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

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

Re: St. Lucie Unit 1
Docket No. 50-335
Cycle 17 Startup Physics Testing Report

Pursuant to St. Lucie Unit 1 Technical Specification 6.9.1.1, the enclosed summary report of plant startup and power escalation testing for Cycle 17 is hereby submitted.

Please contact us should you have any questions regarding this information.

Very truly yours,

Donald E. Jernigan
Vice President
St. Lucie Plant

Enclosure: St. Lucie Unit 1, Cycle 17 Startup Physics Testing Report

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

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ST. LUCIE UNIT 1
CYCLE 17

STARTUP PHYSICS TESTING REPORT

(D/RE/930584-R0)

ST. LUCIE UNIT 1, CYCLE 17
STARTUP TESTING REPORT

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St. Lucie Unit 1, Cycle 17
Startup Physics Testing Report

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St. Lucie Unit 1, Cycle 17
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 1 following the cycle 17 refueling outage. 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

During cycle 15 operation, an increase in iodine chemistry trending indicated the failure of one or more fuel pins. Fuel sipping and ultrasonic test (UT) inspections were performed during the cycle 16 refueling outage. This testing confirmed the presence of failed rods in fuel assemblies residing in very low power locations in the cycle 15 core. Of these failures, 7 of 8 assemblies with failed fuel rods were scheduled for discharge to the spent fuel pool. The remaining assembly with a failed fuel rod was repaired for re-use in the cycle 16 loading pattern. The root cause of the failures was determined by the fuel vendor to be grid-to-rod fretting, this mechanism was expected to cause additional failures during cycle 16 operation.

Cycle 16 chemistry trending across the cycle, supported the prediction made at the conclusion of the cycle 15 fuel inspection and repair campaign and pointed to as many as 9 failures residing in low power fuel. Isotopic ratios suggested the failures were most likely to exist in fuel scheduled to be discharged to the spent fuel pool.

Following shutdown to the cycle 17 refueling outage, fuel inspections were performed utilizing refueling machine in-mast sipping as in the cycle 16 outage. Nine fuel assemblies were identified with possible fuel failures [1]. No fuel containing any identified defects was returned to the core for additional operation.

To mitigate future fuel pin failures of the type seen in cycles 15 and 16, a fuel assembly design employing modified spacer grids was loaded for cycle 17 operation.

This Cycle 17 Startup Report is being submitted in accordance with Technical Specification 6.9.1.1 as the result of the use of fuel assemblies whose design has been modified to include:

1) High thermal performance (HTP) spacer grids,
2) Use of the FuelGuard lower tie-plate for debris resistance enhancement
3) Use of welded spacer-grid-to-guide-tube cage design

4) Reduction in upper end fitting center post height by 0.125" to accommodate higher fuel burn-up,
5) Reduction in lower end-cap length by 0.232" (to maintain the active fuel column at the same axial elevation),
6) Central zone region of 113.9" in length for gadolinia rods (as compared to 116.54" for cycle 16 fuel) with upper and lower cutback regions of 11.4", and
7) Increase in pellet density to 95.35% of theoretical density [2].

The test data collected during startup and summarized in this report indicates there were no observable changes in neutronic or thermal-hydraulic parameters and thus there was no significant impact to the performance of the unit. The test data satisfied all acceptance criteria and demonstrated general conformance to predicted performance.

II. Cycle 17 Fuel Inspection

During the refueling outage, core-wide sipping of fuel used in cycle 16 was performed via a wet sipping system installed in the refueling machine mast. In this inspection campaign, nine fuel assemblies were identified with possible fuel failures. All were thrice-burned batch T assemblies scheduled to be discharged (T-31, T-38, T-39, T-57, T-78, T-81, T-85, and T-90). The nine T-batch assemblies were all on the core periphery in low power locations during cycle 16 operation.

None of the assemblies determined to contain fuel defects were returned to the core for operation in cycle 17.

III. Cycle 17 Fuel Design

The cycle 17 reload consists entirely of fuel manufactured by the Framatome A.N.P. Corporation (FANP) [previously Siemens Power Corporation (SPC)]. The 217 assemblies of the cycle 17 core are comprised of fuel from six batches. Of these, 72 are fresh assemblies (Batch Y), 76 are once burned batch X assemblies, 69 are twice-burned assemblies from batches U, T, S and R. Table 1 provides enrichment information for the cycle 17 reload sub-batches. The design supports a cycle length between 12,074 EFPH and 12,500 EFPH based on a cycle 16 exposure of 11,950 to 12,675 EFPH.

This is the eleventh cycle of operation utilizing gadolinium in the form of Gd_2O_3, as a burnable neutron absorber. Batch Y assemblies consist of enriched UO_2 fuel rods and UO_2-Gd_2O_3 bearing rods (gadolinia burnable absorber fuel rods). UO_2 fuel rods have a central zone enrichment of 3.6 w/o to 4.4 w/o U_{235}, whereas the UO_2-Gd_2O_3 rods have a central zone of 6 to 8 w/o Gd_2O_3 dispersed in a 2.4 w/o to 2.8 w/o U_{235} carrier. The total batch burnable absorber requirement for fresh fuel is 720 Gd_2O_3 rods.

The entire cycle 17 fuel load, batches R, S, T, U, X and Y, consist of the debris resistant fuel assembly design first implemented in cycle 11. This design has long fuel rod lower end caps, which provides protection against debris-induced-fretting in the lower end-fitting region.

Several major mechanical design changes have been implemented in the batch Y fuel. The purposes of these changes are to minimize the potential for grid-to-rod-fretting several to what has been experienced at Unit 1 over the past several cycles, and to transition to FANP's improved standard product. The changes made are:

1) Addition of high thermal performance (HTP) spacer grids, to provide improved grid-rod fretting resistance and additional operating margin to thermal limits.

2) Addition of the FuelGuard bottom end fitting which provides debris-filtering capabilities beyond that provided by the previous lower end fitting design.
3) Use of welded spacer-grid-to-guide-tube cage design instead of the previous snap on attachment. This should improve resistance to fuel assembly bowing due to an increase in assembly stiffness.
4) Reduction in upper end fitting center post height by 0.125" to allow for fuel assembly growth associated with higher burn-ups.
5) A slight reduction in the lower end-cap length by 0.232" to offset the small increase in height of the FuelGuard lower end fitting while still maintaining the active fuel column at the same axial elevation,
6) Increase in pellet density to 95.35% of theoretical density to improve fuel cycle economics and,
7) Central zone region of 113.9" in length for gadolinia rods (as compared to 116.54" for cycle 16 fuel) with upper and lower cutback regions of 11.4".

The cycle 17 core map is represented in Figure 1. The assembly serial numbers and control element assembly's (CEA) serial numbers are given for each core location. A low-leakage fuel management scheme similar to that of Cycle 16 is utilized in the Cycle 17 core design. There are no vessel fluence reduction assemblies (VFRA) in the Cycle 17 core, similar to Cycle 16 core design. The Cycle 17 core-loading pattern is 90 degrees rotationally symmetric.

A core design restriction to have the same design length assemblies under dual CEAs was implemented. The new fuel assembly design will have a 0.125" shorter length to accommodate higher assembly burn-up (improved fuel cycle economies). This is implemented to prevent the potential for mis-latching a dual CEA due to assembly height differences.

IV. CEA Drop Time Testing

Following the core reload and prior to the approach to criticality, CEA drop time testing was performed. The purpose of this test is to demonstrate that the reactivity insertion as a function of time is bounded by the CEA scram worth curve assumed in the FSAR analysis.

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 2.47 seconds with maximum and minimum times of 2.54 seconds and 2.24 seconds, respectively. All drop times were within the 3.1 second requirement of Technical Specification 3.1.3.4 and the reload PC/M 00047 requirements [11].

V. Approach to Criticality

The approach to criticality involved diluting from a non-critical boron concentration of 1743 PPM to a predicted critical boron concentration of 1540 PPM. Inverse count rate ratio (ICRR) plots were maintained during the period of dilution using wide range Nuclear Instrument 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 1, Cycle 17, was achieved on April 28, 2001 at 1439 with CEA group 7 at 120 inches withdrawn and all other CEAs at the all-rods-out (ARO) position. The actual critical concentration was measured to be 1533 PPM.

VI. Zero Power Physics Testing

To ensure that the operating characteristics of the cycle 17 core were consistent with the design predictions, the following tests were performed:

1) Reactivity Computer Checkout;
2) All rods out (ARO) Critical Boron Concentration;
3) Isothermal Temperature Coefficient Measurement; and
4) CEA Group Rod Worth Measurements.

Proper operation of the reactivity computer was verified through the performance of two tests. In the first, reactor power was 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 the 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 in the reload PC/M 00047. Satisfactory agreement was obtained.

The measurement of the all-rods-out (ARO) critical boron concentration was performed. The measured value was 1540 PPM, which compared favorably to the design value of 1546 PPM [7]. This was within the acceptance limits of ± 50 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 2.1 pcm/°F which fell well within the acceptance criteria of ± 2.0 pcm/°F of the design MTC of 1.591 pcm/°F. This satisfies the Unit 1 Technical Specification, which states that the MTC shall be less positive than 7.0 pcm/°F when reactor power is less than 70% 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 applies to the measurements made:

1) The measured value of each test group, or supergroup measured, is within ±15% or ±100 pcm of its corresponding design CEA worths, whichever is greater and,

2) The 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.

VII. 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 98% rated thermal power.

A summary of the flux maps at the 30%, 45% and 98% power plateaus 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 root mean square (RMS) value of the power deviation be less than or equal to 5%. In addition, for the 30% 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 30% power case. These criteria were satisfied.

When the unit reached full power, a calorimetric was performed in accordance with St. Lucie Unit 1 Operating Procedure 1-0120051 for the purpose of calculating the RCS flow rate. The RCS flow rate was determined to have increased slightly from 409,240 gpm (measured in cycle 16) to 410,912 gpm in cycle 17 [8]. This measured flow was well in excess of the Technical Specification minimum of 365,000 gpm and also well within the flow measurement uncertainty.

Within seven effective full power days of attaining the equilibrium value of 100% power, a hot full power (HFP) MTC test was performed by maintaining power constant and varying temperature. The CEA Lead Bank 7 was operated to permit compensation of the resulting reactivity changes. The HFP MTC was measured to be –6.12 pcm/°F. This satisfied the acceptance criteria to verify compliance with Technical Specification 3.1.1.4 to have a measured MTC less positive than +2.0 pcm/°F while thermal power is greater than 70%. The power coefficient was not measured.

VIII. Summary

Compliance with the applicable Unit 1 Technical Specifications was satisfactory and all acceptance criteria were met. The physics and thermal-hydraulic performance test data satisfied all acceptance criteria and demonstrated general conformance to predicted performance.

IX. References

1) Letter, Westinghouse Electric Co. Nuclear Services, Eric Burnett to Ash Pell, Dated April 19, 2001, *TELESCOPE FUEL SIPPING: Sipping Report and Findings"*

2) St. Lucie Unit 1 Cycle 17 Reload PC/M #00047, Rev. 1, Page 19 of 53.

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

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

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

6) St. Lucie Unit 1 Technical Specifications

7) St. Lucie Unit 1 Cycle 17 Reload PC/M #00047, Attachment 16

8) *"RCS Flow Determination By Calorimetric Procedure,"* St. Lucie Unit 1 Operating Procedure 1-0120051

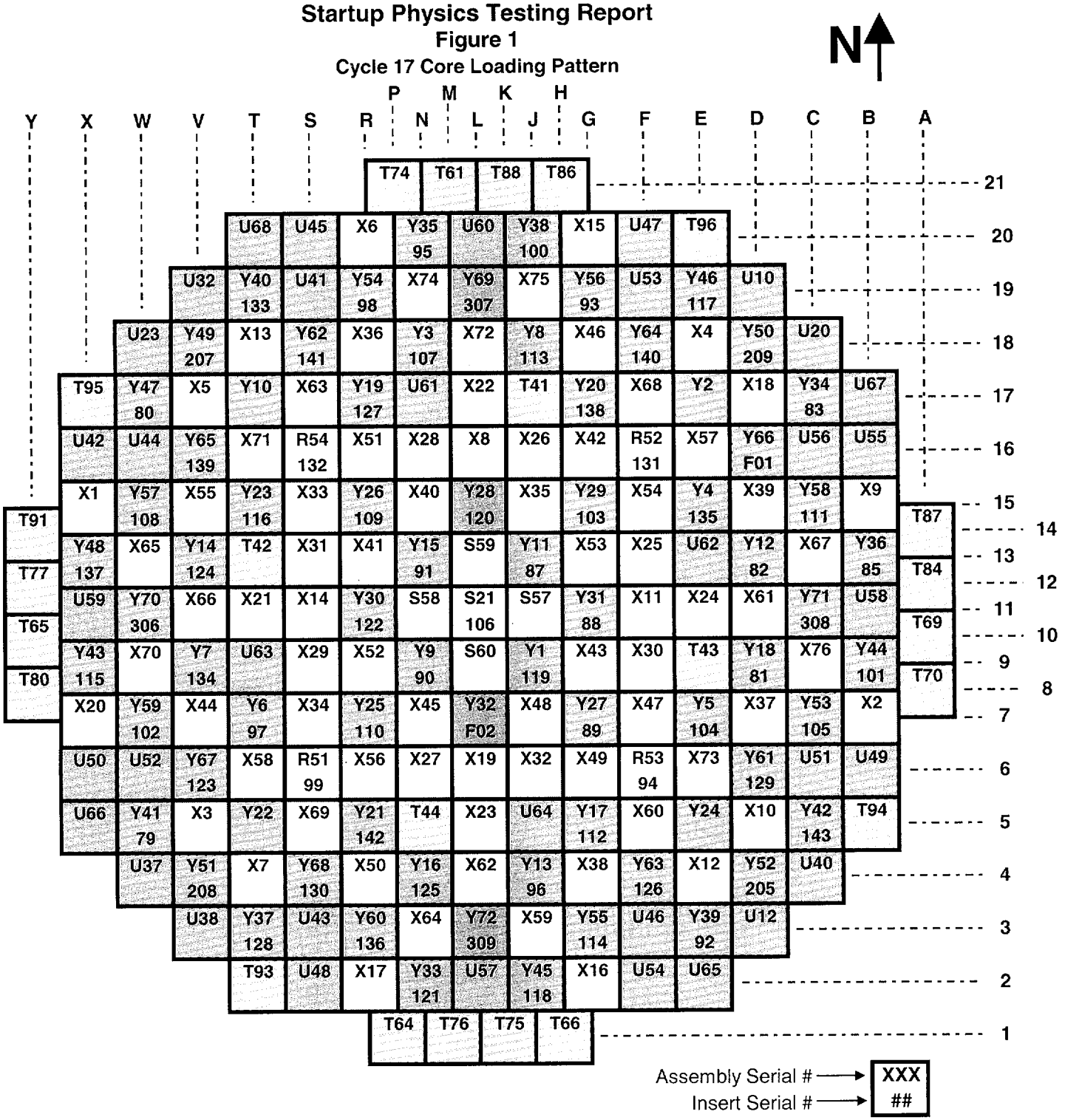
9) St. Lucie Unit 1 Cycle 17 Reload PC/M #00047, Rev. 1, Attachment 2, Page 50 of 215, Figure 4.3-47.

10) *"At Power Determination of Moderator Temperature Coefficient and Power Coefficient,"* Operating Procedure 3200051

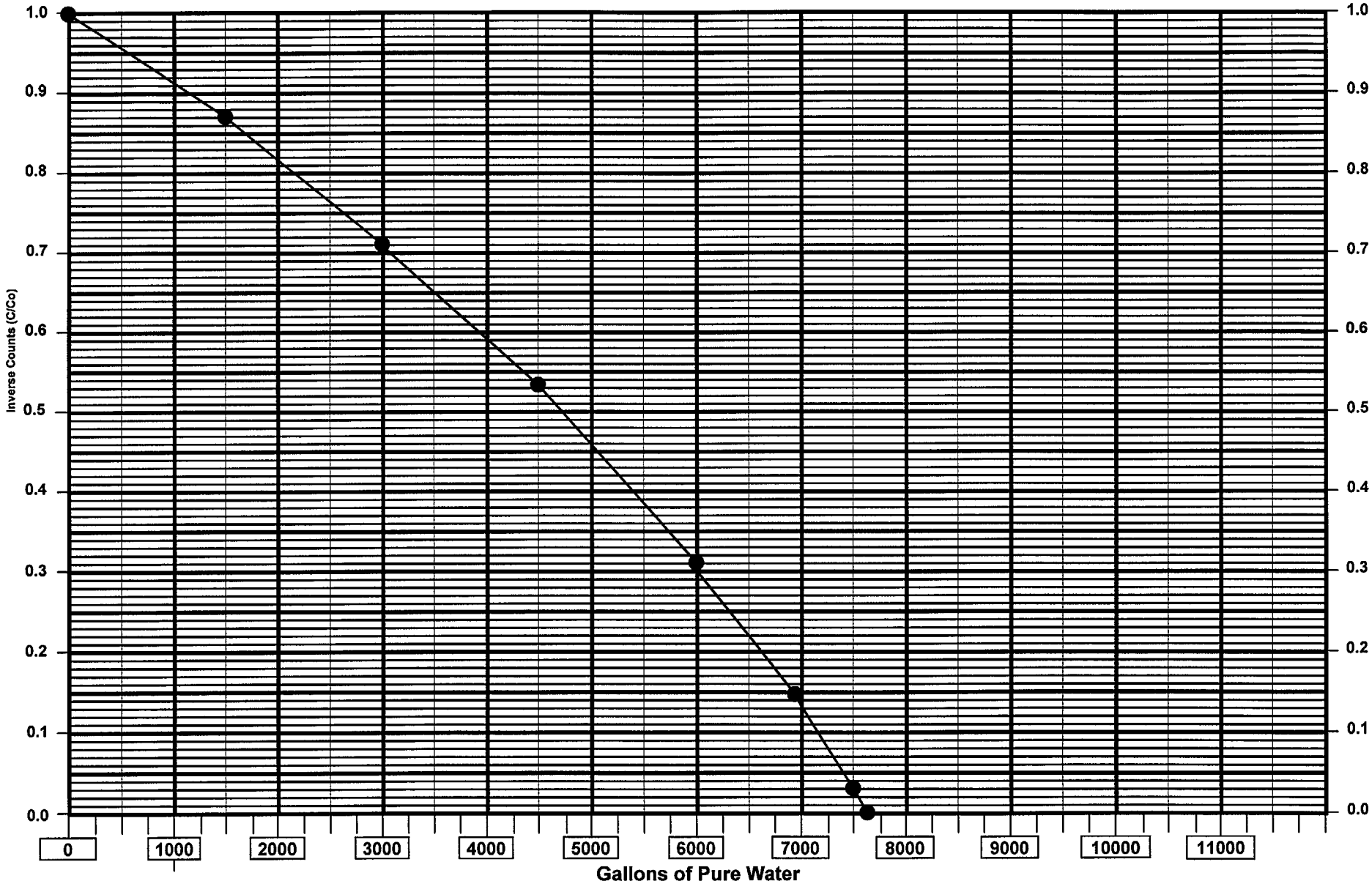
11) *"Periodic Rod Drop Time Test and CEA Position Functional Test,"* Operating Procedure 1-0110054

12) St. Lucie Unit 1 Cycle 17 Reload PC/M #00047, Rev. 1, Attachment 1, Page 2 of 29, Table 1

St. Lucie Unit 1, Cycle 17
Startup Physics Testing Report
Figure 1
Cycle 17 Core Loading Pattern



St. Lucie Unit 1, Cycle 17
Startup Physics Testing Report
Figure 2
Inverse Count Ratio Plot - Channel B



St. Lucie Unit 1, Cycle 17
Startup Physics Testing Report
Figure 3
Inverse Count Ratio Plot - Channel D

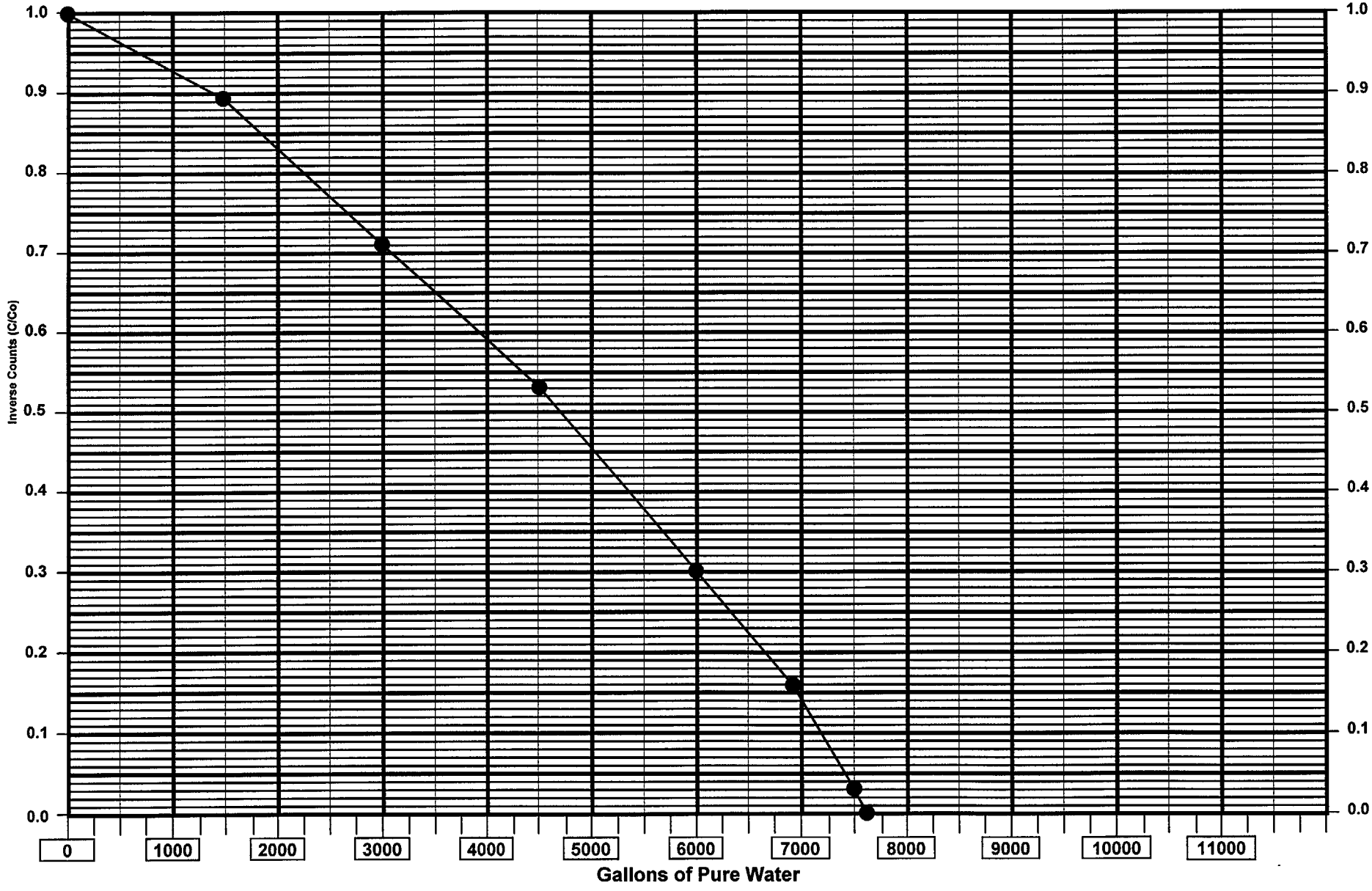


Figure 4

Power Distribution - 30% Power

Measured:	BEACON	Design:
Source	ts1_043001_2246	ts1_043001_2246
Power Level	29.1%	29.1%
Exposure	3.5 EFPH	3.5 EFPH
CEA Position	122	122
Boron Conc.	1430	1430

N

Box #	Measured	Design	Delta	% Diff.
217	0.250	0.262	-0.012	-4.8
216	0.290	0.298	-0.008	-2.8
215	0.290	0.299	-0.009	-3.1
214	0.250	0.262	-0.012	-4.8
213	0.240	0.248	-0.008	-3.3
212	0.350	0.360	-0.010	-2.9
211	0.780	0.799	-0.019	-2.4
210	1.220	1.241	-0.021	-1.7
209	0.740	0.749	-0.009	-1.2
208	1.220	1.242	-0.022	-1.8
207	0.780	0.798	-0.018	-2.3
206	0.350	0.358	-0.008	-2.3
205	0.240	0.248	-0.008	-3.3
204	0.370	0.385	-0.015	-4.1
203	1.060	1.098	-0.038	-3.6
202	0.750	0.762	-0.012	-1.6
201	1.260	1.268	-0.008	-0.6
200	1.260	1.267	-0.007	-0.6
199	1.310	1.311	-0.001	-0.1
198	1.260	1.265	-0.005	-0.4
197	1.250	1.264	-0.014	-1.1
196	0.750	0.759	-0.009	-1.2
195	1.060	1.095	-0.035	-3.3
194	0.370	0.384	-0.014	-3.8
193	0.370	0.384	-0.014	-3.8
192	1.160	1.204	-0.044	-3.8
191	1.280	1.308	-0.028	-2.2
190	1.300	1.311	-0.011	-0.8
189	1.270	1.269	0.001	0.1
188	1.420	1.405	0.015	1.1
187	1.350	1.323	0.027	2.0
186	1.420	1.404	0.016	1.1
185	1.260	1.257	0.003	0.2
184	1.300	1.306	-0.006	-0.5
183	1.280	1.305	-0.025	-2.0
182	1.160	1.204	-0.044	-3.8
181	0.370	0.385	-0.015	-4.1
180	0.240	0.248	-0.008	-3.3
179	1.050	1.095	-0.045	-4.3
178	1.270	1.305	-0.035	-2.8
177	1.380	1.402	-0.022	-1.6
176	1.210	1.209	0.001	0.1
175	1.340	1.320	0.020	1.5
174	1.080	1.052	0.028	2.6
173	1.360	1.318	0.042	3.1
172	1.090	1.057	0.033	3.0
171	1.340	1.316	0.024	1.8
170	1.210	1.207	0.003	0.2
169	1.390	1.402	-0.012	-0.9
168	1.270	1.308	-0.038	-3.0
167	1.050	1.098	-0.048	-4.6
166	0.230	0.248	-0.018	-7.8
165	0.340	0.358	-0.018	-5.3
164	0.740	0.759	-0.019	-2.6
163	1.280	1.306	-0.026	-2.0
162	1.200	1.207	-0.007	-0.6
161	0.850	0.845	0.005	0.6
160	1.160	1.130	0.030	2.6
159	1.270	1.218	0.052	4.1
158	1.320	1.261	0.059	4.5
157	1.280	1.220	0.060	4.7
156	1.170	1.129	0.041	3.5
155	0.860	0.845	0.015	1.7
154	1.210	1.209	0.001	0.1
153	1.290	1.311	-0.021	-1.6
152	0.740	0.762	-0.022	-3.0
151	0.340	0.360	-0.020	-5.9
150	0.770	0.798	-0.028	-3.6
149	1.240	1.264	-0.024	-1.9
148	1.250	1.257	-0.007	-0.6
147	1.330	1.316	0.014	1.1
146	1.160	1.129	0.031	2.7
145	1.210	1.165	0.045	3.7
144	1.190	1.134	0.056	4.7
143	1.180	1.118	0.062	5.3
142	1.200	1.135	0.065	5.4
141	1.220	1.165	0.055	4.5
140	1.170	1.130	0.040	3.4
139	1.340	1.320	0.020	1.5
138	1.260	1.269	-0.009	-0.7
137	1.230	1.268	-0.038	-3.1
136	0.770	0.799	-0.029	-3.8
135	0.250	0.262	-0.012	-4.8
134	0.250	0.262	-0.012	-4.8
133	1.210	1.242	-0.032	-2.6
132	1.250	1.265	-0.015	-1.2
131	1.410	1.404	0.006	0.4
130	1.080	1.057	0.023	2.1
129	1.260	1.220	0.040	3.2
128	1.190	1.135	0.055	4.6
127	1.100	1.048	0.052	4.7
126	0.740	0.696	0.044	5.9
125	1.110	1.048	0.062	5.6
124	1.190	1.134	0.056	4.7
123	1.270	1.218	0.052	4.1
122	1.080	1.052	0.028	2.6
121	1.410	1.405	0.005	0.4
120	1.240	1.267	-0.027	-2.2
119	1.200	1.241	-0.041	-3.4
118	0.290	0.299	-0.009	-3.1
117	0.280	0.298	-0.018	-6.4
116	0.730	0.749	-0.019	-2.6
115	1.310	1.311	-0.001	-0.1
114	1.340	1.323	0.017	1.3
113	1.360	1.318	0.042	3.1
112	1.310	1.261	0.049	3.7
111	1.170	1.118	0.052	4.4
110	0.730	0.696	0.034	4.9
109	0.66	0.624	0.036	5.5
108	0.730	0.696	0.034	4.7
107	1.170	1.118	0.052	4.4
106	1.310	1.261	0.049	3.7
105	1.350	1.318	0.032	2.4
104	1.330	1.323	0.007	0.5
103	1.290	1.311	-0.021	-1.6
102	0.730	0.749	-0.019	-2.6
101	0.290	0.298	-0.008	-2.8
100	0.290	0.299	-0.009	-3.1
99	1.220	1.241	-0.021	-1.7
98	1.260	1.267	-0.007	-0.6
97	1.420	1.405	0.015	1.1
96	1.080	1.052	0.028	2.6
95	1.260	1.218	0.042	3.3
94	1.180	1.134	0.046	3.9
93	1.100	1.048	0.052	4.7
92	0.730	0.696	0.034	4.7
91	1.090	1.048	0.042	3.9
90	1.180	1.135	0.045	3.8
89	1.260	1.220	0.040	3.2
88	1.080	1.057	0.023	2.1
87	1.410	1.404	0.006	0.4
86	1.250	1.265	-0.015	-1.2
85	1.210	1.242	-0.032	-2.6
84	0.250	0.262	-0.012	-4.8
83	0.250	0.262	-0.012	-4.8
82	0.780	0.799	-0.019	-2.4
81	1.260	1.268	-0.008	-0.6
80	1.280	1.269	0.011	0.9
79	1.350	1.320	0.030	2.2
78	1.160	1.130	0.030	2.6
77	1.210	1.165	0.045	3.7
76	1.180	1.135	0.045	3.8
75	1.160	1.118	0.042	3.6
74	1.170	1.134	0.036	3.1
73	1.200	1.165	0.035	2.9
72	1.150	1.129	0.021	1.8
71	1.330	1.316	0.014	1.1
70	1.250	1.257	-0.007	-0.6
69	1.240	1.264	-0.024	-1.9
68	0.770	0.798	-0.028	-3.6
67	0.350	0.360	-0.010	-2.9
66	0.750	0.762	-0.012	-1.6
65	1.300	1.311	-0.011	-0.8
64	1.220	1.209	0.011	0.9
63	0.860	0.845	0.015	1.7
62	1.150	1.129	0.021	1.8
61	1.250	1.220	0.030	2.4
60	1.290	1.261	0.029	2.2
59	1.240	1.218	0.022	1.8
58	1.150	1.130	0.020	1.7
57	0.850	0.845	0.005	0.6
56	1.200	1.207	-0.007	-0.6
55	1.290	1.306	-0.016	-1.2
54	0.740	0.759	-0.019	-2.6
53	0.350	0.358	-0.008	-2.3
52	0.240	0.248	-0.008	-3.3
51	1.070	1.098	-0.028	-2.6
50	1.290	1.308	-0.018	-1.4
49	1.390	1.402	-0.012	-0.9
48	1.210	1.207	0.003	0.2
47	1.330	1.316	0.014	1.1
46	1.070	1.057	0.013	1.2
45	1.330	1.318	0.012	0.9
44	1.060	1.052	0.008	0.8
43	1.320	1.320	0.000	0.0
42	1.200	1.209	-0.009	-0.8
41	1.380	1.402	-0.022	-1.6
40	1.270	1.305	-0.035	-2.8
39	1.060	1.095	-0.035	-3.3
38	0.240	0.248	-0.008	-3.3
37	0.370	0.385	-0.015	-4.1
36	1.170	1.204	-0.034	-2.9
35	1.280	1.305	-0.025	-2.0
34	1.290	1.306	-0.016	-1.2
33	1.250	1.257	-0.007	-0.6
32	1.390	1.404	-0.014	-1.0
31	1.310	1.323	-0.013	-1.0
30	1.390	1.405	-0.015	-1.1
29	1.250	1.269	-0.019	-1.5
28	1.280	1.311	-0.031	-2.4
27	1.270	1.308	-0.038	-3.0
26	1.160	1.204	-0.044	-3.8
25	0.370	0.384	-0.014	-3.8
24	0.370	0.384	-0.014	-3.8
23	1.060	1.095	-0.035	-3.3
22	0.740	0.759	-0.019	-2.6
21	1.240	1.264	-0.024	-1.9
20	1.240	1.265	-0.025	-2.0
19	1.280	1.311	-0.031	-2.4
18	1.230	1.267	-0.037	-3.0
17	1.230	1.268	-0.038	-3.1
16	0.730	0.762	-0.032	-4.4
15	1.050	1.098	-0.048	-4.6
14	0.370	0.385	-0.015	-4.1
13	0.240	0.248	-0.008	-3.3
12	0.350	0.358	-0.008	-2.3
11	0.770	0.798	-0.028	-3.6
10	1.200	1.242	-0.042	-3.5
9	0.720	0.749	-0.029	-4.0
8	1.190	1.241	-0.051	-4.3
7	0.760	0.799	-0.039	-5.1
6	0.340	0.360	-0.020	-5.9
5	0.230	0.248	-0.018	-7.8
4	0.250	0.262	-0.012	-4.8
3	0.280	0.299	-0.019	-6.8
2	0.280	0.298	-0.018	-6.4
1	0.250	0.262	-0.012	-4.8

RMS Deviation: 2.82%

Key:

Box #
Measured
Design
Delta
% Diff.

Figure 5

Power Distribution - 45% Power

	Measured:	Design:
Source	BEACON ts1_050101_2305	ts1_050101_2305
Power Level	45.0%	45.0%
Exposure	10.7	10.7
CEA Position	122	122
Boron Conc.	1328	1328

N

	R	P	N	M	L	K	J	H	G
	T	S						F	E
21			217 0.260 0.266 -0.006 -2.3	216 0.300 0.304 -0.004 -1.3	215 0.300 0.304 -0.004 -1.3	214 0.260 0.266 -0.006 -2.3			
20		V	213 0.240 0.253 -0.013 -5.4	212 0.350 0.366 -0.016 -4.6	211 0.780 0.802 -0.022 -2.8	210 1.210 1.238 -0.028 -2.3	209 0.740 0.754 -0.014 -1.9	208 1.210 1.238 -0.028 -2.3	207 0.780 0.801 -0.021 -2.7	206 0.350 0.364 -0.014 -4.0	205 0.240 0.252 -0.012 -5.0
19	W		204 0.370 0.389 -0.019 -5.1	203 1.060 1.097 -0.037 -3.5	202 0.750 0.766 -0.016 -2.1	201 1.250 1.263 -0.013 -1.0	200 1.250 1.259 -0.009 -0.7	199 1.300 1.311 -0.011 -0.8	198 1.250 1.258 -0.008 -0.6	197 1.240 1.259 -0.019 -1.5	196 0.750 0.763 -0.013 -1.7
18	X		193 0.370 0.388 -0.018 -4.9	192 1.160 1.203 -0.043 -3.7	191 1.260 1.298 -0.038 -3.0	190 1.290 1.304 -0.014 -1.1	189 1.260 1.262 -0.002 -0.2	188 1.410 1.397 0.013 0.9	187 1.330 1.315 0.015 1.1	186 1.400 1.395 0.005 0.4	185 1.250 1.251 -0.001 -0.1
17			180 0.240 0.252 -0.012 -5.0	179 1.050 1.094 -0.044 -4.2	178 1.260 1.296 -0.036 -2.9	177 1.370 1.392 -0.022 -1.6	176 1.200 1.205 -0.005 -0.4	175 1.330 1.316 0.014 1.1	174 1.080 1.053 0.027 2.5	173 1.350 1.312 0.038 2.8	172 1.080 1.057 0.023 2.1
16			165 0.350 0.364 -0.014 -4.0	164 0.740 0.763 -0.023 -3.1	163 1.270 1.299 -0.029 -2.3	162 1.190 1.203 -0.013 -1.1	161 0.860 0.850 0.010 1.2	160 1.160 1.132 0.028 2.4	159 1.260 1.218 0.042 3.3	158 1.320 1.259 0.061 4.6	157 1.270 1.220 0.050 3.9
15	Y		150 0.770 0.801 -0.031 -4.0	149 1.230 1.259 -0.029 -2.4	148 1.240 1.251 -0.011 -0.9	147 1.320 1.313 0.007 0.5	146 1.160 1.131 0.029 2.5	145 1.210 1.170 0.040 3.3	144 1.190 1.140 0.050 4.2	143 1.190 1.126 0.064 5.4	142 1.200 1.141 0.059 4.9
14			135 0.250 0.266 -0.016 -6.4	133 1.200 1.238 -0.038 -3.2	132 1.240 1.258 -0.018 -1.5	131 1.400 1.395 0.005 0.4	130 1.080 1.057 0.023 2.1	129 1.260 1.220 0.040 3.2	128 1.190 1.141 0.049 4.1	127 1.120 1.064 0.056 5.0	126 0.750 0.713 0.037 4.9
13			118 0.290 0.304 -0.014 -4.8	116 0.740 0.754 -0.014 -1.9	115 1.300 1.311 -0.011 -0.8	114 1.330 1.315 0.015 1.1	113 1.350 1.312 0.038 2.8	112 1.310 1.259 0.051 3.9	111 1.180 1.126 0.054 4.6	110 0.750 0.713 0.037 4.4	109 0.68 0.647 0.033 4.9
12			117 0.290 0.304 -0.014 -4.8	115	114	113	112	111	110	109	108
11			116	114	113	112	111	110	109	108	107
10			101 0.290 0.304 -0.014 -4.8	99 1.210 1.238 -0.028 -2.3	98 1.250 1.259 -0.009 -0.7	97 1.410 1.397 0.013 0.9	96 1.080 1.053 0.027 2.5	95 1.270 1.218 0.052 4.1	94 1.190 1.140 0.050 4.2	93 1.120 1.064 0.056 5.0	92 0.750 0.713 0.037 4.9
9			100 0.290 0.304 -0.014 -4.8	99	98	97	96	95	94	93	92
8			84 0.260 0.266 -0.006 -2.3	82 0.780 0.802 -0.022 -2.8	81 1.250 1.263 -0.013 -1.0	80 1.270 1.262 0.008 0.6	79 1.340 1.316 0.024 1.8	78 1.170 1.132 0.038 3.2	77 1.220 1.170 0.050 4.1	76 1.190 1.141 0.049 4.1	75 1.180 1.126 0.054 4.6
7			83 0.250 0.266 -0.016 -6.4	82	81	80	79	78	77	76	75
6			67 0.350 0.366 -0.016 -4.6	66 0.750 0.766 -0.016 -2.1	65 1.300 1.304 -0.004 -0.3	64 1.220 1.205 0.015 1.2	63 0.870 0.850 0.020 2.3	62 1.160 1.131 0.029 2.5	61 1.260 1.220 0.040 3.2	60 1.300 1.259 0.041 3.2	59 1.250 1.218 0.032 2.6
5			52 0.240 0.253 -0.013 -5.4	51 1.070 1.097 -0.027 -2.5	50 1.280 1.298 -0.018 -1.4	49 1.390 1.392 -0.002 -0.1	48 1.210 1.203 0.007 0.6	47 1.330 1.313 0.017 1.3	46 1.070 1.057 0.013 1.2	45 1.340 1.312 0.028 2.1	44 1.070 1.053 0.017 1.6
4				37 0.380 0.389 -0.009 -2.4	36 1.170 1.203 -0.033 -2.8	35 1.280 1.296 -0.016 -1.3	34 1.290 1.299 -0.009 -0.7	33 1.250 1.251 -0.001 -0.1	32 1.390 1.395 -0.005 -0.4	31 1.310 1.315 -0.005 -0.4	30 1.390 1.397 -0.007 -0.5
3					24 0.370 0.388 -0.018 -4.9	23 1.070 1.094 -0.024 -2.2	22 0.750 0.763 -0.013 -1.7	21 1.240 1.259 -0.019 -1.5	20 1.240 1.258 -0.018 -1.5	19 1.290 1.311 -0.021 -1.6	18 1.230 1.259 -0.029 -2.4
2						13 0.240 0.252 -0.012 -5.0	12 0.350 0.364 -0.014 -4.0	11 0.780 0.801 -0.021 -2.7	10 1.200 1.238 -0.038 -3.2	9 0.730 0.754 -0.024 -3.3	8 1.190 1.238 -0.048 -4.0
1							4 0.250 0.266 -0.016 -6.4	3 0.290 0.304 -0.014 -4.8	2 0.290 0.304 -0.014 -4.8	1 0.250 0.266 -0.016 -6.4	

	D	C	B	A
21				
20	206 0.350 0.364 -0.014 -4.0	205 0.240 0.252 -0.012 -5.0		
19	195 1.060 1.094 -0.034 -3.2	194 0.370 0.388 -0.018 -4.9		
18	184 1.280 1.299 -0.019 -1.5	183 1.270 1.296 -0.026 -2.0	182 1.160 1.203 -0.043 -3.7	181 0.370 0.389 -0.019 -5.1
17	169 1.370 1.392 -0.022 -1.6	168 1.260 1.298 -0.038 -3.0	167 1.050 1.097 -0.047 -4.5	166 0.240 0.253 -0.013 -5.4
16	154 1.200 1.205 -0.005 -0.4	153 1.280 1.304 -0.024 -1.9	152 0.740 0.766 -0.026 -3.5	151 0.350 0.366 -0.016 -4.6
15	141 1.220 1.170 0.050 4.1	140 1.170 1.132 0.038 3.2	139 1.330 1.316 0.014 1.1	138 1.250 1.262 -0.012 -1.0	137 1.230 1.263 -0.033 -2.7	136 0.770 0.802 -0.032 -4.2
14	125 1.120 1.064 0.056 5.0	124 1.200 1.140 0.060 5.0	123 1.270 1.218 0.052 4.1	122 1.080 1.053 0.027 2.5	121 1.400 1.397 0.003 0.2	120 1.230 1.259 -0.029 -2.4	119 1.190 1.238 -0.048 -4.0	134 0.250 0.266 -0.016 -6.4
13	107	106	105	104	103	102		
12	91	90	89	88	87	86	85	117 0.290 0.304 -0.014 -4.8
11	74	73	72	71	70	69	68	116
10	59	58	57	56	55	54	53	100 0.290 0.304 -0.014 -4.8
9	44	43	42	41	40	39	38	99
8	29	28	27	26	25			83 0.250 0.266 -0.016 -6.4
7	18	17	16	15	14			82
6	7	6	5					67
5								52
4								37
3								24
2								13
1								4

RMS Deviation: 2.85%

Key:

Box #
Measured
Design
Delta
% Diff.

Figure 6

Power Distribution - 98% Plateau

	Measured: BEACON	Design:
Source	ts1_050301_0122	ts1_050301_0122
Power Level	98.0%	98.0%
Exposure	28.8 EFPH	28.8 EFPH
CEA Position	135.5	135.5
Boron Conc.	1183	1183

N

| | R | P | N | M | L | K | J | H | G | | |

Table 1
Cycle 17 Reload Sub-Batch ID

Sub-Batch	Number of Assemblies	Avg. Enrichment
R4*	4	3.8
S2*	1	3.88
S5*	4	3.80
T3*	4	4.34
T5*	20	4.31
U2*	8	3.96
U3*	16	4.39
U4*	4	4.37
U5*	4	4.34
U6*	4	4.31
X1*	24	4.34
X2*	8	4.29
X3*	24	4.26
X4*	20	4.23
Y1[β]	24	3.72
Y2[β]	8	3.67
Y3[β]	16	4.24
Y4[β]	4	4.13
Y5[β]	8	4.06
Y6[β]	12	4.01

*Reference (9)

[β]Reference (12)

Table 2
Approach to Criticality

Dilution Rate	Initial Boron Concentration	Final Boron Concentration	Dilution Time (minutes)
132 gpm	1743	1690	16
88 gpm	1690	1590	44
44 gpm	1590	1533	41

Table 3
CEA Group Worth Summary

CEA Group	Measured Worth (pcm)	Design * Worth (pcm)	Percent Difference
Reference Group A	879.78	891.00	-1.28
1	923.70	870.00	5.81
2	890.70	836.00	6.14
3 & 6	827.85	811.00	2.04
4	678.97	652.00	3.97
7	613.98	621.00	-1.14
5 & B	600.57	501.00	16.58
Total	5416.55	5182.00	-4.3

*Reference 7

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

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