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Subject: Catawba Nuclear Station, Unit 2
Docket Nos. 50-414
Unit 2 Cycle 11 Startup Report

Catawba Unit 2 Cycle 11 is the first Duke Power nuclear unit to use the Westinghouse Robust Fuel Assembly (RFA). Section 14.3.4, item (3) of our Updated Final Safety Analysis Report states a summary report will be submitted within 90 days following resumption of commercial power operation if a fuel of a different design has been installed.

Pursuant to the above requirements, attached is this summary report for Catawba Nuclear Station Unit 2 Cycle 11.

Any questions concerning this report may be directed to Kay Nicholson at 803-831-3237.

Sincerely,

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Duke Power Company
Catawba Nuclear Station
Unit 2 Cycle 11

STARTUP REPORT

April 2000

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1.0 INTRODUCTION

Catawba Unit Two Cycle 11 is the first Duke Power nuclear unit to use the Westinghouse Robust Fuel Assembly (RFA). The C2C11 core consists of a feed batch of 72 of these fuel assemblies. The feed batch enrichments are 36 F/A's at 3.90% (w/o), and 36 F/A's at 4.20% (w/o). Burnable absorbers accompanying the feed batch are of two designs: Integral Fuel Burnable Absorber (IFBA) and Wet Annular Burnable Absorber (WABA), both manufactured by Westinghouse.

C2C11 core loading commenced at 0635 on March 27, 2000 and concluded at 1837 on March 29, 2000. Initial criticality for Cycle 11 occurred at 0348 on April 8, 2000. Zero Power Physics Testing was completed at 0809 on April 8, 2000. The unit reached full power at 1302 on April 11, 2000. Power Escalation testing, including testing at full power, was completed by April 20, 2000.

Table 1 summarizes important characteristics of the Catawba 2 Cycle 11 core design.

TABLE 1
C2C11 CORE DESIGN DATA

1. C2C10 end of cycle burnup: 448 EFPD

2. C2C11 design length: 495 –10 / +15 EFPD

Region	Fuel Type	Number of Assemblies	Enrichment, w/o U^{235}	Loading, MTU**	Cycles Burned
8	MkBW	9	3.75	4.1058	2&3
10	MkBW	4	3.98	1.8248	3
11A	MkBW	8	4.32/2.0*	3.6496	2
11B	MkBW	16	4.42/2.0*	7.2992	2
12	MkBW	84	4.54/2.0*	38.3208	1
13A	W RFA	36	3.90/2.0*	16.3872	0
13B	W RFA	36	4.20/2.0*	16.3872	0
Totals		193		87.9745	

* 2.00 w/o enriched U blanketed fuel assemblies (6 inches top and bottom)

** Design MTU loadings which were used in all design calculations.

2.0 PRECRITICAL TESTING

Precritical testing includes:

- Core Loading
- Preliminary Calibration of Nuclear Instrumentation
- Dilution of Reactor Coolant System to Estimated Critical Boron concentration
- Rod Drop Timing Test

Sections 2.1 through 2.5 describe results of precritical testing for Catawba 2 Cycle 11.

2.1 Total Core Reloading

The Cycle 11 core was loaded under the direction of PT/0/A/4150/22, Total Core Reloading. Plots of Inverse Count Rate Ratio (ICRR) versus number of fuel assemblies loaded were maintained for each applicable Source Range NIS and Boron Dilution Mitigation System (BDMS) channel.

Core loading commenced at 0635 on March 27, 2000 and concluded at 0950 on 1837 on March 29, 2000. Core loading was verified per PT/0/A/4550/03C, Core Verification, which was completed at 2100 on March 29, 2000.

Figure 1 shows the core loading pattern for Catawba 2 Cycle 11.

2.2 Preliminary NIS Calibration

Periodic test procedure PT/0/A/4600/05E, Preliminary NIS Calibration, is performed before initial criticality for each new fuel cycle. Intermediate range reactor trip and rod stop setpoints are adjusted using measured power distribution from the previous fuel cycle and predicted power distribution for the upcoming fuel cycle. Power Range NIS full power currents are similarly adjusted. Intermediate Range NIS Rod Stop and Rx Trip setpoints are checked and revised as necessary for initial power ascension.

An added conservatism of 20% is applied procedurally to I/R setpoints. Since both I/R NIS detectors had been replaced during the refueling outage, this was a particularly prudent measure given the uncertainly with regard to the detectors' response characteristics under power operation. The effectiveness of this preliminary calibration is discussed in Section 4.10.

Table 4 shows the calibration data calculated by PT/0/A/4600/05E. Calculations were performed on March 30, 2000. Calibrations were completed on April 6, 2000.

2.3 Reactor Coolant System Dilution

The reactor coolant system boron concentration was diluted from the refueling boron concentration to the estimated critical boron concentration per PT/0/A/4150/19B, NC System Dilution Following Refueling. Inverse Count Rate Ratio (ICRR) was plotted versus gallons of demineralized water added.

Initial reactor coolant boron concentration was 2541 ppmB. The estimated critical boron concentration was calculated to be 1770 ppmB. The calculated volume of demineralized water required was 28175 gallons. This change in boron concentration was expected to decrease ICRR from 1.0 to 0.52.

Reactor coolant system dilution at 78 GPM was performed from 1430 to 2035 on April 6, 2000. The final reactor coolant system boron concentration, after allowing system to mix, was 1715 ppmB. Figure 2 shows ICRR versus volume of water used. Overshoot was believed to be attributable to predicted dilution volume inaccuracies related to performance of dilution at relatively low NC System temperature (274°F). The NC System was not diluted below K-eff < 0.99 or Shutdown Margin boron limits. The NCS was subsequently borated to 1780 ppmB prior to reactor startup.

2.4 Control Rod Drop Timing Test

This testing is performed prior to each post-refueling startup to verify that, when dropped from the fully withdrawn position at Hot, No-load conditions, each RCCA completely inserts and that it's drop time is ≤ 2.2 seconds (pursuant to Tech Spec Surveillance Requirement 3.1.4.3). The 2.2 second criterion applies to the time measured from beginning of decay of Stationary Gripper coil voltage to Dashpot entry.

All BOC11 RCCA drop times satisfied the acceptance criterion. Table 2 summarizes not only the BOC11 data, but, for comparison purposes, the BOC10 drop times as well. It should be noted that "Time to DP" is the data to be compared to the 2.2 second criterion. "Time in DP" is a parameter that is measured for the purposes of assessing resistance to the RCCA in the Dash Pot region, which was at one time postulated to be the culprit in increasing drop times industry wide.

TABLE 2
CYCLE 10 AND CYCLE 11 ROD DROP TIMING RESULTS

2BOC10 (10/98)				2BOC11 (4/00)			
Bank	Rod ID	Dashpot entry	Dashpot bottom	Bank	Rod ID	Dashpot entry	Dashpot bottom
CBA	H06	1.57	2.15	CBA	H06	1.57	2.15
	H10	1.56	2.15		H10	1.57	2.12
	F08	1.59	2.19		F08	1.57	2.14
	K08	1.56	2.13		K08	1.57	2.14
CBB	F02	1.58	2.13	CBB	F02	1.62	2.16
	B10	1.56	2.09		B10	1.60	2.12
	K14	1.58	2.14		K14	1.60	2.12
	P06	1.52	2.05		P06	1.55	2.05
	B06	1.57	2.15		B06	1.60	2.13
	F14	1.61	2.20		F14	1.63	2.16
	P10	1.57	2.16		P10	1.58	2.10
	K02	1.66	2.21		K02	1.65	2.16
CBC	H02	1.53	2.05	CBC	H02	1.55	2.11
	B08	1.56	2.12		B08	1.56	2.09
	H14	1.56	2.15		H14	1.58	2.15
	P08	1.60	2.18		P08	1.56	2.11
	F06	1.55	2.11		F06	1.59	2.20
	F10	1.56	2.12		F10	1.56	2.12
	K10	1.51	2.04		K10	1.54	2.12
	K06	1.56	2.12		K06	1.56	2.13
CBD	D04	1.57	2.15	CBD	D04	1.56	2.13
	M12	1.56	2.12		M12	1.57	2.10
	D12	1.58	2.17		D12	1.56	2.07
	M04	1.64	2.26		M04	1.58	2.14
	H08	1.59	2.18		H08	1.63	2.24
SBA	D02	1.66	2.26	SBA	D02	1.61	2.20
	B12	1.59	2.15		B12	1.58	2.19
	M14	1.61	2.19		M14	1.61	2.18
	P04	1.55	2.11		P04	1.56	2.09
	B04	1.59	2.16		B04	1.56	2.12
	D14	1.60	2.16		D14	1.58	2.18
	P12	1.60	2.16		P12	1.58	2.11
	M02	1.66	2.24		M02	1.68	2.25
SBB	G03	1.54	2.13	SBB	G03	1.57	2.14
	C09	1.56	2.12		C09	1.58	2.17
	J13	1.57	2.12		J13	1.58	2.14
	N07	1.56	2.11		N07	1.60	2.18
	C07	1.58	2.13		C07	1.60	2.18
	G13	1.55	2.11		G13	1.57	2.14
	N09	1.55	2.13		N09	1.58	2.15
	J03	1.57	2.12		J03	1.59	2.17
SBC	E03	1.61	2.19	SBC	E03	1.59	2.15
	C11	1.57	2.13		C11	1.58	2.14
	L13	1.55	2.11		L13	1.56	2.14
	N05	1.58	2.13		N05	1.58	2.17
SBD	C05	1.57	2.13	SBD	C05	1.54	2.10
	E13	1.58	2.16		E13	1.56	2.13
	N11	1.56	2.11		N11	1.53	2.10
	L03	1.60	2.18		L03	1.56	2.14
SBE	H04	1.58	2.13	SBE	H04	1.55	2.11
	D08	1.58	2.14		D08	1.57	2.14
	H12	1.58	2.15		H12	1.58	2.17
	M08	1.58	2.13		M08	1.59	2.17

FIGURE 1
CORE LOADING PATTERN, CATAWBA 2 CYCLE 11

180 (top); 90 (left, at row 8); 270 (right, at row 8); 0 (bottom)

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					W03 PD	T12 PD ❷	X55 PD	V10 PD	X56 PD	T60 PD ❷	W19 PD				
2			W93 PD	W60 R441	ZM42 PD	ZM50 R424	ZM5C 4W003	XA1 R401	ZM62 4W006	ZM52 R408	ZM44 PD	W5A R415	W55 PD		
3		W52 PD	ZM39 PD	ZM64 4W00C	X26 R428	XA3 PD	X91 R438	ZM09 16W003	X0C R445	XA2 PD	X0A R416	ZM90 4W014	ZM3A PD	W91 PD	
4		W6A R421	ZM91 4W015	X29 R411	ZM14 16W010	X61 PD	ZM19 16W013	X99 R423	ZM29 16W023	X34 PD	ZM2A 16W024	X46 R432	ZM5A 4W002	W56 R431	
5	W29 PD	ZM45 PD	X23 R404	ZM06 16W002	X66 PD	ZM35 16W031	XA0 PD	ZM0C 16W005	X95 PD	ZM22 16W01C	X1C PD	ZM23 16W019	X6C R427	ZM46 PD	W15 PD
6	T02 PD ❷	ZM53 R443	X13 SS	X96 PD	ZM1C 16W015	X42 R412	X05 PD	X2A R450	X3A PD	XA4 R418	ZM20 16W016	X3C PD	X35 PD	ZM54 R406	T27 PD ❷
7	X21 PD	ZM92 4W016	X01 R437	ZM13 16W009	X92 PD	X51 PD	ZM01 12W001	X09 PD	ZM02 12W002	X6A PD	X62 PD	ZM16 16W012	X5A R446	ZM60 4W004	X30 PD
8	V35 PD	X94 R447	ZM05 16W001	X22 R414	ZM26 16W022	X4A R405	X41 PD	T08 R426 ❶	X19 PD	X24 R430	ZM12 16W00C	X33 R413	ZM11 16W00A	X12 R442	V06 PD
9	X93 PD	ZM69 4W011	X65 R429	ZM33 16W029	X54 PD	X4C PD	ZM03 12W003	X11 PD	ZM04 12W004	X9C PD	X14 PD	ZM31 16W02A	X49 R409	ZM6A 4W012	X63 PD
10	T64 PD ❷	ZM55 R425	X04 PD	X90 PD	ZM25 16W021	X25 R436	X36 PD	X52 R410	X31 PD	X60 R451	ZM36 16W032	X64 PD	X02 SS	ZM4C R402	T62 PD ❷
11	W40 PD	ZM49 PD	X59 R403	ZM24 16W020	X16 PD	ZM21 16W01A	X43 PD	ZM30 16W026	X15 PD	ZM10 16W006	X9A PD	ZM34 16W030	X44 R422	ZM41 PD	W05 PD
12		W62 R439	ZM65 4W009	X50 R419	ZM0A 16W004	X69 PD	ZM15 16W011	X45 R433	ZM2C 16W025	X39 PD	ZM1A 16W014	X03 R449	ZM66 4W010	W59 R400	
13		W6C PD	ZM3C PD	ZM61 4W005	X40 R435	X32 PD	X1A R420	ZM32 16W02C	X20 R444	X10 PD	X5C R417	ZM63 4W00A	ZM40 PD	W51 PD	
14			W61 PD	W94 R440	ZM4A PD	ZM56 R452	ZM59 4W001	X06 R434	ZM6C 4W013	ZM51 R407	ZM43 PD	W54 R448	W65 PD		
15					W24 PD	T19 PD ❷	X53 PD	V41 PD	X2C PD	T29 PD ❷	W12 PD				

FUEL ID: T** = BATCH 8, V** = BATCH 10, W**=BATCH 11, X** = BATCH 12, ZM**=BATCH 13

COMPONENT ID: R***=CONTROL ROD; SS=SECONDARY SOURCE; **W***=BURNABLE POISON; PD=PLUGGING DEVICE (THIMBLE PLUG).

❶ Cycle 7 Reinserts

❷ Cycle 8 Reinserts

TABLE 3
PRELIMINARY NIS CALIBRATION DATA

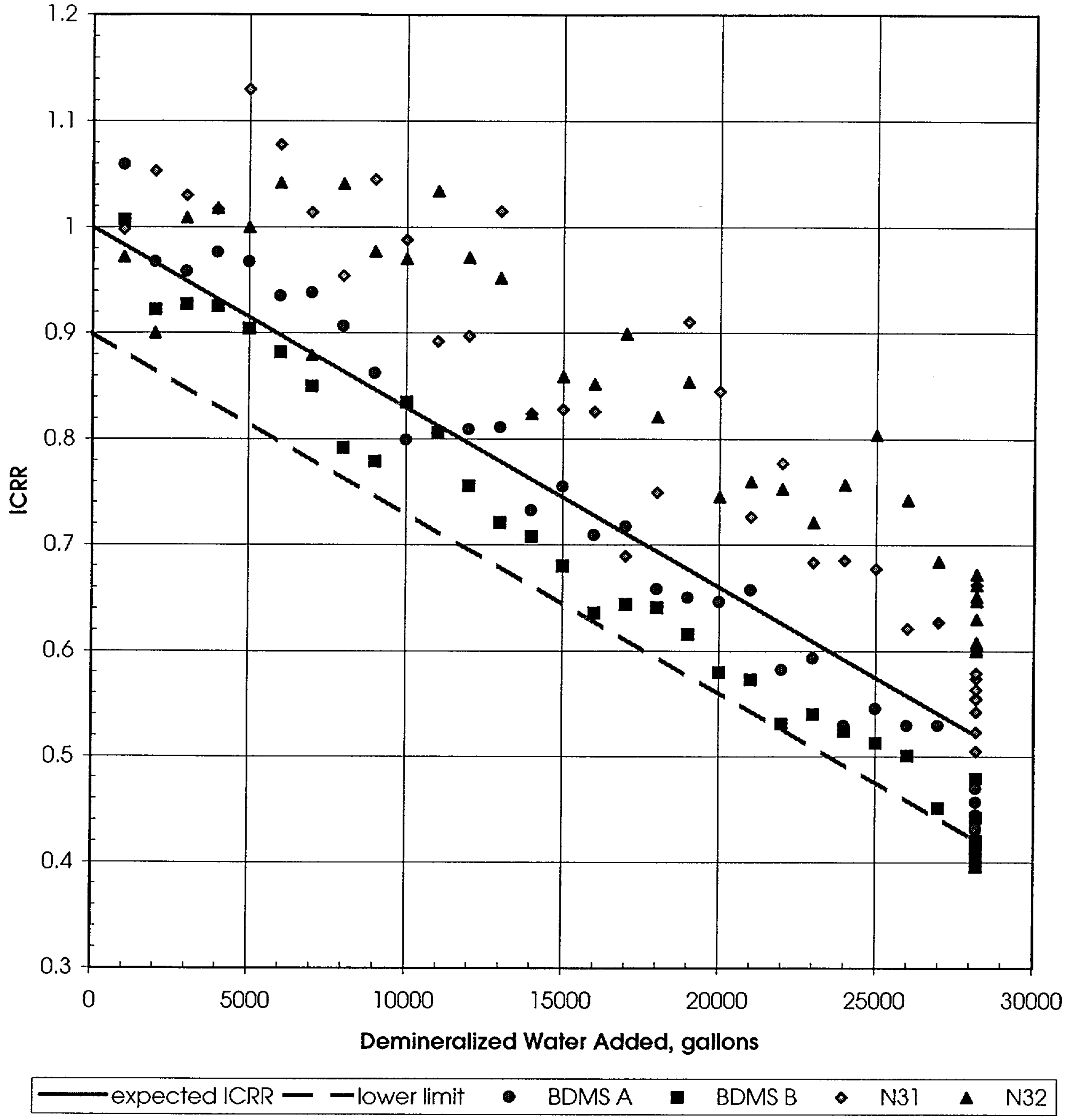
Intermediate Range

Channel	Ratio (BOC 11 ÷ Cycle 10)	Cycle 10 Reactor Trip Setpoint, μAmps	BOC 11 Reactor Trip Setpoint, μAmps	BOC 11 Rod Stop Setpoint, μAmps
N35	0.584	72.0	42.1	33.7
N36	0.587	66.9	39.3	31.4

Power Range

Channel	Ratio (BOC 11 ÷ Cycle 10)	Axial Offset, %	Cycle 10 Full Power Current, μAmps		BOC 11 Full Power Current, μAmps	
			Upper	Lower	Upper	Lower
N41	1.040	+20	288.5	231.2	300.0	240.4
		0	249.8	269.3	259.7	280.0
		-20	211.1	307.4	219.5	319.6
N42	1.020	+20	246.9	196.3	251.9	200.3
		0	214.4	229.0	218.8	233.7
		-20	181.8	261.7	185.5	267.0
N43	1.026	+20	298.1	237.9	305.9	244.1
		0	255.9	276.2	262.6	283.4
		-20	213.6	314.5	219.2	322.7
N44	1.024	+20	252.9	201.4	259.0	206.2
		0	217.9	234.3	223.1	239.9
		-20	182.9	267.2	187.3	273.6

FIGURE 2
ICRR vs. DEMIN WATER ADDED DURING REACTOR COOLANT SYSTEM DILUTION



3.0 ZERO POWER PHYSICS TESTING

Zero Power Physics Testing (ZPPT) is performed at the beginning of each cycle and is controlled by PT/0/A/4150/01, Controlling Procedure for Startup Physics Testing, and PT/0/A/4150/01A, Zero Power Physics Testing. Test measurements are made below the Point of Nuclear Heat using the output of one Power Range NIS detector connected to a Westinghouse Advanced Digital Reactivity Computer (ADRC). Measurements are compared to predicted data to verify core design. The following tests/measurements are included in the ZPPT program:

- 1/M Approach to Criticality
- Reactivity Computer checkout
- Measurement of Point of Nuclear Heat Addition
- Control Rod Worth Measurements via Dynamic Rod Worth Measurement
- All Rods Out Critical Boron Concentration measurement
- All Rods Out Isothermal Temperature Coefficient measurement

Zero power physics testing for Catawba 2 Cycle 11 began at 0223 on April 8, 2000 commencing with rod withdrawal for approach to criticality. ZPPT concluded at 0809 on April 8, 2000 with completion of the ITC Measurement. Table 5 summarizes results from ZPPT. All acceptance criteria were met.

Sections 3.1 through 3.10 describe ZPPT measurements and results.

3.1 1/M Approach to Criticality

Initial criticality for Catawba 2 Cycle 11 was achieved per PT/0/A/4150/19, 1/M Approach to Criticality. In this procedure, Estimated Critical Rod Position (ECP) is calculated based on latest available Reactor Coolant boron concentration. Control rods are withdrawn until Boron Dilution Mitigation System (BDMS) or Source Range NIS count rates double. Inverse Count Rate Ratio (ICRR) is plotted for each S/R NIS and BDMS channel. ICRR data is used to project critical rod position. If projected critical rod position is acceptable, rod withdrawal may continue.

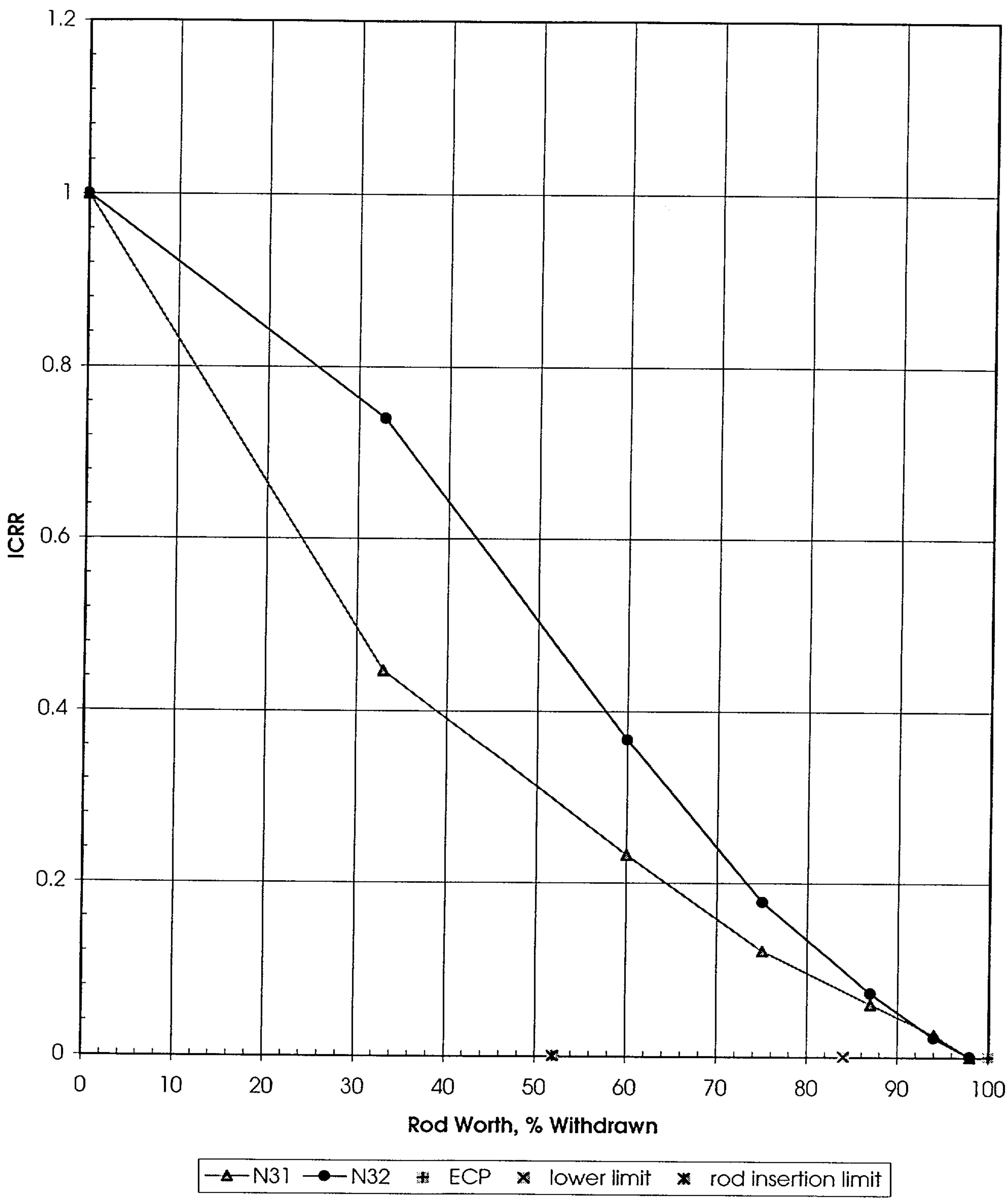
The Estimated Critical Position for C2C11 initial criticality was determined to be All Rods Out (Control Bank D at 226 SWD). Rod withdrawal for the approach to criticality began at 0228 with Criticality subsequently achieved at 0348 on April 8, 2000 at a control position of Control Bank D at 197 SWD.

Figure 3 shows the Source Range NIS ICRR behavior during the approach to criticality. All acceptance criteria of PT/0/A/4150/19 were met.

TABLE 4
SUMMARY OF ZPPT RESULTS

PARAMETER	MEASURED VALUE	PREDICTED VALUE OR ACCEPTANCE CRITERIA
Nuclear Heat	9.0×10^{-7} amps (N42)	N/A
ZPPT Test Limit	8.1×10^{-7} amps (N42)	N/A
ARO Critical Boron	1797 ppmB	1779 ± 50 ppmB
ARO ITC	-5.36 pcm/°F	-5.16 ± 2 pcm/°F
ARO MTC	-3.70 pcm/°F	-3.50 pcm/°F
Control Bank D Worth	673.3 pcm	646 ± 100 pcm
Control Bank C Worth	786.1 pcm	824 ± 124 pcm
Control Bank B Worth	611.6 pcm	630 ± 100 pcm
Control Bank A Worth	377.2 pcm	412 ± 100 pcm
Shutdown Bank E Worth	400.9 pcm	409 ± 100 pcm
Shutdown Bank D Worth	470.0 pcm	458 ± 100 pcm
Shutdown Bank C Worth	478.7 pcm	458 ± 100 pcm
Shutdown Bank B Worth	783.8 pcm	807 ± 121 pcm
Shutdown Bank A Worth	276.0 pcm	261 ± 100 pcm
Total Rod Worth	4857.6 pcm	4905 ± 392 pcm

FIGURE 3
ICRR vs. CONTROL ROD WORTH DURING APPROACH TO CRITICALITY



3.2 Reactivity Computer Checkout

The reactivity computer checkout was performed per PT/0/A/4150/01A, Zero Power Physics Testing, to verify that the Power Range channel connected to the reactivity computer can provide reliable reactivity data. A Reactivity Insertion of between +25 and +40 via control rod withdrawal is used to establish a slow, stable startup rate over which determination of Reactor Period is performed by the ADRC. The resulting Period is then used by the ADRC to determine the corresponding Theoretical Reactivity. Measured Reactivity is compared to the Theoretical Reactivity and verified to be within 4.0% or 1.0 pcm (whichever is greater). This evolution is repeated as necessary to ensure compliance with acceptance criterion.

The checkout was performed for Cycle 11 on April 8, 2000. Results are summarized in Table 5. The acceptance criterion was met with one performance of the checkout.

TABLE 5
REACTIVITY COMPUTER CHECKOUT

Period (seconds)	Theoretical Reactivity (pcm)	Measured Reactivity (pcm)	Absolute Error (pcm)	Percent Error (%)
170.7	34.9	34.0	0.9	-2.66

3.3 Point of Nuclear Heat Addition

The Point of Nuclear Heat Addition is measured by trending Reactor Coolant System temperature, Pressurizer level, flux level, and reactivity while slowly increasing reactor power. A slow, constant startup rate is initiated by rod withdrawal. An increase in Reactor Coolant System temperature and/or Pressurizer level accompanied by a change in reactivity and/or rate of flux increase indicates the addition of Nuclear Heat.

For Cycle 11, the Point of Nuclear Heat Addition was determined per PT/0/A/4150/01A, Zero Power Physics Testing, on April 8, 2000. Table 6 summarizes the data obtained.

The Zero Power Physics Test Limit was set at 8.1×10^{-7} amps on Power Range channel N42 (connected to reactivity computer). This test limit provides 10% margin to nuclear heat for performance of Dynamic Rod Worth Measurement.

TABLE 6
NUCLEAR HEAT DETERMINATION

Reactivity Computer (N42), amps	Intermediate Range Channel N35, amps	Intermediate Range Channel N36, amps
9.30×10^{-7}	7.04×10^{-7}	3.45×10^{-7}

3.4 Dynamic Rod Worth Measurement

Using the Westinghouse Advanced Digital Reactivity Computer (ADRC), the reactivity worth of each RCCA Bank is measured using DRWM technique as follows:

- Control Bank D is withdrawn (in MANUAL) to fully withdrawn position
- Flux level is allowed to increase to just below ZPPT Test Limit
- First RCCA Bank to be measured is inserted in Bank Select Mode in one continuous motion to a Step Demand Counter indication of ~ 2 Steps Wd
- Once the ADRC has signaled that it has acquired sufficient data for measurement, the RCCA Bank is returned to fully withdrawn position
- The next Bank to be tested is then selected and, once flux level has recovered to just below ZPPT Test Limit, the measurement process is repeated
- This test sequence is repeated until all Control and Shutdown Banks have been measured

The measured worth of each RCCA Bank is verified to be within 15% or 100 pcm (whichever criteria is greater) of predicted worth. The sum of the worths of all banks is verified to be within 8% of the sum of predicted worths. This sum is also verified to be ≥ 90% of the predicted total.

The Beginning of Cycle 11 rod worth measurements via DRWM were performed on April 8, 2000 per PT/0/A/4150/01A, Zero Power Physics Testing. Results are summarized in Table 4. All acceptance criteria were met.

3.5 ARO Boron Endpoint Measurement

This test is performed at the beginning of each cycle to verify that measured and predicted total core reactivity are consistent. The test is performed in conjunction with Dynamic Rod Worth Measurement. Reactor Coolant System boron samples are obtained at 30 minute intervals during DRWM. The reactivity difference from criticality to the ARO configuration is measured 9 times over the course of DRWM. These reactivities are averaged to determine the amount of control rod insertion at just critical core conditions. This reactivity is converted to equivalent boron (using the predicted differential boron worth) and added to the average of the boron samples obtained during DRWM to obtain the ARO critical boron concentration.

The Cycle 11 beginning of cycle, hot zero power, all rods out, critical boron concentration was measured on April 8, 2000 per PT/0/A/4150/01A, Zero Power Physics Testing. The ARO, HZP boron concentration was measured to be 1797 ppmB. Predicted ARO critical boron concentration was 1779 ppmB. The acceptance criterion (measured boron within 50 ppmB of predicted) was therefore met.

3.6 ARO Isothermal Temperature Coefficient Measurement

The all rods out (ARO) Isothermal Temperature Coefficient (ITC) is measured at the beginning of each cycle to verify consistency with predicted value. In addition, the Moderator Temperature Coefficient (MTC) is obtained by subtracting the Doppler Temperature Coefficient from the ITC. The MTC is used to ensure compliance with Technical Specification limits.

The Isothermal Temperature Coefficient of Reactivity is measured as follows:

- A cooldown of ~10 °F/hour is initiated.
- Once a constant cooldown rate is established, data gathering on the reactivity computer is initiated.
- After at least 1.1 °F of data is obtained and the error analysis performed by the reactivity computer indicates < 0.1, the cooldown is halted.
- A heatup of ~10 °F/hour back to 557 °F is then initiated. Once a constant heat-up rate is established, data gathering on reactivity computer is initiated and subsequently halted when measurement criteria are satisfied.

Control rod motion is limited to that required to maintain flux below the testing limit. The cooldown/heatup cycle is repeated if additional data is required.

The Beginning of Cycle 11 ITC was measured per PT/0/A/4150/01A, Zero Power Physics Testing, on April 8, 2000. No additional cooldown/heatup cycles were required due to good agreement between initial heatup and cooldown results (difference between the measurements ≤ 1.0 pcm/°F). Table 7 summarizes the data obtained during the measurement.

Average ITC was determined to be –5.36 pcm/°F. Predicted ITC was –5.16 pcm/°F. Measured ITC was therefore within acceptance criterion of predicted ITC ± 2 pcm/°F.

The MTC was determined to be –3.70 pcm/°F. Since the MTC was measured to be negative, compliance with Tech Spec 3.1.3 and SR 3.1.3.1 was ensured without performance of procedure PT/0/A/4150/21, Temporary Rod Withdrawal Limits Determination. Performance of this procedure was waived per PT/0/A/4150/01, Controlling Procedure for Startup Physics Testing.

TABLE 7
ITC MEASUREMENT RESULTS

	Average Temp (°F)	ITC (pcm/°F)
Cooldown	556.0	-5.40
Heatup	556.0	-5.32
Average	556.0	-5.36

4.0 POWER ESCALATION TESTING

Power Escalation Testing is performed during the initial power ascension to full power for each cycle and is controlled by PT/0/A/4150/01, Controlling Procedure for Startup Physics Testing. Tests are performed from 0% through 100% power with major testing plateaus at ~18%,~76%, and 100% power.

Significant tests performed during C2C11 Power Escalation were:

- Core Power Distribution (at ~18%, ~76%, and 100% power)
- One-Point Incore/Excore Calibration (at 18% and 76% power)
- Reactor Coolant Delta Temperature Measurement (at 76% and 100% power)
- Hot Full Power Critical Boron Concentration Measurement (at 100% power)
- Incore/Excore Calibration (at 100% power)
- Calorimetric Reactor Coolant Flow Measurement (at 100% power, This test is not under the control of PT/0/A/4150/01)
- Evaluation of Intermediate Range NIS Rod Stop and Rx Trip Setpoints

In addition to the tests listed above, PT/0/A/4150/01 performs evaluations of the Movable Incore Detector System, and on-line (OAC) Thermal Power program. The results of these are not included in this report.

Power Escalation Testing for Catawba 2 Cycle 11 began on April 9, 2000. Full power was reached on April 11, 2000. Full power testing was completed on April 18, 2000. Sections 4.1 through 4.7 describe the significant tests performed during power escalation and their results.

4.1 Core Power Distribution

Core power distribution measurements are performed during power escalation at Low Power (< 40% F.P.), Intermediate Power (between 40% F.P. and 80% F.P.), and High Power (> 90% F.P.). Measurements are made to verify flux symmetry and to verify core peaking factors are within limits. Data obtained during this test are also used to check calibration of Power Range NIS channels and to calibrate them if required (see sections 4.2 and 4.6). Measurements are made using the Moveable Incore Detector System and analyzed using Duke Power's COMET code (evolved from Shanstrom Nuclear Associates' CORE package and FCF's MONITOR code, respectively).

The Catawba 2 Cycle 11 Core Power Distribution measurements were performed on April 9, 2000 (18% power), April 10, 2000 (76% power), and April 13, 2000 (100% power). Tables 8 through 10 summarize the results. All acceptance criteria were met.

TABLE 8
CORE POWER DISTRIBUTION RESULTS
18% POWER

Plant Data

Map ID:	FCM/2/11/001
Date of Map:	April 9, 2000
Cycle Burnup:	0.06 EFPD
Power Level:	18.238% F.P.
Control Rod Position:	Control Bank D at 210 Steps Wd
Reactor Coolant System Boron Concentration:	1729 ppmB

COMET Results

Core Average Axial Offset:	12.529%
Tilt Ratios for Entire Core Height: Quadrant 1:	0.98629
Quadrant 2:	1.00886
Quadrant 3:	1.02044
Quadrant 4:	0.98441
Maximum F_Q (nuclear):	2.130
Maximum $F_{\Delta H}$ (nuclear):	1.577
Maximum Error between Pred. and Meas $F_{\Delta H}$:	8.07%
Average Error between Pred. and Meas. $F_{\Delta H}$:	3.17%
Maximum Error between Expected and Measured Detector Response:	8.09%
RMS of Errors between Expected and Measured Detector Response:	3.72%
Minimum F_Q Operational Margin:	24.63%
Minimum F_Q RPS Margin:	8.87%
Minimum F_Q Steady State Margin:	50.33%
Minimum $F_{\Delta H}$ Surveillance Margin:	25.86%
Minimum $F_{\Delta H}$ Steady State Margin:	22.41%

TABLE 9
CORE POWER DISTRIBUTION RESULTS
76% POWER

Plant Data

Map ID:	FCM/1/10/002
Date of Map:	April 10, 2000
Cycle Burnup:	0.787 EFPD
Power Level:	76.439% F.P.
Control Rod Position:	Control Bank D at 215 Steps Wd
Reactor Coolant System Boron Concentration:	1464 ppmB

COMET Results

Core Average Axial Offset:	-5.562%
Tilt Ratios for Entire Core Height: Quadrant 1:	1.00185
Quadrant 2:	0.99641
Quadrant 3:	1.00574
Quadrant 4:	0.99600
Maximum F_Q (nuclear):	1.839
Maximum $F_{\Delta H}$ (nuclear):	1.473
Maximum Error between Pred. and Meas $F_{\Delta H}$:	7.83%
Average Error between Pred. and Meas. $F_{\Delta H}$:	2.20%
Maximum Error between Expected and Measured Detector Response:	7.90%
RMS of Errors between Expected and Measured Detector Response:	3.0%
Minimum F_Q Operational Margin:	7.52%
Minimum F_Q RPS Margin:	7.04%
Minimum F_Q Steady State Margin:	39.26%
Minimum $F_{\Delta H}$ Surveillance Margin:	23.48%
Minimum $F_{\Delta H}$ Steady State Margin:	23.59%

TABLE 10
CORE POWER DISTRIBUTION RESULTS
100% POWER

Plant Data

Map ID:	FCM/1/10/003
Date of Map:	April 13, 2000
Cycle Burnup:	3.252 EFPD
Power Level:	99.930% F.P.
Control Rod Position:	Control Bank D at 214 Steps Wd
Reactor Coolant System Boron Concentration:	1160 ppmB

COMET Results

Core Average Axial Offset:	-9.166%
Tilt Ratios for Entire Core Height: Quadrant 1:	0.99940
Quadrant 2:	0.99920
Quadrant 3:	1.00159
Quadrant 4:	0.99981
Maximum F_Q (nuclear):	1.858
Maximum $F_{\Delta H}$ (nuclear):	1.435
Maximum Error between Pred. and Meas $F_{\Delta H}$:	5.78%
Average Error between Pred. and Meas. $F_{\Delta H}$:	1.55%
Maximum Error between Expected and Measured Detector Response:	5.77%
RMS of Errors between Expected and Measured Detector Response:	2.02%
Minimum F_Q Operational Margin:	2.54%
Minimum F_Q RPS Margin:	11.63%
Minimum F_Q Steady State Margin:	19.74%
Minimum $F_{\Delta H}$ Surveillance Margin:	8.59%
Minimum $F_{\Delta H}$ Steady State Margin:	20.56%

4.2 One-Point Incore/Excore Calibration

PT/0/A/4600/05D, One-Point Incore/Excore Calibration, is performed using results of Power Range NIS data taken during the Low Power Level Flux Map (18% F.P. for C2C11) and the measured incore axial offset. Power Range channels are calibrated before exceeding 50% in order to have valid indications of Axial Flux Difference and Quadrant Power Tilt Ratio for subsequent power ascension. The calibration is checked using the Intermediate Power Level Flux Map (76% F.P. for C2C11). If necessary, Power Range NIS is recalibrated per PT/0/A/4600/05D or PT/0/A/4600/05A, Incore/Excore Calibration.

Data for the Low Power Level calibration was obtained on April 9, 2000 and all Power Range NIS calibrations were completed the same day. Results are presented in Table 11. All acceptance criteria were met.

TABLE 11
LOW POWER LEVEL
ONE-POINT INCORE/EXCORE CALIBRATION RESULTS

Reactor Power = 18.238% Axial Offset = 12.529%

Measured Power Range Currents, μAmps

	N41	N42	N43	N44
Upper	43.8	33.8	44.2	34.0
Lower	41.3	31.8	43.0	33.0

Ratio, Extrapolated (from measured) Currents to "Expected" (from last calibration) Currents

	N41	N42	N43	N44
Upper	0.9921	0.8892	0.9491	0.8801
Lower	1.0589	0.9625	1.0429	0.9848

New Calibration Currents, μAmps

Axial Offset, %	N41		N42		N43		N44	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
+20	252.8	213.3	194.9	164.1	255.9	222.3	196.5	170.5
0	218.9	248.4	169.2	191.4	219.6	258.1	169.3	198.3
-20	184.9	283.6	143.5	218.8	183.4	293.9	142.1	226.2

Data for the Intermediate Power Level calibration was obtained at 76% F.P. on April 10, 2000. Comparison of Indicated Excore AFD with Measured Incore AFD (obtained from the flux map) indicated the need for an additional One Point Incore/Excore calibration (per PT/0/A/4600/05D). The criterion for this requirement is a difference between Incore and Excore AFD > 2.0% (but < 3.0%). In this case the difference was 2.939%. Power Ascension was restricted to 90% F.P. pending completion of the NIS recalibration, which was completed on April 11,2000. Results are presented in Table 12. All acceptance criteria were met.

TABLE 12
INTERMEDIATE POWER LEVEL
ONE-POINT INCORE/EXCORE CALIBRATION RESULTS

Reactor Power = 76.439%　　　Axial Offset = -5.562%

Measured Power Range Currents, μAmps

	N41	N42	N43	N44
Upper	164.0	133.0	169.0	133.8
Lower	195.8	156.5	205.8	160.8

Ratio, Extrapolated (from measured) Currents to "Expected" (from last calibration) Currents

	N41	N42	N43	N44
Upper	1.0161	0.9545	1.0014	0.9521
Lower	1.0505	0.9898	1.0475	1.0053

New Calibration Currents, μAmps

Axial Offset, %	N41		N42		N43		N44	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
+20	258.9	211.6	209.2	168.8	270.0	223.3	212.6	174.0
0	224.2	246.4	181.6	196.9	231.7	259.3	183.2	202.5
-20	189.4	281.3	154.1	225.0	193.5	295.2	153.8	230.9

4.3 Reactor Coolant Loop Delta Temperature Measurement

Reactor Coolant System (NC) Hot Leg and Cold Leg temperature data is normally obtained at approximately 75% F.P. and at 100% F.P. per PT/0/A/4600/26, NC Temperature Calibration, to ensure that full power delta temperature constants (ΔT_0) are valid. ΔT_0 is used in the Overpower and Overtemperature Delta Temperature reactor protection functions.

In the case of C2C11, the four pre-existing loop ΔT_0's were evaluated at 76% F.P. on April 10, 2000 and found to be acceptable (present ΔT_0 no more than 1.2°F above calculated). Power ascension proceeded to 100% F.P. where the ΔT_0's were re-evaluated. At full power, on April 12, 2000, the Loop 2A and 2C ΔT_0 constants were found to be exceed acceptance criterion (present ΔT_0 within 0.6°F of calculated) and were therefore subsequently adjusted by 7300 Process personnel. It was discovered that the Loop 2C error was attributable to a bad T_{COLD} processing card. Table 13 summarizes the test results.

TABLE 13
REACTOR COOLANT DELTA TEMPERATURE DATA

Reactor Power = 76.4526%

	Loop A	Loop B	Loop C	Loop D
Meas. T_{HOT}, °F	600.3	602.7	600.2	601.7
Meas. T_{COLD}, °F	552.9	553.7	553.4	554.5
Calc. Δh, BTU/lb	62.838	65.358	62.143	62.812
Calc. Δh_0, BTU/lb	82.192	85.488	81.283	82.158
Calc. ΔT_0, °F	59.6	61.7	59.0	59.6
Current ΔT_0, °F	59.7	61.9	60.0	60.0
Difference, °F	-0.1	-0.2	-1.0	-0.4

Reactor Power = 99.7954%

	Loop A	Loop B	Loop C	Loop D
Meas. T_{HOT}, °F	615.3	618.3	615.4	617.2
Meas. T_{COLD}, °F	555.0	556.2	557.3	557.0
Calc. Δh, BTU/lb	82.354	85.479	79.513	82.635
Calc. Δh_0, BTU/lb	82.522	85.654	79.676	82.804
Calc. ΔT_0, °F	60.4	62.2	58.1	60.2
Current ΔT_0, °F	59.7	61.9	60.0	60.0
Difference, °F	**0.7**	0.3	**-1.9**	0.2

4.4 Hot Full Power Critical Boron Concentration Measurement

The Hot Full Power critical boron concentration is measured using PT/0/A/4150/04, Reactivity Anomaly Calculation. Reactor Coolant boron concentration is measured (average of three samples) with reactor at essentially all rods out, Hot Full Power, equilibrium xenon conditions. The measured boron is corrected for any off-reference condition (e.g. inserted rod worth, temperature error, difference from equilibrium xenon) and compared to predicted value.

A simple assessment of the accuracy of the predicted excess reactivity of the new core is performed by comparing the difference between predicted Beginning of Life HZP and HFP critical boron concentrations with the difference between measured BOL HZP and HFP critical boron concentrations. Acceptance criteria is met by verifying that Measured ΔBoron is within ±50 ppmB of Predicted ΔBoron.

For Catawba 2 Cycle 11, the Hot Full Power critical boron concentration was measured on April 17, 2000. The measured critical boron concentration was 1160 ppmB. Predicted HFP critical boron concentration was 1144 ppmB. The ARO Boron Endpoint Measurement during ZPPT yielded a measured HZP Boron Concentration of 1797 ppmB (prediction being 1779 ppmB). The Predicted ΔBoron was therefore 637 ppmB, while the Measured ΔBoron was 635 ppmB. The difference of 2 ppmB between these two parameters easily satisfied the acceptance criterion.

4.5 Incore/Excore Calibration

Excore NIS Power Range channels are calibrated at full power per PT/0/A/4600/05A, Incore/Excore Calibration. Incore data (flux maps) and Power Range NIS currents are obtained at various axial power distributions. A least squares fit of the output of each detector (upper and lower chambers) as a function of measured incore axial offset is determined. The slopes and intercepts of the fit for the upper and lower chamber for each channel are used to determine calibration data for that channel.

This test was performed for Catawba 2 Cycle 11 on April 17 and 18, 2000. All Power Range NIS calibrations were completed on April 19. Nine flux maps, with axial offsets ranging from -16.585% to -2.262% were used. Table 14 summarizes the results. All acceptance criteria were met.

TABLE 14
INCORE/EXCORE CALIBRATION RESULTS

Full Power Currents, Microamps

Axial Offset, %	N41		N42		N43		N44	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
+20%	266.1	212.5	217.1	171.1	276.4	224.1	219.0	176.9
0%	231.8	249.6	188.3	200.0	238.8	261.6	189.2	205.6
-20%	197.5	286.7	159.5	228.9	201.2	299.1	159.4	234.3

Correction (M_J) Factors

N41	N42	N43	N44
1.348	1.343	1.330	1.346

4.6 Calorimetric Reactor Coolant Flow Measurement

With clean venturis, PT/2/A/4150/13B, Calorimetric Reactor Coolant Flow Measurement, is performed to validate the Operator Aid Computer's calculations of Reactor Thermal Power and Reactor Coolant Flowrate.

The results of this test, performed for C2C11, are summarized in Table 15. All acceptance criteria were met.

TABLE 15
CALORIMETRIC REACTOR COOLANT FLOW MEASUREMENT

Run Number	Total Calculated Reactor Coolant Flow (GPM)	Calculated Thermal Power Level (%)
1	392848	99.565
2	392966	99.517
3	392779	99.521
Average	392864	99.534

4.10 Intermediate Range NIS Setpoint Evaluation

PT/0/A/4150/01, Controlling Procedure for Startup Physics Testing, performs an evaluation of Intermediate Range NIS response in comparison to 20% (Rod Stop) and 25% F.P. (Rx Trip) setpoints preliminarily instated per PT/0/A/4600/05E prior to Unit Startup. This evaluation acquires N35 and N36 indication data as close to 20% and 25% Thermal Power as possible, and then uses it to perform a linear extrapolation to derive expected I/R NIS Channel responses at 31% F.P. The extrapolated channel responses are then compared to the instated 25% F.P. I/R NIS Rx Trip setpoints to ensure existing setpoints do not exceed the channels' indication at 31% F.P. This verifies that the Rx Trip setpoints have been established conservatively enough to ensure compliance with allowable Tech Spec tolerance on this Reactor Protection function.

Both Intermediate Range detectors were replaced during the 2EOC10 Refueling Outage. Based on the assumption that the new detectors' response characteristics would be relatively unchanged, the previously instated setpoints were merely adjusted (per PT/0/A/4600/05E, which also applies a 3% conservatism on derived setpoints) as necessary to compensate for the changes in radial power distribution predicted for the new core. On April 9, 2000, during C2C11 Startup, it was discovered that due to unanticipated behavior by I/R Channel N36 (it's response starting lagging behind that of N35 as reactor power was increased above 5% F.P.) this channel's 25% F.P. Reactor Trip setpoint was nonconservative with respect to the 31% F.P. allowable limit. N36's 25% F.P. trip bistable was not received until an actual power level of 32.83% F.P. was reached.

I/R Channel N36 was immediately declared inoperable and entered into the Tech Spec Action Item Log. The channel was returned to service and cleared from TSAIL following completion of the necessary setpoint adjustments on April 10, 2000.

A Past Operability evaluation concluded that since extrapolation of N36's indication from power levels where it's Protection Function was enable (< 10% F.P., P10 enabled) demonstrated compliance with the 31% allowable limit, the detector was operable where required by Tech Specs. There was therefore no Tech Spec violation associated with this incident. It was during power ascension subsequent to P-10, for reasons presently unknown (but under evaluation), that the detector's response began to significantly deviate, resulting in it's ultimate inoperabilty.