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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Gentlemen:

Re: St. Lucie Unit 1
Docket 50-335
St. Lucie Unit 1, Cycle 10
Startup Physics Testing Report

In accordance with St. Lucie Unit 1 Technical Specification 6.9.1.1., the attached Unit 1 Cycle 10 Startup Physics Testing Report is being submitted.

Should you have any questions, please contact us.

Very truly yours,

D.A. SAGER
By

D. A. Sager
Vice President
St. Lucie Plant

DAS:JMP:kw

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

DAS/PSL #232

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St. Lucie Unit 1, Cycle 10
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 a summary of the startup physics testing performed following 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 10 Fuel Design

The cycle 10 core consists entirely of fuel manufactured by the Advanced Nuclear Fuels Corp.(ANF). The 217 fuel assemblies in the cycle 10 core are comprised of fuel from five batches. Of these, 92 are fresh batch M, 92 are once burnt batch L, 16 are twice burnt batch K, 9 are thrice burnt batch J, and 8 are thrice burnt batch H assemblies. A further breakdown of the distinct sub-batches is contained in Table1.

This is the fourth 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 "M" fuel is the third cycle of fuel provided by ANF that uses long lower end-caps as a means of providing protection against debris fretting in the lower end-fitting region.

The cycle 10 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 10 reload differs from cycle 9 in three respects:

1) The amount of Gadolinia (Gd) in this reload has been increased from a maximum of 6 w/o to 8 w/o in selected assemblies. The use of the Gadolinia and a low leakage loading pattern is designed to achieve a desireable power distribution and reduce the beginning-of-cycle (BOC) boron concentration.

2) The reload employs a low-leakage design and uses batch H and batch J fuel on the periphery to further reduce the fluence on the reactor vessel for life extension

purposes.

3) Forty (40) Control Element Assemblies (CEA's) were replaced as a part of 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.

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 2.23 seconds with maximum and minimum times of 2.38 seconds and 2.13 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 1814 ppm to a predicted critical boron concentration of 1530 ppm. The actual critical concentration was observed to be 1546 ppm. Inverse countrate ratio plots were maintained during the dilution process using wide range channels A and B. 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 begining and ending boron concentrations.

Initial criticality for St. Lucie Unit 1, cycle 10 was achieved on April 15, 1990 at 0750 with CEA group 7 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 10 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

These tests were performed in accordance with approved procedures.

Reactivity Computer proper operation is 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 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 performed 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 1598.4 ppm which compared favorably with the predicted value of 1571 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 4.41 pcm/°F which fell well within the acceptance criteria of ± 2.0 pcm/°F of the design MTC of 4.92 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, one at a time. 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.

ANF later evaluated the results of the rod worth measurements and adjusted the measured and predicted worths for differences between the ideal lead group position and its actual position during the test. These results are summarized in Table 4 and demonstrate excellent 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 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.

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 -2.25 pcm/°F which was within ±2.0 pcm/°F of the design value of -1.597 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 10 Startup and Operations Report,*" ANF-90-016(P), dated March 15, 1990.

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

3) Letter from J.L. Holm (ANF) to J. D. Mantyh (FPL), Dated June 18, 1990, Attachment 2 "*Trip Report- St. Lucie Unit 1 Cycle 10 Startup and Physics Testing.*"

Figure 1

Cycle 10 Core Loading Pattern

NORTH

Y X W V T S R P N M L K J H G F E D C B A

	Y	X	W	V	T	S						F	E	D	C	B	A
21							H111	J01	J07	H103							
20					K03	M02	L66	M09 65	L74	M15 64	L71	M07	K05				
19				K17	M24 63	L07	M36 62	L22	M39 302	L28	M32 123	L02	M20 77	K22			
18			K21	M26 201	L17	M46 122	L90	M54 121	L83	M58 120	L88	M50 119	L15	M28 204	K18		
17		K08	M18 55	L14	M90	L58	M62 118	L54	M70	L52	M66 117	L63	M91	L18	M21 52	K04	
16		M06	L03	M52 116	L62	M74 81	L38	M78	L75	M82	L48	M75 82	L60	M47 115	L05	M04	
15		L70	M30 75	L87	M67 80	L46	L10 114	L35	M86 74	L32	L12 113	L40	M63 83	L92	M33 112	L67	
14	H102																H112
13		M14 40	L26	M59 111	L50	M84	L31	M42 110	L43	M43 109	L36	M79	L55	M55 108	L24	M11 35	
12	J06																J02
11		L77	M38 301	L82	M72	L78	M88 107	L41	J42 76	L42	M87 106	L80	M71	L81	M37 303	L79	
10	J04																J08
9		M12 31	L23	M56 105	L56	M80	L34	M44 104	L44	M41 103	L29	M83	L49	M60 102	L25	M13 26	
8	H110																H104
7		L68	M34 101	L91	M64 79	L39	L11 100	L30	M85 99	L33	L09 98	L45	M68 84	L85	M29 97	L69	
6		M03	L06	M48 96	L59	M76 95	L47	M81	L73	M77	L37	M73 85	L61	M51 94	L04	M05	
5		K02	M22 14	L20	M92	L64	M65 93	L51	M69	L53	M61 92	L57	M89	L16	M17 11	K06	
4			K20	M27 203	L13	M49 91	L86	M57 90	L84	M53 89	L89	M45 88	L19	M25 202	K23		
3				K24	M19 6	L01	M31 87	L27	M40 304	L21	M35 86	L08	M23 3	K19			
2					K07	M08	L72	M16 2	L76	M10 1	L65	M01	K01				
1							H101	J05	J03	H109							

XXX	FUEL ID
YY	INSERT ID

Figure 2
Wide Range CH. A Dilution

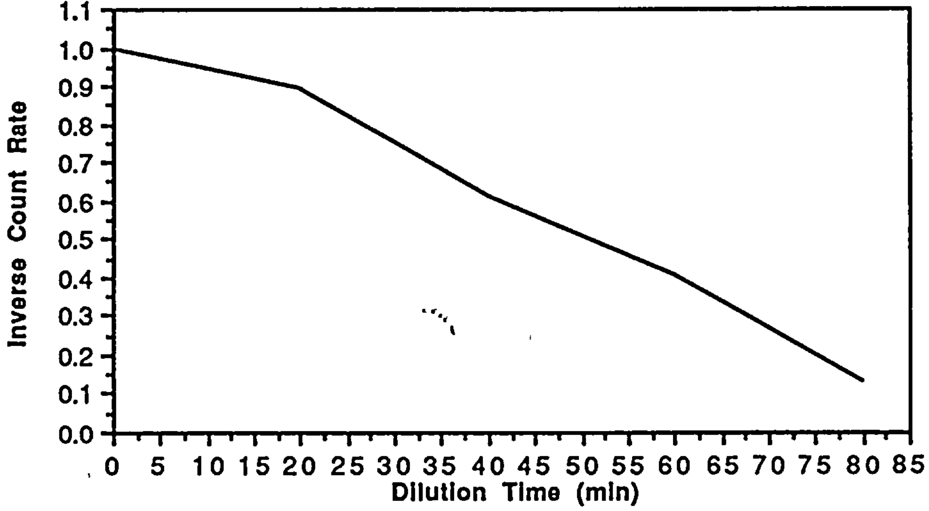

Figure 3
Wide Range CH. B Dilution

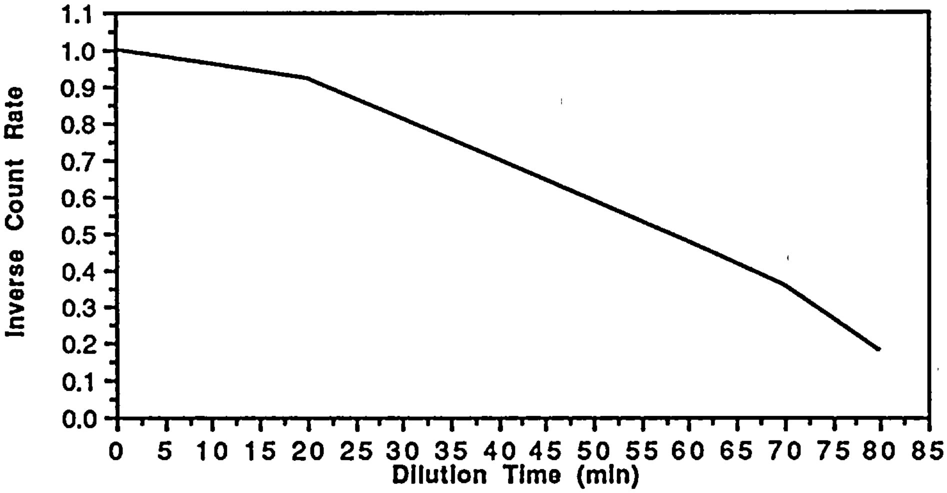

Figure 4
RCS Boron Dilution Plot

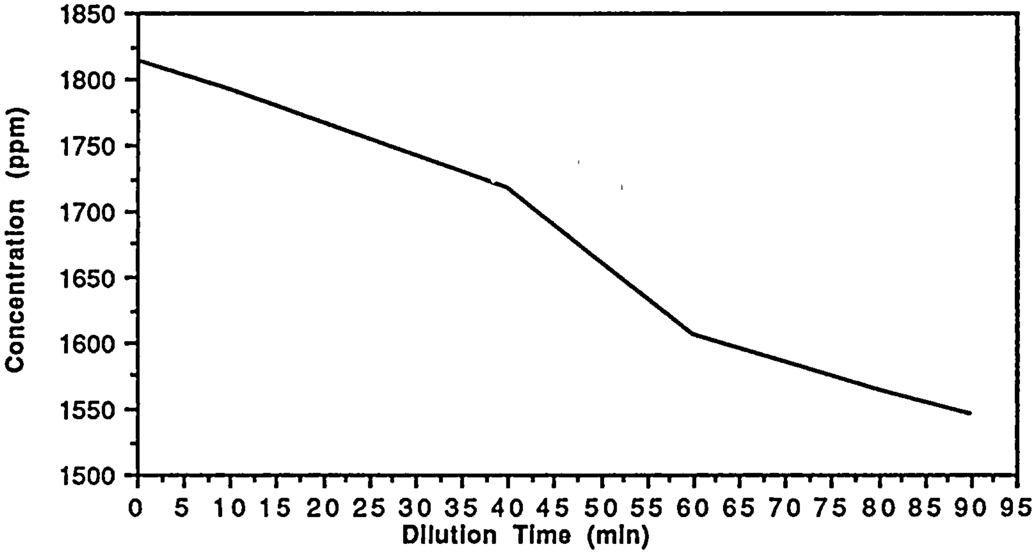

Figure 5

RELATIVE POWER DISTRIBUTION AT 50%

Measured

Snapshot INPAXH2
Power Level 50.0%
Burnup 23.41 EFPH
CEA Position 122.35"
Tilt = 0.0052
$F_{xy}^{T} = 1.65$
$F_{r}^{T} = 1.600$
Fq = 2.3488

Design

Power Level 50.00%
Burnup 10.00 EFPH
CEA Position 122.0"

Data Source ANF-90-016 (P)

					0.769 0.760 0.009 1
	Meas. Design (M-D) Loc			1.230 1.222 0.008 10	1.030 1.018 0.012 2
			1.171 1.167 0.004 18	1.085 1.086 -0.001 11	1.243 1.242 0.001 3
		1.263 1.256 0.007 24	1.084 1.083 0.001 19	1.245 1.259 -0.014 12	1.059 1.078 -0.019 4
	1.208 1.195 0.013 29	1.082 1.078 0.004 25	1.249 1.256 -.0007 20	1.044 1.079 -0.035 13	1.237 1.258 -0.021 5
1.085 1.083 0.002 33	1.147 1.137 0.010 30	1.283 1.272 0.011 26	1.059 1.066 -0.007 21	1.245 1.265 -0.020 14	1.052 1.072 -0.020 6
0.398 0.389 0.009 34	1.108 1.102 0.006 31	1.175 1.157 0.018 27	1.206 1.217 -0.011 22	1.128 1.148 -0.020 15	1.197 1.218 -0.021 7
	0.370 0.377 -0.007 32	0.887 0.901 -0.014 28	0.685 0.721 -0.036 23	1.110 1.144 -0.034 16	0.787 0.811 -0.024 8
				0.185 0.194 -0.009 17	0.279 0.286 -0.007 9

Figure 6

RELATIVE POWER DISTRIBUTION AT 80%

Measured

Snapshot INPAX1Z
Power Level 80.00%
Burnup 50.66 EFPH
CEA Position 131.3"
Tilt = 0.0048
F_{xy}^T =1.628
F_r^T = 1.575
Fq =2.256

Design

Power Level 80.00%
Burnup 30.00 EFPH
CEA Position 131.0"

Data Source ANF-90-016(P)

Meas. Design (M-D) Loc

					0.811 0.806 0.005 1
				1.252 1.246 0.006 10	1.053 1.049 0.004 2
			1.188 1.183 0.005 18	1.111 1.106 0.005 11	1.261 1.261 0.0 3
		1.267 1.259 0.008 24	1.101 1.100 0.001 19	1.288 1.270 0.018 12	1.069 1.093 -0.024 4
	1.205 1.189 0.016 29	1.087 1.080 0.001 25	1.261 1.259 0.002 20	1.084 1.090 -0.006 13	1.245 1.265 -0.020 5
1.098 1.079 0.019 33	1.142 1.127 0.015 30	1.271 1.260 0.011 26	1.060 1.067 -0.007 21	1.254 1.266 -0.012 14	1.051 1.082 -0.031 6
0.383 0.382 0.001 34	1.089 1.079 0.010 31	1.154 1.138 0.016 27	1.204 1.203 0.001 22	1.141 1.146 -0.005 15	1.221 1.232 -0.011 7
	0.375 0.370 0.005 32	0.885 0.881 0.004 28	0.705 0.710 -0.005 23	1.127 1.132 -0.005 16	0.811 0.816 -0.005 8
				0.193 0.195 -0.002 17	0.291 0.290 0.001 9

Figure 7

RELATIVE POWER DISTRIBUTION AT 100%

Measured

Snapshot INPAXEP
Power Level 98.00%
Burnup 94.17 EFPH
CEA Position 135.0"
Tilt = 0.0038
F_{xy}^{T} =1.619
F_{r}^{T} =1.581
F_{q} =2.2117

Design

Power Level 100.00%
Burnup 75.0 EFPH
CEA Position 135.0"

Data Source ANF-90-016(P)

Meas.
Design
(M-D)
Loc

					0.828 0.831 -0.003 1
				1.261 1.263 -0.002 10	1.066 1.069 -0.003 2
			1.196 1.198 -0.002 18	1.121 1.122 -0.001 11	1.269 1.274 -0.005 3
		1.266 1.263 0.003 24	1.107 1.111 -0.004 19	1.296 1.279 0.017 12	1.078 1.106 -0.028 4
	1.201 1.185 0.016 29	1.087 1.084 0.003 25	1.258 1.262 -0.004 20	1.088 1.098 -0.010 13	1.245 1.271 -0.026 5
1.093 1.064 0.029 33	1.137 1.118 0.019 30	1.262 1.252 0.010 26	1.058 1.068 -0.010 21	1.249 1.266 -0.170 14	1.052 1.087 -0.035 6
0.385 0.375 0.010 34	1.083 1.061 0.022 31	1.147 1.128 0.019 27	1.197 1.194 0.003 22	1.137 1.144 -0.007 15	1.216 1.230 -0.140 7
	0.377 0.365 0.012 32	0.882 0.868 0.014 28	0.705 0.703 0.002 23	1.121 1.123 -0.002 16	0.812 0.817 -0.005 8
				0.195 0.195 0.00 17	0.294 0.293 0.001 9

Table 1

Cycle 10 Reload Sub-batch ID

Sub-Batch	# of Assemb	Enrich.
H1	8	3.67
J1	8	3.60
J2	1	3.55
K1	16	3.60
L1	8	3.84
L2	20	3.81
L3	28	3.75
L4	24	3.72
L5	12	3.72
M1	16	4.00
M2	12	3.97
M3	16	3.90
M4	44	3.89
M5	4	3.87

Table 2

Approach to Criticality

Dilution Rate	Init. Boron Conc.	Final Boron Conc.	Dilution Time(min)
132 gpm	1814 ppm	1718 ppm	40
88 gpm	1718 ppm	1546 ppm	50

Table 3

Comparisons of ANF Calculatons With Measured Values

CEA Group Worth Summary

CEAGroup	Measured	Design	% Diff.
7	495	540	9.9 %
6	355	360	1.4 %
5	360	397	10.27 %
4	565	591	4.60 %
3	357	425	19.0 %
2	777	746	-3.98 %
1	732	744	1.64 %
B	523	535	2.29 %
A	1040	980.6	-5.71 %
Total	5204	5318.6	2.2 %

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

HZP Critical Boron

Condition	Measured	Design(Adj)	Difference (M-D)
ARO	1598.4 ppm	1571 ppm	27.4 ppm

Moderator Temperature Coefficient

Condition	Measured	Design(Adj)	Difference(M-D)
ARO	+4.41 pcm/°F	+4.92 pcm/°F	-0.51 pcm/°F

Table 4

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

CEA Group Worth Summary

CEA Group	Measured (pcm)*	Design (Adj.)*	% Diff.
7	516	523	1.36 %
6	367	364	-0.82 %
5	374	390	4.28 %
4	584	599	2.57 %
3	368	425	15.49%
2	789	749	-5.07 %
1	746	741	-0.67%
B	543	527	-2.95 %
A	1015	977	-3.74 %
Total	5302	5295	-0.13 %.

% Diff = (D/M-1)100

* Reference 3