St. Lucie Unit 2 Cycle 6

Startup and Operations Report

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I Introduction

The purpose of this report is to provide a description of the fuel design, core load, and a summary of the startup physics testing performed following refueling. Startup physics testing is performed in accordance with approved Procedures and the ANSI 19.6.1 Standard. The purpose of the testing is to verify 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
   - Isothermal Temperature Coefficient Measurement
   - CEA Worth Measurements

3) Power Ascension Testing.
   - Fuel Assembly loading verfication
   - 50% Power Relative Power Distribution
   - 80% Power Relative Power Distribution
   - 100% Power Relative Power Distribution

II Cycle 6 Fuel Design

The Cycle 6 core shown in Figure 1 consists entirely of fuel manufactured by ASEA Brown Boveri Combustion Engineering (ABB/CE). This reload (Batch "H" fuel) makes up the second batch of debris resistant fuel provided by ABB/CE that uses the long lower endcaps as a means of providing protection against debris induced fretting in the lower end-fitting region. This results in 156 fuel assemblies of this debris resistant design contained in the Cycle 6 core.

The Cycle 6 reload employs a low-leakage design which places burned fuel in all locations along the core periphery.

The 217 fuel assemblies in the Cycle 6 core are comprised of fuel from four batches. Of these, 76 are fresh batch H, 80 are once burnt batch G, 49 are twice burnt batch F, 12 are thrice burnt batch E. A further breakdown of the distinct sub-batches is contained in the following Table.

Fuel Sub-batch Identification

Batch ID	# of Assemb.	Fuel ID	Initial Enrichment
H	12	H01..H12	4.20
H*	8	H13..H20	4.20
H/	32	H21..H52	4.20/3.80
HX	24	H53..H76	3.80
G	16	G01..G16	4.00
G*	20	G17..G36	4.00
G/	32	G37..G68	4.00/3.60
GX	12	G69..G80	3.60
F	16	F01..F16	3.60
F*	20	F17..F36	3.60
F/	12	F37..F48	3.60/3.20
FX	1	F60	3.20
E	4	E01..E03,E05	3.60
E/	4	E29,E37,E39,E40	3.60
E1	4	E66,E69..E71	3.20

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 The objective of this test was to measure the time of insertion from the fully-withdrawn position (UEL) to the 90% inserted position under hot, full-flow conditions.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 2.81 seconds with maximum and minimum times of 3.00 seconds and 2.60 seconds respectively. All drop times were within the requirements of Technical Specifications 3.1.3.4.

III Approach to Criticality

The approach to criticality involved diluting from a non-critical boron concentration of 2004 ppm to a predicted critical boron concentration of 1737 ppm. The actual critical concentration was observed to be 1744 ppm. Inverse Countrate ratio plots were maintained during the dilution process using Startup Range channels 1 and 2. Refer to Figure 2 for data. A plot of boron concentration versus dilution time is provided in Figure 3. The following Table summarizes the dilution rates and times as well as beginning and ending boron concentrations.

Approach to Criticality

Diltuion Rate	Initial Boron Concentration	Final Boron Concentration	Dilution Time
132 gpm	2004 ppm		34 minutes
88 gpm		1744 ppm	53 minutes

87 minutes

Initial criticality for St. Lucie Unit 2, Cycle 6 was achieved on November 28, 1990 at 1800 with CEA group 5 at 55 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 6 were the following:

1) Reactivity Computer Checkout
   - Test Power Range Determination
   - Reactor Period Measurements
2) All Rods Out Critical Boron Concentration
3) Isothermal Temperature Coefficient Measurement
4) CEA Group Rod Worth Measurements
   - Boration/Dilution - Reference Group (Group B)
   - Rod Swap - Remaining CEA Groups

These tests were performed in accordance with approved Operating Procedures, and based upon the acceptance criteria of ANSI 19.6.1 unless superseded by the requirements of St. Lucie Unit 2 Technical Specifications.

Reactivity Computer proper operation was verified through the performance of two tests. In the first, power is elevated sufficiently high to ensure maximum sensitivity of the instrument while ensuring adequate margin to the point of adding heat. The second test verifies the reactivity computer's 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.

The All Rod's Out Critical Boron Concentration was performed. The measured value was 1783.8 ppm which compared favorably with the predicted value of 1784 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 3.76 pcm/°F which fell well within the acceptance criteria of ± 2.0 pcm/°F of the design MTC of 3.58 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 worth. 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, one at a time. For the Cycle 6 testing a new technique of grouping together one or more CEA groups into Higher Worth Groups (Supergroup) was performed. CEA groups 3, 4, &5 were grouped together, Groups 1 & 2 were grouped together, and finally Group A was tested by itself. A comparison of the measured and design CEA reactivity worth is provided in the following Table.

CEA Rod Worth Summary

CEA Group	Measured worth	Predicted worth	% Difference (D-M/M)*100
Reference	2101.7	2124	1.06%
S/D B			
3, 4, &5	1641.7	1636.2	0.30%
S/D A	1616.7	1653	-2.24%
1 & 2	1681.7	1769	-5.19%
Total Worth	7041.8	7182.2	-1.99%

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 worth, 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.

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 50%, 80%, 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) *"St. Lucie Unit 2, Cycle 6 Zero Power Testing Information"*, F2-90-059, dated November 1, 1990.

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

3) *"St. Lucie Unit 2 Cycle 6 Fuel Cycle Design Report"*, F2-90-015, dated April 9, 1990.

4) Operating Procedure OP 0030221 "Unit 2 Initial Criticality Following Refueling", Revision 12, COMPLETED.

5) Operating Procedure OP 0110052 "Zero Power Physics Testing After Reload", Revision 10, COMPLETED.

6) Operating Procedure OP 0010133 "Reactor Engineering Power Ascension Program", Revision 10, COMPLETED.

Figure 1

St. Lucie Unit 2 Cycle 6 Core Map

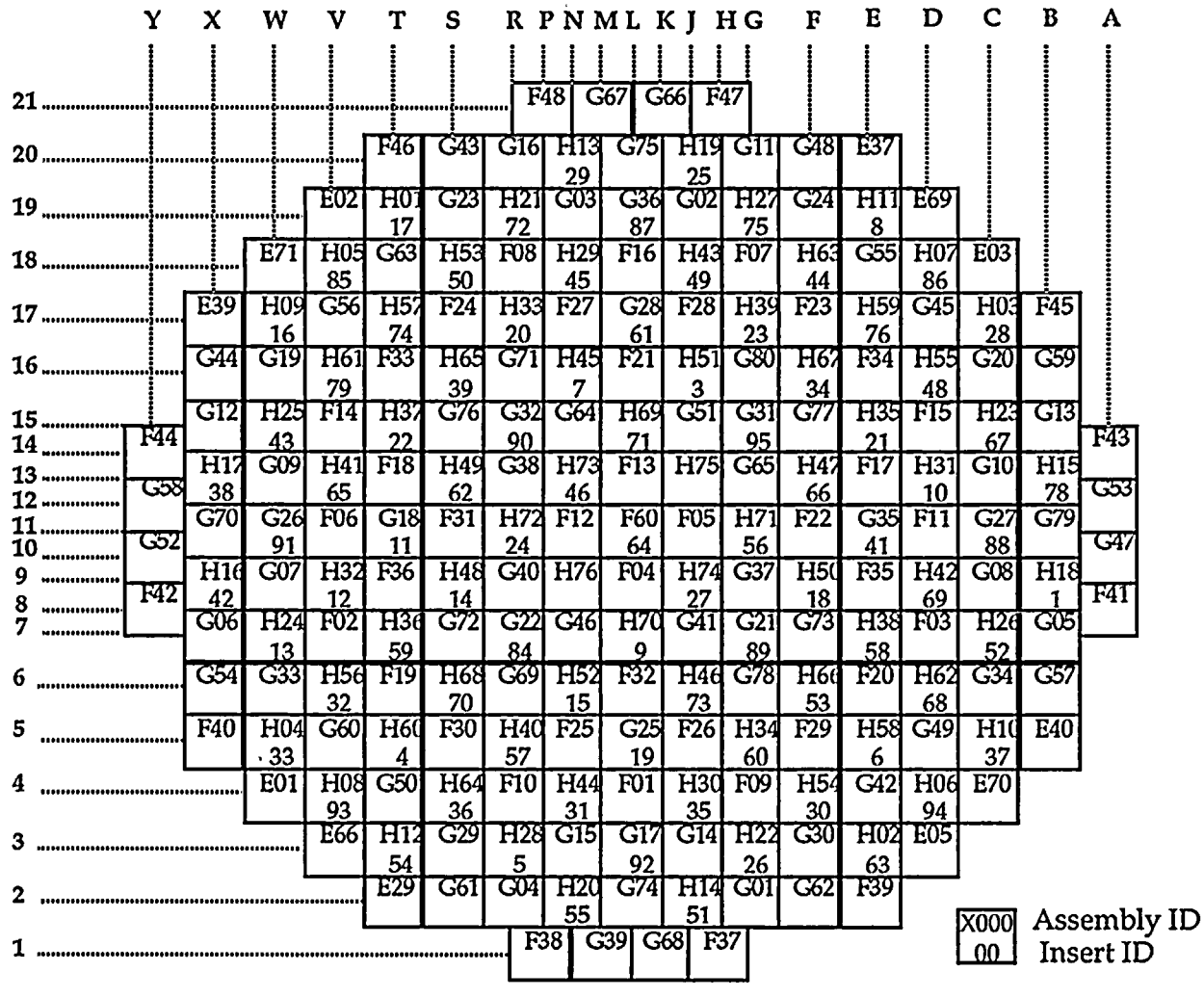

Figure 2

Inverse Countrate Startup Channels 1 and 2

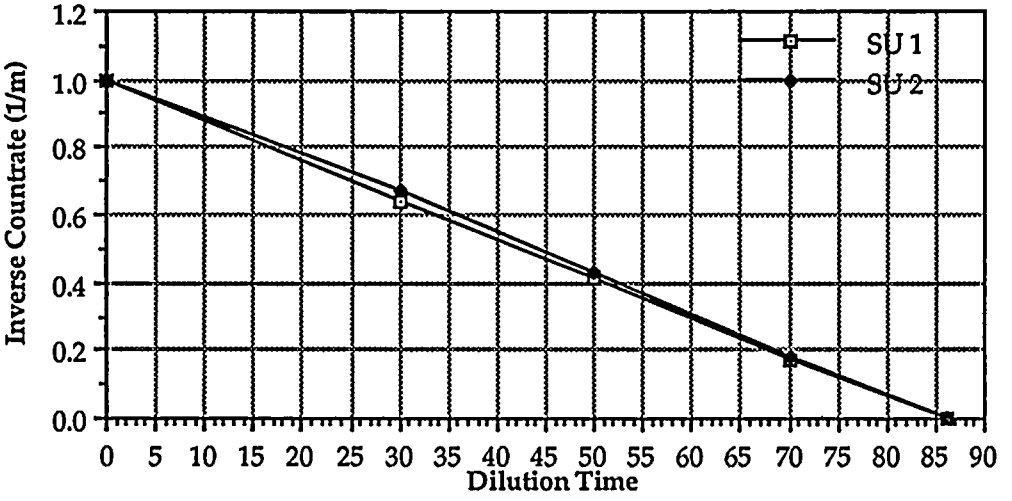

Figure 3

RCS Boron vs. Dilution Time

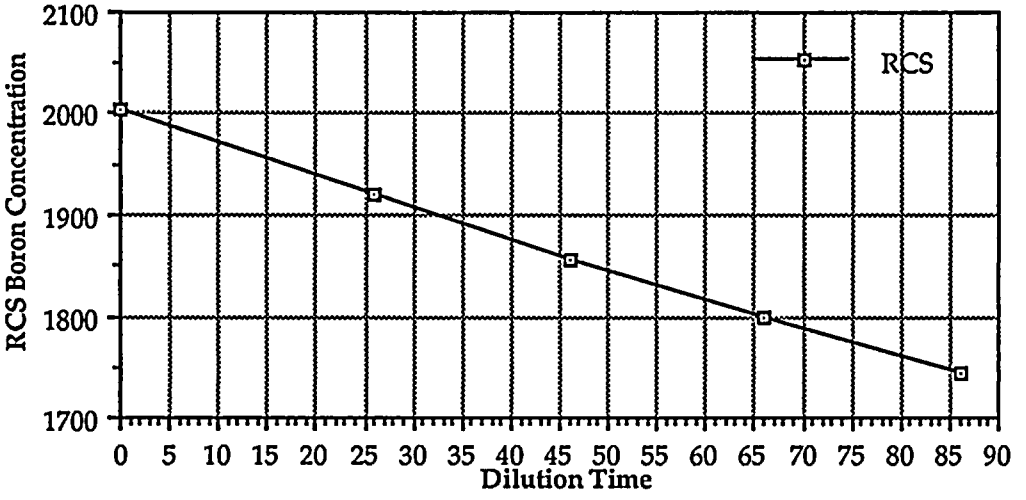

Figure 4

Integral Worth Curve - Reference Group (S/D Group B)

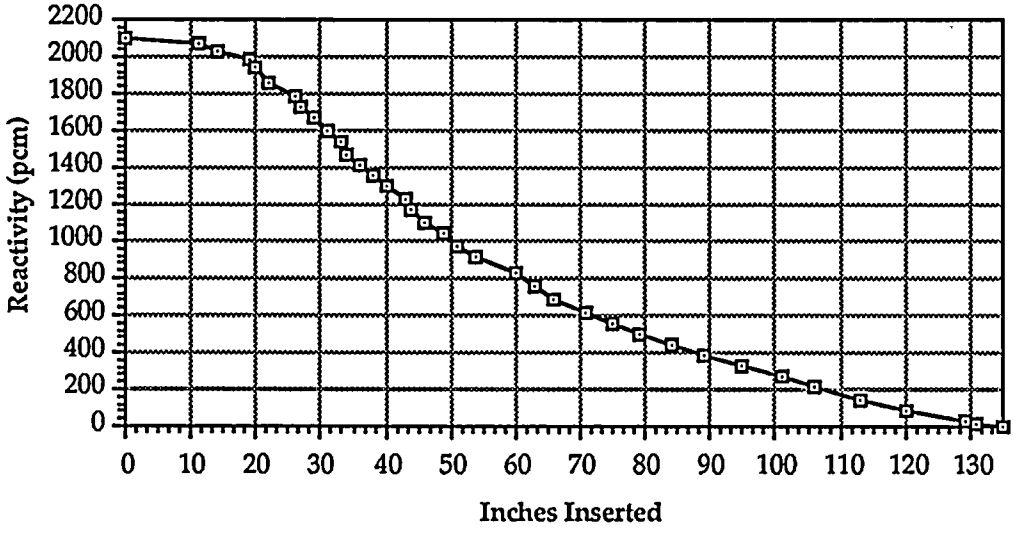

Figure 5
Power Distribution - 50% Power

MEASURE: (CECOR/INPAX)			DESIGN:		
SNAPSHOT ID #	B120690.DAT		DATA SOURCE:		
POWER LEVEL	49.05	%	POWER LEVEL	50	%
EXPOSURE	13.77	EFPH	EXPOSURE	10	EFPH
CEA POSITION	119	"	CEA POSITION	122	"
BORON CONC	1567	PPM	BORON CONC	1568	PPM

					0.6550 0.6190 0.0360 [34]
				1.2660 1.2540 0.0120 [32]	0.8290 0.8040 0.0250 [33]
			1.2330 1.2170 0.0160 [29]	1.1660 1.1700 -0.0040 [30]	1.3170 1.3170 0.0000 [31]
		1.3460 1.3460 0.0000 [25]	1.1500 1.1290 0.0210 [26]	1.3870 1.3820 0.0050 [27]	0.9160 0.8870 0.0290 [28]
	1.3130 1.3290 -0.0160 [20]	0.9560 0.9360 0.0200 [21]	1.3910 1.3790 0.0120 [22]	0.9450 0.8890 0.0560 [23]	1.0930 1.0510 0.0420 [24]
1.0830 1.1060 -0.0230 [14]	1.1030 1.1100 -0.0070 [15]	1.3320 1.3340 -0.0020 [16]	0.9640 0.9460 0.0180 [17]	1.4180 1.4050 0.0130 [18]	1.0040 0.9810 0.0230 [19]
0.3320 0.3350 -0.0030 [8]	1.0280 1.0450 -0.0170 [9]	1.0760 1.0670 0.0090 [10]	1.3780 1.4000 -0.0220 [11]	1.2680 1.2750 -0.0070 [12]	1.2100 1.2030 0.0070 [13]
	0.2440 0.2550 -0.0110 [3]	0.5420 0.5350 0.0070 [4]	0.8530 0.8600 -0.0070 [5]	1.1820 1.2070 -0.0250 [6]	0.9060 0.9050 0.0010 [7]
			0.2620 0.2590 0.0030 [1]	0.4460 0.4380 0.0080 [2]	

KEY
MEASURED
DESIGN
DELTA [D]

RMS DEVIATION = 1.9423 %

Figure 6
Power Distribution - 80% Power

MEASURE: (CECOR/INPAX)			DESIGN:		
SNAPSHOT ID #	A120990		DATA SOURCE:		
POWER LEVEL	75.01	%	POWER LEVEL	80.00	%
EXPOSURE	43.46	EFPH	EXPOSURE	30.00	EFPH
CEA POSITION	131	"	CEA POSITION	131	"
BORON CONC	1389	PPM	BORON CONC	1420	PPM

					0.6670 0.6480 0.0190 [34]
				1.2830 1.2760 0.0070 [32]	0.8410 0.8300 0.0110 [33]
			1.2460 1.2430 0.0030 [29]	1.1800 1.1890 -0.0090 [30]	1.3310 1.3340 -0.0030 [31]
		1.3550 1.3520 0.0030 [25]	1.1600 1.1440 0.0160 [26]	1.4000 1.3910 0.0090 [27]	0.9240 0.9060 0.0180 [28]
	1.3140 1.3200 -0.0060 [20]	0.9640 0.9430 0.0210 [21]	1.3990 1.3770 0.0220 [22]	0.9540 0.9020 0.0520 [23]	1.0990 1.0660 0.0330 [24]
1.0820 1.1010 -0.0190 [14]	1.1020 1.1020 0.0000 [15]	1.3300 1.3210 0.0090 [16]	0.9620 0.9460 0.0160 [17]	1.4130 1.3930 0.0200 [18]	1.0010 0.9860 0.0150 [19]
0.3360 0.3400 -0.0040 [8]	1.0240 1.0330 -0.0090 [9]	1.0660 1.0550 0.0110 [10]	1.3660 1.3720 -0.0060 [11]	1.2500 1.2560 -0.0060 [12]	1.1980 1.2010 -0.0030 [13]
	0.2430 0.2590 -0.0160 [3]	0.5380 0.5360 0.0020 [4]	0.8460 0.8500 -0.0040 [5]	1.1710 1.1850 -0.0140 [6]	0.8980 0.9020 -0.0040 [7]
			0.2630 0.2620 0.0010 [1]	0.4430 0.4430 0.0000 [2]	

KEY
MEASURED
DESIGN
DELTA [D]

RMS DEVIATION = 1.5497 %

Figure 7
Power Distribution - 100% Power

MEASURE: (CECOR/INPAX)			DESIGN:		
SNAPSHOT ID #	ACDT		DATA SOURCE:		
POWER LEVEL	98	%	POWER LEVEL	100	%
EXPOSURE	90	EFPH	EXPOSURE	75	EFPH
CEA POSITION	136	"	CEA POSITION	136	"
BORON CONC	1355	PPM	BORON CONC	1344	PPM

					0.6760 0.6670 0.0090 [34]
				1.2980 1.2910 0.0070 [32]	0.8500 0.8480 0.0020 [33]
			1.2550 1.2590 -0.0040 [29]	1.1900 1.2030 -0.0130 [30]	1.3420 1.3460 -0.0040 [31]
		1.3600 1.3560 0.0040 [25]	1.1660 1.1550 0.0110 [26]	1.4110 1.3980 0.0130 [27]	0.9300 0.9200 0.0100 [28]
	1.3120 1.3150 -0.0030 [20]	0.9680 0.9480 0.0200 [21]	1.4060 1.3760 0.0300 [22]	0.9610 0.9110 0.0500 [23]	1.1030 1.0760 0.0270 [24]
1.0800 1.0930 -0.0130 [14]	1.1010 1.0960 0.0050 [15]	1.3290 1.3130 0.0160 [16]	0.9610 0.9470 0.0140 [17]	1.4110 1.3850 0.0260 [18]	0.9990 0.9900 0.0090 [19]
0.3370 0.3410 -0.0040 [8]	1.0220 1.0240 -0.0020 [9]	1.0610 1.0470 0.0140 [10]	1.3600 1.3550 0.0050 [11]	1.2390 1.2440 -0.0050 [12]	1.1900 1.1980 -0.0080 [13]
	0.2420 0.2610 -0.0190 [3]	0.5350 0.5370 -0.0020 [4]	0.8420 0.8430 -0.0010 [5]	1.1640 1.1720 -0.0080 [6]	0.8930 0.9000 -0.0070 [7]
			0.2630 0.2640 -0.0010 [1]	0.4400 0.4440 -0.0040 [2]	

KEY
MEASURED
DESIGN
DELTA [D]

RMS DEVIATION = 1.4860 %