WISCONSIN ELECTRIC POWER COMPANY

POINT BEACH NUCLEAR PLANT

UNIT 2 CYCLE 18 STARTUP

November, 1991

BY

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PREFACE

This report is intended to document in a concise format the results of the physics testing program and unit systems response during the startup of Unit 2 following Refueling 17 in November 1991.

Westinghouse performed the core design calculations for Unit 2 Cycle 18. The reactivity coefficients were calculated based on estimated Cycle 17 burnup of 10,750 MWD/MTU. Actual burnup was 10,778 MWD/MTU. Cycle 17 was ended on September 28, 1991, with a peak assembly burnup of 44,478 MWD/MTU and average assembly burnup of 31,050 MWD/MTU. Electrical power was first generated during Cycle 18 on November 14, 1991.

This report is intended primarily for the use of Wisconsin Electric Power Company personnel as a readily accessible, complete compilation of reduced data.

1.0 REFUELING

1.1 Summary

Fuel Movement

A complete core unload was performed to allow the safety injection system to be taken out of service for modifications.

The core was unloaded from about 0130 hours on October 9, 1991 to 1530 on October 11, 1991 by plant operations personnel. The shifts were slightly shorter than before, with the first shift working 0600-1530 and the second shift 1530-0100. Noteworthy items during the unload were:

1. SFP underload trip setpoint was lowered from 1000 lbs. to 9[illegible] lbs. because some of the optimized fuel assemblies (F/As) without inserts weighed close to 1000 lbs.

2. F/A M25 from core location I9 experienced an overload when being raised out of the core. Since this is a standard F/A with a control rod, the overload was insignificant. The tare setting was readjusted to prevent further spurious overloads.

3. A white flaky substance was noticed coming off of F/As as they were drawn into the mast of the manipulator. This substance was not observed on any F/As as they were later ultrasonicly tested (UTd) in the SFP.

4. The takeup reel for the air supply stopped rotating about a foot from full takeup. At the same time the measuring tape for elevation readings was pulled off its takeup reel. The tape was removed since the primary indication of elevation was still working (digital readout). Operations personnel had to manually assist in the last foot of takeup of the air supply.

After the core unload, UT examinations were performed in the SFP on all reload F/As taken out of the core. There were no indications of any leaking fuel pins. The average time between examinations was about 30 minutes from October 11, 1991 to October 16, 1991.

From October 16, 1991 to October 18, 1991, inserts were moved to obtain the configuration needed for the next cycle. All insert moves were performed without incident.

From October 17, 1991 to October 18, 1991 and on October 21, 1991, UT examinations were performed on all the discharge fuel. No indications were found of any leaking fuel pins.

Visual Inspections After Core Unload

1. One control rod (R502) was inspected at the periscope to determine the condition of the chrome coated rodlets after one cycle of operation. There were some rub marks, but they were superficial.

2. F/A R69 was inspected at the periscope because the hot channel factor for the location it was in (C3) during Cycle 17, was about 10 percent higher than for symmetric locations. The in-core thermocouple (T/C) at C3 was also reading higher than normal during Cycle 17. There was no indication of any abnormalities on F/A R69.

   Another T/C at core location F6 read lower temperatures than expected. A Maintenance Work Request was submitted to check the T/C wiring for the two T/Cs in question, to look for reversed wires or other problems. The T/C head connections were already removed before they could be checked for reversed connections. However, the rest of the wiring was checked and was satisfactory.

   Westinghouse investigated the abnormal peaking factor at core location C3. Preliminary conclusions were that the computer codes used to generate the core design may have given a bias to C3 when the core design was folded out from quarter core symmetry starting at the diagonal intersecting C3. Newer computer codes were used for Unit 2 Cycle 18 with good symmetry between C3 and its symmetric partners.

The core reload was started on October 23, 1991 at about 2330 hours and was completed on October 27, 1991 at 2315 hours. The following notes highlight the reload:

1. Excore detector baseline count rates taken after three F/As were loaded in front of each detector. There were no source assemblies loaded. The count rates were 75 CPS for N31, 47 CPS for N32 and 11 CPS for the spare detector (wide range detector N40 near core location A7. The maximum count rates were 89 CPS for N31, 65 CPS for N32 and 19 CPS for N40. The administrative limit for count rates was twice the baseline count rates for two of three channels. These limits were met for the entire reload.

2. Cavity visibility was very poor and did not improve substantially for about three days.

3. F/A V77 was loaded off both core pins. This was noticed by observing a 1½ inch gap at top of core after V77 was released by the manipulator.

4. F/A T78 was loaded off both core pins. It was not noticed until F/A S53 was lowered into an adjacent location with a load loss of about 550 lbs. 15 inches above the core pins. F/A T78 was inspected with only slight scratches noticed. F/A S53 was inspected with no signs of damage.

5. New F/A V60 with new RCCA R148 was moved to temporary core location M7 after it couldn't be loaded into C5 because adjacent F/As were leaning into C5. When trying to re-engage F/A V60 to return it to location C5, the correct elevation for latching could not be obtained. After several efforts it was noticed that:

   a. F/A V60 top nozzle was displaced into core location M8 about 3 inches with the manipulator mast raised about 1 foot above the top nozzle and indexed the same amount over M8.

b. T e hub of the RCCA was caught in the mast gripper mechanism with the RCCA raised about 1 foot out of the F/A.

F/A V60 was moved back to a vertical position in location M7 by moving the mast over M7. Several attempts were made to free the RCCA hub by shaking the mast with no success.

A TV camera was lowered to determined the exact cause of binding. The RCCA hub was wedged between two gripper fingers. The gripper was in the disengaged position. It was decided to go to the grip position. Even though the gripper fingers were mechanically prevented from moving to the grip position, there was enough clearance to obtain slight movement, which was enough to free the RCCA hub after shaking of the mast cables.

The dummy F/A was moved into containment to check the operation of the mast gripper. Then V60 was transferred to the new fuel elevator for closeup inspection. Mr. M. Arlotti (West. NFD) performed the inspection, which was witnessed by plant personnel. Both F/A V60 and RCCA R148 passed the inspection and were qualified for reuse. Only minor scratches were found on the outside of the hub of the RCCA and on the top nozzle of F/A V60. The RCCA was also checked for straightness and was found to be in good alignment with the F/A and passed a drag test.

1.2 Core Design

The following fuel design changes were incorporated in the new fuel for the first time in Point Beach Unit 2:

1. Axial fuel blankets consisting of natural uranium dioxide fuel pellets at each end of the fuel stack to reduce neutron leakage and improve uranium utilization.

2. Integral fuel burnable absorbers (IFBAs). Instead of using burnable poison rodded assemblies (BPRAs) as external inserts in F/As, selected fuel rods contain fuel pellets coated with a one mil thickness of zirconium diboride. IFBAs provide power peaking and moderator temperature coefficient control.

3. Fuel rod bottom end plugs with increased radius at the tip. This has no effect on core safety considerations.

New fuel (V51 - V78) for Cycle 18 consists of 16 OFAs with 3.6 w/o U-235 and 12 OFAs with 4.0 w/o U-235.

This is the first cycle not using secondary source assemblies.

The as-loaded core matches the initial core loading pattern. The core configuration is shown in Figure 1-1. Of the 121 F/As loaded, 120 are OFAs and 1 is of the older standard design (from the SFP) in location G-7. The as-loaded burnups for each F/A are shown in Figure 1-2.

Two control rods used in Cycle 18 (R2 and R14) were replaced with new control rods (R506 and R148) in accordance with procedure FC-15, Fuel Assembly and Control Rod Tracking, which controls the service life of control rods.

FIGURE 1-1

FINAL CORE LOADING PATTERN U2C18

					A-6 R82 2H214	A-7 S54 2H206	A-8 R70 2H213					
			B-4 S55	B-5 T65	B-6 V68 R126	B-7 V75	B-8 V70 R5	B-9 T68	B-10 S52			
		C-3 S71	C-4 V52	C-5 V60 R148	C-6 T54	C-7 T72 R135	C-8 T60	C-9 V62 R133	C-10 V54	C-11 S70		
	D-2 S53	D-3 V55	D-4 U69 R139	D-5 S68	D-6 U65	D-7 U57	D-8 U68	D-9 S65	D-10 U71 R116	D-11 V56	D-12 S58	
	E-2 T78	E-3 V63 R127	E-4 S73	E-5 T64 R10	E-6 U54	E-7 S72	E-8 U55	E-9 T69 R149	E-10 S74	E-11 V64 R110	E-12 T66	
F-1 R69 2H209	F-2 V71 R7	F-3 T59	F-4 U78	F-5 U60	F-6 T57 R53	F-7 U77	F-8 T51 R11	F-9 U61	F-10 U66	F-11 T61	F-12 V72 R29	F-13 R72 2H204
G-1 S51 2H216	G-2 V76	G-3 T76 R114	G-4 U62	G-5 S76	G-6 U67	G-7 H17 R107	G-8 U76	G-9 S67	G-10 U51	G-11 T67 R18	G-12 V77	G-13 S62 2H212
H-1 R67 2H208	H-2 V73 R32	H-3 T53	H-4 U73	H-5 U53	H-6 T62 R34	H-7 U72	H-8 T52 R17	H-9 U58	H-10 U74	H-11 T55	H-12 V67 R506	H-13 R79 2H211
	I-2 T73	I-3 V65 R31	I-4 S78	I-5 T70 R112	I-6 U59	I-7 S77	I-8 U56	I-9 T71 R28	I-10 S66	I-11 V59 R109	I-12 T74	
	J-2 S60	J-3 V57	J-4 U64 R103	J-5 S75	J-6 U63	J-7 U52	J-8 U75	J-9 S63	J-10 U70 R98	J-11 V51	J-12 S61	
		K-3 S69	K-4 V58	K-5 V66 R111	K-6 T58	K-7 T77 R8	K-8 T56	K-9 V61 R115	K-10 V53	K-11 S64		
			L-4 S57	L-5 T63	L-6 V74 R502	L-7 V78	L-8 V69 R84	L-9 T75	L-10 S59			
					M-6 R77 2H203	M-7 S56 2H207	M-8 R78 2H205					

FIGURE 1-2

BOL BURNUP DATA

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						R82 40688 216B	S54 38295 217A	R70 41512 216B					
B				S55 38482 217A	T65 27130 218B	V68 0 220B	V75 0 220B	V70 0 220B	T68 26581 218B	S52 38511 217A			
C			S71 38552 217B	V52 0 220A	V60 0 220A	T54 28831 218A	T72 27170 218B	T60 28761 218A	V62 0 220A	V54 0 220A	S70 38317 217B		
D		S53 38082 217A	V55 0 220A	U69 13360 219B	S68 32610 217B	U65 13211 219B	U57 14260 219A	U68 13464 219B	S65 32351 217B	U71 13289 219B	V56 0 220A	S58 38169 217A	
E		T78 26263 218B	V63 0 220A	S73 32276 217B	T64 27555 218B	U54 15569 219A	S72 38910 217B	U55 16010 219A	T69 27510 218B	S74 32487 217B	V64 0 220A	T66 27141 218B	
F	R69 41689 216B	V71 0 220B	T59 28986 218A	U78 13255 219B	U60 15802 219A	T57 28324 218A	U77 14285 219B	T51 27297 218A	U61 15830 219A	U66 13327 219B	T61 29306 218A	V72 0 220B	R72 40975 216B
G	S51 38004 217A	V76 0 220B	T76 27051 218B	U62 14192 219A	S76 38232 217B	U67 13387 219B	H17 28506 10B	U76 13638 219B	S67 38968 217B	U51 13913 219A	T67 27223 218B	V77 0 220B	S62 37951 217A
H	R67 40955 216B	V73 0 220B	T53 28405 218A	U73 13083 219B	U53 15451 219A	T62 27426 218A	U72 13549 219B	T52 27699 218A	U58 15897 219A	U74 13489 219B	T55 29303 218A	V67 0 220B	R79 41149 216B
I		T73 26413 218B	V65 0 220A	S78 32523 217B	T70 27432 218B	U59 15442 219A	S77 38434 217B	U56 15478 219A	T71 27459 218B	S66 32007 217B	V59 0 220A	T74 26598 218B	
J		S60 38461 217A	V57 0 220A	U64 13395 219B	S75 31995 217B	U63 13417 219B	U52 14173 219A	U75 13358 219B	S63 32495 217B	U70 14007 219B	V51 0 220A	S61 38860 217A	
K			S69 38652 217B	V58 0 220A	V66 0 220A	T58 29315 218A	T77 27262 218B	T56 28910 218A	V61 0 220A	V53 0 220A	S64 38449 217B		
L				S57 38698 217A	T63 26693 218B	V74 0 220B	V78 0 220B	V69 0 220B	T75 26923 218B	S59 38627 217A			
M						R77 40875 216B	S56 38334 217A	R78 41278 216B					

ASSEMBLY ID #
BURNUP (MWD/MT)
ASSEMBLY FUEL REGION

2.0 CONTROL ROD OPERATIONAL TESTING

2.1 Hardware Changes/Incidents

Two new control rods were used in Cycle 18 at core locations C5 and H12. The ARO position is 228 steps as specified in the Setpoint Document and Procedure FC-15.

During rod movement for cold rod drop testing, control rod position indication system showed control rod C7 moving out when Bank C was selected. Control rod G7 rod position indication remained at the full in position. It was assumed that the RPI cables for these two rods were swapped. Subsequent investigation showed that RPI connections for G7 and C7 were correct. It was found that the control rod drive mechanism connectors were inadvertently swapped. The situation was corrected and testing resumed. Reference MWR No. 915080.

A new test instrument was used along with and as a replacement to the Visicorder. Qualification of the new test instrument was made by comparing traces made at the same time using the two instruments in parallel. The new test instrument uses a multiplexer to allow the measurement of rod stepping or rod drops on all 33 rods at once. However, rod stepping will still be performed one rod at a time to verify that all wiring connections are correct.

2.2 Rod Drop Times

See Figures 2-1, 2-2 and 2-3 showing all the rod drop times and RCS conditions. All rod drop times were well within the Technical Specification Limit of 2.2 seconds to dashpot.

Instead of pulling the stationary gripper fuse to initiate a rod drop measurement on one rod, the reator trip breaker was opened to initiate the drop of several rods at once. There is a slight difference in the shape of the rod drop trace at the start. This is because there is no more arcing of current across a fuse as it is pulled from its fuse holder. Because of the difference in the shape of the rod drop trace, a conservative starting point for the drop was chosen which increased the rod drop times slightly. Scatter of the rod drop times did not change significantly.

2.3 Control Rod Mechanism Testing

All lift, moveable and stationary gripper signal trace shapes were normal.

2.4 Rod Position Calibration

During hot rod drop testing, LVDT voltages were recorded at 20 steps and 200 steps to verify that the RPI coils were responding normally. Once full power operating conditions were obtained, the full out rod positions for any RPIs reading lower than 228 steps were verified. Then the RPIs were aligned using the SPAN adjustment without changing the ZERO settings.

FIGURE 2-1

PBNP U2C18 COLD ROD DROP TIMES

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B						SA 1.37 1.88		SA 1.44 1.93					
C					CA 1.39 1.90		CD 1.42 1.94		CA 1.45 1.91				
D				CC 1.35 1.90						CC 1.41 1.93			
E			CA 1.32 1.78		SB 1.44 1.97				SB 1.47 2.00		CA 1.37 1.84		
F		SA 1.42 1.94				CB 1.45 1.98		CB 1.46 1.98				SA 1.39 1.89	
G			CD 1.38 1.89				CC 1.41 1.85				CD 1.40 1.93		
H		SA 1.37 1.87				CB 1.42 1.95		CB 1.50 2.02				SA 1.43 1.98	
I			CA 1.40 1.90		SB 1.42 1.94				SB 1.48 2.07		CA 1.36 1.86		
J				CC 1.46 1.99						CC 1.36 1.91			
K					CA 1.45 1.91		CD 1.44 1.94		CA 1.36 1.32				
L						SA 1.41 1.92		SA 1.36 1.89					
M													

LEGEND

BANK	
x.xx	— Time To Dashpot (sec)
x.xx	— Time To Seat (sec)

Maximum drop time (dash) = H-8 1.50
Minimum drop time (dash) = E-3 1.32
Average time (dash) = 1.41

DATE 1/7/92

TIME 11:16

TEMP 128 °F

FLOW 100 %

PRES 350 PSIA

FIGURE 2-2

PBNP U2C18 HOT ROD DROP TIMES

	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B						SA 1.38 1.90		SA 1.42 1.91					
C					CA 1.42 1.93		CD 1.48 1.97		CA 1.46 1.91				
D				CC 1.40 1.95						CC 1.45 1.95			
E			CA 1.42 1.88		SB 1.40 1.93				SB 1.47 2.00		CA 1.42 1.90		
F		SA 1.43 1.95				CB 1.44 1.95		CB 1.45 1.95				SA 1.42 1.90	
G			CD 1.40 1.90				CC 1.42 1.86				CD 1.40 1.92		
H		SA 1.40 1.90				CB 1.47 1.97		CB 1.48 1.99				SA 1.43 1.96	
I			CA 1.43 1.93		SB 1.43 1.95				SB 1.46 2.02		CA 1.41 1.91		
J				CC 1.45 1.96						CC 1.40 1.93			
K					CA 1.47 1.93		CD 1.44 1.94		CA 1.38 1.83				
L						SA 1.45 1.95		SA 1.38 1.88					
M													

LEGEND

BANK
x.xx — Time To Dashpot (sec)
x.xx — Time To Seat (sec)

Maximum drop time (dash) = H-8 1.48
Minimum drop time (dash) = K-9 1.38
Average time (dash) = 1.43

DATE 11/15/91

TIME 10:37

TEMP 530 °F

FLOW 1 0 %

PRES 2000 PSIA

3.0 THERMOCOUPLE AND RTD CALIBRATION VERIFICATION

During initial RCS heatup for Cycle 18, loop RTDs and incore thermocouples were checked for normal response throughout the heatup range of about 195°F to 530°F (HZP). Table 3-1 shows the results. All 16 RTDs were within the expected 2°F deviation of each other throughout the heatup. Core exit thermocouples responded normally. One thermocouple (I10) is OOS.

TABLE 3-1

RTD CALIBRATION CHECK

RTD Element	RTD Temperatures from Measured Resistances (°F)							
LOOP A - COLD LEG								
R 401B	200.3	249.8	306.3	345.9	406.6	453.6	499.5	528.9
R 405B	200.2	249.7	306.2	345.5	406.2	453.2	499.1	528.1
W 402B	199.9	249.5	306.0	345.1	406.1	453.2	499.2	528.3
W 406B	199.9	249.6	306.1	345.1	406.2	453.2	499.2	528.4
LOOP A - HOT LEG								
R 401A	200.1	249.7	306.2	345.2	406.3	453.3	499.3	528.3
R 405A	200.7	250.4	306.8	345.7	406.7	453.5	499.4	528.3
W 402A	200.1	249.9	306.4	344.9	406.3	453.3	499.3	528.3
W 406A	199.8	249.6	306.1	344.5	405.9	452.9	498.8	527.8
LOOP B - COLD LEG								
B 403B	200.1	249.9	306.5	344.2	406.4	453.4	499.5	528.5
B 407B	200.4	250.4	307.0	345.2	406.9	453.9	500.0	529.0
Y 404B	200.7	250.8	307.5	344.7	407.1	454.1	500.1	528.9
Y 408B	200.2	250.2	306.8	343.9	406.5	453.5	499.7	528.6
LOOP B - HOT LEG								
B 403A	200.0	249.9	306.3	344.3	406.0	452.9	498.8	527.8
B 407A	199.9	249.8	306.3	343.7	406.1	453.0	499.1	528.0
Y 404A	201.1	251.5	308.1	345.6	407.6	454.5	500.4	529.2
Y 408A	199.9	250.2	306.8	344.3	406.5	453.7	499.9	528.9
RTD AVERAGE	200.2	250.1	306.6	344.9	406.5	453.4	499.5	528.4
S.G. TEMP	197	246	305	342	404	452	499	527
CORE EXIT T/C	200	253	309	346	408	455	50[illegible]	529

4.0 PRESSURIZER TESTS

4.1 Thermal Transients

Pressurizer pressure increase rate with spray valves indicated shut and all heaters on was 14.5 psi/min. This is typical and close to the nominal value of 14 psi/min. During the thermal equilibrium test, Heater Group A was required to be on 56 percent of the time to maintain pressure with main spray valves shut. Spray valve effectiveness was normal with the "A" loop valve decreasing pressure at 128 psi/min and the "B" loop at 150 psi/min.

Spray bypass valve positions were adjusted so that spray line temperatures were maintained above 475°F.

4.2 Heater Capacity

Pressurizer heater capacity was determined from direct volt/amp readings on each group of heaters. Table 4-1 shows that heater capacity is above Technical Specification requirements of 100 KW minimum for the heater groups operational during emergency conditions (Groups A, C and D). Heater Group A current readings were slightly greater than normal.

TABLE 4-1

HEATER GROUP POWER SUPPLY READINGS

Heater Group	I-Current	V-Voltage	KW-Energy Input
	(amps)	(volts)	$KW=\sqrt{3}xVxI/1000$
A	301	483	252
B	250	480	208
C	226	478	187
D	223	476	184
E	229	480	190
TOTAL			1,021

5.0 CONTROL SYSTEMS

There were no difficulties encountered during heatup or startup of the pressurizer level, pressurizer pressure, and rod control systems.

6.0 TRANSIENTS

There were no transient tests performed during startup or approach to full power. The limitation on power ramp less than 3 percent/hr was exceeded during the initial approach to full power. The maximum ramp occurred just above 20 percent power and was determined to be 7.3 percent/hr by RCS ΔT.

7.0 INITIAL CRITICALITY AND REACTIVITY COMPUTER CHECKS

7.1 Initial Criticality

The approach to criticality was made in two phases. The first step, which began at 2130 hours on November 12, 1991, was the withdrawal of control rods until Bank D reached 180 steps. The reactor coolant boron concentration was then decreased by dilution until criticality was achieved. The dilution rate averaged about 110 ppm/hr or 43 gpm. When criticality was reached near 0100 on November 13, 1991, actual measured boron concentration was 11 ppm greater than estimated concentration of 1394 ppm. ICRR plots were maintained during each phase of the approach to criticality. All plots were as expected with a more pronounced "knee" in the dilution phase due to the absence of the secondary sources.

The reactor conditions at the time of criticality were determined to be as follows:

Date:	May 19, 1991
Time:	0100
RCS Temperature:	530 °F
RCS Pressure:	1985 psig
Rod Position:	Bank D at 180 steps
Boron Concentration:	1405 ppm

7.2 Reactivity Computer Setup and Checkout

7.2.1 Setup

Table 7-2 shows the reactivity computer setup results. Test 1 is a static test which tests for the reactivity zero point. Test 2 is a dynamic test which inputs an exponentially increasing flux to test for a positive reactivity output.

7.2.2 Checkout

Following criticality, acceptable zero power physics testing flux levels were determined. The flux level at which nuclear heat appeared was about $3 \cdot 10^{4}$ amps on the Keithley picoammeter. Normal flux levels for physics testing are about one-third the point of adding heat by procedure.

The reactivity computer's response was also checked using actual core flux. Control Bank D was pulled from a critical position to obtain distinctly different reactivity levels. For each reactivity level, flux doubling time was measured with a stopwatch. Measured reactivity was then compared to design reactivity calculated from the measured doubling time. Table 7-1 shows the results. Differences were within 5 percent, which is acceptable.

TABLE 7-1

REACTIVITY COMPUTER CHECKOUT

Measured Doubling Time (sec)	Measured Reactivity (pcm)	Calculated Doubling Time (sec)	Difference $\frac{M-D}{D} \times 100$
86.5	43	88.7	+3%
51.0	63.5	53.9	-5%
40.7	75	43.0	-5%

TABLE 7-2

CSCN 680 11-18-88
MINIAC COMPUTER SETUP

UNIT	CYCLE	DATE	BURNUP MWD/MTU	BETA TOTAL	I	L-STAR (MS)
2	18	01-09-92	0	0.005921	0.97	21.3

DELAYED GROUP	1	2	3	4	5	6
BETA FRACTION	0.000192	0.001224	0.001098	0.002341	0.000858	0.000207
LAMBDA	0.0128	0.0315	0.1212	0.3224	1.4047	3.8557

INPUT POT NUMBER	11	12	21	22	31	32
SETTING	1.1919	3.7399	1.2909	3.6605	1.1691	0.7742
AS LEFT #1	1.1915	3.739	1.291	3.662	1.170	0.774
AS LEFT #2						

FEEDBACK POT NUMBER	13	14	23	24	33	34
SETTING	1.2800	3.1500	1.2120	3.2240	1.4047	3.8557
AS LEFT #1	1.280	3.149	1.212	3.224	1.405	3.854
AS LEFT #2						

TEST 1 SET POT 36 TO 9.200 (VOLTS). POT 35 SHOULD BE 5.7434 AS LEFT #1 5.706 AS LEFT #2 ________
ADJUST POT 35 UNTIL AMPLIFIER 14 (RHO) OUTPUT IS 0.0 VOLTS.

AMPLIFIER NUMBER	11	12	21	22	31	32
AMPLIFIER VOLTS	8.56704	10.92297	9.79855	10.44554	7.65679	1.84727
AS LEFT #1	8.58	11.0	9.89	10.54	7.70	1.85
AS LEFT #2						

TEST 2 SET POT 26 TO ABOUT 0.75 V

POT 25 SETTING	0.20	0.50	0.80	1.10	1.40	1.70	2.00	2.30	2.60
PERIOD (SEC)	500.00	200.00	125.00	90.91	71.43	58.82	50.00	43.48	38.46
T-DBLG (SEC)	346.57	138.63	86.64	63.01	49.51	40.77	34.66	30.14	26.66
OBSERVED T-D #1	319.92	134.16	83.18	60.28	47.26	38.87	32.75	28.49	25.05
OBSERVED T-D #2									
EXPECTED RHO (PCM)	12.87	29.52	43.83	56.42	67.66	77.84	87.13	95.69	103.63
OBSERVED RHO #1	14.09	30.65	45.59	59.45	69.16	79.10	88.26	96.68	104.94
OBSERVED RHO #2									

DATE	INITIALS
11/10/91	DRB

8.0 CONTROL ROD WORTH MEASUREMENTS

8.1 Test Description

A new method of measuring rod worth, developed by Westinghouse, was tested for accuracy prior to the normal rod swap method. This new method, called "Dynamic Rod Worth" measures rod worth by the rate at which a group of rods shuts down the reactor as they are inserted in a continuous fashion to bottom of core. This method does not require any boron changes or the use of a reactivity computer. The data for all rods was collected in less than two hours. The results are not available as the analysis methodology had not yet been developed. This test was performed on November 13, 1991 per Appendix A to Procedure RESP 4.1 for the U2C18 startup.

The rod worth verification, utilizing rod exchange ("rod swap"), was divided into two parts. In the first part, the reactivity worth of the reference bank was obtained from reactivity computer measurements and boron endpoint data during RCS boron dilution. In the second part, the critical height of the reference bank was measured after exchange with each remaining bank.

In the rod exchange technique, the reference bank is defined as that bank with the highest worth of all banks, control or shutdown, when inserted into the core alone. For this cycle the reference bank was Control Bank A (CA), as was the case in all prior rod swap tests.

Using the analog reactivity computer, reactivity measurements were made during the insertion of Control Bank A from the fully-withdrawn to the fully-inserted position. The average current (flux level) during the measurement was maintained within the physics testing range and temperature was held steady near 530°F. Critical boron concentration measurements (boron endpoints) were made before and after the insertion of Control Bank A (see Section 10.0). Figure 8-1 shows the results of the differential worth measurements.

Starting at a critical position with the reference bank fully inserted and Control Bank C fully out, a new critical configuration at constant RCS boron concentration was established with Control Bank C fully inserted and Control Bank A at 136 steps. Control Bank C was then withdrawn and Control Bank A inserted to one step to establish the initial conditions for the next exchange. This sequence was repeated until a critical position was established for the reference bank with each of the other banks individually inserted. Criticality determinations before and after each exchange were made with the reactivity computer.

The sequence of events during the rod exchange and a summary of the rod exchange data is presented in Table 8-1.

8.2 Data Analysis and Test Results

The integral reactivity worth of the measured bank is inferred from the swapped portion of Control Bank A by the following equation:

$$W_X^I = W_R^M - \Delta\sigma_1 - (\alpha_X)(\Delta\sigma_2) + W_X^E$$

where:

W_X^I = The inferred worth of Bank X, pcm.

W_R^M = The measured worth of the reference bank, Control A, from fully withdrawn to fully inserted with no other bank in the core.

α_X = A design correction factor taking into account the fact that the presence of another control rod bank is affecting the worth of the reference bank.

$\Delta\sigma_2$ = The measured worth of the reference bank from the elevation at which the reactor is just critical with Bank X in the core to the reference bank fully withdrawn condition. This worth was measured with no other bank in the core.

$\Delta\sigma_1$ = The measured worth of the reference bank from the fully inserted condition to the elevation at which the reactor was just critical prior to the worth measurement of Bank X. In this test $\Delta\sigma_1$ is zero because Bank A was fully inserted.

W_X^E = The worth of Bank X from the initial position (before the start of the exchange) to 228 steps. This worth is measured by the normal endpoint worth method.

Final values for the integral worth of control and shutdown banks inferred from the measurement data are tabulated in Table 8-2. Values for α_X, obtained from the design predictions, are also listed in Table 8-2.

8.3 Evaluation of Test Results

A comparison of the measured/inferred bank worths with design predictions is presented in Table 8-2.

In evaluating the test results, the standard review and acceptance criteria below were used.

Review Criteria:

a. The measured worth of the reference bank agrees with design predictions within ±10 percent.

b. The inferred individual worth of each remaining bank agrees with design predictions within ±15 percent or ±100 pcm, whichever is greater.

c. The sum of the measured and inferred worths of all control and shutdown banks is less than 1.1 times the predicted sum.

Acceptance Criteria:

The sum of the measured/inferred worths of all control and shutdown banks is greater than 0.9 times the predicted sum.

All review and acceptance criteria were met. Although Control Bank B was outside the ±15 percent part of criterion "B", it was within the 100 pcm limit. This is consistent with recent results from prior cycles.

TABLE 8-1

CRITICAL ROD CONFIGURATION DATA

Bank	Time	RCS Tavg (°F)	CA Position Steps	Bank Position Steps
CC CC	1920 1955	530 530	1 136	229 1
SB SB	2018 2035	530 530	1 94	229 1
SA SA	2056 2110	530 530	1 125	229 1
CB CB	2127 2139	530 530	1 80	229 1
CD CD	2150 2203	530 530	1 100	229 1

Boron concentration was 1296 ppm.

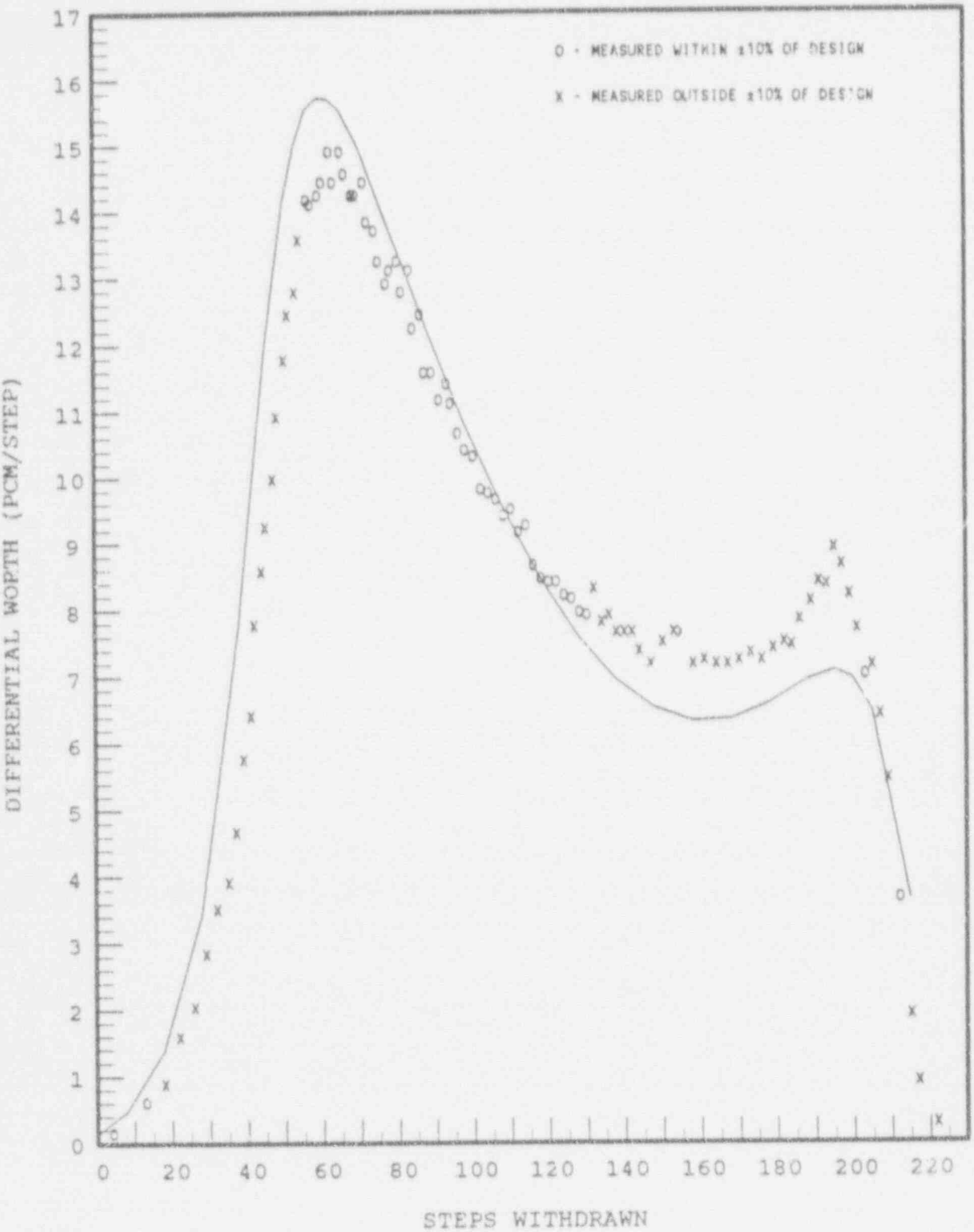
TABLE 8-2

COMPARISON OF INFERRED/MEASURED BANK WORTHS
WITH DESIGN PREDICTIONS

Bank X	$\Delta\sigma_2$	α_x	W_X^E	W_X^I	W_X^P	(I-P)/P x 100
	pcm		pcm	pcm	pcm	%
CC	601	0.982	0	1131	1143	-1.1
SB	995	1.018	0	708	712	-0.6
SA	695	0.967	0	1053	1033	+1.9
CD	1165	1.065	0	792	770	+2.9
CB	920	1.010	0	480	510	-5.9
CA				1721	1751	-1.7
TOTAL				5885	5919	-0.6

FIGURE 8-1

PBNP UNIT 2 CYCLE 18 BOL HZP
REFERENCE BANK DIFFERENTIAL WORTH



9.0 TEMPERATURE COEFFICIENT MEASUREMENTS

A near all rods out isothermal temperature coefficient measurement was taken during zero power physics testing. The measured value is the average of the recorded reactor coolant system heatups and cooldowns. Reactivity from the reactivity computer and reactor coolant system temperature were recorded on an X-Y plotter and two-pen recorder.

Measured ARO isothermal temperature coefficient was +0.9 pcm/°F, within the review criteria of ±3 pcm/°F of the design isothermal temperature coefficient of +0.8 pcm/°F for 530°F and 1424 ppm.

10.0 BORON WORTH AND ENDPOINT MEASUREMENTS

Figure 10-1 shows RCS boron concentration during zero power physics testing. Table 10-1 shows results of the endpoint measurements. The measured boron worth was obtained by dividing bank worth (pcm) into change in boron concentration between endpoints. The review criterion of ± 0.5 pcm/ppm was met.

TABLE 10-1

BORON WORTH AND ENDPOINTS

Bank Configuration	Endpoint		Bank Worth		Boron Worth	
	Design	Measured	Design	Measured	Design	Measured
	ppm	ppm	ppm	ppm	pcm/ppm	pcm/ppm
ARO	1409	1424	----	----		
CA in	1235	1248	1751	1721	-10.1	-10.1

At measurement conditions (530°F)

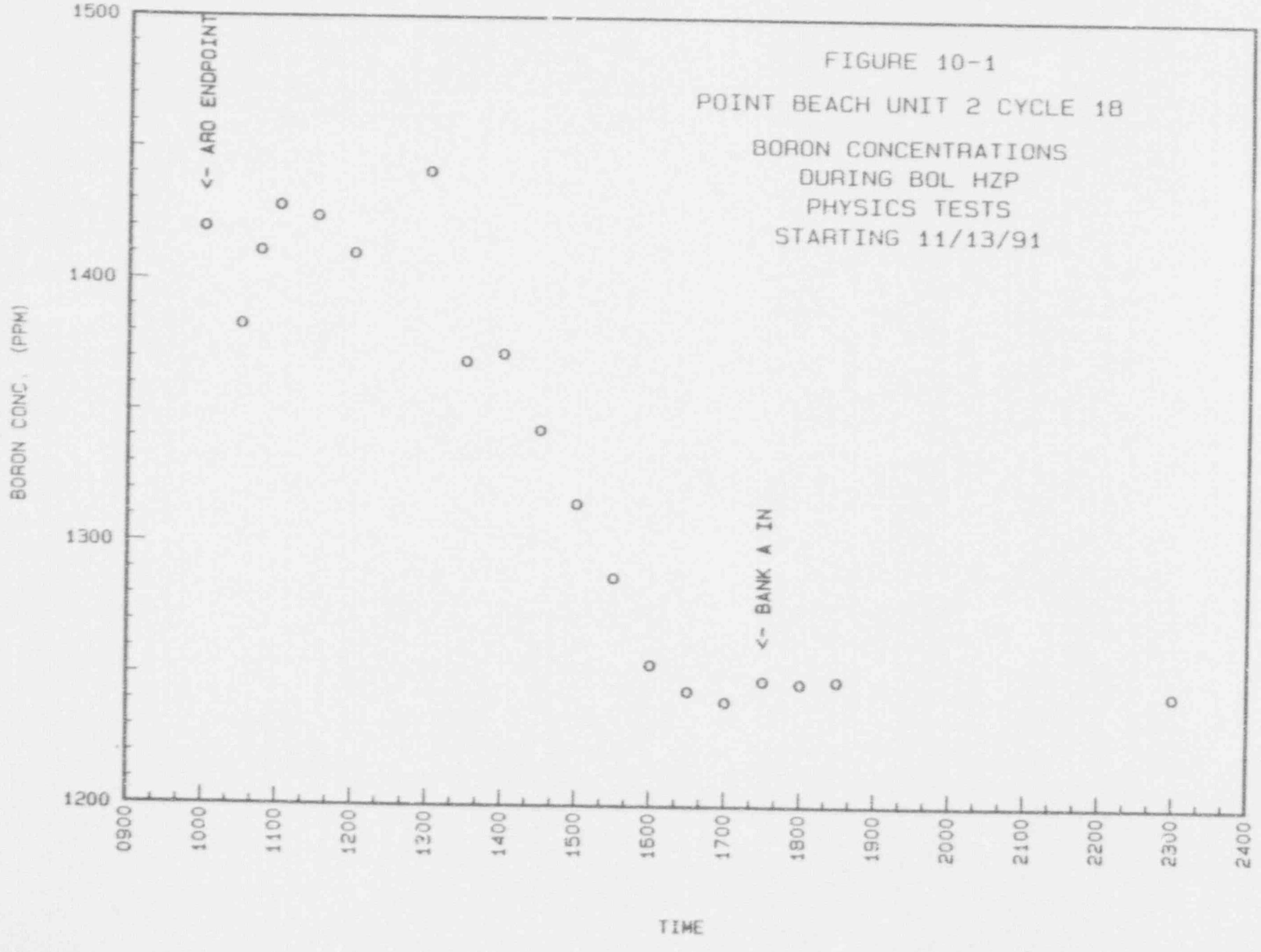


FIGURE 10-1
POINT BEACH UNIT 2 CYCLE 18
BORON CONCENTRATIONS
DURING BOL HZP
PHYSICS TESTS
STARTING 11/13/91
<- ARO ENDPOINT
<- BANK A IN
BORON CONC. (PPM)
1500
1400
1300
1200
TIME
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

11.0 POWER DISTRIBUTION

Table 11-1 illustrates the margin of hot channel factors to their full power limits during initial power increase to full load. Flux maps were taken using ANSI Standard ANS-19.6.1-1985 as guidance. Allowed power levels were calculated using the relationships for FH and FQ versus power level in Technical Specification 15.3.10.B.1.a.

Measured axial power distribution, compared to design, is shown in Figures 11-1 and 11-2.

TABLE 11-1

INITIAL POWER ESCALATION
FLUX MAP RESULTS

MAP NO.	DATE	POWER %	THIM. MISS.	ALLOWED POWER		BANK STEPS	AO %
				FDH	FQ		
1	11-14-91	28	0	89	95	187	+16.7
2	11-18-91	75	0	102	110	193	+7.0
3	11-19-91	95	0	106	113	195	+2.5
4	11-20-91	99.7	0	112	114	197	+4.0
7	11-25-91	99.8	0	116	117	208	+4.9

FIGURE 11-1

POINT BEACH UNIT 2 CYCLE 18
CORE AVERAGE NORMALIZED AXIAL POWER DISTRIBUTION
28% POWER BOL

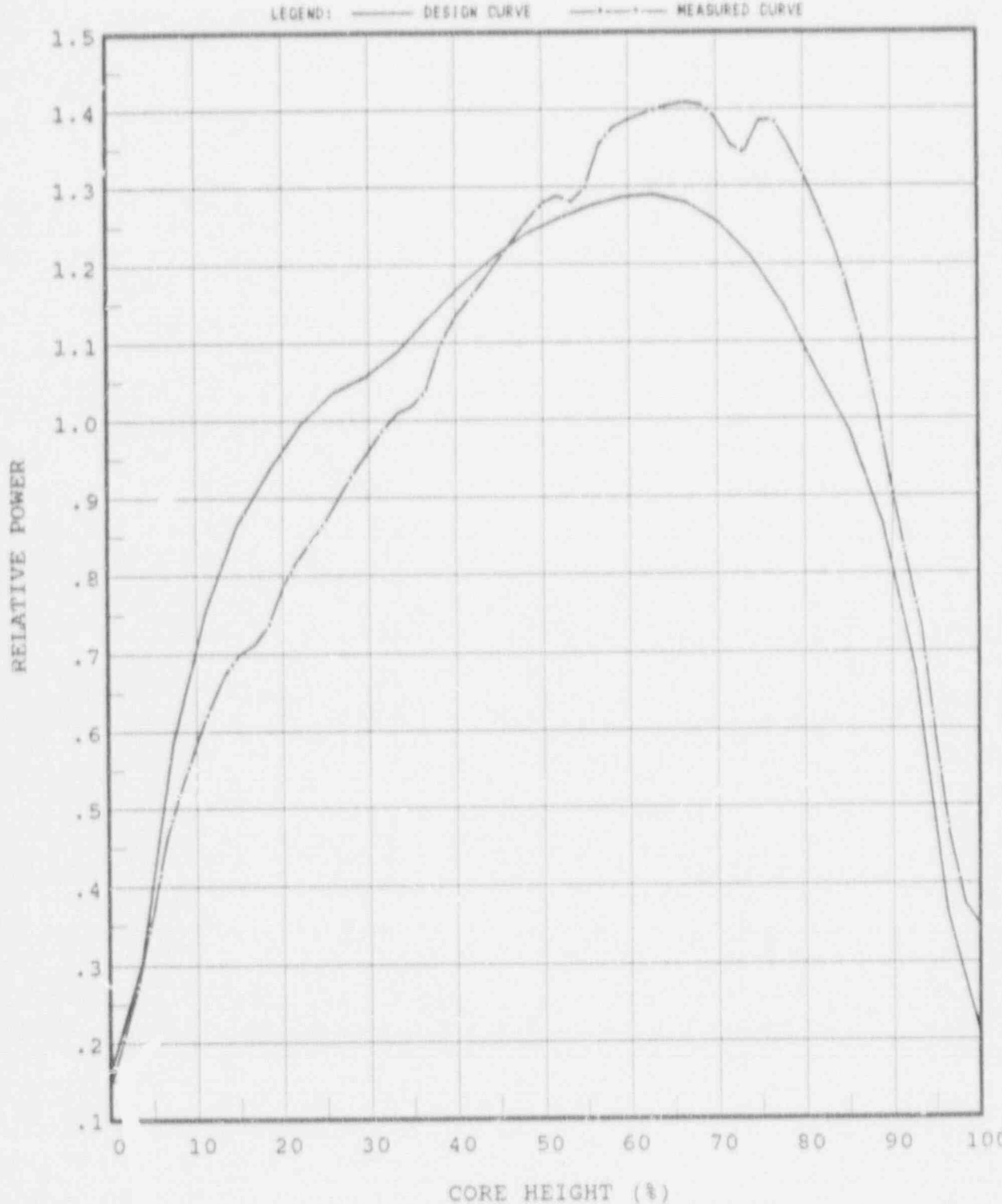
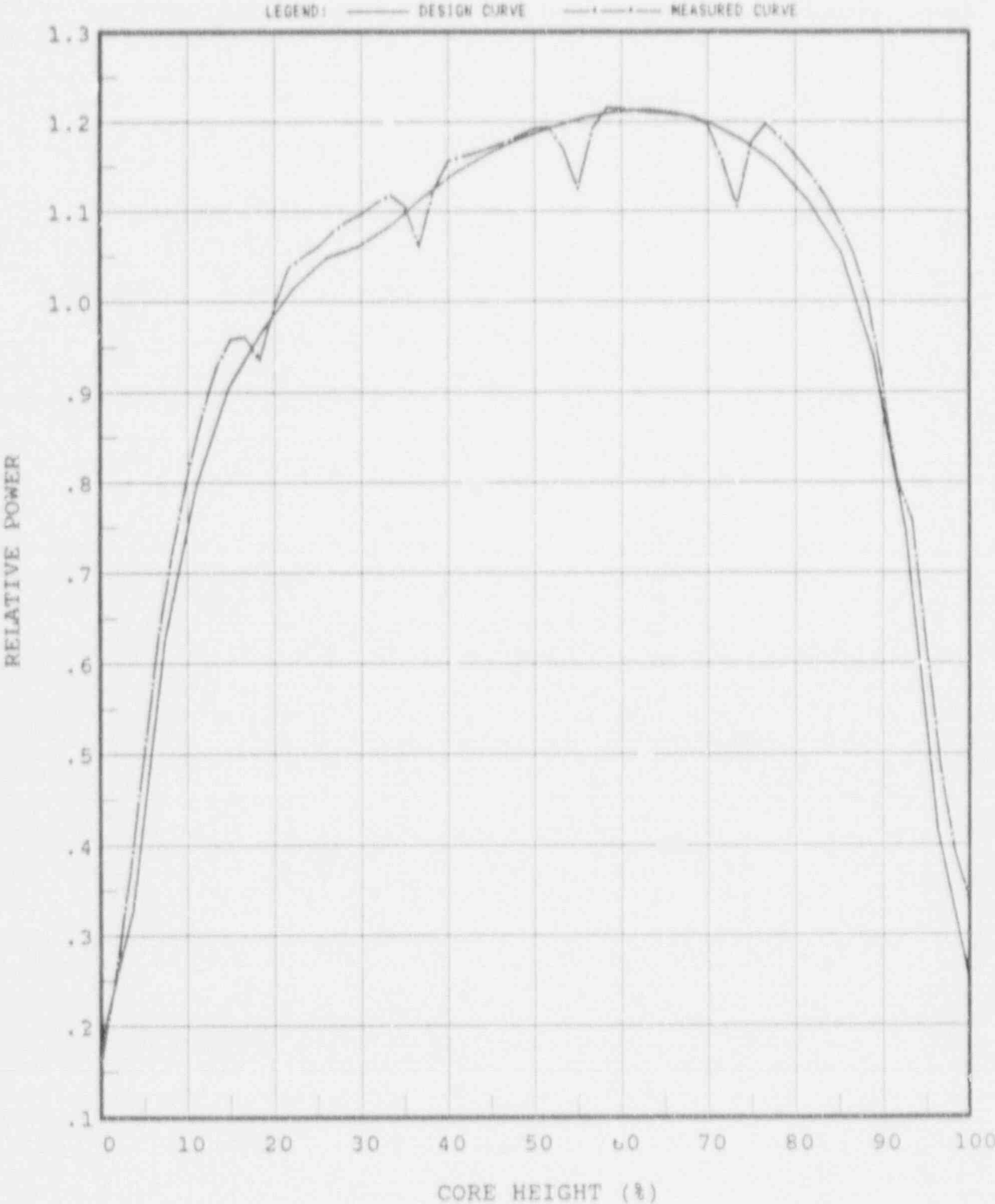


FIGURE 11-2

POINT BEACH UNIT 2 CYCLE 18
CORE AVERAGE NORMALIZED AXIAL POWER DISTRIBUTION
HFP BOL EQXE



12.0 XENON REACTIVITY

Xenon reactivity behavior data for Unit 2 Cycle 17 was supplied by Westinghouse separate from the WATCH data package. Point Beach code Xenon will be run with a TDF1 of 0.95 and TDF2 of 1.2 to remain consistent with the Xenon Tables. Tables are supplied for BOL, MOL and EOL conditions.

13.0 SHUTDOWN MARGIN CONSIDERATIONS

Rod swap results were within acceptance criteria and were accepted as valid proof of rod worth for shutdown margin determination. See Section 8.0 for rod swap details. Thus WCAP-12903 Table 6.2 was accepted as a valid shutdown margin determination. Table 13-1 calculates the excess worth available to Unit 2 Cycle 18.

TABLE 13-1

EXCESS SHUTDOWN WORTH AVAILABLE
FOR A FULL POWER TRIP

	BOL (pcm)	EOL (pcm)
Shutdown Margin From WCAP	3770	4110
Required Shutdown	-1000	-2770
Excess Worth	-2770	-1340

14.0 EXCORE DETECTOR BEHAVIOR

14.1 Intermediate Range Detectors

Intermediate range detector currents versus power level are shown in Figure 14-1. Intermediate range detector trip setpoints were estimated from the design power sharing of the closest F/As to the detectors. The trip setpoints were reached within the expected reactor power level range of 20 percent - 25 percent. This shows that the core design changes for Cycle 18 had the expected impact on intermediate range detector response.

14.2 Power Range Detectors

Table 14-1 lists the "tilt free" power range detector calibration currents corresponding to 105 percent power at BOL. These currents were calculated using the multi-map method at 100 percent power. The multi-map method was used as a conservative measure to ensure that core design changes did not affect the power range detectors unevenly.

The first flux maps for the multi-map calibration were taken on December 4, 1991 at a burnup of 600 MWD/MTU. At this time, Bank D position was at 212 steps to keep delta flux at or below +5 percent. Also, the low-low insertion limit alarm was set at about 192 steps. These conditions restricted the maneuvering normally done to obtain the desired delta flux and rod position combinations for the flux maps. The test was canceled to wait for more normal equilibrium core conditions with rods further out. On December 12, 1991 rods were fully withdrawn with delta flux near +6 percent to start another set of flux maps. The test was completed on December 13, 1991.

Table 14-2 shows the changes in the installed axial offset constants. The changes are probably due to statistical variances since the last multi-map calibration, more than Cycle 18 design changes. As shown, the only channel that was changed was N41. This was the only change that was in the conservative direction. The other three channels already had axial offset constants that were conservative, compared to the new constants obtained from the test.

Power range quadrant tilt alarms are designed to alert for rapidly developing tilts. Natural core tilts are eliminated by obtaining calibration currents for the core with a tilt. A tilt is indicated only when actual currents deviate from the calibration currents even though the core already may have a tilt before the start of the deviation. This practice complies with Technical Specifications and the Westinghouse position on core tilt.

TABLE 14-1

POWER RANGE DETECTOR
BOL CALIBRATION CURRENTS (105%)

		N41	N42	N43	N44
Cycle 14	T	314	334	350	305
	B	263	297	317	277
Cycle 15	T	267	280	286	256
	B	229	255	265	238
Cycle 16	T	253	260	280	234
	B	211	232	259	215
Cycle 17	T	255	260	277	235
	B	219	242	262	222
Cycle 18	T	254	255	270	235
	B	215	237	254	218

TABLE 14-2

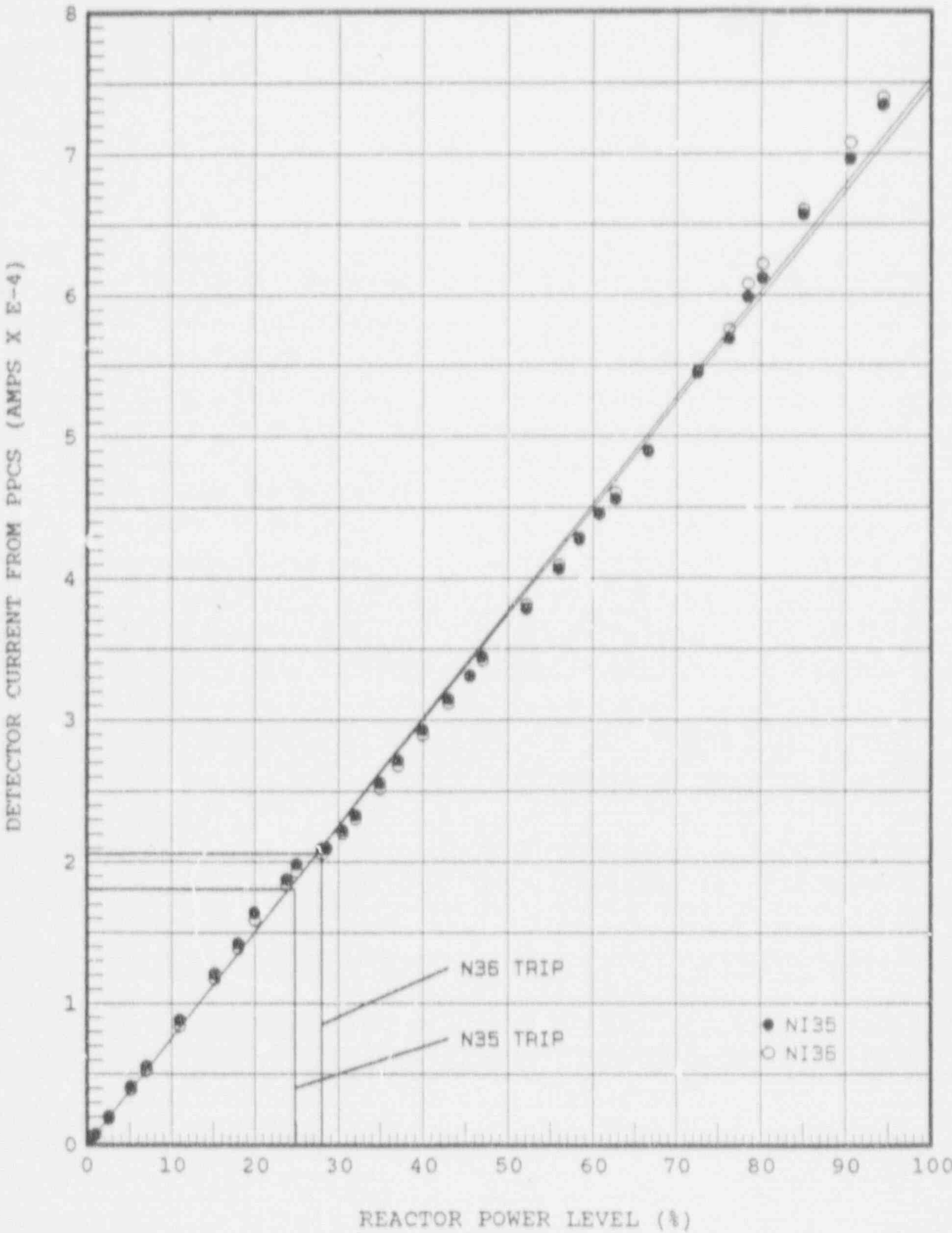
AXIAL OFFSET CONSTANTS

	N-41	N-42	N-43	N-44
Before	1.55	1.55	1.63	1.55
After	1.58	1.55	1.63	1.55

FIGURE 14-1

UNIT 2 CYCLE 18

NI35 AND NI36 RESPONSE TO POWER LEVEL



15.0 OVERPOWER, OVERTEMPERATURE AND DELTA FLUX SETPOINTS CALCULATION

15.1 Overpower and Overtemperature ΔT Setpoints

Shown below are the equations from Technical Specification 15.2.3.1.B.4/5, effective during Cycle 18.

Overpower ΔT

$$\left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_o\left[K_4 - K_5\left(\frac{\tau_5 S}{\tau_5 S+1}\right)\left(\frac{1}{1+\tau_4 S}\right)T - K_6\left[T\left(\frac{1}{1+\tau_4 S}\right) - T'\right]\right]$$

Overtemperature ΔT

$$\left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_o\left[K_1 - K_2\left(T\left(\frac{1}{1+\tau_4 S}\right) - T'\right)\left(\frac{1+\tau_1 S}{1+\tau_2 S}\right) + K_3\,(P-P') - f\,(\Delta I)\right]$$

See Tables 15-1 and 15-2 for the constants associated with this cycle of operation.

15.2 Delta Flux Input to Overtemperature ΔT Setpoint

The overtemperature ΔT setpoint is reduced when the excore detectors sense a percent power mismatch between the top and bottom of the core. The dead band is +5 percent and -17 percent before the setpoints are reduced. For each percent (more than 5 percent) the top detector output exceeds the bottom detector, the setpoints are reduced an equivalent of 2 percent of the rated power. For each percent (more than -17 percent) the bottom detector exceeds the top detector, the setpoints are reduced an equivalent of 2 percent of rated power.

TABLE 15-1

OVERPOWER ΔT CONSTANTS

ΔT_0 = Indicated ΔT at rated power, °F

T = Average temperature, °F

T' ≤ 573.9°F

K_4 ≤ 1.089 of rated power

K_5 = 0.0262 for increasing T
= 0.0 for decreasing T

K_6 = 0.00123 for $T \geq T'$
= 0.0 for $T < T'$

τ_7 = 10 seconds

τ_3 = 2 seconos 'or Rosemount or equivalent , TD
= 0 seconds fur Sostman or equivalent RTD

τ_4 = 2 seconds for Rosemount or equivalent RTD
= 0 seconds for Sostman or equivalent RTD

TABLE 15-2

OVERTEMPERATURE ΔT CONSTANTS

ΔT_o	= Indicated ΔT at rated power, °F
T	= Average temperature, °F
T'	≤ 573.9°F
P	= Pressurizer pressure, psig
P'	= 2235 psig
K_1	≤ 1.30
K_2	= 0.0200
K_3	= 0.000791
τ_1	= 25 seconds
τ_2	= 3 seconds
τ_3	= 2 seconds for Rosemount or equivalent RTD = 0 seconds for Sostman or equivalent RTD
τ_4	= 2 seconds for Rosemount or equivalent RTD = 0 seconds for Sostman or equivalent RTD

16.0 FUEL PERFORMANCE

Figure 16-1 shows relatively low coolant activity just before refueling with still lower activity after refueling. There is indication of iodine spiking during large power transients. This may be caused by a minor fuel defect. We were unable to discover this with UT examination, but we are continuing to evaluate RCS chemistry.

17.0 CONCLUSION

The following results of refueling activities should be highlighted.

1. The bank swap method for measuring rod worth produced relatively excellent results.

2. Core design changes including natural uranium blankets and IFBAs did not significantly change the excore detectors.

3. During initial power escalation, the magnitude of core power distribution hot channel factors were typical, compared to those obtained in prior cycles.

The other Unit 2 Cycle 18 startup and refueling activity results were normal.

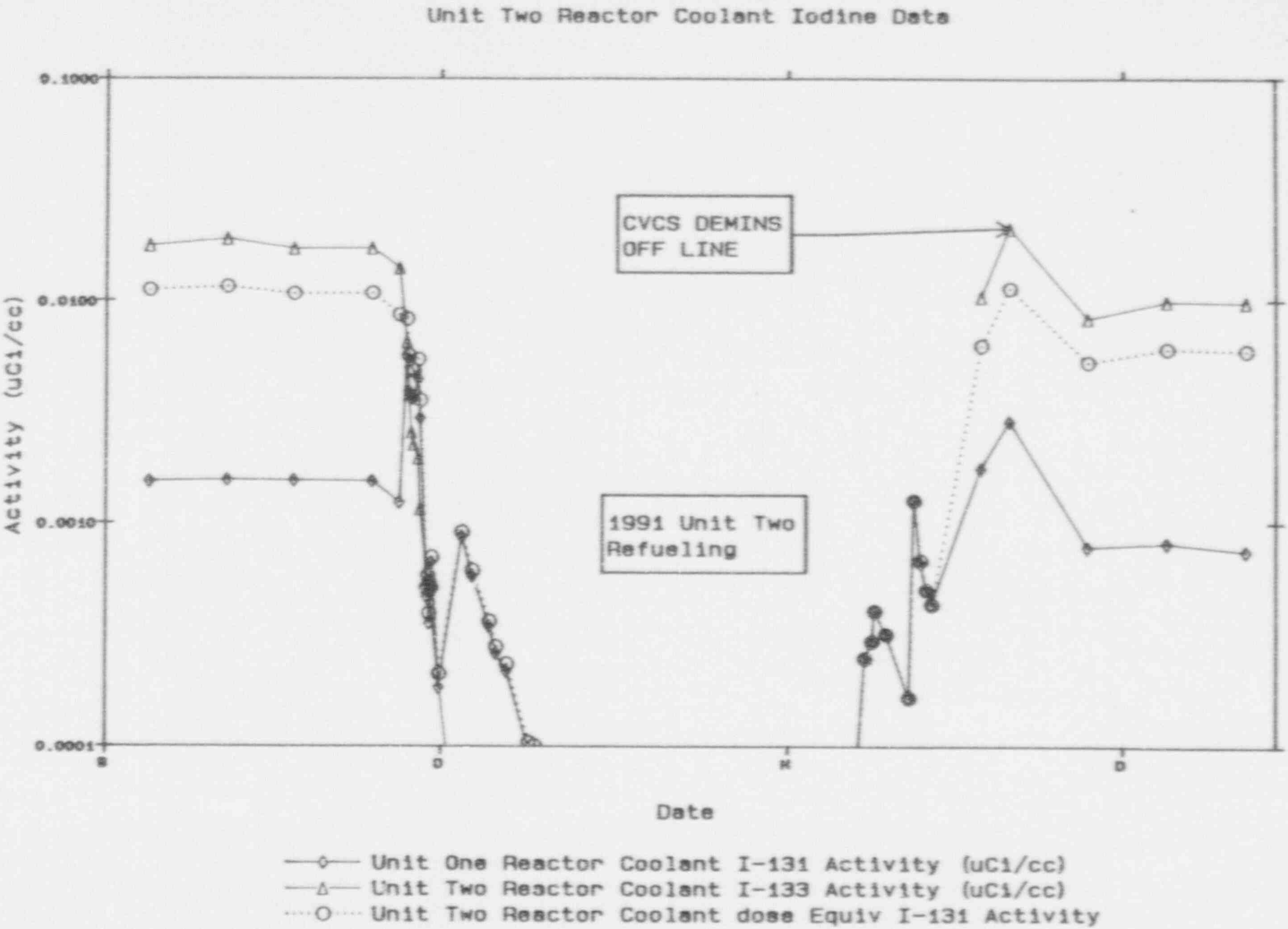

Unit Two Reactor Coolant Iodine Data
0.1000
0.0100
0.0010
0.0001
Activity (uCi/cc)
CVCS DEMINS OFF LINE
1991 Unit Two Refueling
S
O
N
D
Date
Unit One Reactor Coolant I-131 Activity (uCi/cc)
Unit Two Reactor Coolant I-133 Activity (uCi/cc)
Unit Two Reactor Coolant dose Equiv I-131 Activity

FIGURE 16-1