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

FPL

August 9, 2007

L-2007-121
10 CFR 50.36

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

Re: St. Lucie Unit 1
Docket No. 50-335
Cycle 21 Startup Report

Pursuant to St. Lucie Unit 1 Technical Specification (TS) 6.9.1.1, Florida Power & Light Company (FPL) is submitting the Cycle 21 Startup Report. This report is required due to the replacement of an excore detector and, the implementation of Startup Test Activity Reduction (STAR).

Please contact us if there are any questions regarding this submittal.

Very truly yours,

Gordon L. Johnston
Site Vice President
St. Lucie Plant

GLJ/KWF

Attachment

IE26
NRR

St. Lucie Unit 1, Cycle 21
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 testing performed at St. Lucie Unit 1 following the Cycle 21 refueling. The startup testing verifies that 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.

This Cycle 21 Startup Report is being submitted in accordance with Technical Specification 6.9.1.1 due to:

1. Replacement of an excore detector and,
2. Implementation of Startup Test Activity Reduction [STAR].

The test data satisfied acceptance criteria, or was satisfactorily dispositioned in accordance with the corrective action program, and demonstrated general conformance to predicted performance.

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II. Cycle 21 Fuel Design

The Cycle 21 reload consists entirely of fuel manufactured by AREVA-NP, Inc (AREVA). The primary design change to the core for Cycle 21 is the replacement of 73 irradiated fuel assemblies with 72 fresh Region CC fuel assemblies and 1 irradiated fuel assembly (Region S) currently residing in the spent fuel pool. All assemblies in the Cycle 21 reload core are of the debris resistant design. The fuel assembly design of Region CC fuel is the same as that of the previous cycle Region BB fuel design. This fuel design includes the use of high thermal performance (HTP) spacer grids and the use of FuelGuard lower tie plate. The fuel assembly design for Region CC fuel utilizes radial enrichment zoning similar to that used in Region BB fuel. A new 20 Gad pattern is used in Sub-region CC5 (4 assemblies).

The safety analysis for Cycle 21 reload design was performed by AREVA-NP and by FPL using NRC approved methodology. The analyses for Cycle 21 reload support a Departure from Nucleate Boiling Ratio (DNBR) limit at the 95/95 probability/confidence level, consistent with the applicable DNB correlation previously approved by the NRC. The linear heat rate (LHR) corresponding to the fuel centerline melt limit for Cycle 21 is 23.67 kW/ft. All analyses in support of this EP were performed with the assumption of steam generator tube plugging level not to exceed 15% average, with a maximum asymmetry of ± 7% about the average. It has been determined that the design and operation of the Cycle 21 reload core will meet the 10 CFR 50.59 (c)(2) criteria.

The Cycle 21 core map is represented in Figure 1. The assembly serial numbers and control element assembly (CEA) serial numbers are given for each core location.

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III. CEA Drop Time Testing

Following the core reload and prior to the approach to criticality, CEA drop time testing was performed. 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 2.38 seconds with maximum and minimum times of 2.46 seconds and 2.24 seconds, respectively (Reference 7). All drop times were within the 3.1 second requirement of Technical Specification 3.1.3.4 and within the safety analysis requirements supporting the reload PC/M 06162 requirements (Reference 6).

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IV. Approach to Criticality

The approach to criticality involved diluting from a non-critical boron concentration of 1762 ppm to a predicted critical boron concentration of 1537 ppm. Inverse Count Rate Ratio (ICRR) plots were maintained during the dilution process using wide range 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 21, was achieved on May 26, 2007 at 9:17 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 1552 ppm (Reference 1).

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V. Zero Power Physics Testing

To ensure that the operating characteristics of the Cycle 21 core were consistent with the design predictions, the following tests were performed:

1) Reactivity Computer Checkout;
2) All Rods Out Critical Boron Concentration; and,
3) Isothermal Temperature Coefficient Measurement.

Proper operation of the reactivity computer is ensured by performing the "Reactivity Computer Checkout." This part of the testing determines the appropriate testing range and checks that reactivity changes are being correctly calculated by the reactivity computer's internal algorithms. The testing range is selected such that the signal to noise ratio is maximized and that testing is performed below the point of adding nuclear heat. The reactivity calculation is checked by performing a positive and negative reactor period test through respective introduction of a known amount of positive and negative reactivity. The results of the reactivity computer checkout were compared to the appropriate predictions supplied in the reload PC/M 06162 (Reference 6). Satisfactory agreement was obtained.

The measurement of the all-rods-out (ARO) critical boron concentration was performed. The measured value was 1545 ppm which compared favorably with the design value of 1544 ppm (Reference 2). 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 1.558 pcm/°F which fell well within the acceptance criteria of + 2.0 pcm/°F of the design MTC of 1.856 pcm/°F. This complies with Unit 1 Technical Specification 3.1.1.4 requirements that the maximum upper limit shall be +7 pcm/°F at <70% of RATED THERMAL POWER.

Rod worth measurements were not performed due to the implementation of the STAR program (Reference 9). Appendix A contains further information on the implementation of STAR for Unit 1 Cycle 21.

All acceptance criteria were met.

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VI. 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 greater than 98% rated thermal power. The incore detectors and thimble tubes were replaced for Cycle 21 due to the elongation of the previous thimbles. Both the replacement incore detectors and thimbles are of a shorter design that restored the incore detector elevations to their height prior to Cycle 19. A shape annealing factor (SAF) (Reference 5) test was performed in conjunction with the power ascension (Reference 3). This test was required due to the replacement of the "D" Linear Range nuclear instrument channel detector. The replaced excore detector for channel D was of the same shorter length detector design as was used in Unit 2 in Cycle 15. The SAF measurement data for all the replaced excore detectors showed a good statistical correlation coefficient and agreement with the trend of the other RPS channels indicating that the calculated SAFs are valid and acceptable for use.

The measured SAFs for all the excore detectors and the control channels met all acceptance criteria limits.

A summary of the flux maps at the 30%, 45% and 98% power levels is provided in Figures 4, 5, and 6. These flux maps are used for comparing the measured power distribution with the predicted power distribution. For the purposes of power ascension, the acceptance criteria require the root mean square (RMS) value of the power deviation to be less than or equal to 5%. The individual assembly powers should be within 10% of the predicted power for assembly powers greater than or equal to 0.9 (30% and 98% plateaus). In addition, for the 30% plateau the relative power density (RPD) should be within 0.1 RPD units of predicted for assembly powers less than or equal to 0.9. These criteria were satisfied.

Additionally, calorimetric, nuclear, and delta T power calibrations were performed at each power plateau prior to advancing reactor power to the next higher level specified by procedure.

A determination of RCS flow by calorimetric parameters (Reference 8) was performed and the measured result of 410,922 gpm met the minimum acceptance criteria of 379,945 gpm (Technical Specification required flow of 365,000 gpm + uncertainties).

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VII. Summary

Compliance with the applicable Unit 1 Technical Specifications was satisfactory. The acceptance criteria for all the startup testing parameters were met.

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VIII. References

1) *"Unit 1 Initial Criticality Following Refueling,"* Pre-Operational Procedure 1-3200088, Rev. 28B.

2) *"Reload Startup Physics Testing,"* Pre-Operational Procedure 3200091, Rev. 26

3) *"Reactor Engineering Power Ascension Program,"* Pre-Operational Procedure 3200092, Rev. 30.

4) St. Lucie Unit 1 Technical Specifications, Amendment 200.

5) *"Shape Annealing Factor Test,"* Pre-Operational Test Procedure 3200093, Rev. 13B.

6) St. Lucie Unit 1 Cycle 21 Reload PC/M #06162, Rev 1.

7) *"Periodic Rod Drop Time and CEA Position Functional Test,"* Operating Procedure 1-0110054, Rev. 36C.

8) *"RCS Flow Determination by Calorimetric,"* Operating Procedure 1-0120051, Rev. 22A.

9) WCAP- 16011-P-A, Rev. 0, "Startup Test Activity Reduction Program," February 2005.

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FIGURE 1
CYCLE 21 CORE LOADING PATTERN

	Y	X	W	V	T	S	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
21								AA42		AA45		AA40		AA60							
20					AA52	AA47	BB61		CC7 411		BB4		CC10 454		BB47	AA54	AA49				
19				AA68	AA13 144	CC12	CC35 425		BB20		CC69 307		BB8		CC43 443	CC18	AA1 432	AA62			
18			AA65	CC1 210	CC46	BB9 447	BB36		BB46 429		BB52		BB39 419		BB22	BB11 434	CC56	CC2 211	AA76		
17		AA35	AA12 444	CC57	BB25	BB55	CC34 451		AA66		CC65		AA63		CC38 145	BB48	BB30	CC51	AA11 428	AA43	
16		AA56	CC19	BB6 146	BB38	CC52 405	AA15		CC22		BB27		CC24		AA2	CC48 435	BB67	BB19 147	CC6	AA31	
15		BB40	CC49 440	BB21	CC42 453	AA8	AA20 422		AA27		CC45 456		AA21		AA19 433	AA14	CC33 438	BB33	CC55 421	BB62	
14	AA59																				AA37
13		CC20 148	BB7	BB43 449	AA71	CC25	AA24		CC30 413		BB51		CC31 436		AA22	CC21	AA70	BB53 402	BB10	CC8 427	
12	AA46																				AA29
11		BB2	CC70 306	BB58	CC41	BB31	CC40 448		BB63		S51 L1		BB45		CC62 416	BB24	CC60	BB44	CC71 308	BB3	
10	AA39																				AA30
9		CC15 446	BB5	BB54 404	AA75	CC32	AA23		CC23 424		BB68		CC28 406		AA28	CC29	AA64	BB37 417	BB17	CC16 431	
8	AA48																				AA58
7		BB41	CC54 439	BB23	CC68 F01	AA5	AA18 450		AA25		CC53 445		AA26		AA17 409	AA7	CC50 430	BB26	CC59 423	BB60	
6		AA32	CC13	BB14 414	BB42	CC39 426	AA9		CC26		BB28		CC27		AA10	CC64 403	BB66	BB13 149	CC14	AA55	
5		AA50	AA4 452	CC37	BB35	BB65	CC44 410		AA73		CC58		AA61		CC47 420	BB56	BB34	CC61	AA16 442	AA41	
4			AA72	CC3 212	CC63	BB12 412	BB29		BB64 415		BB57		BB50 150		BB32	BB18 441	CC67	CC4 213	AA74		
3				AA69	AA6 408	CC9	CC36 401		BB15		CC72 309		BB16		CC66 407	CC11	AA3 418	AA67			
2					AA51	AA38	BB59		CC5 455		BB1		CC17 437		BB49	AA33	AA44				
1								AA57		AA34		AA53		AA36							

Assembly Serial # → XXX
Insert Serial # → ##

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Figure 2. Wide Range Channel B Boron Dilution

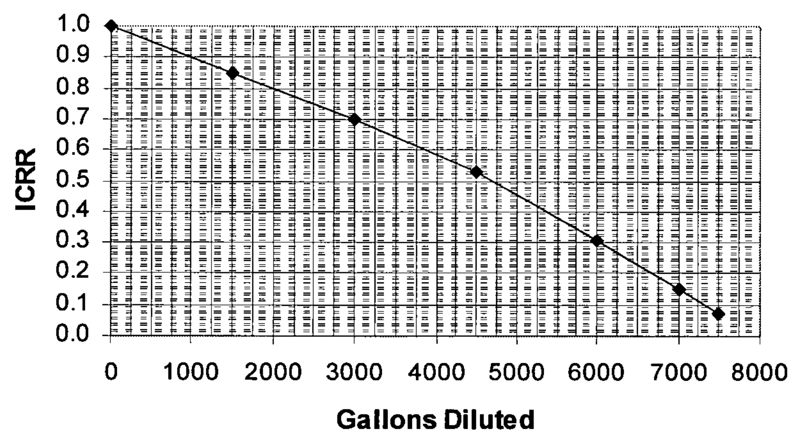

Figure 3. Wide Range Channel D Boron Dilution

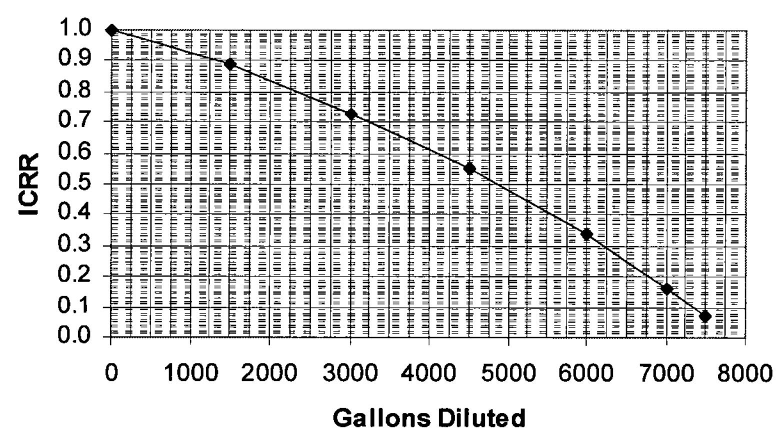

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Figure 4
POWER DISTRIBUTION COMPARISON WITH DESIGN – 30% POWER

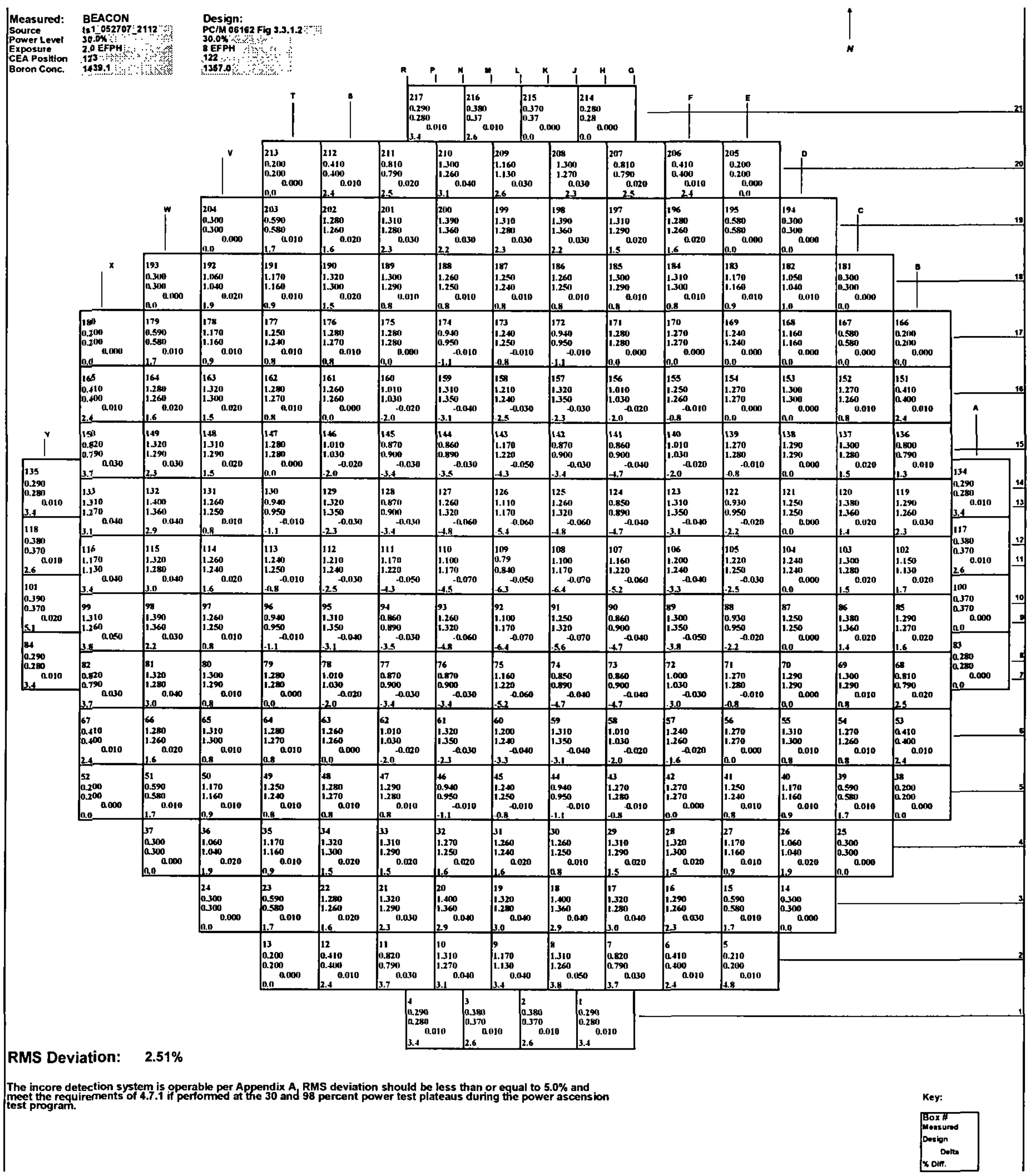

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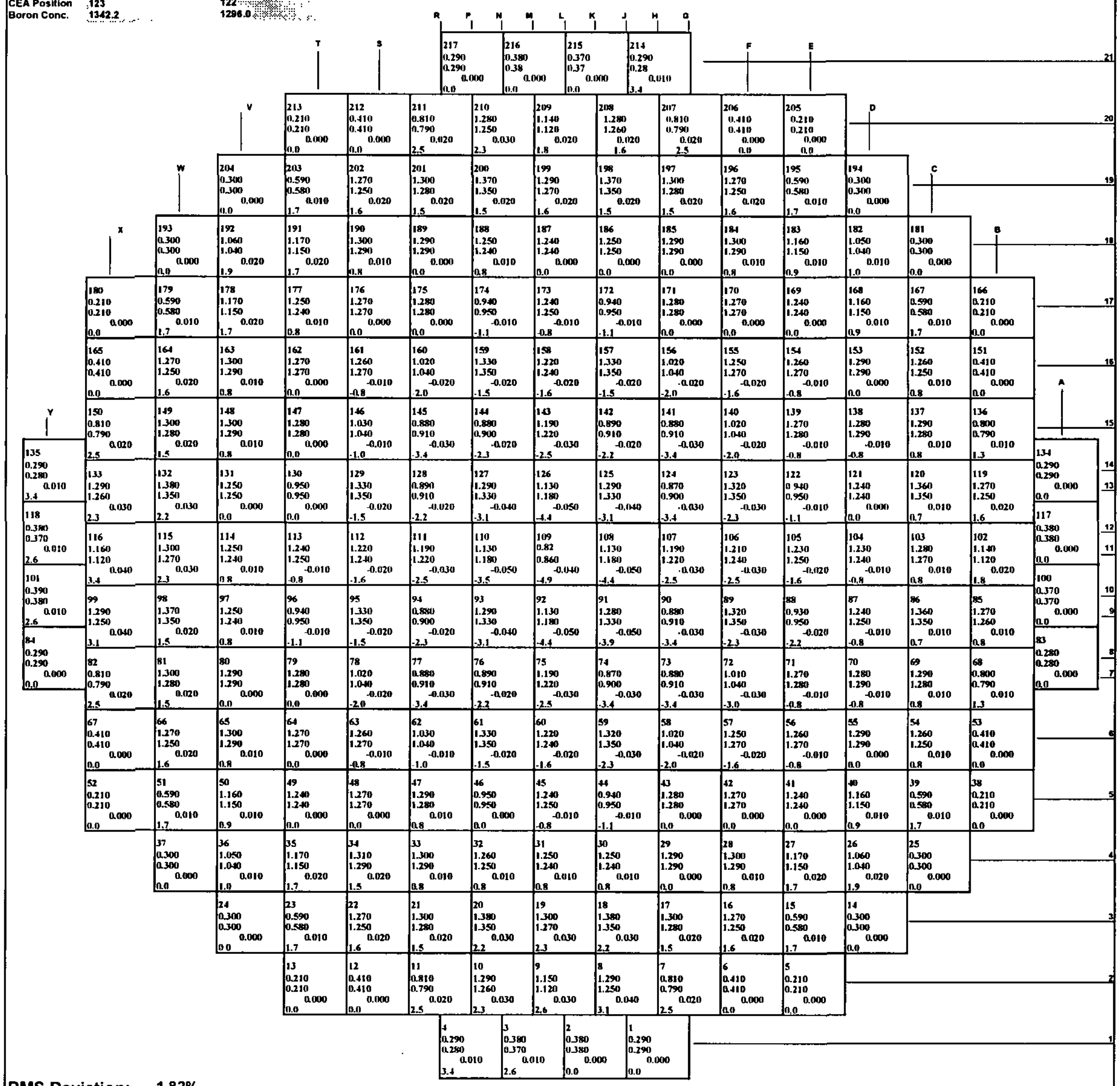
Figure 5
POWER DISTRIBUTION COMPARISON WITH DESIGN – 45% POWER

	Measured: BEACON	Design:
Source	st1c21_052607_45pla	PC/M 06162 Fig 3.3.1.3
Power Level	42.1%	45.0%
Exposure	6.2 EFPH	16 EFPH
CEA Position	123	122
Boron Conc.	1342.2	1296.0



RMS Deviation: 1.82%

The incore detection system is operable per Appendix A, RMS deviation should be less than or equal to 5.0% and meet the requirements of 4.7.1 if performed at the 30 and 98 percent power test plateaus during the power ascension test program.

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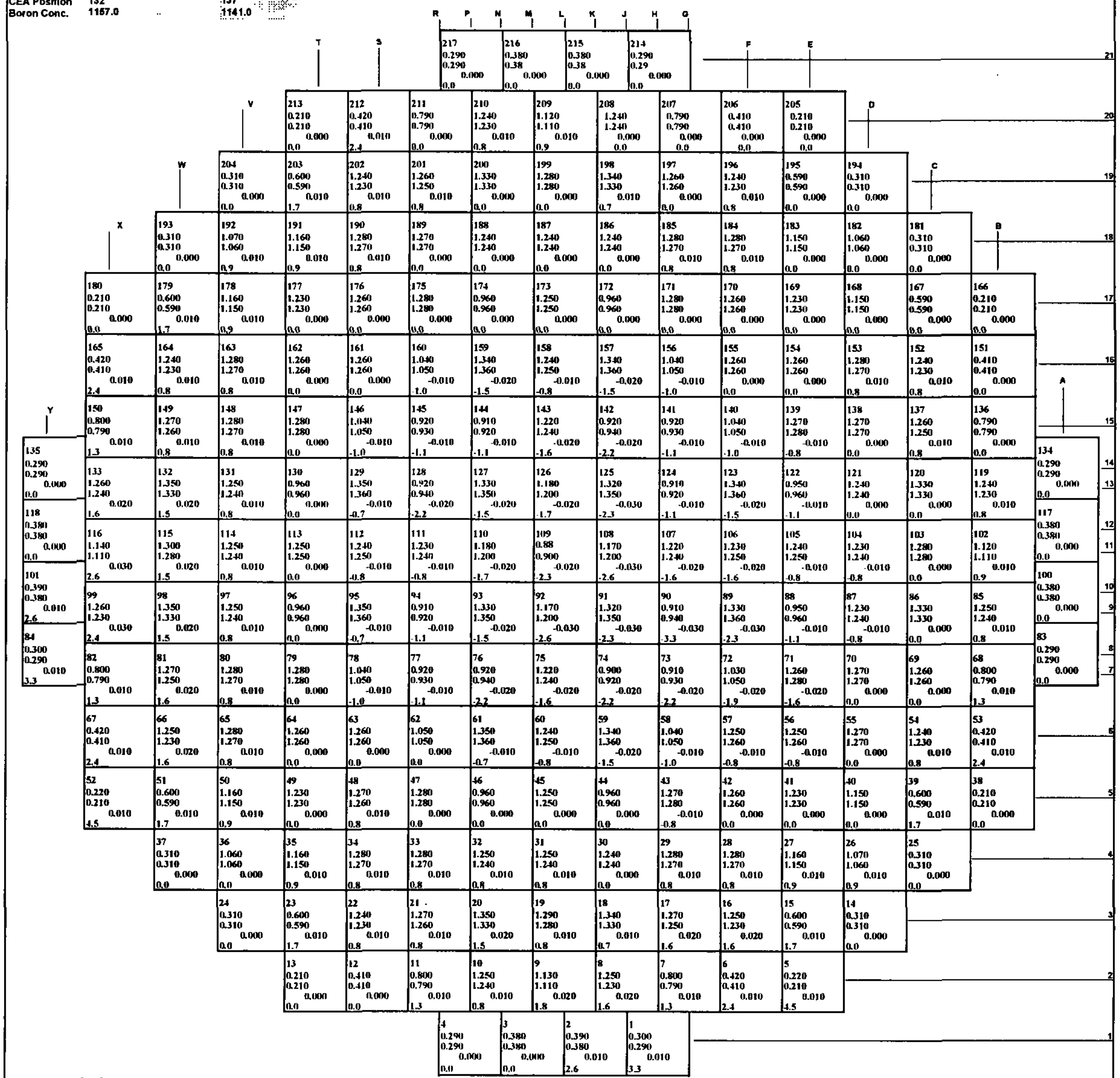
Figure 6

POWER DISTRIBUTION COMPARISON WITH DESIGN – 98% POWER

Measured:	BEACON	Design:
Source	ts1_052907_1025	PC/M 06182 Fig 3.3.1.6
Power Level	94.2%	98.0%
Exposure	29.9 EFPH	40 EFPH
CEA Position	132	137
Boron Conc.	1157.0	1141.0



RMS Deviation: 1.15%

The incore detection system is operable per Appendix A, RMS deviation should be less than or equal to 5.0% and meet the requirements of 4.7.1 if performed at the 30 and 98 percent power test plateaus during the power ascension test program.

Key:
Box #
Measured
Design
Delta
% Diff.

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Table 1
Cycle 21 Reload Sub-Batch ID*

Sub-Batch	Number of Assemblies
S4	1
AA1	20
AA2	8
AA3	32
AA4	16
BB1	4
BB2	16
BB3	16
BB4	32
CC1	4
CC2	16
CC3	12
CC4	36
CC5	4

*Reference 6

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Table 2
Approach to Criticality

Dilution Rate	Initial Boron Concentration (ppm)	Final Boron Concentration (ppm)	Approximate Dilution Time (minutes)
132 gpm	1762	1687	21
88 gpm	1687	1587	64
44 gpm	1587	1562	110

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Background

The St. Lucie Unit 1, Cycle 21 startup from refueling successfully utilized the Startup Test Activity Reduction (STAR) Program in accordance with Westinghouse Topical Report, WCAP-16011-P-A, Rev. 0 (Reference A-1). This was the first application of the STAR Program at St. Lucie Unit 1. The current implementation eliminates the CEA worth measurement only and there is no change to the MTC testing requirements. The conditions and limitations of the NRC safety evaluation for the STAR Program topical report (Reference A-1) requires that "each licensee using STAR to submit a summary report following the first application, either successful or not, of STAR to its plant. The report should (a) identify the core design method used, (b) compare the measured and calculated values and the differences between these values to the corresponding core design method uncertainties and (c) show compliance with the STAR applicability requirements. If the application of STAR is unsuccessful, identify the reasons why the STAR application failed."

This summary report provides the NRC with the required information specified in the Conditions and Limitations section of the NRC safety evaluation for the STAR topical report.

Core Design Method Used

The core design method used for St. Lucie Unit 1 Cycle 21 reload core was the PHOENIX-P/ANC code design package described in Reference A-2. The PRISM code described in Reference A-3 was used for the alternate method calculations.

Cycle 21 STAR Program Test Results (Comparison of Measured and Calculated Values)

A comparison of the last measured cycle values (Cycle 20) and the corresponding calculated values for the key physics parameters is provided in Table 3 along with the design method/analysis uncertainties.

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Table 3: Key Parameters from PSL-1 Cycle 20

Parameter	Measured	Predicted	Safety Analysis / Design Method Uncertainty	Within Criteria?
BOC HZP CBC	1449.7 ppm	1456.0 ppm	≥100 ppm	Yes
BOC HZP CEA WORTH (Bank B)	394.25 pcm	419.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 3)	543.26 pcm	512.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 7)	543.26 pcm	522.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 5/6)	597.70 pcm	608.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 2)	716.28 pcm	733.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 4)	760.82 pcm	740.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank 1)	754.56 pcm	762.00 pcm	15%	Yes
BOC HZP CEA WORTH (Bank A)	896.36 pcm	925.00 pcm	15%	Yes
BOC HZP CEA WORTH (Total)	5206.50 pcm	5221.00 pcm	10%	Yes
BOC HZP ITC	0.538 pcm/°F	0.628 pcm/°F	1.8 pcm/°F	Yes
Power Distribution (RMS, 30%)	0.80%		±5.00% *	Yes
Power Distribution (RMS, 45%)	1.12%		±5.00% *	Yes
Power Distribution (RMS, 98%)	1.09%		±5.00% *	Yes

*Procedural limit based on guidance in ANSI Standard 19.6.1 – 1997.

The measured to predicted values for Cycle 20 were all within the acceptance criteria and design method/safety analysis uncertainties. This demonstrates compliance with Applicability Requirements of Table 3.4 for "Core Design", Items 1 and 2 in the STAR Topical.

Table 4 provides a summary of tests performed during the startup of the current Cycle 21.

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Table 4: Summary of Tests Performed for Cycle 21

TEST	**POWER**	**Location**	Within Test Criteria
CEA Drop Time	Shutdown	Test results located in Section III of this document.	YES
CEA Drop Characteristics	Shutdown	CEA coupling verified by CEA drop characteristics	YES
CBC	HZP	Test results located in Sections IV and V of this document.	YES
ITC	HZP	Test results located in Section V of this document.	YES
MTC Surveillance	HZP	Test results located in Section V of this document.	YES
Incore Flux Symmetry	Low (30%)	Test results located in Section VI and Figure 4 of this document.	YES
Incore Power Distribution	Intermediate (45%)	Test results located in Section VI and Figure 5 of this document.	YES
Incore Power Distribution	HFP (98%)	Test results located in Section VI and Figure 6 of this document.	YES
ΔCBC HZP-HFP	HFP	The difference in boron concentration was within 3.5 ppm of prediction.	YES

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Compliance with STAR Applicability Requirements

STAR Applicability Requirements are conditions that must be satisfied to use the STAR Program. The STAR Applicability Requirements are provided in Table 3-4 of Reference A-1 and provide assurance that the core can be operated as designed when used in conjunction with the proposed tests. The STAR Applicability Requirements involve the following areas:

- Core Design
- Fabrication
- Refueling
- Startup Testing
- CEA Lifetime

Conformance with the STAR Applicability Requirements is documented in accordance with plant processes and procedures. Demonstration of compliance with each of the STAR applicability requirements was documented in STAR Cycle Specific Startup Test Checklists that were completed during the core design and startup testing for Cycle 21. Attachment A-1 contains STAR Cycle Specific Startup Test Checklists that verify the applicability requirements of Reference A-1 are satisfied.

References

A-1. WCAP- 16011-P-A, Rev. 0, "Startup Test Activity Reduction Program," February 2005.

A-2. WCAP-11596-P-A, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," June 1988.

A-3. SIEMENS EMF-96-029 (P)(A) "Reactor Analysis System for PWRs," 1/8/97.

Core Design Applicability Requirements

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The core design for Cycle 21 (cycle for STAR implementation) consists of the following:

- A cycle length of 16.8 EFPM
- An average enrichment of 4.08 w/o U-235
- A maximum enrichment of 4.3 w/o U-235
- A reload of 72 fresh assemblies
- A burnable absorber type of Gd_2O_3
- A CEA absorber type of B_4C
- A low leakage fuel management scheme

Requirements from Table 3.4, "Core Design" section (Pages 3-9 and 3-10) in WCAP-16011-P-A

STAR Topical Applicability Requirement	Requirement	Requirement Satisfied Yes / No
Core Design Item 1	See Table 3	YES
Core Design Item 2	See Table 3	YES
Core Design Item 3 (first bullet)	Cycle Length	YES
Core Design Item 3 (second bullet)	Average Enrichment	YES
Core Design Item 3 (second bullet)	Maximum Enrichment	YES
Core Design Item 3 (third bullet)	Fraction of Core Reloaded	YES
Core Design Item 3 (fourth bullet)	Fuel Type	YES
Core Design Item 3 (fifth bullet)	Burnable Absorber Type	YES
Core Design Item 3 (sixth bullet)	CEA Absorber Type	YES
Core Design Item 3 (seventh bullet)	Fuel Management	YES
Core Design Item 4 (first bullet)	CEA Worth Reconciliation	YES – Within 5%

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CEA Lifetime Applicability Requirements

Requirements from Table 3.4, "CEA Lifetime" section (Page 3-11)
in WCAP-16011-P-A

STAR Topical Applicability Requirement	Requirement	Requirement Satisfied Yes / No
CEA Lifetime Items 1, 2, 3	CEA lifetime requirements consistent with the St. Lucie Unit 1 CEA lifetime management program/evaluation, which adheres to the STAR Topical criteria on CEA Lifetime?	YES

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Fabrication Applicability Requirements

Requirements from Table 3.4, "Fabrication" section (Page 3-11) in WCAP-16011-P-A

STAR Topical Applicability Requirement	Requirement	Requirement Satisfied Yes / No
Fabrication Item 1.a	FPL final core design/burnable absorber letter in agreement with the final manufacturing document to ensure STAR Topical Applicability Requirements Fabrication Item 1.a.	YES
Fabrication Item 1.b, 1.c	The STAR Topical Applicability Requirements Fabrication Items 1.b and 1.c are consistent between FPL final core design/burnable absorber letter and the final manufacturing document (for each rod type).	YES
Fabrication Item 1.c (2)	STAR Topical Fabrication Item 1.c (2) is consistent with the fuel design requirements (fuel assembly orientation)?	YES
Fabrication Item 1.d	The STAR Topical Applicability Requirements Fabrication Item 1.d for each fuel assembly is correct per the requirements of the FPL final core design/burnable absorber letter.	YES
Fabrication Items 2.a, 2.b, 2.c, 2.d	For new CEAs, is the final manufacturing document is consistent with the design specifications for STAR Topical Applicability Requirements Fabrication Items 2.a, 2.b, 2.c, and 2.d.	N/A – No new CEAs for Cycle 21

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Refueling Applicability Requirements

Requirements from Table 3.4, "Refueling" section (Page 3-11)
in WCAP-16011-P-A

STAR Topical Applicability Requirement	Requirement	Requirement Satisfied Yes / No
Refueling Item 1	Core verification	YES
Refueling Item 2	CEA coupling	YES

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Startup Testing Applicability Requirements

Requirements from Table 3.4, "Startup Testing" section (Page 3-11) in WCAP-16011-P-A

The measured to predicted value for the ARO HZP CBC difference was 1.0 ppm for Cycle 21.

STAR Topical Applicability Requirement	Requirement	Requirement Satisfied Yes / No
Startup Testing Item 1	Measured to Predicted ARO HZP CBC	YES