Wisconsin
Electric
POWER COMPANY

231 W. Michigan, P.O. Box 2046, Milwaukee, WI 53201 (414) 221-2345

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Gentlemen:

DOCKET NO. 50-301
CYCLE 16 STARTUP REPORT
POINT BEACH NUCLEAR PLANT UNIT 2

In accorance with Point Beach Technical Specification 15.6.9.1.A.1.c and 15.6.9.1.A.2.a, we are submitting the attached summary report of the startup and power escalation of Point Beach Unit 2 with a low-low leakage core design using enhanced Optimized Fuel Assemblies.

Please contact us if you have any questions concerning this submittal.

Very truly yours,

CW Fay

C. W. Fay
Vice President
Nuclear Power

Attachment

Copies to NRC Regional Administrator, Region III
NRC Resident Inspector

IE26
1/1

A subsidiary of Wisconsin Energy Corporation

JANUARY 9, 1990

WISCONSIN ELECTRIC POWER COMPANY
POINT BEACH NUCLEAR PLANT
UNIT 2 CYCLE 16 STARTUP
NOVEMBER, 1989

BY

R. J. BRUNO

P. N. KURTZ

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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 15. The organization of the report follows that utilized in previous startup reports.

Westinghouse performed the core design calculations for Unit 2 Cycle 16. The reactivity coefficients were calculated based on estimated Cycle 15 burnup of 10,200 MWD/MTU. Actual cycle 15 burnup was 10,205 MWD/MTU. Cycle 15 was ended on September 23, 1989, with a peak assembly burnup of 45,996 MWD/MTU and average assembly burnup of 28,622 MWD/MTU. Electrical power was first generated during Cycle 16 on November 25, 1989.

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

The core was completely unloaded so that the core barrel could be removed from the reactor vessel for a Section XI ten year reactor vessel inspection. The unload started on October 10, 1989, seventeen days after Cycle 15 end of life shutdown. The unload went smoothly and was completed on October 12, 1989. A discharge fuel assembly (P56) experienced a torn grid when being lowered into spent fuel pit location SD-13.

All necessary fuel assembly insert changes for Cycle 16 were made in the spent fuel pit from October 12, 1989 to October 17, 1989 using one 10 hour shift. All plug devices were removed from reload fuel assemblies. None of the inserts were damaged. The insert tools worked properly for the duration of the moves.

After completion of the insert moves, all of the Cycle 15 fuel assemblies were ultrasonically tested (UT) for leaking fuel rods using the company owned equipment. In addition, several candidates for reuse, discharged from prior cycles, were tested. No leaking fuel rods were found. Average time to perform a UT in the SFP was 30 minutes.

The core reload started on November 6, 1989 and was completed on November 10, 1989. Several changes were made to the sequence to park bowed or twisted fuel assemblies in temporary locations until their locations were boxed. All temporary core configurations conformed to the procedural requirement that a 2x2 array of new fuel shall not be made, ensuring adequate shutdown margin. No fuel handling mishaps occurred during the reload. Once baseline count rates were established for the excore detectors, the count rates did not change throughout the remainder of the reload sequence. The introduction of the sources in core locations H-3 and F-11, approximately doubled the count rates on source range detectors N31 and N36 from about 80 and 70 cps to 210 and 180 cps respectively. The spare detector located away from the sources (wide range detector channel N40), responded with about 15 cps throughout the reload.

No major equipment breakdowns occurred during the reload. A loose fitting on the fuel gripper air cylinder had to be tightened, resulting in about 3 hours of down time. All fuel movement operations and UT testing were performed by PBNP personnel. The final core configuration was verified to match the design core configuration, by using a TV camera to scan the top of the core, reading the fuel assembly ID numbers and insert types.

1.2 Core Design

The final core configuration is shown in Figure 1-1 and matches the Westinghouse designed core layout shown in WCAP-12362, "The Nuclear Design and Core Management of the Point Beach Unit 2 Nuclear Reactor, Cycle 16." The as-loaded burnups for each fuel assembly are shown in Figure 1-2.

New fuel consisted of Vantage-5 type fuel assemblies, twelve with an enrichment of 3.4% U-235 and sixteen enriched to 3.8% U-235. No axial blankets, boron coated fuel pellets or extra grids for flow mixing were used in this core design. However, other Vantage-5 design features were used for the first time, such as removable top nozzles and debris catching bottom nozzles.

Of the 121 assemblies loaded, 115 are of the Optimized Fuel Assembly (OFA) design (also a Vantage-5 feature) and 6 are of the older standard design with wider fuel rods (0.422 inches diameter vs. 0.400 inches diameter for OFA's).

Besides the normal array of inserts, part length Hafnium rods were loaded on the "flats" of the core to decrease neutron fluence to the reactor vessel welds nearest the core. This will help extend reactor vessel lifetime.

All plug devices were removed for Cycle 16.

All the new features of this core design were analyzed in WCAP 11872, "Final Report for Increased Peaking Factors and Fuel Upgrade Analysis, Point Beach Nuclear Plant, Units 1 and 2, June 1988."

FIGURE 1-1

CORE LOADING

					A- 6 Q53 2H205	A- 7 Q55 2H207	A- 8 Q74 2H203					
			B- 4 Q79	B- 5 R74	B- 6 T65 R98	B- 7 T52 4P142	B- 8 T68 R135	B- 9 R80	B-10 Q77			
		C- 3 N23	C- 4 T70	C- 5 S73 R133	C- 6 R54	C- 7 S72 R32	C- 8 R51	C- 9 S74 R111	C-10 T76	C-11 Q70		
	D- 2 Q73	D- 3 T77	D- 4 Q68 R53	D- 5 S60	D- 6 T54 8P111	D- 7 K58	D- 8 T55 8P114	D- 9 S61	D-10 Q58 R11	D-11 T64	D-12 Q60	
	E- 2 R81	E- 3 S68 R71	E- 4 S52	E- 5 R72 R28	E- 6 R53	E- 7 S70	E- 8 R58	E- 9 R78 R115	E-10 S55	E-11 S65 R5	E-12 R68	
F- 1 Q65 2H211	F- 2 T78 R84	F- 3 R62	F- 4 T60 8P110	F- 5 R65	F- 6 R69 R14	F- 7 S54	F- 8 R70 R18	F- 9 R52	F-10 T61 8P113	F-11 R64 S59	F-12 T66 R103	F-13 Q66 2H208
G- 1 Q56 2H212	G- 2 T51 4P141	G- 3 S76 R31	G- 4 K54	G- 5 S71	G- 6 S51	G- 7 M19 R110	G- 8 S62	G- 9 S64	G-10 K53	G-11 S67 R7	G-12 T62 4P143	G-13 Q81 2H216
H- 1 Q71 2H204	H- 2 T73 R2	H- 3 R55 S510	H- 4 T53 8P109	H- 5 R59	H- 6 R77 R114	H- 7 S56	H- 8 R79 R8	H- 9 R60	H-10 T58 8P112	H-11 R66	H-12 T74 R149	H-13 Q82 2H209
	I- 2 R75	I- 3 S75 R116	I- 4 S59	I- 5 R82 R10	I- 6 R57	I- 7 S69	I- 8 R63	I- 9 R67 R112	I-10 S57	I-11 S63 R29	I-12 R76	
	J- 2 Q64	J- 3 T71	J- 4 Q72 R34	J- 5 S53	J- 6 T59 8P108	J- 7 K64	J- 8 T56 8P115	J- 9 S58	J-10 Q67 R17	J-11 T72	J-12 Q61	
		K- 3 Q69	K- 4 T67	K- 5 S78 R127	K- 6 R56	K- 7 S77 R107	K- 8 R61	K- 9 S66 R109	K-10 T69	K-11 Q52		
			L- 4 Q59	L- 5 R71	L- 6 T63 R126	L- 7 T57 4P140	L- 8 T75 R139	L- 9 R73	L-10 Q62			
					M- 6 Q54 2H213	M- 7 Q76 2H206	M- 8 Q78 2H214					

UNIT 2 CYCLE 16 FINAL CORE CONFIGURATION   10:06:13 a.m. 12/11/89

FIGURE 1-2

BOL BURNUP DATA

PBNP UNIT 2 START OF CYCLE 16

	1	2	3	4	5	6	7	8	9	10	11	12	13
A						Q53 36632 215	Q55 36057 215	Q74 35106 215					
B				Q79 35741 215	R74 26308 216B	T65 0 218B	T52 0 218A	T68 0 218B	R80 26550 216B	Q77 36681 215			
C			N23 31782 113B	T70 0 218B	S73 10802 217B	R54 25765 216A	S72 11911 217B	R51 25409 216A	S74 10877 217B	T76 0 218B	Q70 36498 215		
D		Q73 36255 215	T77 0 218B	Q68 32179 215	S60 12396 217A	T54 0 218A	K58 35759 210	T55 0 218A	S61 12756 217A	Q58 32337 215	T64 0 218B	Q60 35901 215	
E		R81 26712 216B	S68 11043 217B	S52 12767 217A	R72 24519 216B	R53 25043 216A	S70 11754 217B	R58 25155 216A	R78 24844 216B	S55 12746 217A	S65 10996 217B	R68 20437 216B	
F	Q65 35143 215	T78 0 218B	R62 25937 216A	T60 0 218A	R65 24942 216A	R69 23935 216B	S54 12893 217A	R70 24410 216B	R52 25418 216A	T61 0 218A	R64 26197 216A	T66 0 218B	Q66 35311 215
G	Q56 35928 215	T51 0 218A	S76 11904 217B	K54 35850 210	S71 11838 217B	S51 12353 217A	M19 28529 112B	S62 12775 217A	S64 11739 217B	K53 35460 210	S67 11986 217B	T62 0 218A	Q81 36412 215
H	Q71 34933 215	T73 0 218B	R55 26498 216A	T53 0 218A	R59 24573 216A	R77 23783 216B	S56 12909 217A	R79 24284 216B	R60 25789 216A	T58 0 218A	R66 25192 216A	T74 0 218B	Q82 35515 215
I		R75 26095 216B	S75 11020 217B	S59 12861 217A	R82 24428 216B	R57 25243 216A	S69 11989 217B	R63 25287 216A	R67 24763 216B	S57 12810 217A	S63 11000 217B	R76 26307 216B	
J		Q64 36065 215	T71 0 218B	Q72 31890 215	S53 12322 217A	T59 0 218A	K64 35623 210	T56 0 218A	S58 12638 217A	Q67 32202 215	T72 0 218B	Q61 35122 215	
K			Q69 35714 215	T67 0 218B	S78 10893 217B	R56 25502 216A	S77 11839 217B	R61 26536 216A	S66 10979 217B	T69 0 218B	Q57 35950 215		
L				Q59 35938 215	R71 26585 216B	T63 0 218B	T57 0 218A	T75 0 218B	R73 26211 216B	Q62 36172 215			
M						Q54 35109 215	Q76 36152 215	Q78 35614 215					

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

2.0 CONTROL ROD OPERATIONAL TESTING

2.1 Hardware Changes/Incidents

Table 2-1 shows which control rods were carried over from Cycle 15 and which control rods were replaced. Of the replacements, five were new rods from storage in the new fuel vault (R98, R126, R135, R139, and R149). The others were cleared for reuse based on eddy current testing in January, 1989. All rods carried over from Cycle 15 had less than 7 cycles of operation.

One replacement control rod (R71) had hairline cracks at the rodlet tips which were found during visual inspections in 1983. At that time Wisconsin Electric committed to not using R71 again. In August of 1989 R71 was picked as a replacement rod based on eddy current testing results showing acceptable wear. After R71 was loaded in the core and the reactor vessel head was in place, the documentation on the crack was found in the file for R71. Westinghouse was contacted to reevaluate the condition of R71. Based on a broadened database of control rod wear, Westinghouse recommended that R71 could be used for one more cycle. Therefore, R71 was left in the core for Cycle 16 and the NRC was notified.

All wiring connections to the RV head for rod position indication and rod control were replaced during the refueling outage. After correcting some wiring mistakes discovered during rod drop testing, the RPI and rod control systems functioned normally.

2.2 Rod Drop Times

See Figures 2-1 and 2-2 for rod drop times and RCS parameters.

Cold rod drop times for some rods were slightly faster than the drop times for other control rod banks because the rods were dropped from 223 steps instead of 228 steps. Some step counters were off by 5 steps as a result of an oversight during rod stepping tests just prior to rod drops.

All rod drop times were well within the Technical Specification limit of 2.2 seconds (15.3.10.E).

2.3 Control Rod Mechanism Timing

Traces of control rod gripper coils currents were obtained for all rods. All traces of the lift, moveable and stationary coil currents were considered satisfactory after correcting a wiring mistake at the RV head for Rod D4.

2.4 Rod Position Calibration

During hot rod drop testing, LVDT voltages were read at 20 steps and 200 steps to determine if any voltages were abnormal. Additional readings were made on Control Bank D rods every 20 steps to verify the new head connections had not changed the RPI coil characteristics. Each plot of voltage vs. step was normal.

"Zero" adjustments were made with rods at 20 steps under hot zero power full flow conditions.

"Span" adjustments were made at full power after rods were verified to be fully withdrawn using RESF 1.2, "Rod Control System: Rod Position Verification and Rod Position Indicator Alignment."

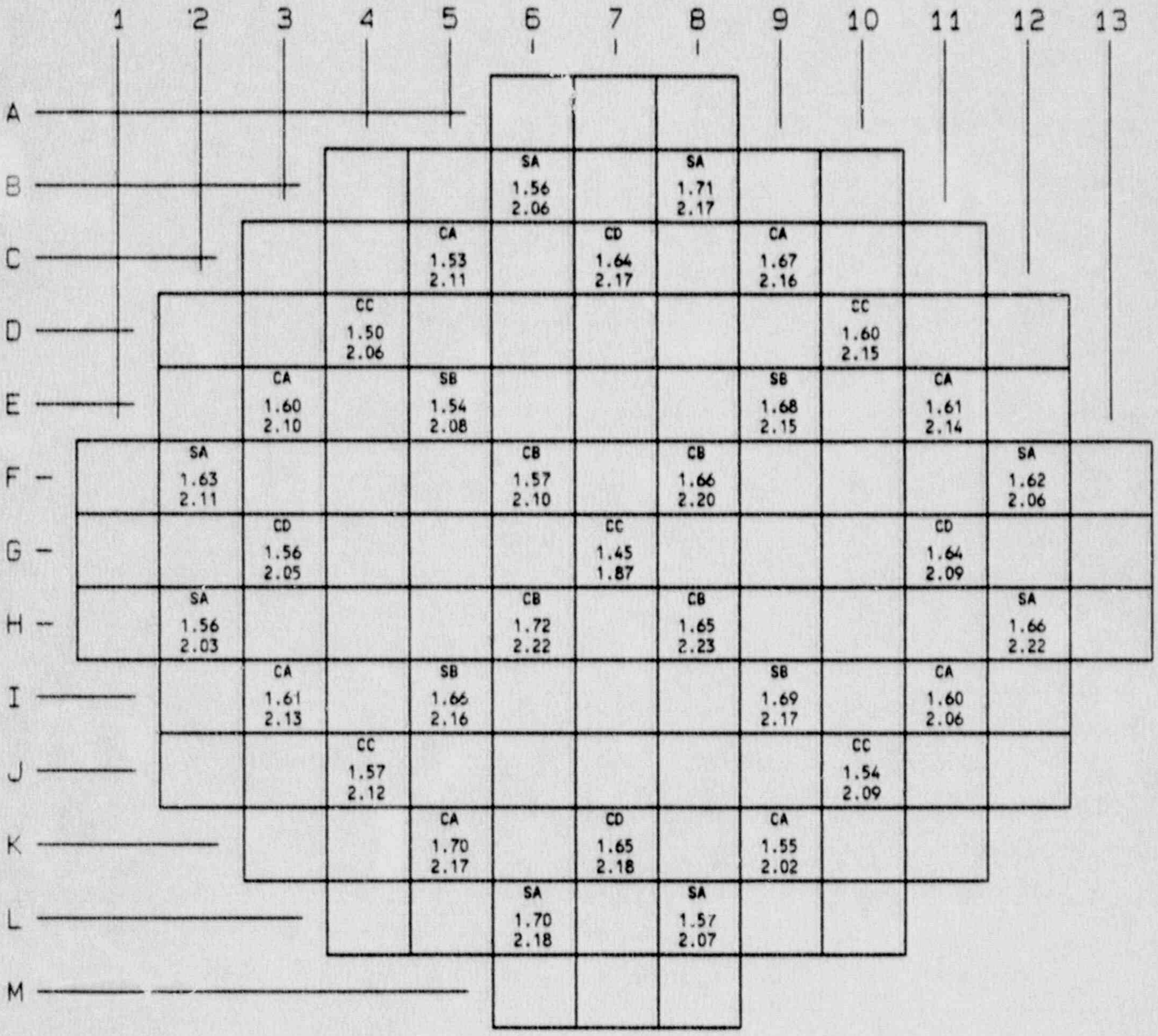
TABLE 2-1

CYCLE 16 CONTROL RODS

Discharged From Cycle 15	Replacements	Used in Cycle 15
R54	R98	R107
R65	R135	R133
R79	R32	R114
R62	R53	R109
R68	R11	R110
R57	R71	R111
R76	R28	R116
R82	R5	R127
R69	R14	R112
R55	R18	R115
R81	R31	R103
R61	R7	R84
R64	R2	
R73	R8	
R63	R149	
R83	R10	
R56	R29	
R72	R34	
R66	R17	
R77	R126	
R80	R139	

FIGURE 2-1

PBNP U2C16 COLD ROD DROP TIMES



	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B						SA 1.56 2.06		SA 1.71 2.17					
C					CA 1.53 2.11		CD 1.64 2.17		CA 1.67 2.16				
D				CC 1.50 2.06						CC 1.60 2.15			
E			CA 1.60 2.10		SB 1.54 2.08				SB 1.68 2.15		CA 1.61 2.14		
F		SA 1.63 2.11				CB 1.57 2.10		CB 1.66 2.20				SA 1.62 2.06	
G			CD 1.56 2.05				CC 1.45 1.87				CD 1.64 2.09		
H		SA 1.56 2.03				CB 1.72 2.22		CB 1.65 2.23				SA 1.66 2.22	
I			CA 1.61 2.13		SB 1.66 2.16				SB 1.69 2.17		CA 1.60 2.06		
J				CC 1.57 2.12						CC 1.54 2.09			
K					CA 1.70 2.17		CD 1.65 2.18		CA 1.55 2.02				
L						SA 1.70 2.18		SA 1.57 2.07					
M													

LEGEND

BANK	
X.XX	— Time To Dashpot (sec)
X.XX	— Time To Seat (sec)

Maximum drop time (dash) = H-6 1.72
Minimum drop time (dash) = G-7 1.45
Average time (dash) = 1.61

DATE 11/20/89

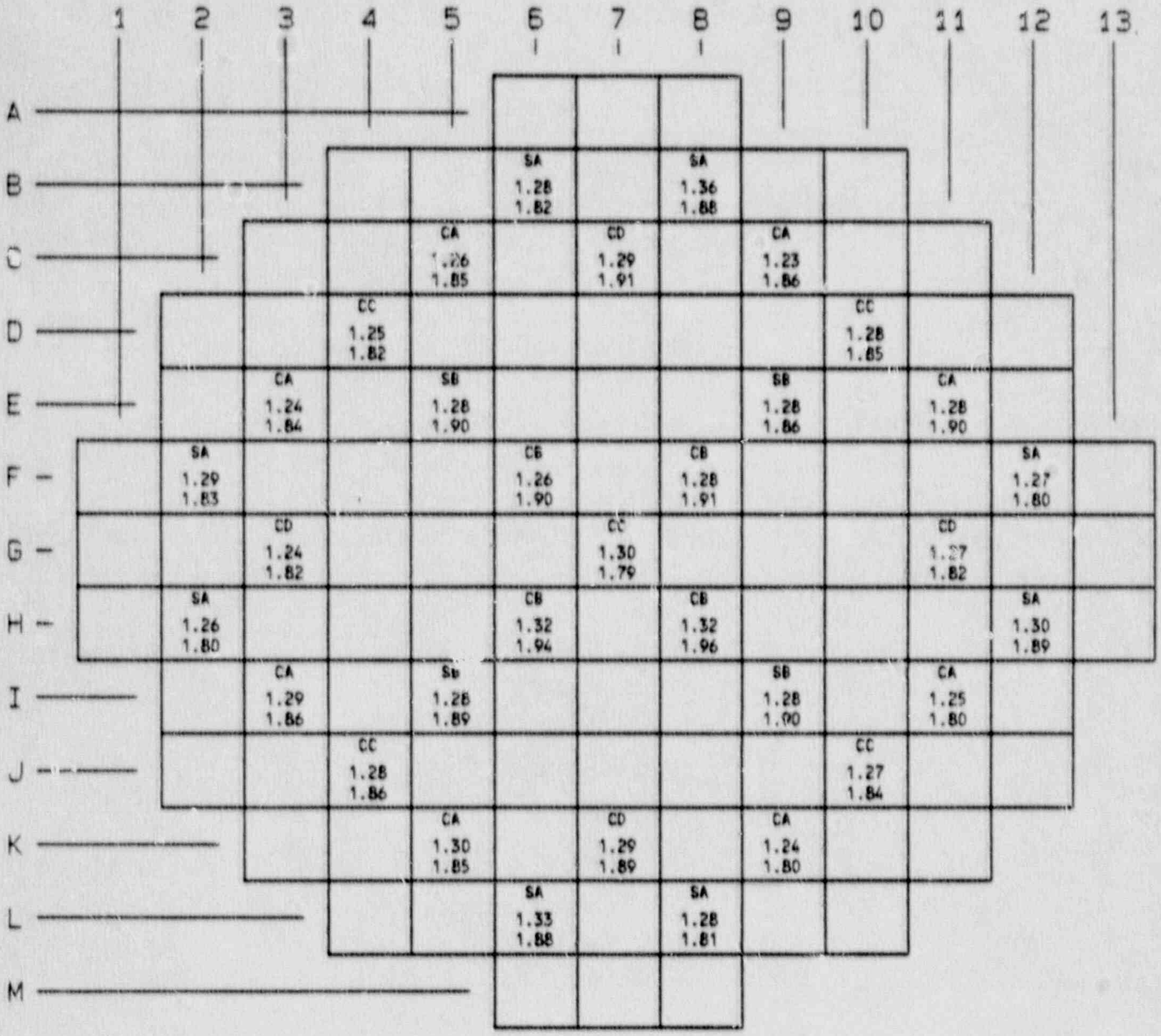
TEMP 180 °F

FLOW 100 %

PRES 330 PSIA

FIGURE 2-2

PBNP U2C16 HOT ROD DROP TIMES



	1	2	3	4	5	6	7	8	9	10	11	12	13
A													
B						SA 1.28 1.82		SA 1.36 1.88					
C					CA 1.26 1.85		CD 1.29 1.91		CA 1.23 1.86				
D				CC 1.25 1.82						CC 1.28 1.85			
E			CA 1.24 1.84		SB 1.28 1.90				SB 1.28 1.86		CA 1.28 1.90		
F		SA 1.29 1.83				CB 1.26 1.90		CB 1.28 1.91				SA 1.27 1.80	
G			CD 1.24 1.82				CC 1.30 1.79				CD 1.27 1.82		
H		SA 1.26 1.80				CB 1.32 1.94		CB 1.32 1.96				SA 1.30 1.89	
I			CA 1.29 1.86		SB 1.28 1.89				SB 1.28 1.90		CA 1.25 1.80		
J				CC 1.28 1.86						CC 1.27 1.84			
K					CA 1.30 1.85		CD 1.29 1.89		CA 1.24 1.80				
L						SA 1.33 1.88		SA 1.28 1.81					
M													

LEGEND

BANK

x.xx — Time To Dashpot (sec)

x.xx — Time To Seat (sec)

Maximum drop time (dash) = B-8 1.36

Minimum drop time (dash) = C-9 1.23

Average time (dash) = 1.28

DATE 11/23/89

TEMP 530 °F

FLOW 100 %

PRES 1995 **PSIA**

3.0 THERMOCOUPLE AND RTD CALIBRATION

During initial RCS heatup for Cycle 16, loop RTD's and incore thermocouples were checked for normal response throughout the heatup range of about 300°F to HZP. Table 3-1 gives each RTD temperature, steam generator temperature and average core exit thermocouple temperature for eight different measurements during the heatup. All 16 RTD's were within the expected 2°F deviation of each other throughout the heatup. Core exit thermocouple I10 was the only thermocouple not responding.

TABLE 3-1

RTD CALIBRATION CHECK

RTD Element	RTD Temperatures from Measured Resistances (°F)							
LOOP A - COLD LEG								
R 401B	315.62	350.55	417.67	447.19	474.27	497.55	520.73	530.51
R 405B	315.51	350.40	417.31	446.73	473.75	496.95	520.09	529.78
W 402B	315.30	350.28	417.63	446.77	473.84	496.90	520.12	529.85
W 406B	315.40	350.46	417.80	446.76	474.01	496.93	520.14	529.85
LOOP A - HOT LEG								
R 401A	315.50	330.43	417.61	447.02	473.84	497.03	520.35	530.14
R 405A	316.16	351.11	418.32	447.55	474.34	497.41	520.66	530.46
W 402A	315.56	350.66	417.92	447.03	474.11	496.90	520.27	530.07
W 406A	315.24	350.29	417.49	446.58	473.63	496.37	519.72	529.53
LOOP B - COLD LEG								
B 403B	315.60	350.69	418.01	447.18	474.25	496.80	520.45	530.34
B 407B	316.06	351.22	418.55	447.62	474.80	497.48	520.86	530.74
Y 404B	316.49	351.72	418.88	447.92	474.98	497.22	520.69	530.75
Y 408B	315.83	351.01	418.24	447.33	474.45	496.69	520.23	530.33
LOOP B - HOT LEG								
B 403A	315.42	350.52	417.67	446.66	473.81	496.33	519.61	529.54
B 407A	315.35	350.52	417.76	446.82	473.91	496.23	519.78	529.83
Y 404A	317.02	352.28	419.37	448.21	475.37	497.62	520.87	530.86
Y 408A	316.21	351.46	418.57	447.55	474.91	497.20	520.66	530.75
RTD AVERAGE	316	351	418	447	474	497	520	530
S.G. SAT. TEMP	307	348	415	446	474	496	520	530
CORE EXIT T/C TEMP	319	355	419	449	475	497	520	530

4.0 PRESSURIZER TESTS

4.1 Thermal Transients

Pressurizer pressure increase rate with spray valves indicated shut and all heaters on was 13 psi/min. This is close to the nominal value of 14 psi/min. During the thermal equilibrium test, heater group D was cycled on about 3/4 of the time to maintain pressure with main spray valves shut. Spray valve effectiveness was normal with pressure decreases greater than 110 psi/min.

Spray bypass valve positions were not changed as the result of these tests.

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 total.

TABLE 4-1

HEATER GROUP POWER SUPPLY READINGS

Heater Group	I-Current (amps)	V-Voltage (volts)	KW-Energy Input $KW = \sqrt{3} \times V \times I/1000$
A	287	484	240
B	237	479	196
C	237	484	198
D	220	481	183
E	233	476	192
		TOTAL	1009

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. There were no violations of the fuel conditioning restrictions on power and rod stepping rates.

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 0139 hours on November 24, 1989, 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 was 97 ppm/hr or 50 gpm. The critical boron concentration of 1267 ppm was close to the predicted value of 1269 ppm. ICRR plots were maintained during each phase of the approach to criticality. All plots turned out to be normal.

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

Date	November 24, 1989
Time	0806
RCS Temperature	530°F
RCS Pressure	1985 psig
Rod Position	Bank D at 178 steps
Boron Concentration	1267 ppm

The intermediate range detector trip block permissive came in with source range counts between 50,000 and 70,000 CPS.

7.2 Reactivity Computer Setup and Checkout

7.2.1 Setup

Table 7-1 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 5 microamps. 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 7-2 shows the results.

TABLE 7-1

MINIAC COMPUTER SETUP

UNIT	CYCLE	DATE	BURNUP MWD/MTU	BETA TOTAL	I	L-STAR (MS)
2	16	12-13-89	0	0.006017	0.97	17.6

DELAYED GROUP	1	2	3	4	5	6
BETA FRACTION	0.000196	0.001244	0.001116	0.002380	0.000871	0.000210
LAMBDA	0.0128	0.0315	0.1211	0.3222	1.4040	3.8565
INPUT POT NUMBER	11	12	21	22	31	32
SETTING	1.2168	3.8010	1.3109	3.7192	1.1862	0.7856
AS LEFT #1	1.216	3.801	1.311	3.720	1.186	0.785
AS LEFT #2						
FEEDBACK POT NUMBER	13	14	23	24	33	34
SETTING	1.2800	3.1500	1.2110	3.2220	1.4040	3.8565
AS LEFT #1	1.280	3.150	1.211	3.221	1.403	3.857
AS LEFT #2						

TEST 1 SET POT 36 TO 9.100 (VOLTS). POT 35 SHOULD BE 5.8365 AS LEFT #1 5.86 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	8.65046	10.98079	9.85093	10.50413	7.68831	1.85367
AS LEFT #1	8.65	10.99	9.84	10.55	7.68	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	350	139	88	63	50	41	35	30	27
OBSERVED T-D #2									
EXPECTED RHO (PCM)	13.09	30.03	44.59	57.39	68.82	79.17	88.62	97.32	105.39
OBSERVED RHO #1	13.5	30.0	44.5	57.4	68.7	79.3	88.7	97.5	106.0
OBSERVED RHO #2									

DATE	INITIALS
10/89	PNK

TABLE 7-2

REACTIVITY COMPUTER CHECKOUT

Measured Doubling Time (sec.)	Design Doubling Time (sec.)	Measured Reactivity (pcm)	Calculated Reactivity (pcm)
88.2	83.4	46	44
45.6	53.5	65	73
30.0	38.1	83	98

8.0 CONTROL ROD WORTH MEASUREMENT

8.1 Test Description

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 which 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 at 211 steps, a new critical configuration at constant RCS boron concentration was established with Control Bank C fully inserted and Control Bank A at 104 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:

$W_X^I = W_R^M - \Delta\rho_1 - (\alpha_X)\ (\Delta\rho_2) + W_X^E$ 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.

$\Delta\rho_2$ = 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.

$\Delta\rho_1$ = 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 $\Delta\rho_1$ is zero.

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 were 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%.

b. The inferred individual worth of each remaining bank agrees with design predictions within ±15% 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.

As shown on Table 8-2, all review and acceptance criteria were met.

TABLE 8-1

CRITICAL ROD CONFIGURATION DATA

Bank Measured	Time	RCS Tavg (°F)	CA Position (Steps)	Measured Bank Position (Steps)
CC	1810	530	1	211
CC	1820	530	104	1
CC	1832	530	1	211
SB	1843	530	1	213
SB	1855	530	93	1
SB	1910	530	1	212
SA	1950	530	1	214
SA	2000	530	143	1
SA	2030	530	1	214
CB	2035	530	1	216
CB	2055	530	77	1
CB	2112	530	1	216
CD	2134	530	1	214
CD	2147	530	127	1
CD	2206	530	1	214

Boron concentration was 1126 ppm.

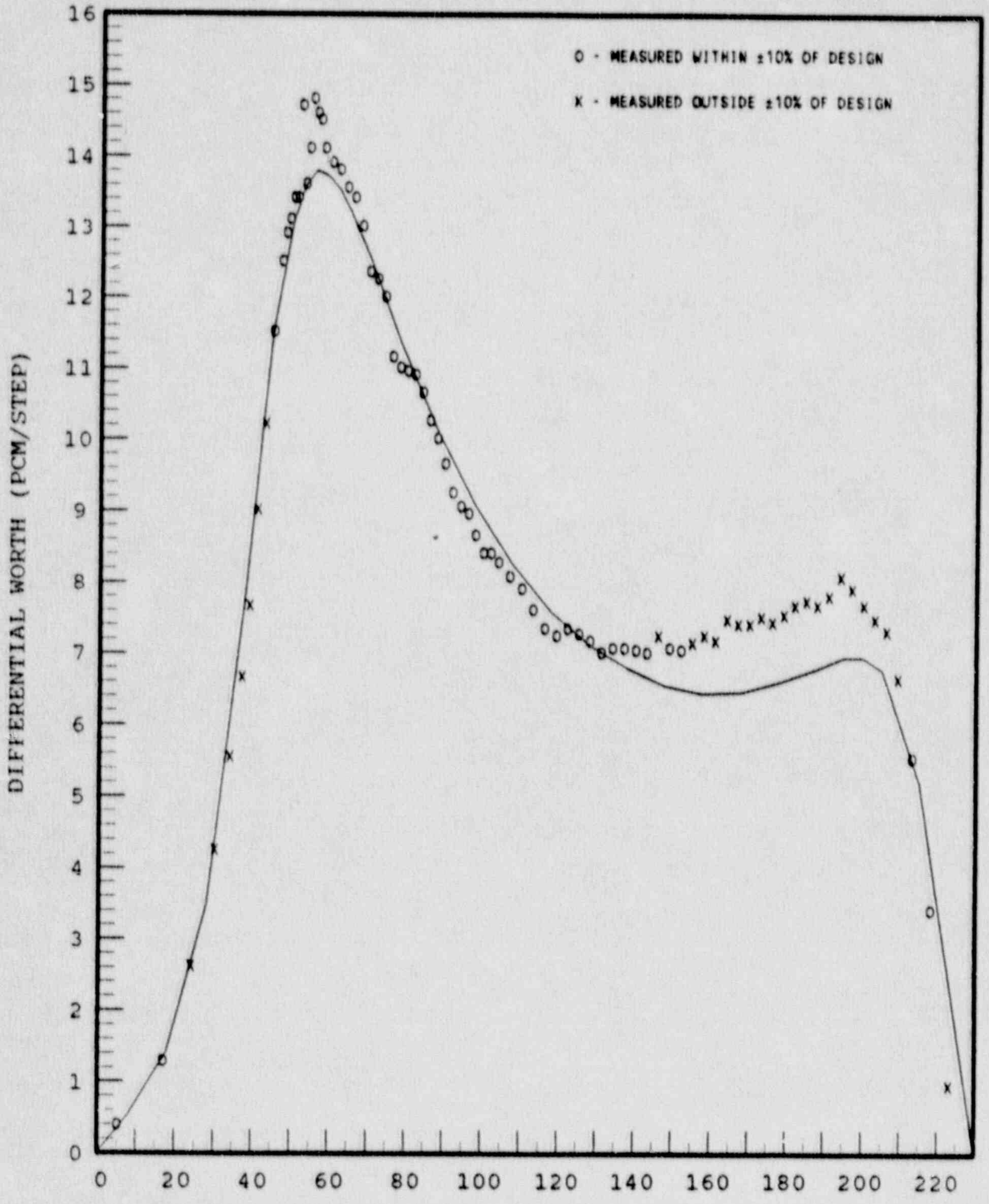
TABLE 8-2

COMPARISON OF INFERRED/MEASURED BANK WORTHS WITH DESIGN PREDICTIONS

Bank X	$\Delta\rho_2$ (pcm)	α_X	W_X^E (pcm)	W_X^I (pcm)	W_X^P (pcm)	$\left(\frac{I-P}{P} \right) \times 100$ (%)
CC	869	1.009	36	854	892	-4.3
SB	967	1.043	33	719	782	-8.0
SA	574	0.897	32	1211	1127	+7.4
CB	697	1.083	33	483	553	-12.7
CD	1149	0.982	32	1042	1024	+1.8
CA	---	-----	---	1694	1641	+3.2
		TOTAL		6003	6019	-0.3

FIGURE 8-1

PBNP UNIT 2 CYCLE 16 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 measurement test conditions and results are given in Table 9-1. The measured values are 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 temperature coefficient was -0.3 pcm/°F, within the review criteria of ±3 pcm/°F of the design isothermal temperature coefficient of +0.1 pcm/°F.

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

	Endpoint		Bank Worth		Boron Worth	
Bank Configuration	Design[1] (ppm)	Measured (ppm)	Design (pcm)	Measured (pcm)	Design (pcm/ppm)	Measured (pcm/ppm)
ARO	1289	1286	----	----		
CA in	1129	1126	1641	1694	-10.3	-10.6

[1] At measurement conditions (530°F)

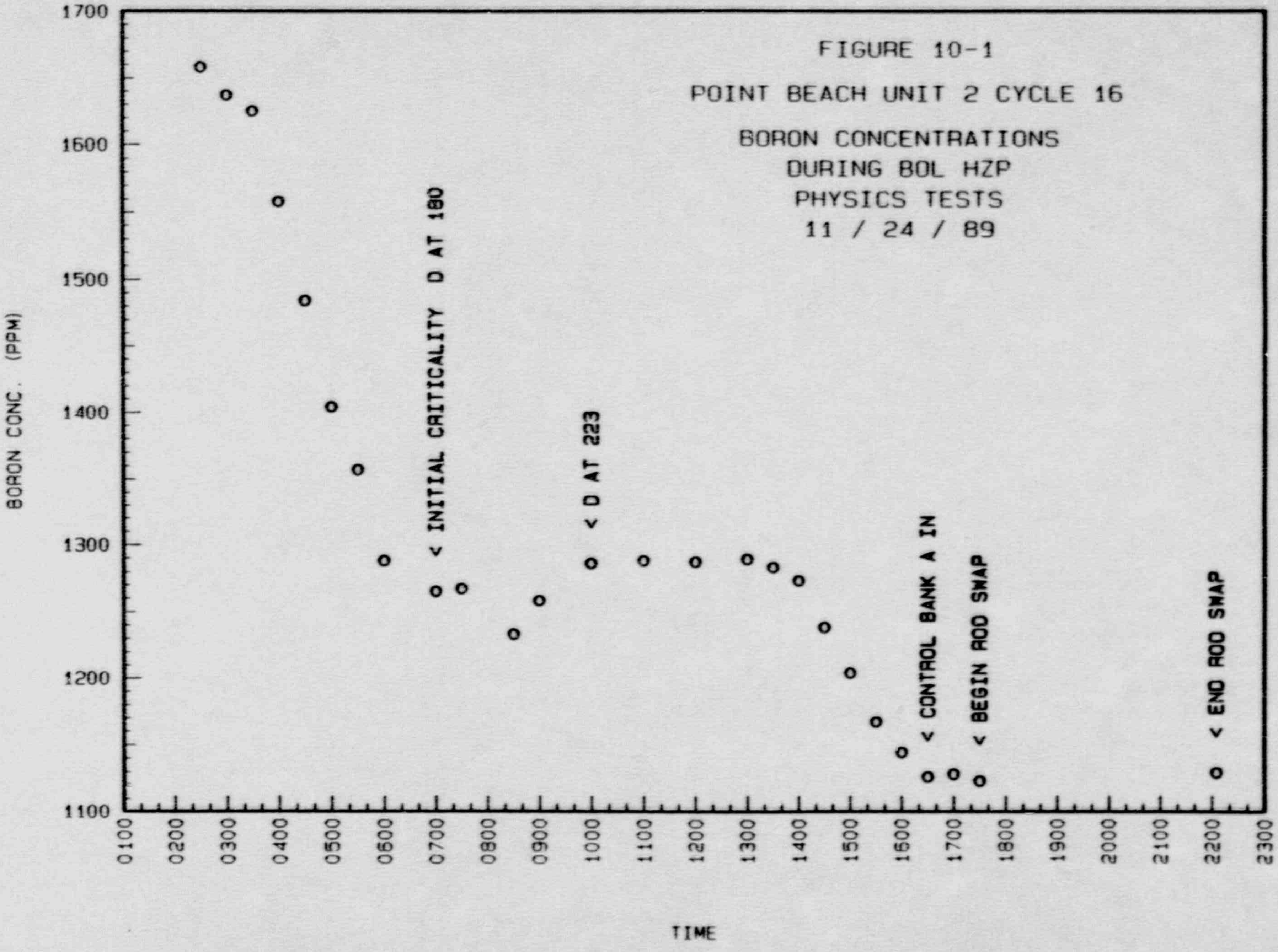


FIGURE 10-1

POINT BEACH UNIT 2 CYCLE 16

BORON CONCENTRATIONS
DURING BOL HZP
PHYSICS TESTS
11 / 24 / 89

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 FΔH and FQ versus power level in Technical Specification 15.3.10.B.1.a. The overpower trip setpoint was initially set at 83% power to ensure peaking factor limits were not exceeded. After the 75% power flux map was taken, the setpoint was raised to its normal value of 107% power.

Measured axial power distribution compared to design is shown in Figure 11-1 and 11-2. The map taken at 28% power was with rods inserted about 10 steps deeper than the design curve was generated for. This accounts for the difference in shapes of the curves in Figure 11-1.

TABLE 11-1

INITIAL POWER ESCALATION
FLUX MAP RESULTS

Flux Map Number	Date	Power (%)	Thimbles Missing	Allowed Power (%)		Bank D	AO
				FΔHN	FQN		
1	11-25-89	28	5	92	95	165	+3.8
2	11-27-89	75	5	113	112	189	+3.6
3	11-28-89	95	0	101	110	197	+1.1
4	11-29-89	100	0	102	112	200	+2.5

FIGURE 11-1

POINT BEACH UNIT 2 CYCLE 16
CORE AVERAGE NORMALIZED AXIAL POWER DISTRIBUTION
28% POWER BOL

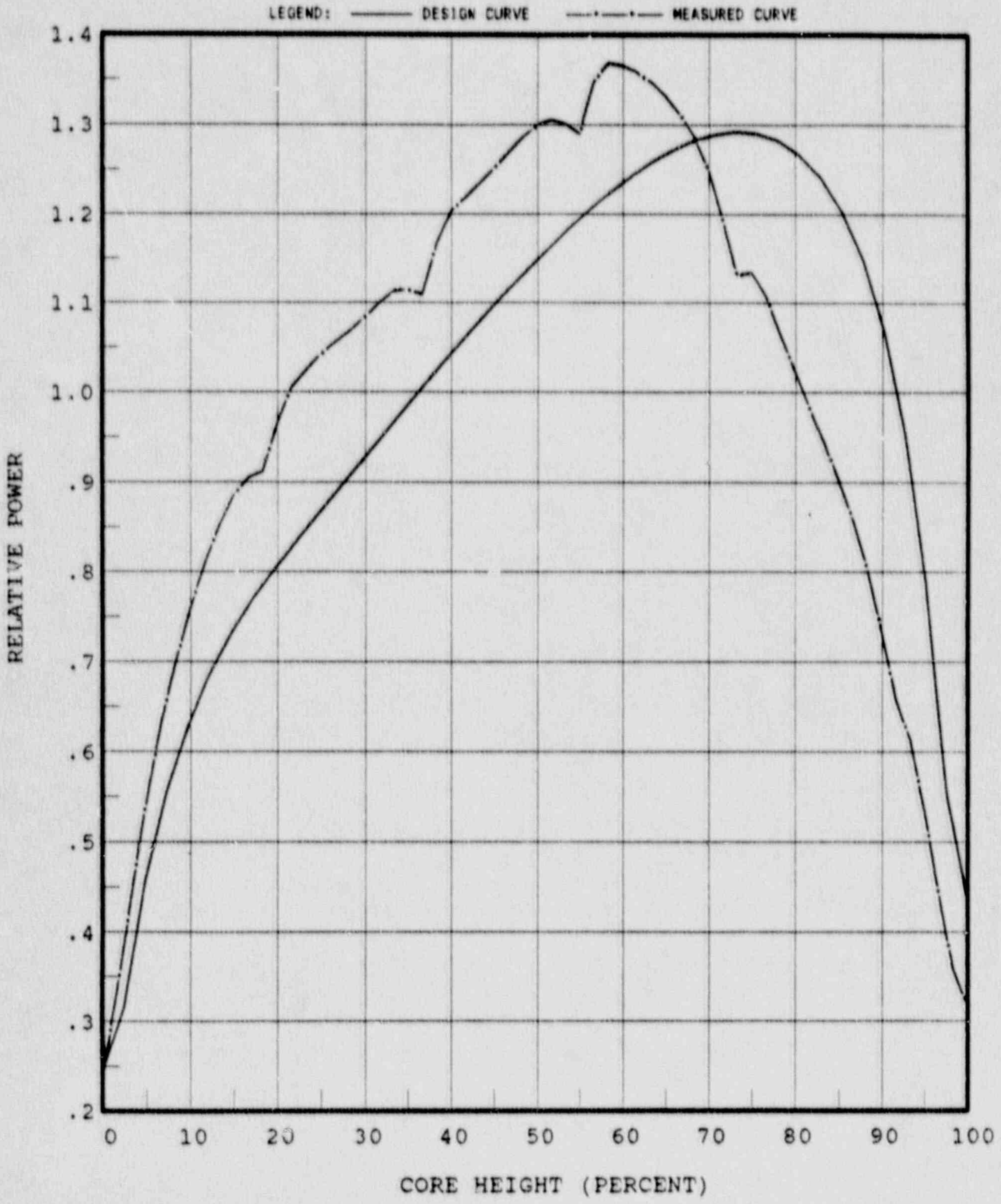
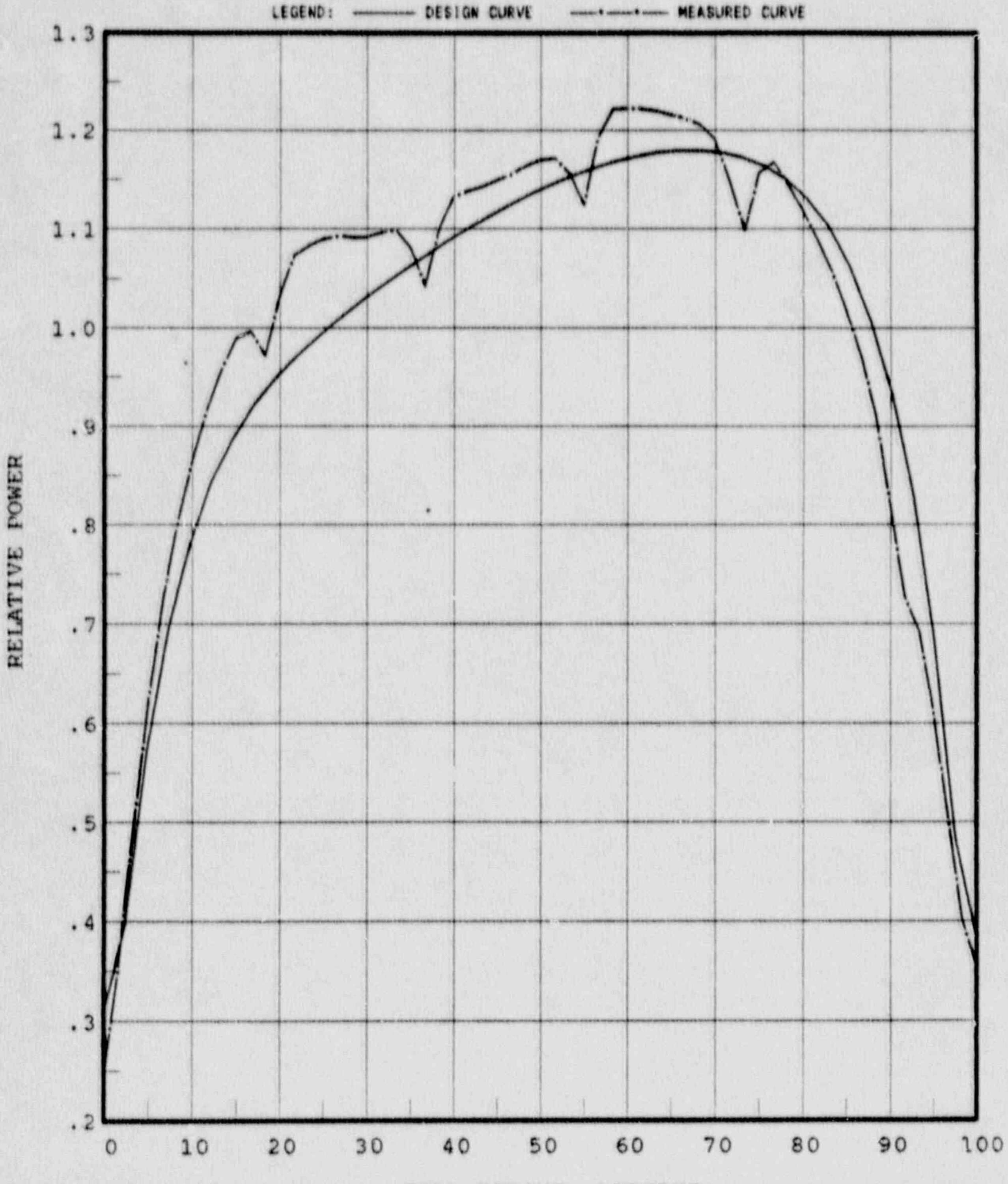


FIGURE 11-2

POINT BEACH UNIT 2 CYCLE 16
CORE AVERAGE NORMALIZED AXIAL POWER DISTRIBUTION
HFP BOL EQXE



12.0 XENON REACTIVITY

Xenon reactivity behavior data for Unit 2 Cycle 16 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-12362 Table 6.2 was accepted as a valid shutdown margin determination. Table 13-1 calculates the excess worth available to Unit 2 Cycle 16.

TABLE 13-1

EXCESS SHUTDOWN WORTH AVAILABLE FOR A FULL POWER TRIP

	BOL (pcm)	EOL (pcm)
Shutdown Margin From WCAP	-3850	-3510
- Required Shutdown	-1000	-2770
= Excess Worth	-2850	-740

14.0 EXCORE DETECTOR BEHAVIOR

14.1 Intermediate Range Detectors

In anticipation of a reduction in intermediate range detector currents from the hafnium rods positioned in front of the detectors, the source range trip setpoint was raised from 1×10^5 to 5×10^5 CPS. This gave the operator more time to block SR trip after reaching 1 E-10 amps on the IR channels. Because actual IR attenuation was less than expected, the original SR trip setpoint would have given adequate but less margin for blocking the trip.

Intermediate range detector currents versus power level are shown in Figure 14-1. Intermediate range detector trip signals activated at about 2.2 E-4 amps for N35 and 1.3 E-4 amps for N36. Excore detector power level at the time the trip signals occurred was 26% for N35 and 20% for N36. The hafnium poisons reduced intermediate range detector output by about 20%.

The pre-startup trip setpoint for N36 was 2.4 E-4 amps. After the setpoint was set in, the detector was replaced. The new detector had a lower sensitivity and its level had not reached the trip setpoint by the time 28% power was reached. The trip would have occurred just below the Technical Specification limit of 40% power. A new setpoint was entered based on actual detector output for 20% power.

14.2 Power Range Detectors

Table 14-1 lists the "tilt free" power range detector calibration currents corresponding to 105% power at BOL. These currents were calculated using the multi-map method at 100% power. A multi-map calibration was performed to verify that the new changes in core design did not significantly change the linear response of the excore detectors. Output of both the top and bottom detectors was reduced by about 5% because of the hafnium rods and L4P (low low leakage loading pattern).

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

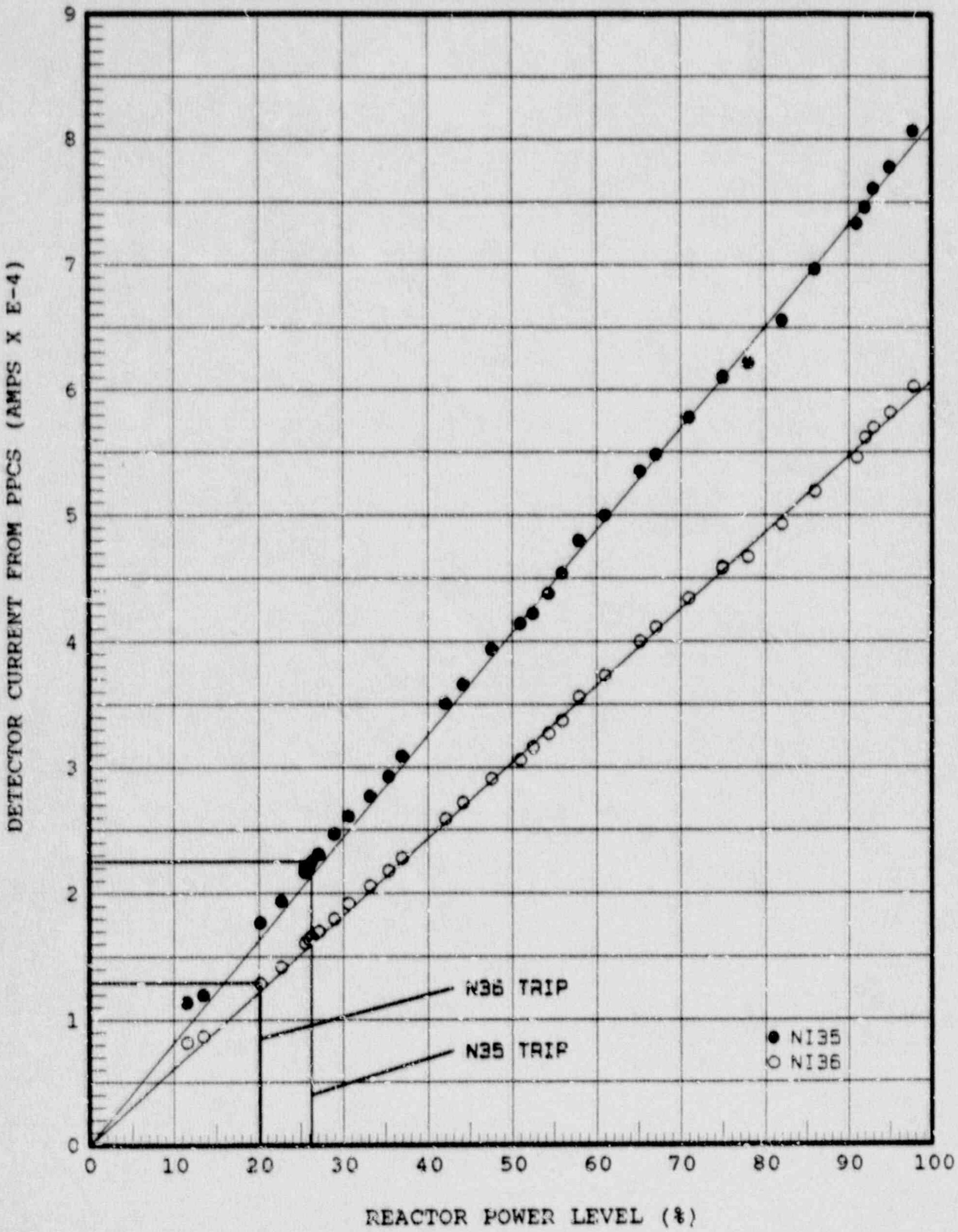
POWER RANGE DETECTOR
BOL CALIBRATION CURRENTS (105%)

		41	42	43	44
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

FIGURE 14-1

UNIT 2 CYCLE 16 BOL

NI35 AND NI36 RESPONSE TO POWER LEVEL



15.0 OVERPOWER, OVERTEMPERATURE AND DELTA FLUX SETPOINTS CALCULATION

15.1 Overpower and Overtemperature ΔT Setpoints Calculation

Discussion of the setpoints and equations has been sufficiently covered in previous reports.

The equations are:

Overpower $\Delta T \left(\frac{1}{1+\tau_3 S} \right)$

$$\leq \Delta T_o \; [K_4 - K_5 \left(\frac{\tau_5 S}{\tau_5 S + 1} \right) \left(\frac{1}{1+\tau_4 S} \right) T - K_6 \; [T \left(\frac{1}{1+\tau_4 S} \right) - T^1]$$

Overtemperature $\Delta T \left(\frac{1}{1+\tau_3 S} \right)$

$$\leq \Delta T_o \; (K_1 - K_2 (T \left(\frac{1}{1+\tau_4 S} \right) - T^1) \left(\frac{1+\tau_1 S}{1+\tau_2 S} \right) + K_3 \; (P-P^1) - f(\Delta I))$$

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% and -17% before the setpoints are reduced. For each percent (more than 5%) the top detector output exceeds the bottom detector, the setpoints are reduced an equivalent of 2% of the rated power. For each percent (more than -17%) the bottom detector exceeds the top detector, the setpoints are reduced an equivalent of 2% of rated power.

TABLE 15-1

OVERPOWER ΔT CONSTANTS

ΔT_o = Indicated ΔT at rated power, °F

T = Average temperature, °F

T^1 = 573.9°F

$K_4 \leq 1.089$ 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 $T < T^1$

τ_5 = 10 seconds

f(ΔI) as defined in Section 15.2

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

TABLE 15-2

OVERTEMPERATURE ΔT CONSTANTS

ΔT_o = Indicated ΔT at rated power, °F

T = Average temperature, °F

T^1 = 573.9°F

P = Pressurizer pressure, psig

P^1 = 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

UT examination of Cycle 16 reload fuel identified no leaking fuel rods. Further evidence of no leakers is shown in Figure 16-1 showing relatively low coolant activity before and after refueling.

17.0 CONCLUSION

The following results of cycle startup testing should be highlighted.

1. The bank swap method for measuring rod worth produced acceptable results, including a normal differential shape. This shows that the new core design features had little affect on this measurement.
2. The hafnium poisons did not cause operational difficulties with the source, intermediate, or power range excore detectors.
3. Cores with higher enrichments may require more time to escalate to full power during the initial cycle startup. Allowing xenon poison buildup helps to lower localized power peaks.
4. The new RPI head cabling did not affect the coil stack output as seen by the process computer in specific, or the RPI system in general.

The remaining Unit 2, Cycle 16 startup test results were normal.

FIGURE 16-1

UNIT TWO REACTOR COOLANT IODINE DATA