UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report No.: 50-302/90-23

Licensee: Florida Power Corporation
3201 34th Street, South
St. Petersburg, FL 33733

Docket No.: 50-302 License No.: DPR-72

Facility Name: Crystal River 3

Inspection Conducted: July 9-13, 1990

Inspector: P. T. Burnett 8-15-90 Date Signed

Approved by: G. A. Belisle, Chief 8/15/90 Date Signed
Test Programs Section
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope:

This routine, unannounced inspection addressed the areas of post refueling startup tests for cycle 8 and comparison of those results with the results for cycle 7. End-of-life reactivity measurements were also reviewed.

Results:

Comparisons of fuel cycle parameters for the current and previous cycles showed little change for most parameters, and many of the cycle-to-cycle differences were within measurement uncertainty. Control rod worths for the current cycle are reduced from earlier values because the rods are operating in less reactive, more burned, fuel assemblies than used in the past. This was a deliberate act to increase fuel utilization. Shutdown margin requirements are satisfied throughout the current cycle.

The measured values obtained during zero power and power escalation testing all satisfied the appropriate acceptance criterion for agreement with predicted values.

After an extended search, the licensee was unable to produce the Visicorder charts used to measure and evaluate the required control rod drop time measurements. The charts are quality records and were required to be attached to the completed procedure, which was retrievable and did provide objective evidence that the test had been performed. The licensee was informed by

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telephone on July 27, 1990, that the loss of the Visicorder records would be a violation. (Paragraph 3.b)

Throughout zero power and power escalation testing, the licensee maintained positive and conservative control of high flux trip setpoints and effectively eliminated the possibility that the setpoints would be non-conservative by virtue of a calibration error.

If cycle burns to a zero boron concentration in the reactor coolant system, the full power moderator temperature coefficient will be -30.6pcm/°F, which is slightly more negative than allowed by current Technical Specifications. The licensee and Babcock and Wilcox are currently reviewing the problem and are expected to provide a timely solution. Terminating the cycle at ~80 ppm boron in the reactor coolant system is one solution.

For the Technical-Specification-required measurement of the moderator temperature coefficient at power, at 300ppmB, for the last fuel cycle, the licensee used both the Babcock and Wilcox standard methodology and the boron swing method used by most other licensees in Region II with similar surveillance requirements. Babcock and Wilcox methodology yielded a value of -11.6 pcm/°F; boron swing yielded -26.6 pcm/°F; and the predicted value was -24.0 pcm/°F. The licensee was encouraged to use the boron swing method for the current fuel cycle.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

G. L. Boldt, Vice President, Nuclear Production
*M. E. Collins, Superintendent, Nuclear Safety and Reliability
*M. W. Culver,Senior Reactor Specialist
*B. J. Hickle, Manager Plant Operations
J. R. Kraiker, Superintendent, Nuclear Management Support
*W. L. Rossfeld, Manager Nuclear Compliance
*R. C. Widell, Director, Nuclear Operations Site Support
*M. S. Williams, Nuclear Regulatory Specialist

Other licensee employees contacted included engineers, security force members, and office personnel.

Other Organizations

*R. J. Finnin, Resident Engineer, BWNS

NRC Resident Inspectors

W. H. Bradford, Resident Inspector
*P. Holmes-Ray, Senior Resident Inspector

*Attended exit interview on July 13, 1990.

Acronyms and initialisms used throughout this report are listed in the last paragraph.

2. References (72700)

The following documents were reviewed to verify acceptance criteria for the tests discussed in this inspection report and to obtain background information to aid in the review of the completed test procedures.

a. BWFC Letter, TNW-90-78, Dated June 8, 1990, Cycle 8 Redesign - LOCA Limits and F_Q. The maneuvering analysis will be based upon a LOCA limit of 16.1 kW/ft at the six foot elevation for all burnups.

b. BWFC Letter, TNW-90-75, dated June 1, 1990, Error Adjusted Alarm Setpoints, transmitted BWFC Document No. 86-1177727-00, "CR-3 Cycle 8 Limits and Setpoints." The results verified the original Cycle 8 operating limits. Cycle 8 is the third cycle to operate with gray (Inconel) APSRs. Setpoints are for 4- and 3-pump incore and excore imbalance limits and rod insertion setpoints for various ranges of burnup throughout the cycle.

c. BWFC Technical Document No. 51-1176-528-00, Mechanical Maneuvering Recommendations, February 22, 1990.

d. BWFC Letter, D90-46, Dated February 26, 1990, RCS Flow Recommendations. Provides flow acceptance criteria for Cycle 8.

e. BWFC Letter TNW-90-73, Dated May 24, 1990, Revised Power Escalation Test Specification, transmitted Technical document 62-1178381-01, "Crystal River 3, Cycle 8 Power Escalation Test Specification."

f. BWFC Technical Document 62-1177745-00, Zero Power Physics Test/ TS-8710-01/Crystal River Three Cycle 8/NSC-85H. Describes how to perform the tests, and is essentially a writeup of the test procedures to be written by the licensee staff.

g. BWFC Letter TNW-90-76, Dated June 4, 1990, Cycle 8 Physics Test Manual, transmitted Technical Document 61-1179584-00," Physics Test Manual Crystal River - III Cycle 8 NSC-85H." The latter provides acceptance criteria, based upon the redesigned cycle 8, for zero power and power escalation tests.

h. Technical Document 61-1179591-00, Physics Operating Manual, Crystal River - III Cycle 8 NSC-85H. Approved June 13, 1990.

i. BAW-2102 (Revision 1, June 1990), Crystal River Unit 3 - Cycle 8 Reload Report. Justifies operation at 2544 MWt using approved analytical techniques.

j. Crystal River Unit 3, Cycle 7 Startup Report, April 1988

k. BAW-10120P (Topical Report), Comparison of Core Physics Calculations with Measurements.

In summary, the transition from cycle 7 to cycle 8 (the current cycle) introduced no changes in maximum design conditions for power, pressure, flow, core bypass, power shape, hot channel factors, MDNBR, DNB limit, or heat flux. The BAW comparison of key parameters used in accident analysis showed that cycle 8 was conservative with respect to FSAR values except for MTC at EOL and total control rod worth: 12.9 %dk/k (FSAR) and 7.94 %dk/k (cycle 8). The new fuel assemblies (Batch 10) are the B4Z design, which was first loaded in Batch 9 for cycle 7. Thus, these fuel assemblies are not new in concept nor do they use different component materials from previous batches.

3. Precritical Tests (72700)

The following, completed precritical tests were reviewed for content and application:

a. PT-100 (Revision 14), Controlling Procedure for Precritical Testing, controlled and sequenced the tests discussed in this paragraph and the following internal tests: setup and checkout of the reactimeter and RTD normalization constants. The test was started on June 20, 1990 and was completed on June 22, 1990.

b. SP-102, Control Rod Drop Time Tests was performed on June 20, 1990. The procedure required that the Visicorder traces, used to measure and confirm that control rod drop times were acceptable, be attached to the completed procedure and be transmitted with it to the records vault for retention. However, the traces could not be produced for inspection either during the inspection or in the following week. This has been identified as violation 50-302/90-23-01: Failure to retain rod drop time Visicorder traces, a quality record. The licensee was informed of the violation in a telephone call on July 27, 1990.

c. SP-224 (Revision 5), Reactor Coolant Flow Measurement Determination, was performed on June 20, 1990. The difference in flow between loops was 2.39% of loop average flow, which was in excess of the acceptance criterion that the loop flows agree within 2% or less. Review of the acceptance criterion by plant and vendor personnel did not identify a requirement for such a stringent criterion within the safety analyses, vendor test recommendations or the limits and precautions document. Hence the criterion was waived at PRC meeting 90-25.

No additional violations or deviations were identified.

4. Initial Criticality and Zero Power Physics Tests (61708, 61710, 72700)

The following, completed startup tests were reviewed for content and application:

a. PT-110 (Revision 15), Controlling Procedure for Zero Power Physics Testing, was conducted from June 20, 1990 to June 23, 1990. The activities controlled by this procedure included the approach to criticality and the procedures discussed later in this paragraph. Prior to the approach to criticality, both source range nuclear instruments (NI-1 and NI-2) were shown to be operating properly by demonstrating that each passed a ten-observation chi-squared test. The inspector independently analyzed the test data and confirmed the licensee's results. The trip setpoint of the PRNIs was reduced to approximately 0.5% of full power as one of the initial conditions of the test. The approach to criticality was begun with control rod groups 1-4 fully withdrawn and the RCS boron concentration reduced to 2013 ppmB. Then group 8 (the APSRs) was pulled to 25% withdrawn and left in that position for the balance of the process. Rod groups 5 and 6 were withdrawn, without overlap, in 25% increments. Inverse multiplication was calculated and plotted independently against rod reactivity for each SRNI at the end of each increment of withdrawal. Predictions of criticality were made prior to the next increment. Finally, criticality was achieved with group 7 at 24% withdrawn at 5:20 am on June 21, 1990.

At criticality, the SRNIs were still on scale, but the IRNIs had not begun to respond. Power was increased to demonstrate successfully that there was a decade of overlap in power from the power that IRNIs came on scale to the power at which excitation voltage to the SRNI detectors tripped off.

The reactimeter was checked out by comparing its reactivity solutions for a range of positive and negative periods with those obtained by measuring the reactor period with a stopwatch and solving the inhour equation for reactivity. Although step 10.2 indicated that the range for the checkout should be ± 50 pcm, the most negative reactivity to satisfy the the 5% agreement criterion was -43 pcm. With the exceptions noted below, application of the reactimeter was limited to the calibrated span.

b. PT-116 (Revision 8), Sensible Heat Determination, was completed on June 21, 1990. The maximum power for zero power tests was established at 0.3 times the sensible heat power. The PRNIs were adjusted to indicate 1% of full power at the upper testing power level. The trip setpoint remained at 5% of full power.

c. PT-111 (Revision 9), Hot Zero Power All Rods Out Critical Boron Test, was completed on June 21, 1990. With an RCS C_B of 2091 ppmB, the ARO reactivity was 100 pcm, although the reactimeter had been checked out only to +50 pcm. The additional boron to compensate 100 pcm was calculated to be 14 ppmB, yielding an ARO C_B of 2105 ppmB, which satisfied the acceptance criterion of 2056 ± 100 ppmB. (For cycle 7, the ARO C_B was 2033 ppmB.) The error in boron to compensate the positive reactivity introduced by using the reactimeter outside of its calibrated span was judged to be insignificant with respect to the measurement of total C_B at ARO.

d. SP-103 (Revision 9), Moderator Temperature Coefficient Determination at Startup Following Refueling, was performed on June 22, 1990. Three measurements were made in succession starting with a 4.9°F heatup, followed by a 9.7°F cooldown, and a 4.2°F heatup. The three ITCs, 2.86 pcm/F°, 1.80 pcm/°F, and 2.14 pcm/°F all agreed within 1 pcm/°F of the average value whether calculated directly or weighted by either temperature change or reactivity change. After adjusting for the DTC of -1.68 pcm/°F the MTCs from the three measurements were +4.54 pcm/°F, +3.48 pcm/°F, and +3.82 pcm/°F, respectively.

(The cycle 7 MTC was +3.76 pcm/°F) Each satisfied the acceptance criterion (TS 3.1.1.3) that the MTC at HZP and ARO be less than 9 pcm/°F. Enclosure 2 of the procedure provided the methodology for extrapolation of the MTC to full power conditions. The hot, full-power MTC was determined to be -4.5 pcm/°F, which appeared to satisfy the TS 3.1 1.3.b requirement that the MTC be less than zero at 95% RTP and higher. The inspector commented to the licensee that the procedure should provide an extrapolation to 95% RTP for direct comparison of the result with the TS limit.

The EOL MTC was not extrapolated. The predicted value at C_B = C ppmB is -30.64pcm/°F. At C_B = 300ppmB, the MTC(predicted) is -25.94 pcm/°F. It appears the the limiting value, -30pcm/°F will be reached at 84 to 41 ppmB. BAW is currently reperforming the steam line break analysis.

e. PT-112 (Revision 10), Hot Zero Power Regulating Rod Group Worth and Differential Boron Worth Measurement, was performed on June 22, 1990. Regulating rod groups 7, 6, and 5 were successively inserted in discrete increments, without overlap, to compensate a continuous dilution of the RCS boron. The reactivity worth of each increment was measured using the reactimeter. Some of the the reactivity measurements exceeded the calibrated range of the reactimeter of -43 pcm to 50 pcm. As with PT-111, the first reactivity increment was 100 pcm. Some of the negative reactivities were -50 to -54.5 pcm, which exceeded the calibration value of -43 pcm. Because most of the reactivity trace analyzed in each of these instances was within the calibrated range of the reactimeter, the effect on the measurement was judged to be negligible. However, using an instrument outside its calibrated range is poor practice.

The measured and predicted group worths are shown below:

	Reactivity Worth (pcm)		
Group	Measured	Predicted	
7	675.5	705.0	
6	664.0	752.0	
5	1187.0	1075.0	
total	2526.5	2532.0	
(total	3071.0	3163.0	cycle 7)

The agreement between predicted and measured values for each individual rod group satisfied the 15% acceptance criterion and the agreement for total rod worth satisfied the 10% acceptance criterion.

The measured differential boron worth was -8.01 pcm/ppmB (Cycle 7 was -7.81 pcm/ppmB) and agreed within the 15% acceptance criterion with the predicted value of -7.29 pcm/ppmB.

Other than rod worths, the measured parameters for cycle 8 were little different from cycle 7. No violations or deviations were identified.

5. Power Escalation Tests (72700, 61702, 61705, 61706, 61710)

Power escalation testing was controlled by PT-120 (Revision 16), Controlling Procedure for Power Escalation Testing. Specific tests, measurements, and calculations required by PT-120 were conducted in accordance with the enclosures to PT-12 and the test and surveillance procedures discussed below.

Prior to increasing power above the zero power testing range, procedure steps within PT-120 proper called for setting the PRNI trip setpoints to 50-55% of full power, confirming that PT-110 (see paragraph 4) was completed satisfactorily, confirming that the MTC (SP-103 discussed in paragraph 4.d) was satisfactory, and performing SP-421 (the reactivity balance procedure). Then power was increased to 38% RTP; a heat balance was performed; and the PRNIs were recalibrated to the heat balance and the trip setpoints increased to 80% RTP. Power was then increased to the intermediate power test level (40 - 75% RTP). An incore power distribution map obtained at 69.6% RTP failed one acceptance criterion: The RMS difference between predicted and measured fuel assembly radial power peaking factors exceeded the 5% limit. The power map was evaluated by BWFC. That evaluation showed that the failure was caused by large percentage differences (15 - 21%) between measured and predicted powers in low-power (.3 - .4 times average), peripheral assemblies. The BWFC conclusion was that there was no safety significance to the failure and that power escalation should continue. That evaluation and conclusion were presented to and accepted by the PRC in meeting 90-26, and power escalation continued. The same problem, with the same source, evaluation and conclusion, was encountered with an incore power distribution measured in the full power testing range. (The inspector suggested that weighting the squared differences by the product of predicted and measured relative powers would produce a more significant statistic.)

a. Enclosure 1, Core Symmetry Test, was completed successfully on June 23, 1990, at 25% of full power.

b. Enclosure 2, 40-75% FP Test Plateau, documented the completion of:
   (1) Comparison of radial power peaking factors (discussed above),
   (2) Comparison of measured and predicted maximum total power peaking factors, which was successful,
   (3) Linear heat rate analysis and power extrapolation, which justified power escalation to RTP, and
   (4) Minimum DNBR extrapolation, which justified escalation to RTP.

c. Heat Balance Procedures

   (1) SP-312C (Revision 0), Quarterly Heat Balance Verification, compared the plant computer heat balance with an independent

calculation. At 38% RTP, the two calculations agreed within 0.54% RTP, which satisfied the 2% agreement acceptance criterion.

(2) SP-312A (Revision 2), Daily Heat Balance Power Comparison, was performed at 38% RTP to confirm calibration of the PRNIs.

(3) SP-312D (Revision 0), Backup Heat Balance Calculations, was performed at 38% RTP to confirm that the manually calculated heat balance agreed with computer calculations in the event of a loss of the computer.

d. SP-438 (Revision 1), Incore Neutron Detectors Channel Check, was performed to confirm operability of a sufficient number of incore detectors to perform the surveillances required by TS. All acceptance criteria were satisfied.

e. SP-104 (Revision 25), Hot Channel Factors Calculations, was performed at 69.6% RTP and 98.2% RTP. In both cases, F_Q, Nuclear Heat Flux Hot Channel Factor, $F_{dH}N$, Nuclear Enthalpy Rise Hot channel Factor, MLHR, maximum linear heat rate, were satisfactory.

Discussions with plant personnel revealed that incore power distributions are anticipated to approach the limiting values at 100 to 150 EFPD cycle exposure, when the BPRAs are nearly depleted. However, the licensee does not expect to have to reduce power to remain within limits.

Throughout zero power and power escalation testing, the licensee maintained positive and conservative control of high flux trip setpoints and effectively eliminated the possibility that the setpoint would be non-conservative by virtue of a calibration error. The tests reviewed used a variety of reactivity units within and among the tests, such as E-4 %dk/k, E-5 dk/k, microrho, and pcm. Such a variety of units can lead to confusion and misinterpretation of results.

No violations or deviations were identified.

6. Cycle 7 Surveillance Activities (61707, 61708)

The following surveillance procedures performed during cycle 7 were reviewed for content and performance:

a. SP-421 (Revision 33), Reactivity Balance Calculations, was performed with the required frequency throughout cycle 7. The final calculation of the cycle was performed on March 7, 1990, and yielded a core reactivity 0.32% dk/k more reactive that predicted. This was well within the ± 1% dk/k tolerance allowed by TS 4.1.1.1.1.2.

b. SP-101 (Revision 14), Moderator Temperature Coefficient Determination at 300 ppm Boron, was performed twice during cycle 7. The first measurement was made on December 30, 1989, at 95% RTP and a RCS boron concentration of 304 ppm, and used standard BAW methods. That methodology assumes that control rods can be calibrated at power using the reactimeter and appropriate correction factors to account for doppler feedback. (See paragraph 1.k (section 2.2.3).) The result after correcting for a DTC of -0.178 E-04 dk/k/°F was -1.16 E-04 dk/k/°F. Extrapolated to full power, the MTC was -1.20 E-04 dk/k/°F.

The second test was performed on January 11, 1990, at 95% RTP and an initial equilibrium boron concentration of 270 ppm. Boration rather than control rod insertion was used to reduce the reactivity to induce a RCS temperature reduction at constant power. After correcting for a DTC of -0.133 E-04 dk/k/°F, the resulting MTC was -2.66 E-04 dk/k/°F, which was within 10% of the predicted value of -2.4 E-04 dk/k/°F.

In view of the clearly superior results of the second method of MTC measurement at power, which is the method most commonly used at Region II facilities, the licensee was urged by the inspector to use that method in the future. With the predicted MTC at EOL near the TS limit, the best possible measurement should be performed at 300 ppmB. To assure confidence in the results, the MTC should be measured for both a heatup and a cooldown, in any order. The results of the two measurements should agree within the larger of 1 pcm/°F or 10%.

No violations or deviations were identified.

7. Exit Interview (30703)

The inspection scope and findings were summarized on July 13, 1990, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. No dissenting comments were received from the licensee. Proprietary material was reviewed in the course of the inspection, but is not included in this report. The licensee was informed by telephone on July 27, 1990 that the failure to retain the Visicorder traces from the control rod drop times tests would be a violation as discussed in paragraph 3.b.

VIO 50-302/90-23-01: Failure to retain rod drop time Visicorder traces, a quality record.

8. Acronyms and Initialisms Used Throughout This Report

APSR	axial power shaping rod
ARO	all rods out
BAW	Babcock and Wilcox
BPRA	burnable poison rod assembly
BWFC	Babcock and Wilcox Fuel Company
BWNS	Babcock and Wilcox Nuclear Services Company
dk/k	reactivity
DNB	departure from nucleate boiling
DNBR	departure from nucleate boiling ratio
DTC	doppler temperature coefficient
E	power of ten
EFPD	effective full power days
EOL	end of (core or cycle) life
F_{dH}^N	nuclear enthalpy rise hot channel factor
F_Q	nuclear heat flux hot channel factor
FSAR	Final Safety Analysis Report
HZP	hot zero power
IRNI	intermediate range nuclear instrument
ITC	isothermal temperature coefficient
kW	kilowatt
LOCA	loss of coolant accident
MDNBR	minimum departure from nucleate boiling ratio
MLHR	maximum linear heat rate
MTC	moderator temperature coefficient
MWt	megawatt thermal
NI	nuclear instrument
pcm	percent millirho, a unit of reactivity
ppm	parts per million
ppmB	parts per million boron
PRC	plant review committee
PRNI	power range nuclear instrument
PT	periodic test
RCS	reactor coolant system
RMS	root mean square
RTD	resistance temperature device
RTP	rated thermal power
SP	surveillance procedure
SRNI	source range nuclear instrument
TS	Technical Specifications
VIO	violation