these, 84 are fresh batch P assemblies consisting of 76 natural uranium axial blanket assemblies and 8 Vessel Fluence Reduction Assemblies (VFRAs), 92 are once burnt batch M, 33 are twice burnt batch L, and 8 are thrice burnt batch K assemblies. A further breakdown of the distinct sub-batches is contained in Table1.

This is the fifth cycle of operation utilizing gadolinia, in the form of Gd_2O_3, as a burnable absorber, coupled with the use of natural uranium blankets at the top and bottom of each fuel assembly. The batch "P" fuel is the fourth cycle of fuel provided by SNP that uses long lower end-caps as a means of providing protection against debris fretting in the Lower End-Fitting region.

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. The Cycle 11 reload differs from Cycle 10 in two respects:

1) The reload employs a new low-leakage design that relies on batch L fuel around the periphery, augmented with Flux Reduction Assemblies in the core flats to further reduce the fluence on reactor vessel welds for life extension purposes.

   Each VFRA is constructed to the design of a standard fuel assembly with the exception of the fuel pellets loaded in each fuel rod. The VFRA design utilizes depleted uranium instead of standard reload enrichments. In addition, each of the outer four guide tube finger holes is loaded with a full-length Hafnium insert to further suppress the flux at the vessel boundary.

2) Twenty-one (21) Control Element Assemblies (CEA's) were installed to complete a comprehensive replacement program recommended by Combustion Engineering. Industry data has shown that B_4C-tipped CEA's can experience cracking of the clad due to swelling of the burnable absorber within. This replacement completes the change-out process. All Type 1 CEAs in the Unit 1 core have all five fingers of the silver-indium-cadmium design.

Following the fuel shuffle and prior to the approach to criticality, CEA drop time testing was performed. The objective of this test was to measure the time of insertion from the fully-withdrawn position (UEL) to the 90% inserted position under hot, full-flow conditions. The average CEA drop time was found to be 2.35 seconds with maximum and minimum times of 2.56 seconds and 2.16 seconds respectively. All drop times were within the requirements of Technical Specifications 3.1.3.4. (i.e. less than or equal to 3.1 seconds).

III. Approach to Criticality.

The approach to criticality involved diluting from a non-critical boron concentration of 1602 ppm to a predicted critical boron concentration of 1355 ppm. The actual critical concentration was observed to be 1353 ppm. Inverse countrate ratio plots were maintained during the dilution process using wide range channels B and D. Refer to Figures 2 and 3 for data. A plot of boron concentration versus dilution time is provided in Figure 4. Table 2 summarizes the dilution rates and times as well as beginning and ending boron concentrations.

Initial criticality for St. Lucie Unit 1, Cycle 11 was achieved on December 20, 1991 at 2021 with CEA group 7 at 48 inches withdrawn and all other CEA's at the All Rods Out (ARO) position.

IV. Zero Power Physics Testing

The major tests performed for the startup of Cycle 11 were the following:

1) Reactivity Computer Checkout

2) CEA Symmetry Test

3) All Rods Out Critical Boron Concentration

4) Isothermal Temperature Coefficient Measurement

5) CEA Group Rod Worth Measurements

The tests above were performed in accordance with approved procedures.

Proper operation of the Reactivity Computer is verified through the performance of two tests. In the first, reactor power is elevated sufficiently high to ensure maximum sensitivity of the instrument and at the same time preserve adequate margin to the point of adding heat. The second test ascertains response to a known value of positive or negative reactivity by measuring the values of positive or negative reactor periods that result. The results of the Reactivity Computer checkout were compared to the appropriate predictions supplied by the fuel vendor. Satisfactory agreement was noted.

Verification of proper CEA Latching is confirmed through the use of a CEA Symmetry Test for those groups which contain dual CEA's (Shutdown groups A&B). The prescribed acceptance criteria is that the reactivity measured for each dual CEA shall be within ±15.0 pcm of the average reactivity measured for the entire group. There were no unlatched CEA's for either shutdown group.

The All Rod's Out Critical Boron concentration was performed. The measured value was 1392.5 ppm which compared favorably with the predicted value of 1399 ppm. This was within the acceptance limits of ± 100 ppm.

The measurement of the Moderator Temperature Coefficient (MTC) was performed. The MTC was determined to be 2.56 pcm/°F which fell well within the acceptance criteria of ± 2.0 pcm/°F of the design MTC of 1.73 pcm/°F (corrected). This agreed favorably with the Unit 1 Technical Specification 3.1.1.4 which states the MTC shall be less positive than 7.0 pcm/°F.

The final section of interest for low power physics testing is in the measurement of CEA Group Rod Worths. Rod worth measurements were performed using the Rod Swap methodology. This method involves exchanging the reference group (measured by 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 is within ±15% or ±100 pcm of the design CEA worths, whichever is greater.

2) The measured worth of the Reference Group, and the total worth for all the CEA groups measured is within ±10% of the total design worth.

Test Group 2 failed to meet acceptance criteria #1 in that the measured reactivity worth of this group (816.7 pcm) exceeded the design worth (687 pcm) by 15.9%. Measurements of the remaining CEA groups were within the acceptance criteria. In addition, even though Group 2 failed the rod worth evaluation, the total worth of all CEA groups was within 10% of the total design worth.

Siemens Nuclear Power Corp. later evaluated the results of the rod worth measurements and adjusted the measured worths for differences between the ideal lead group position and its actual position during the measurement of the Reference Bank integral rod worth curve. These results are summarized in Table 4 and demonstrate satisfactory agreement between measured and predicted values.

V. Power Ascension Program

During Power Ascension, the fixed incore detector system is utilized to verify that the fuel is loaded properly and there are no abnormalities occurring in the various core parameters (core peaking factors, LHR, and Tilt) for power plateaus at 25%, 50%, and >98% rated thermal power. Calorimetric, Nuclear, and ΔT power calibrations were performed at each of the plateaus prior to advancing reactor power to the next higher power level.

At 25% reactor power a fuel misload verification is performed based on information gathered from the incore instrument system. This check pointed to an assembly at core location Y-14 that had a measured relative power density (RPD) in excess of the upper acceptance limit set forth in the Power Ascension procedure. The fuel assembly in question is a hafnium Fluence Reduction Assembly (VFRA) and is the only instrumented VFRA assembly in the core. To confirm there was no fuel assembly misloaded into core location Y-14 an analysis of the flux map was performed by the Nuclear Fuel Department of FP&L. The study concluded there was no misload involved (ref. 4).

A summary of the results of the flux maps at each power level is provided in Figures 5, 6, and 7.

Within seven days of attaining 100% power, a Hot Full Power (HFP) MTC test was performed by maintaining power constant and varying temperature. The center CEA (7-1) is inserted to permit compensation of the resulting reactivity changes. The HFP MTC was measured to be -4.56 pcm/°F which was within ±2.0 pcm/°F of the design value of -4.90 pcm/°F. This test also verified compliance with Technical Specification 3.1.1.4 which requires the measured MTC be less negative than -28.0 pcm/°F and less positive than 2.0 pcm/°F while thermal power is greater than 70%. The power coefficient was not measured.

VI. Summary

Compliance with the applicable Technical Specifications was satisfactory.

VII. References

1) *"St. Lucie Unit 1, Cycle 11 Startup and Operations Report,"* EMF-91-216(P), dated November 1991.

2) *"St. Lucie Unit 1 Technical Specifications"*

3) Presentation given by Siemens Nuclear Power Corp. to FP&L, February 1992

4). Letter from W. M. Nutt to E. J. Wunderlich: NF-92-067, dated Jan. 27, 1992, *"St. Lucie Unit 1 BOC 11 - Core Location Y-14 RPD Outside Misload Verification Acceptance Limit."*

Figure 1
Cycle 11 Core Loading Pattern

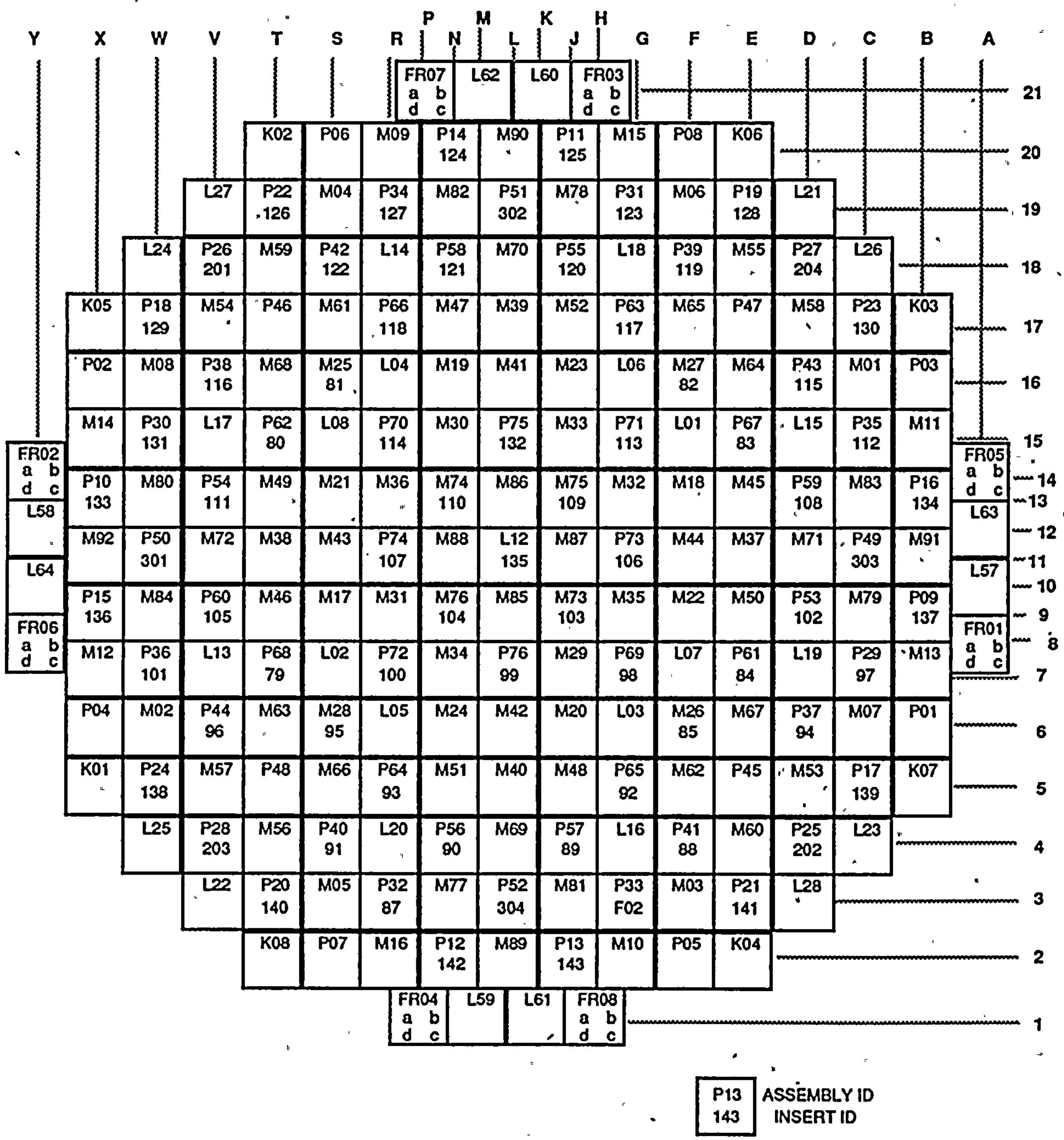


FIGURE 2
WIDE RANGE CHANNEL "B" BORON DILUTION

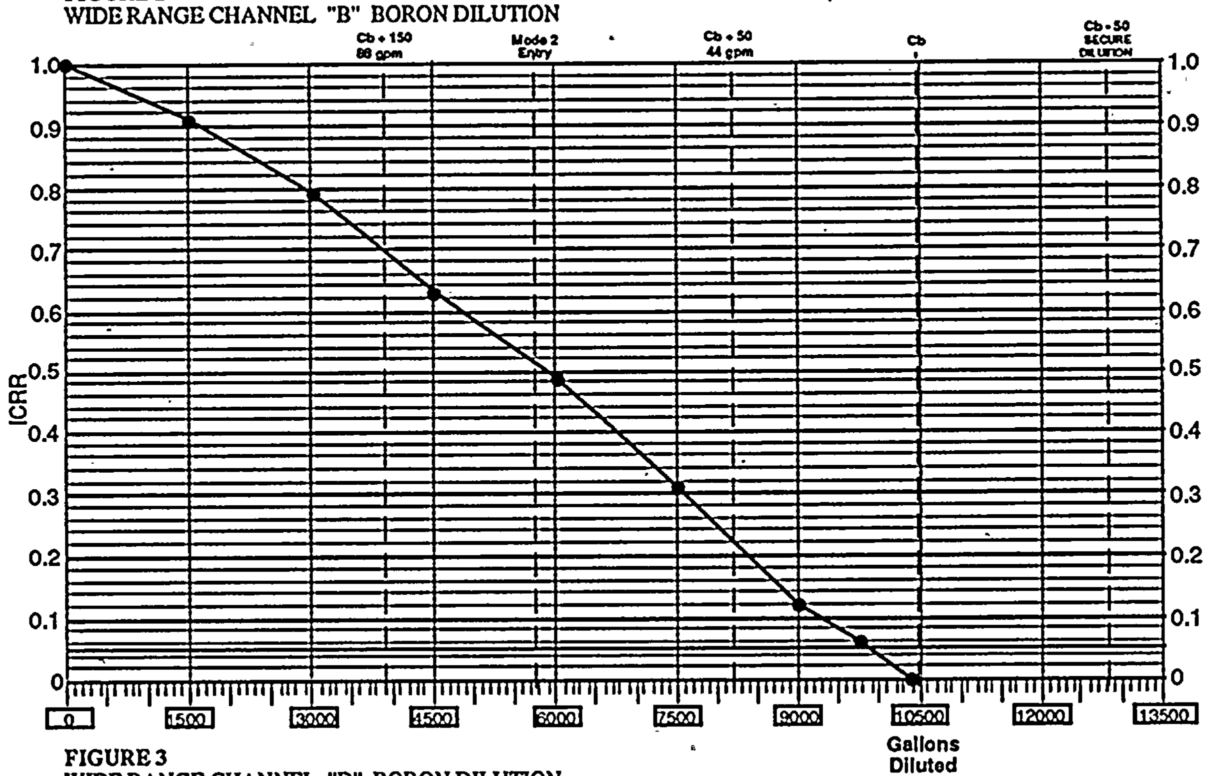


FIGURE 3
WIDE RANGE CHANNEL "D" BORON DILUTION

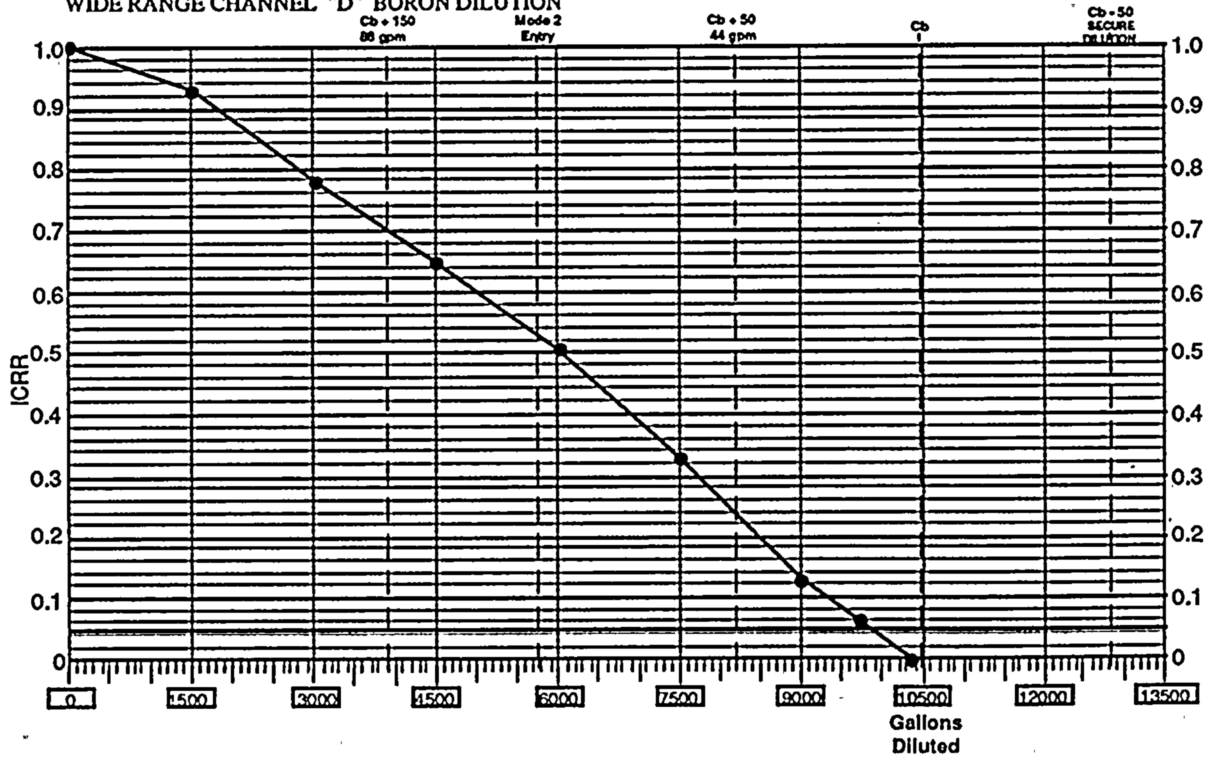
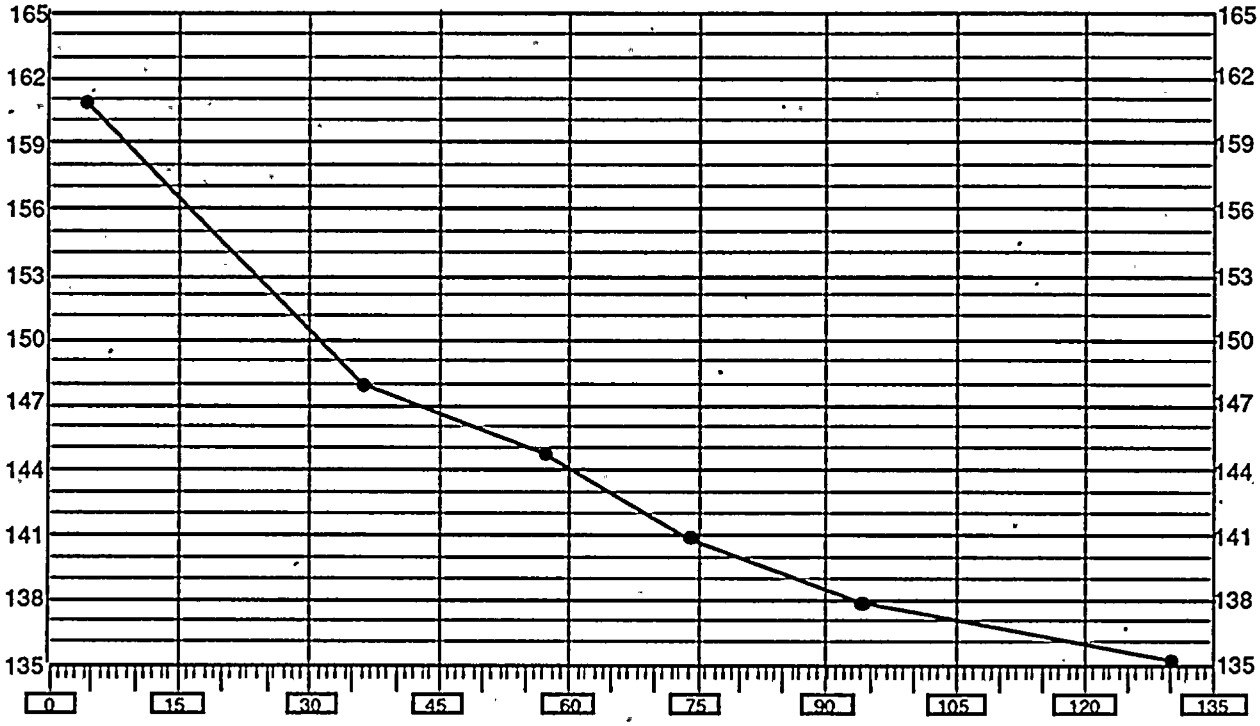


FIGURE 4
RCS BORON DILUTION

BORON CONCENTRATION VS. TIME



MINUTES OF DILUTION

FIGURE 5

POWER DISTRIBUTION COMPARISON WITH DESIGN
AT 25 % POWER

MEASURE: (CECOR/INPAX)

UNIT 1

SNAPSHOT ID #	INPAX29	
POWER LEVEL	29.5%	%
EXPOSURE	3.50	EFPH
CEA POSITION	122"	"
BORON CONC.	1366	PPM

DESIGN:

DATA SOURCE:	EMF-91-216(P)	
POWER LEVEL	25%	%
EXPOSURE	5	EFPH
CEA POSITION	122	"
BORON CONC	1399	PPM

					0.6980 0.7020 -0.0040 [1]
				0.9770 0.9760 0.0010 [10]	0.9000 0.9260 -0.0260 [2]
			1.1270 1.1180 0.0090 [18]	1.0690 1.0690 0.0000 [11]	1.1210 1.1240 -0.0030 [3]
		1.1600 1.1560 0.0040 [24]	0.9150 0.9250 -0.0100 [19]	1.1790 1.1850 -0.0060 [12]	1.1230 1.1130 0.0100 [4]
	1.3200 1.3210 -0.0010 [29]	1.1490 1.1370 0.0120 [25]	1.1910 1.2350 -0.0440 [20]	1.1020 1.1240 -0.0220 [13]	1.1450 1.1410 0.0040 [5]
1.1150 1.1330 -0.0180 [33]	1.1020 1.1230 -0.0210 [30]	1.2730 1.3180 -0.0450 [26]	0.7860 0.9200 -0.1340 [21]	1.2240 1.2700 -0.0460 [14]	1.1640 1.1350 0.0290 [6]
0.3810 0.3920 -0.0110 [34]	1.1650 1.1930 -0.0280 [31]	1.2960 1.3150 -0.0190 [27]	1.1990 1.2690 -0.0700 [22]	1.0770 1.1160 -0.0390 [15]	1.2230 1.2380 -0.0150 [7]
	0.3580 0.3880 -0.0300 [32]	1.0110 1.0440 -0.0330 [28]	0.8610 0.8990 -0.0380 [23]	1.1500 1.1950 -0.0450 [16]	0.8250 0.8660 -0.0410 [8]
			0.0590 0.0540 0.0050 [17]	0.2360 0.2470 -0.0110 [9]	

KEY

MEASURED
DESIGN
DELTA [ID]

RMS DEVIATION = 3.5362 %

FIGURE 6

POWER DISTRIBUTION COMPARISON WITH DESIGN AT 50 % POWER

MEASURE: (CECOR/INPAX) UNIT 1

SNAPSHOT ID # 11223110.DAT
POWER LEVEL 44.7 %
EXPOSURE 9.0 EFPH
CEA POSITION 122 "
BORON CONC. 1155 PPM

DESIGN:

DATASOURCE: EMF-91-216(P)
POWER LEVEL 50 %
EXPOSURE 10 EFPH
CEA POSITION 122 "
BORON CONC 1399 PPM

					0.7210 0.7350 -0.0140 [1]
				0.9970 1.0080 -0.0110 [10]	0.9200 0.9600 -0.0400 [2]
			1.1410 1.1440 -0.0030 [18]	1.0860 1.0980 -0.0120 [11]	1.1380 1.1530 -0.0150 [3]
		1.1670 1.1680 -0.0010 [24]	0.9280 0.9460 -0.0180 [19]	1.1910 1.2070 -0.0160 [12]	1.1340 1.1360 -0.0020 [4]
	1.3130 1.3100 0.0030 [29]	1.1480 1.1390 0.0090 [25]	1.1950 1.2440 -0.0490 [20]	1.1090 1.1390 -0.0300 [13]	1.1510 1.1560 -0.0050 [5]
1.1060 1.1100 -0.0040 [33]	1.0960 1.1090 -0.0130 [30]	1.2660 1.3040 -0.0380 [26]	0.7900 0.9250 -0.1350 [21]	1.2230 1.2720 -0.0490 [14]	1.1640 1.1410 0.0230 [6]
0.3800 0.3840 -0.0040 [34]	1.1540 1.1650 -0.0110 [31]	1.2880 1.2890 -0.0010 [27]	1.1910 1.2480 -0.0570 [22]	1.0740 1.1110 -0.0370 [15]	1.2180 1.2320 -0.0140 [7]
	0.3610 0.3820 -0.0210 [32]	1.0010 1.0180 -0.0170 [28]	0.8530 0.8810 -0.0280 [23]	1.1420 1.1790 -0.0370 [16]	0.8260 0.8630 -0.0370 [8]
				0.0600 0.0550 0.0050 [17]	0.2400 0.2500 -0.0100 [9]

KEY
MEASURED
DESIGN
DELTA ID

RMS DEVIATION = 3.3611 %

FIGURE 7

POWER DISTRIBUTION COMPARISON WITH DESIGN AT 100%

MEASURE: (CECOR/INPAX)

UNIT 1

SNAPSHOT ID #	I1228213.DAT	
POWER LEVEL	98.22	%
EXPOSURE	100.7	EFPH
CEA POSITION	132	"
BORON CONC.	955	PPM

DESIGN:

DATA SOURCE:	EMF-91-216(P)	
POWER LEVEL	100	%
EXPOSURE	75	EFPH
CEA POSITION	135	"
BORON CONC	914	PPM

					0.8140 0.8270 -0.0130 [1]
				1.0610 1.0740 -0.0130 [10]	0.9990 1.0320 -0.0330 [2]
			1.1880 1.1890 -0.0010 [18]	1.1420 1.1500 -0.0080 [11]	1.1950 1.2070 -0.0120 [3]
		1.1960 1.1890 0.0070 [24]	0.9810 0.9820 -0.0010 [19]	1.2380 1.2450 -0.0070 [12]	1.1750 1.1780 -0.0030 [4]
	1.2980 1.2900 0.0080 [29]	1.1470 1.1430 0.0040 [25]	1.2500 1.2560 -0.0060 [20]	1.1450 1.1630 -0.0180 [13]	1.1820 1.1840 -0.0020 [5]
1.1020 1.0870 0.0150 [33]	1.0970 1.0870 0.0100 [30]	1.2820 1.2770 0.0050 [26]	0.9310 0.9330 -0.0020 [21]	1.2670 1.2740 -0.0070 [14]	1.1680 1.1550 0.0130 [6]
0.3890 0.3690 0.0200 [34]	1.1260 1.1110 0.0150 [31]	1.2470 1.2370 0.0100 [27]	1.2100 1.2140 -0.0040 [22]	1.0920 1.1040 -0.0120 [15]	1.2240 1.2420 -0.0180 [7]
	0.3700 0.3670 0.0030 [32]	0.9670 0.9650 0.0020 [28]	0.8360 0.8420 -0.0060 [23]	1.1200 1.1470 -0.0270 [16]	0.8200 0.8610 -0.0410 [8]
			0.0550 0.0560 -0.0010 [17]	0.2470 0.2560 -0.0090 [9]	

KEY

MEASURED DESIGN DELTA [ID]

RMS DEVIATION = 1.3837 %

Table 1
Cycle 11 Reload Sub-batch ID

Sub-Batch	# of Assemb	Enrich.
K1	8	3.60
L1	8	3.84
L2	17	3.81
L4	8	3.72
M1	16	4.00
M2	12	3.97
M3	16	3.90
M4	44	3.89
M5	4	3.87
P1	16	3.75
P2	12	3.75
P3	40	3.75
P4	4	3.75
P5	4	3.75
P6	8	0.30

Table 2
Approach to Criticality

Dilution Rate	Init. Boron Conc.	Final Boron Conc.	Dilution Time(min)
132 gpm	1609 ppm	1500 ppm	31
88 gpm	1500 ppm	1402 ppm	48
44 gpm	1402 ppm	1353 ppm	51

Table 3

Comparisons of SNP Calculations With Measured Values

CEA Group Worth Summary

CEAGroup	Measured	Design	% Diff.
7	616.1	559	-9.3 %
B/6	740.6	649	-12.4 %
2	816.7	687	-15.9 %
4	764.2	683	-10.6 %
1	834.2	735	-11.9 %
5/3	875.4	856	-2.2 %
A	1136.5	1166.8	-6.2%
Total	5783.7	5235.8	-9.4%

Note: All worths in pcm
% Diff = (D/M-1)100

HZP Critical Boron

Condition	Measured	Design(Adj)	Difference (M-D)
ARO	1392.5 ppm	1399 ppm	-6.5 ppm

Moderator Temperature Coefficient

Condition	Measured	Design(Adj)	Difference(M-D)
ARO	+2.56 pcm/°F	+1.73 pcm/°F	+0.69 pcm/°F

Table 4

Comparison of SNP Calculations with Measured Values After Compensating for Lead Bank Position

CEA Group Worth Summary

CEA Group	Adjusted * Measured (pcm)	Design	% Diff.
7	590	559	-5.24 %
B/6	715	649	-9.23 %
2	791	687	-13.1 %
4	738	683	-7.45 %
1	808	735	-9.03 %
5/3	850	856	0.71 %
A	1136	1066.8	-6.09 %
Total	5628	5235.8	-7.49 %.

% Diff = (D/M-1)100

* Reference 3