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September 1, 1992

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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Re: St. Lucie Unit 2
Docket 50-335
St. Lucie Unit 2, Cycle 7
Startup Physics Testing Report

In accordance with St. Lucie Unit 2 Technical Specification 6.9.1.1, the attached Unit 2 Cycle 7 Startup Physics Testing Report is being submitted.

Should you have any questions, please contact us.

Very truly yours,

D. A. Sager
Vice President
St. Lucie Plant

DAS:JJB:kw

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

DAS/PSL #770-92

IE26
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St. Lucie Unit 2, Cycle 7
Startup Physics Testing 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 to summarize the startup physics testing performed at St. Lucie Unit 2 following the Cycle 7 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,
   - Reactivity Computer Checkout
   - ARO Boron Concentration
   - CEA Worth Measurements
3) Power Ascension Testing.
   - Fuel Assembly loading verification
   - 25% Power Relative Power Distribution
   - 50% Power Relative Power Distribution
   - 100% Power Relative Power Distribution

II. Cycle 7 Fuel Design

The Cycle 7 reload consists of 68 fresh fuel assemblies (Region J), 76 once burned assemblies (Region H) and 73 twice burned assemblies (Region G). Table 1 provides enrichment information for the Cycle 7 reload sub-batches. The mechanical design for the fresh fuel assemblies, Region J, is nearly the same as for Region H fuel (Cycle 6); the only mechanical difference is that region J has four crimp holes instead of two, as in previous cycles, to secure the upper end fitting posts to the guide tubes. The Region J fuel assemblies use the debris resistant fuel assembly (DRFA) design, making the entire Cycle 7 fuel load of debris resistant fuel assemblies.

The Cycle 7 core map is represented in Figure 1. The assembly serial numbers and Control Element Assembly (CEA) serial numbers are given for each core location. Cycle 7 employs a low-leakage design. Twenty-four twice-irradiated region G assemblies and twenty-four once irradiated region H fuel assemblies are placed on the core periphery and the fresh fuel, Region J, is loaded inboard.

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 2.77 seconds with maximum and minimum times of 2.92 seconds and 2.62 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 1744 ppm to a predicted critical boron concentration of 1487 ppm. The actual critical concentration was observed to be 1476 ppm. Inverse countrate ratio (ICRR) plots were maintained during the dilution process using wide range channels B and D and startup channels 1 and 2. Refer to Figures 2 through 4B 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 7 was achieved on June 24, 1992 at 0300 with CEA group 5 at 60 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 7 were the following:

1) Reactivity Computer Checkout

2) All Rods Out Critical Boron Concentration

3) Isothermal Temperature Coefficient Measurement

4) 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 reactivity measuring system 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 obtained.

The All Rod's Out Critical Boron concentration was performed. The measured value was 1513.67 ppm which compared favorably with the design value

of 1524 ppm. 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 obtained. The MTC was determined to be 0.94 pcm/°F which fell well within the acceptance criteria of ± 3.0 pcm/°F of the design MTC of 1.19 pcm/°F (corrected). This agreed favorably with the Unit 2 Technical Specification 3.1.1.4 which states the MTC shall be less positive than 5.0 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.

All acceptance criteria were met in that the Reference Group measure worth was within ±10% design worth and each test group was within ±15% or ±100 pcm design worth.

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

VI. Summary

Compliance with the applicable Technical Specifications was satisfactory.

VII. References

1) *Reload Startup Physics Testing,"* Pre-Operational Number 3200091, Revision 0.

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

3) "St. Lucie Unit 2, Cycle 7 Fuel Reload PC/M-067-292E.

4) *"Initial Criticality,"* Pre-Operational Test Procedure Number 2-3200088, Revision 3.

Figure 1
Unit 2 Cycle 7
Revision 1

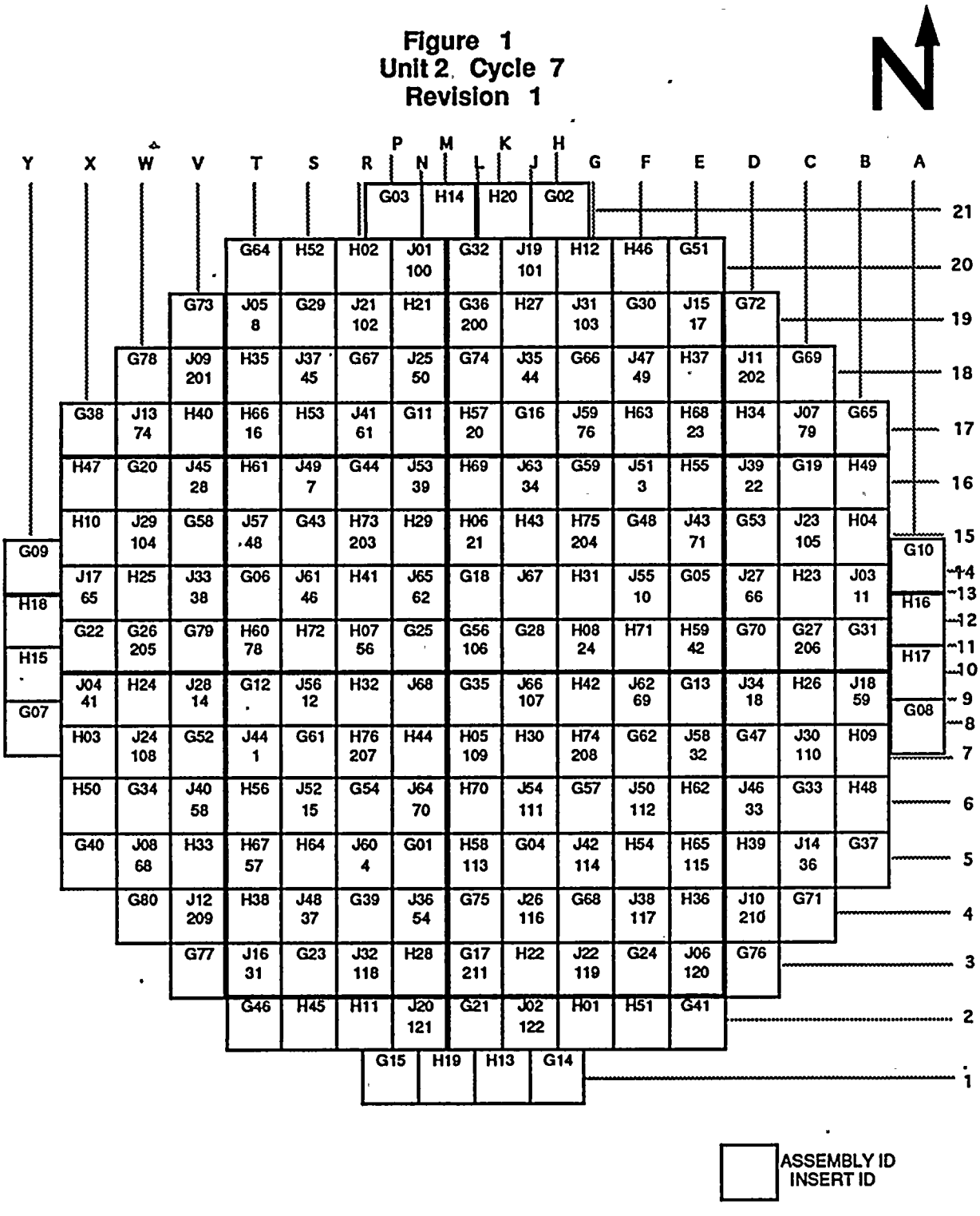

FIGURE 2
WIDE RANGE CHANNEL "B" BORON DILUTION

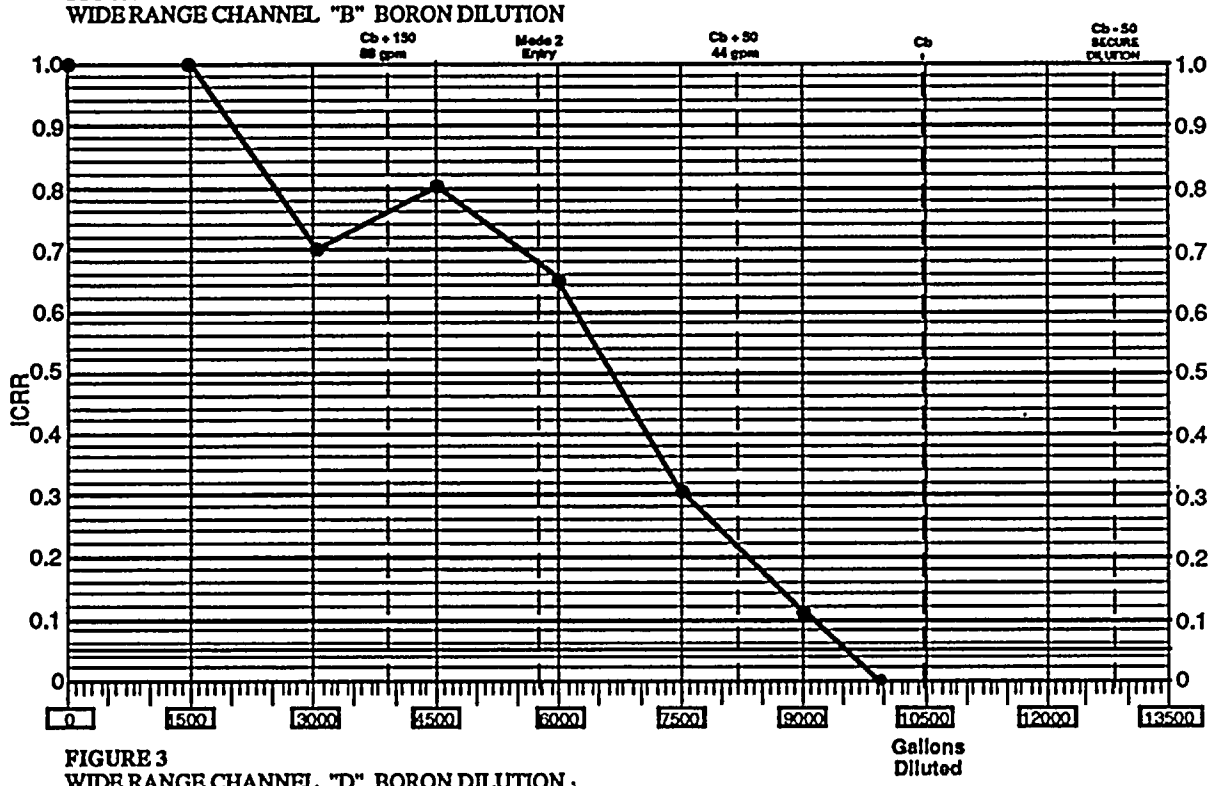

FIGURE 3
WIDE RANGE CHANNEL "D" BORON DILUTION

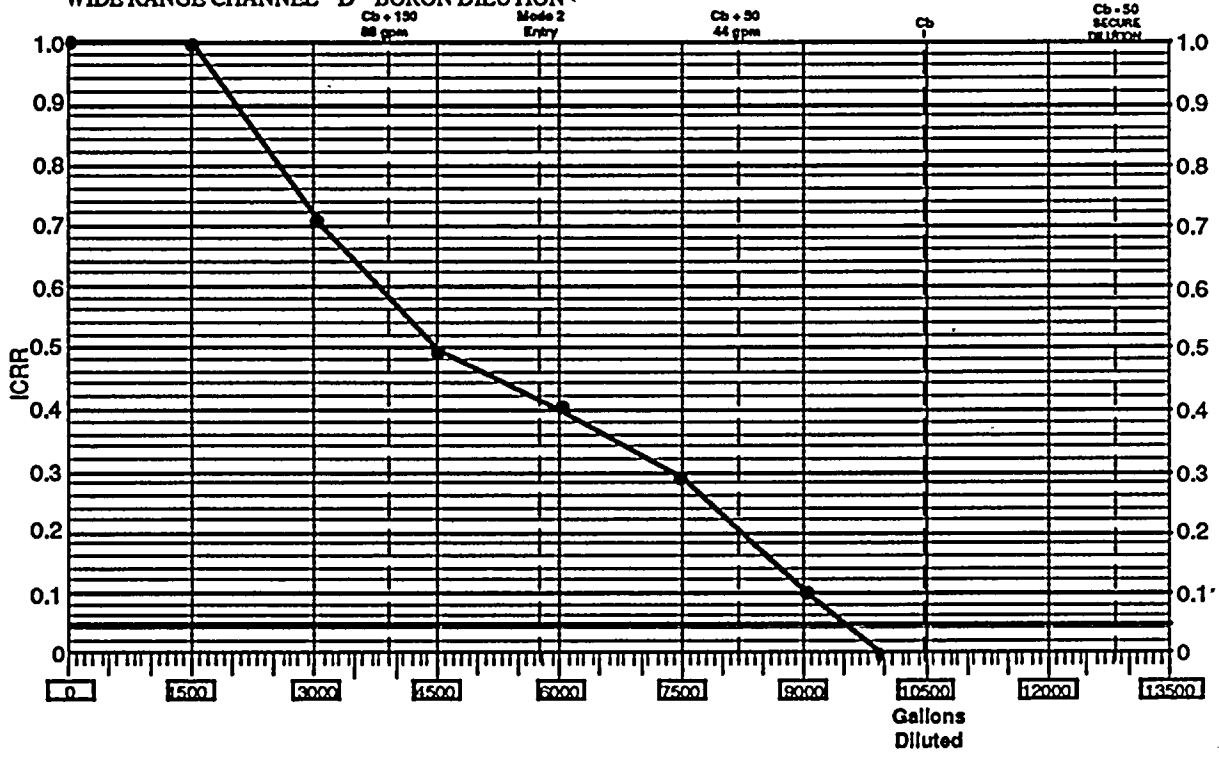

FIGURE 4A
STARTUP CHANNEL "1" BORON DILUTION

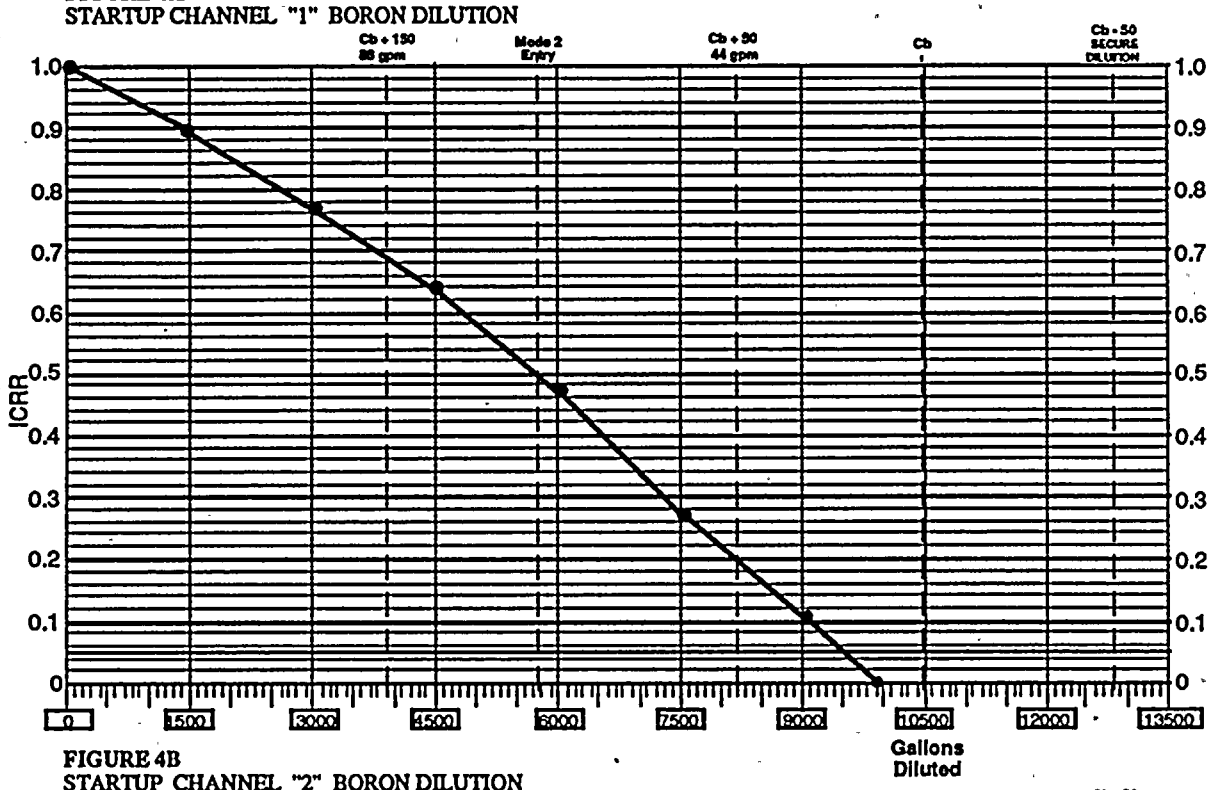

FIGURE 4B
STARTUP CHANNEL "2" BORON DILUTION

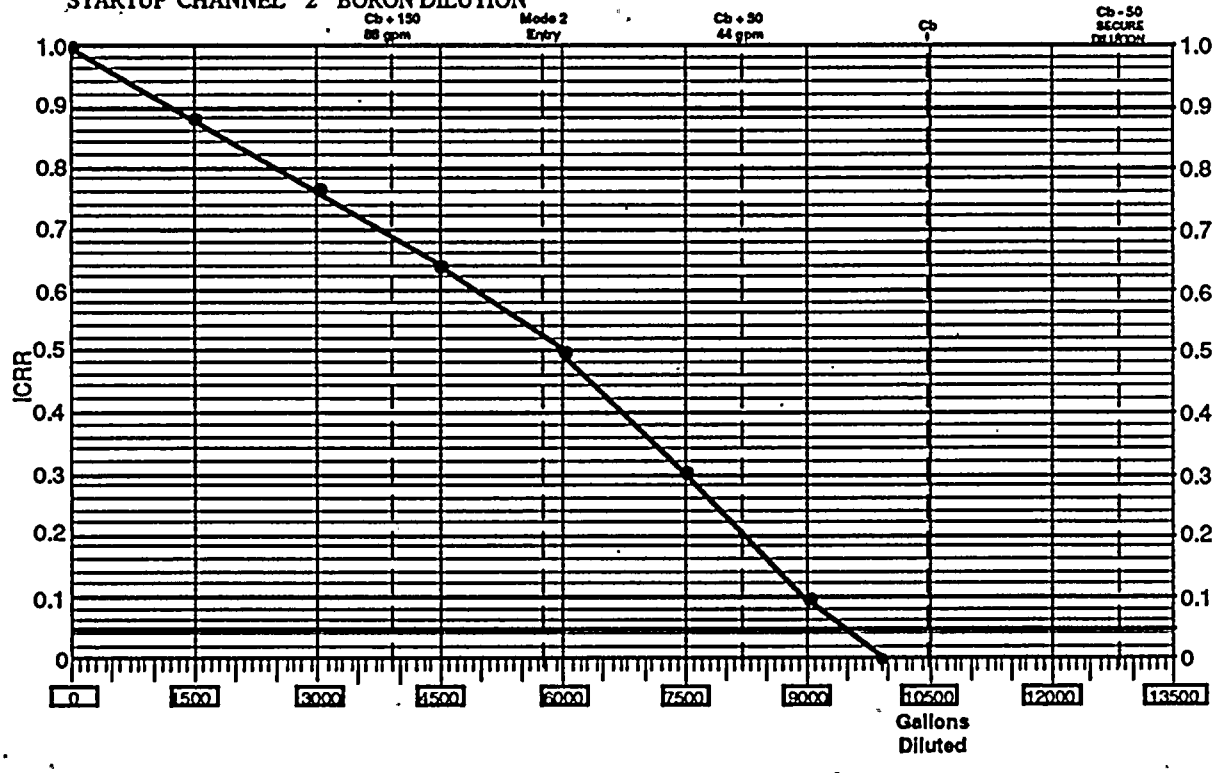

FIGURE 5
POWER DISTRIBUTION COMPARISION WITH DESIGN AT 25% POWER

MEASURE: (CECOR/INPAX) UNIT 2

SNAPSHOT ID #A062692.DAT
POWER LEVEL 27.2 %
EXPOSURE .32 EFPH
CEA POSITION 122"
BORON CONC. 1426 PPM

DESIGN:

DATA SOURCE: F2-92-054
POWER LEVEL 25
EXPOSURE 5 EFPH
CEA POSITION 122"
BORON CONC 1088 PPM

					0.7440 0.6870 0.0570 [34]
				1.2660 1.2460 0.0200 [32]	0.8990 0.8550 0.0440 [33]
			1.1700 1.1090 0.0610 [29]	1.2390 1.2040 0.0350 [30]	1.2740 1.2620 0.0120 [31]
		1.3780 1.3650 0.0130 [25]	1.0990 1.0340 0.0650 [26]	1.3720 1.3530 0.0190 [27]	1.1890 1.1780 0.0110 [28]
	1.1780 1.1650 0.0130 [20]	1.2260 1.2000 0.0260 [21]	1.3830 1.3640 0.0190 [22]	1.1150 1.0730 0.0420 [23]	1.1240 1.0740 0.0500 [24]
1.1820 1.2160 -0.0340 [14]	1.1570 1.1740 -0.0170 [15]	1.3190 1.3300 -0.0110 [16]	1.1410 1.1030 0.0380 [17]	1.3720 1.3490 0.0230 [18]	0.8930 0.8270 0.0660 [19]
0.3830 0.3680 0.0150 [8]	1.0400 1.0630 -0.0230 [9]	0.8540 0.8310 0.0230 [10]	1.3050 1.3110 -0.0060 [11]	1.1960 1.1680 0.0280 [12]	0.8830 0.8180 0.0650 [13]
	0.2680 0.2530 0.0150 [3]	0.5310 0.4990 0.0320 [4]	0.8800 0.8590 0.0210 [5]	1.2370 1.2430 -0.0060 [6]	0.8060 0.7500 0.0560 [7]
			0.3310 0.3060 0.0250 [1]	0.5410 0.5040 0.0370 [2]	

KEY
MEASURED
DESIGN
DELTA [ID]

RMS DEVIATION = 3.5189 %

FIGURE 6
POWER DISTRIBUTION COMPARISION WITH DESIGN AT 50% POWER

MEASURE: (CECOR/INPAX) UNIT 2

SNAPSHOT ID # C062892.DAT
POWER LEVEL 47.31 %
EXPOSURE 9.32 EFPH
CEA POSITION 122"
BORON CONC. 1302

DESIGN:
DATA SOURCE: F2-92-054
POWER LEVEL 47.31 %
EXPOSURE 10.00 EFPH
CEA POSITION 122 "
BORON CONC 1309

						0.7440 0.7340 0.0100 [34]
				1.2650 1.2750 -0.0100 [32]	0.8980 0.8940 0.0040 [33]	
			1.1650 1.1490 0.0160 [29]	1.2350 1.2300 0.0050 [30]	1.2720 1.2820 -0.0100 [31]	
		1.3680 1.3630 0.0050 [25]	1.0890 1.0580 0.0310 [26]	1.3660 1.3650 0.0010 [27]	1.1850 1.1990 -0.0140 [28]	
	1.1670 1.1600 0.0070 [20]	1.2150 1.1980 0.0170 [21]	1.3740 1.3570 0.0170 [22]	1.1090 1.0860 0.0230 [23]	1.1200 1.0970 0.0230 [24]	
1.1760 1.1920 -0.0160 [14]	1.1440 1.1560 -0.0120 [15]	1.3090 1.3070 0.0020 [16]	1.1320 1.0990 0.0330 [17]	1.3670 1.3380 0.0290 [18]	0.8870 0.8490 0.0380 [19]	
0.3790 0.3740 0.0050 [8]	1.0330 1.0440 -0.0110 [9]	0.8460 0.8300 0.0160 [10]	1.2950 1.2790 0.0160 [11]	1.1860 1.1520 0.0340 [12]	0.8760 0.8350 0.0410 [13]	
	0.2710 0.2620 0.0090 [3]	0.5260 0.5070 0.0190 [4]	0.8700 0.8440 0.0260 [5]	1.2250 1.2050 0.0200 [6]	0.7930 0.7520 0.0410 [7]	
			0.3260 0.3100 0.0160 [1]	0.5340 0.5090 0.0250 [2]		

KEY
MEASURED
DESIGN
DELTA ID

RMS DEVIATION = 2.4743 %

FIGURE 7
POWER DISTRIBUTION COMPARISION WITH DESIGN AT 100% POWER

MEASURE: (CECOR/INPAX) UNIT 2

SNAPSHOT ID # A070392.DAT
POWER LEVEL 98.84 %
EXPOSURE 108 EFPH
CEA POSITION ARO
BORON CONC. 1060

DESIGN:
DATA SOURCE: F2-92-054
POWER LEVEL 100%
EXPOSURE 75 EFPH
CEA POSITION ARO
BORON CONC 1088

					0.7600 0.6870 0.0730 [34]
				1.2820 1.2460 0.0360 [32]	0.9110 0.8550 0.0560 [33]
			1.1740 1.1090 0.0650 [29]	1.2470 1.2040 0.0430 [30]	1.2890 1.2620 0.0270 [31]
		1.3680 1.3650 0.0030 [25]	1.0950 1.0340 0.0610 [26]	1.3780 1.3530 0.0250 [27]	1.1980 1.1780 0.0200 [28]
	1.1550 1.1650 -0.0100 [20]	1.2070 1.2000 0.0070 [21]	1.3720 1.3640 0.0080 [22]	1.1100 1.0730 0.0370 [23]	1.1270 1.0740 0.0530 [24]
1.1630 1.2160 -0.0530 [14]	1.1200 1.1740 -0.0540 [15]	1.2930 1.3300 -0.0370 [16]	1.1200 1.1030 0.0170 [17]	1.3640 1.3490 0.0150 [18]	0.9010 0.8270 0.0740 [19]
0.3740 0.3680 0.0060 [8]	1.0210 1.0630 -0.0420 [9]	0.8340 0.8310 0.0030 [10]	1.2780 1.3110 -0.0330 [11]	1.1750 1.1680 0.0070 [12]	0.8700 0.8180 0.0520 [13]
	0.2780 0.2530 0.0250 [3]	0.5180 0.4990 0.0190 [4]	0.8460 0.8590 -0.0130 [5]	1.2080 1.2430 -0.0350 [6]	0.7850 0.7500 0.0350 [7]
			0.3190 0.3060 0.0130 [1]	0.5260 0.5040 0.0220 [2]	

KEY
MEASURED
DESIGN
DELTA [ID]

RMS DEVIATION = 3.7848 %

Table 1

Cycle 7 Reload Sub-batch ID

Sub-Batch	# of Assemb	Enrich.
G	16	4.00
G*	20	4.00
G/	25	4.00/3.60
GX	12	3.60
H	12	4.20
H*	8	4.20/3.80
H/	32	3.80
HX	24	3.80
J	20	4.10
J/	16	3.70
JX	32	3.70

Table 2

Approach to Criticality

Dilution Rate	Init. Boron Conc.	Final Boron Conc.	Dilution Time(min)
132 gpm	1744 ppm	1637 ppm	45
88 gpm	1637 ppm	1537 ppm	49
44 gpm	1537 ppm	1437 ppm	51

Table 3

CEA Group Worth Summary

CEA Group	Measured Worth (pcm)	Design * Worth (pcm)	% Diff.
Ref. Grp.	2079	2085	+.3%
1,2	1810	1851	+2.3%
3,4,5	1538	1555	+1.1%
A	1735	1773	+2.2%
Total	7162	7264	+1.4%

% Diff = (D/M-1)100

* Reference 3