Core 21 Startup Program
For
The Yankee Nuclear Power Station

February 1991

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I. INTRODUCTION

The Core 20-21 refueling at the Yankee Nuclear Power Station began on June 23, 1990 and was completed with the startup of Core 21 on November 11, 1990. This report provides details of the Startup Program for Core 21.

The intent of the Startup Program is to ensure the proper condition of the reactor and fuel from a mechanical as well as nuclear standpoint. During the refueling outage, fuel assemblies and control rods were inspected, utilizing various methods, to assure their sound physical condition. During the physics testing, various nuclear parameters and coefficients were measured and recorded to verify the design calculations used in analyzing plant transients and accidents. The nuclear parameters also provide a guide for operator understanding of the Core 21 physics characteristics during routine plant operation.

II. SUMMARY OF RESULTS

Table 1 contains a summary of the Startup Program physics testing results. Predicted values and acceptance criteria tolerances are from Reference Documents 1 and 2. All parameters measured and/or determined were found to meet the Acceptance Criteria with the exception of the Control Rod Group B integral worth. The difference in measured-to-predicted Group B integral worth was acceptable since the total integral worth of all groups measured was within the expected tolerance.

III. STARTUP PROGRAM - MECHANICAL

A. Fuel Assemblies

Yankee Core 21 is loaded with 36 new zircaloy clad 3.9 w/o fuel assemblies and four new zircaloy clad 3.5 w/o assemblies around the perimeter of the core, with 32 once-burned zircaloy clad 3.9 w/o fuel assemblies and four once-burned Zircaloy clad 3.7 w/o assemblies in the center region as shown in Figure 1. Sixteen of the fresh assemblies have solid zircaloy inert rods in selected positions, six per A assembly, and either ten or five per B assembly depending on the core location. The B assemblies have one or two special guide bars and the A assemblies have one special guide bar (Figure 13). Spacer stiffener strips are attached to these special guide bars at various positions along the axial length. These modifications were performed at Combustion Engineering prior to delivery to Yankee as a precaution against flow-induced fretting wear as described in Reference 1.

During the Core 20-21 fuel shuffle, the once-burned recycle assemblies were inspected ultrasonically and visually to check for leaking fuel rods. All assemblies were found to be free of any fuel damage, with the exception of one fuel rod from Core Location No. 75. This fuel rod was removed and replaced by a solid zircaloy rod.

Upon completion of fuel loading, assembly positioning was checked by underwater television and video tape. The video tape was then reviewed independently to verify the core loading.

B. Control Rods

The Yankee core has 24 Ag-In-Cd control rods with zircaloy followers. The rods are divided into three shutdown groups (A, B, and D) and one controlling group (C) as shown in Figure 2.

At the beginning of the Core 20-21 refueling, a supplemental control rod drop timing test was performed in which all of the rods were dropped simultaneously. This test verified that the current method of drop testing, in which rods are dropped by individual groups, provides results which are conservative compared to drop testing all the rods simultaneously. During the performance of this test, Control Rods 17 and 18 did not fully insert. Due to this occurrence, additional control rod inspections were added to the Control Rod Maintenance Program.

During the Core 20-21 refueling, all 24 control rods were subject to visual, straightness, and length inspections. Based on the results of these inspections, four control rods were determined to have excessive bow and were replaced. All of the rods in Groups A, B, and C were rotated 90 degrees clockwise and returned to the core, with the exception of one Group B rod which was replaced. Of the eight rods in Group D, three were new, four were rotated 180 degrees and returned to the core, and one was rotated 90 degrees clockwise and returned to the core. Following completion of fuel loading, all control and shim rods were checked for excessive drag force and found acceptable. Following completion of reactor vessel upper internals installation, all control rods were again checked for excessive drag force and found acceptable.

Prior to initial criticality, control rod exercises were performed to verify proper functioning of the control rod drive system. The exercises involved moving the rods from 0" to 90" and back to 0" again. Additionally, control rod drop times were measured as a final check that there was no binding or obstruction. The drop time is the interval between when the power is cut to the rod stationary gripper coil until the rod drive shaft passes the 6" coil on the indicating stack. The rod drop times are measured using a calibrated Visicorder. A detailed tabulation of the control rod inspection results and drop times is shown in Table 2.

IV. STARTUP PROGRAM - NUCLEAR

A. Physics Testing

Zero power physics testing data is collected by intentionally varying one core parameter and measuring its effect on reactivity while other parameters are held as constant as possible. The variable parameters affecting reactivity include boron concentration, temperature, and control rod position. The correlations derived from this data include boron worth, moderator temperature coefficient, control rod worths, and xenon plus power defect.

Zero to full power physics testing consisted of increasing reactor power to specified levels and then utilizing the Incore Detection System to determine power distribution and linear heat generation rates.

For the Core 21 zero power physics testing, a Westinghouse Digital Reactivity Computer (DRC) and Digital Reactivity Analyzer (DRA) were used to perform the test measurements.

The reactivity data was obtained by connecting two plant excore nuclear instrumentation channels into the Westinghouse DRC. Channels 3 and 7, which were used for testing, are positioned in the same excore detector thimble at different vertical positions. The DRC calculated reactivity by solving the differential in-hour equation for each of the flux signals. Delayed neutron constants for Core 21, as calculated by the Yankee Nuclear Services Division (YNSD), were entered into the DRC prior to physics testing. Table 3 contains a listing of Core 21 delayed neutron fractions used. Dynamic checks of the DRC were performed at the beginning, end, and periodically throughout the test program to verify proper calibration of the computer.

An average Main Coolant System Temperature (T_{ave}) input was provided to the DRC from the main control board. The control rod positions obtained from the main control board were manually entered into the DRC by physics test personnel during the testing.

Boron concentrations of the main coolant, pressurizer, and low pressure surge tank were supplied by the Chemistry Department based upon titration analysis of the aforementioned samples. The use of low pressure surge tank and pressurizer samples provides a more precise accounting of the boron conditions in the Main Coolant System (MCS) during testing. The sampling was performed at numerous times throughout the physics test program. Multiple sampling and repeated titration provided a high degree of reliability in the boron concentration data.

The DRA calculated the values of the reactivity parameters in test using the reactivity, temperature, and rod position data as necessary.

Power distribution data was obtained through the use of the Plant Incore Flux Mapping System (both moveable and fixed) in conjunction with the CDC Computer System. YNSD performed the analysis of all flux mapping data.

B. Critical Boron Concentrations

Just critical boron concentrations were measured as close as possible to the following conditions:

- o All Rods Out
- o Group C Inserted

Refer to Table 4 for the results. Note that the measured values have been adjusted from the actual control rod positions to allow one-to-one comparison with predicted values.

C. Control Rod Group Worths

Differential rod worths were measured for Groups C, A, and B using the dilution balance technique. A continuous dilution is used to produce a positive reactivity response. Control rod group motion is then used to balance this effect. Reactivity is allowed to vary from a just critical state producing a sawtoothed graphical measurement of differential control rod group worth.

From this data, differential and integral rod worths are derived. Tables 5, 6, and 7 provide a tabulation of the results. Figures 3, 5, and 7 provide graphical representation of rod group differential worths. Figures 4, 6, and 8 provide graphical representation of rod group integral worths.

D. Moderator Temperature Coefficient (MTC)

The Isothermal Temperature Coefficient (ITC) was measured by varying MCS temperature and measuring the resultant reactivity change. In order to increase the accuracy of this measurement, the pressurizer, MCS and low pressure surge tank were monitored to assure equalized boron concentrations prior to measurement. The equalized boron concentrations coupled with no rod motion during the test assure that reactivity effects other than temperature will be minimized during the test.

The ITC measurements were conducted as close as possible to the following conditions:

All Rods Out (ARO)
Group C Inserted

Three heatup and cooldown cycles were conducted for each set of conditions with an ITC determined for each temperature change.

Each ITC was calculated by averaging the differential change in reactivity with respect to temperature during each temperature variation. The average of the results from the three cycles was used as the ITC for the given condition.

The MTC was determined by subtracting the Fuel Temperature Coefficient (FTC) from the ITC. The measured MTC was corrected for control rod positioning to allow for direct comparison to predicted values.

Table 8 provides a listing of the MTC data as determined from measurement. Table 9 provides a listing of the MTC results with comparison to the predicted values.

E. Power Distribution

An incore flux map (YR-21-002) was taken at approximately 25% power to check for gross quadrant tilt. Figure 9 shows the results of the gross quadrant tilt measurement. The maximum tilt was calculated to be 2.3%, which is within the 5% acceptance criteria.

An incore flux map (YR-21-004) was taken at 63.6% power to check the relative radial power distribution. Figure 10 shows the comparison of measured versus predicted integrated fission reaction rates. All measured locations show acceptable agreement between measured and predicted reaction rates. Incore flux map (YR-21-004) was also used to check that the LHGR, F_q, and $F_{\Delta H}$ (nuclear) were within Technical Specification limits. Figure 11 shows the results of these measurements which were acceptable.

F. Power Plus Xenon Defect

The power plus xenon defect refers to the negative reactivity associated with an increase in reactor power. Moderator and fuel temperature coefficients contribute to the power defect, while the xenon defect relates to the xenon concentration present in the core.

Primary system data (temperature, boron concentration, rod position, pressure, etc.) was taken at zero power and at two other steady-state power levels (63.6%, 92.3%) during power ascension. A reactivity balance was performed between the zero power data and each of the other power level data sets to determine the reactivity effects of power plus xenon. The predicted xenon plus power defected was adjusted to match the conditions which existed at the time of measurement. Adjustments were made for power level, moderator temperature, samarium concentration, and burnup. The adjusted predicted value is then compared to the measured power plus xenon defect. Table 10 provides the reactor conditions of the measurements and the results of the calculations.

V. RELOAD DESIGN EVALUATION

As a means of fuel damage prevention, 16 fresh fuel assemblies in the southwest, northwest, and southeast core quadrants were fabricated with solid zircaloy rods and special guide bars with spacer stiffener strips. There were 130 fuel pins in the fresh fuel and 117 fuel pins in the recycled fuel replaced by inert rods and guide bars, resulting in a core total of 207 inert rods and 40 special guide bars. In addition, one fuel rod was replaced by a solid zircaloy rod during refueling operations in the recycled fuel. This lowers the total number of fuel pins from the design value of 17,518 to 17,270; the net effect being a higher core average linear heat generation rate of 4.458 versus the nominal value of 4.395. Figure 12 is provided to show the locations and number of replaced pins for Core 21 operation, with Figure 13 depicting the different lattice configurations of the modified fuel assemblies. All of these fuel modifications, except for the one reconstituted rod, were assumed in the original reload design analysis, as reported in Reference 1, and were implemented into the current licensing analysis models.

A factor, which had a very small impact relative to the original core licensing design calculations, was the core average burnup. The reload design assumed a Core 20 cycle average exposure of 16,700 MWd/Mtu, while the actual value was 16,830 MWd/Mtu. This minor deviation was well within the bounds of the Core 21 licensing calculations performed in support of the reload design.

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TABLE 1

CORE 21 STARTUP PROGRAM
PHYSICS TESTING RESULTS

Parameter	Predicted Value	Measured Value	Difference or % Difference	Accept Crit. Tolerance
Control Rod Drop Times	--------	1.93 sec(1)	--------	≤2.5 sec
Critical Boron Concen.				
ARO	2027 ppm	2109 ppm(2)	+4.0%	±10%
Group C In	1795 ppm	1895 ppm(2)	+5.6%	±10%
Control Rod Group Worths				
Group C	1740 pcm	1697 pcm	-2.5%	±7.5%
Group A	1230 pcm	1207 pcm	-1.9%	±7.5%
Group B	2250 pcm	2077 pcm	-7.7%	±7.5%
Total	5220 pcm	4981 pcm	-4.6%	±7.5%
Moderator Temperature Coef.				
ARO	-3.1 pcm/°F	-0.27 pcm/°F(2)	+2.83 pcm/°F	±5.0 pcm/°F
Group C In	-6.8 pcm/°F	-3.47 pcm/°F(2)	+3.33 pcm/°F	±5.0 pcm/°F
Gross Quadrant Tilt	--------	2.3%	--------	±5.0%
Radial Power Distribution (Reaction Rate Comparison)	-------- --------	+2.9% -2.9%	-------- --------	+5.0% -5.0%
Power Plus Xenon Defects				
0 - 63.6% Power	2944 pcm	3246 pcm	+10.3%	--------
0 - 92.3% Power	3675 pcm	4058 pcm	+10.4%	--------

(1) Maximum value.

(2) Corrected for control rod position to allow for direct comparison with predicted values.

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TABLE 2

CORE 20-21 REFUELING
CONTROL ROD INSPECTION RESULTS

Rod Position	Original Serial No.	Bow (Inches)	Replacement Serial No.	Drop Time (Seconds)
1	A132	.220	--	1.52
2	A156	.075	--	1.48
3	A151	.075	--	1.50
4	A157	.075	--	1.53
5	A130	.175	--	1.44
6	A142	.158	--	1.51
7	A113	.175	--	1.53
8	A131	.225	--	1.58
9	A134	.250	A153	1.54
10	A147	.075	--	1.84
11	A140	.183	--	1.49
12	A145	.125	--	1.70
13	A137	.150	--	1.51
14	A146	.062	--	1.53
15	A150	.125	--	1.74
16	A152	.088	--	1.52
17	A138	.350	A155	1.59
18	A141	.333	A154	1.88
19	A143	.220	--	1.66
20	A148	.100	--	1.56
21	A136	.350	A162	1.53
22	A144	.183	--	1.93
23	A149	.200	--	1.58
24	A127	.183	--	1.91

TABLE 3

YANKEE CORE 21
DELAYED NEUTRON FRACTIONS

GROUP	FRACTION BETA BAR	EFFECTIVE FRACTION	LAMBDA (SEC)-1
1	.00018985	.00019057	.01252
2	.00135250	.00135765	.03055
3	.00123548	.00124016	.11507
4	.00253255	.00254197	.30930
5	.00086905	.00087234	1.16389
6	.00030901	.00031024	3.04560

BETA EFFECTIVE = .006513
BETA BAR = .006488
I BAR = 1.003774
PROMPT NEUTRON LIFETIME = 20.03 MICROSECONDS

STARTUP RATE (DECADES/MIN.)	PERIOD (SEC.)	REACTIVITY (PERCENT)
.100	260.6	.0271
.500	52.1	.0981
1.000	26.1	.1522
2.606	10.0	.2486

TABLE 4

CRITICAL BORON CONCENTRATIONS
(PPM)

Control Rod Position	Predicted	Measured	Corrected[1]	Difference
ARO	2027	2108[2]	2109	+4.0%
Group C In	1795	1896[3]	1895	+5.6%

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(1) Corrected for control rod position to allow for direct comparison with predicted values.

(2) Group C @ 87.875 inches withdrawn.

(3) Group C @ 5.000 inches withdrawn.

TABLE 5

YANKEE ROWE CORE 21 GROUP C WORTH

	BANK POSITION DATA				REACTIVITY DATA		
TIME	INITIAL	FINAL	AVERAGE	DH	DP	SUMDP	DP/DH
14:33	90.00	79.88	84.94	10.13	53.30	53.30	5.26
14:38	79.88	73.13	76.50	6.75	68.33	121.63	10.12
14:42	73.13	68.25	70.69	4.88	73.02	194.64	14.98
14:47	68.25	63.75	66.00	4.50	76.42	271.06	16.98
14:52	63.75	59.25	61.50	4.50	85.55	356.61	19.01
14:57	59.25	55.50	57.38	3.75	74.27	430.88	19.81
15:02	55.50	52.13	53.81	3.38	78.38	509.26	23.22
15:06	52.13	49.13	50.63	3.00	73.46	582.72	24.49
15:11	49.13	46.13	47.63	3.00	74.22	656.93	24.74
15:15	46.13	43.50	44.81	2.63	73.50	730.43	28.00
15:21	43.50	41.25	42.38	2.25	66.14	796.57	29.40
15:25	41.25	39.00	40.13	2.25	70.13	866.70	31.17
15:31	39.00	36.38	37.69	2.63	82.27	948.97	31.34
15:36	36.38	34.13	35.25	2.25	72.86	1021.82	32.38
15:40	34.13	32.25	33.19	1.88	59.48	1081.30	31.72
15:44	32.25	30.38	31.31	1.88	60.55	1141.86	32.29
15:49	30.38	28.13	29.25	2.25	74.68	1216.54	33.19
15:54	28.13	25.88	27.00	2.25	69.33	1285.87	30.81
15:58	25.88	23.63	24.75	2.25	65.48	1351.34	29.10
16:03	23.63	21.00	22.31	2.63	74.51	1425.85	28.38
16:07	21.00	18.38	19.69	2.63	66.92	1492.77	25.49
16:12	18.38	15.75	17.06	2.63	58.40	1551.17	22.25
16:15	15.75	10.13	12.94	5.63	79.70	1630.87	14.17
16:21	10.13	0.00	5.06	10.13	66.61	1697.48	6.58

Where:

- DH = Change in height of rod group, inches
- DP = Measured reactivity change, pcm
- SUMDP = Total reactivity worth of rod group at final position
- DP/DH = Differential reactivity worth of rod group at the average position

TABLE 6

YANKEE ROWE CORE 21 GROUP A WORTH

	BANK POSITION DATA			REACTIVITY DATA			
TIME	INITIAL	FINAL	AVERAGE	DH	DP	SUMDP	DP/DH
02:41	90.00	70.63	80.31	19.38	164.20	164.20	8.47
02:45	70.63	65.38	68.00	5.25	70.20	234.40	13.37
02:50	65.38	60.13	62.75	5.25	76.61	311.01	14.59
02:54	60.13	55.25	57.69	4.88	80.24	391.25	16.46
02:58	55.25	50.75	53.00	4.50	80.70	471.95	17.93
03:03	50.75	46.25	48.50	4.50	86.65	558.60	19.26
03:07	46.25	42.50	44.38	3.75	76.94	635.55	20.52
03:11	42.50	38.38	40.44	4.13	88.93	724.48	21.56
03:16	38.38	34.63	36.50	3.75	83.39	807.87	22.24
03:20	34.63	30.88	32.75	3.75	81.37	889.24	21.70
03:24	30.88	26.75	28.81	4.13	85.83	975.07	20.81
03:28	26.75	22.25	24.50	4.50	81.14	1056.20	18.03
03:31	22.25	17.00	19.63	5.25	72.56	1128.77	13.82
03:38	17.00	0.00	8.50	17.00	78.31	1207.07	4.61

Where:

DH = Change in height of rod group, inches
DP = Measured reactivity change, pcm
SUMDP = Total reactivity worth of rod group at final position
DP/DH = Differential reactivity worth of rod group at the average position

TABLE 7

YANKEE ROWE CORE 21 GROUP B WORTH

	BANK POSITION DATA				REACTIVITY DATA		
TIME	INITIAL	FINAL	AVERAGE	DH	DP	SUMDP	DP/DH
03:43	90.00	78.75	84.38	11.25	84.79	84.79	7.54
03:48	78.75	71.63	75.19	7.13	95.73	180.51	13.44
03:53	71.63	66.00	68.81	5.63	94.26	274.77	16.76
03:59	66.00	61.50	63.75	4.50	86.31	361.08	19.18
04:04	61.50	57.38	59.44	4.13	89.96	451.04	21.81
04:09	57.38	53.63	55.50	3.75	92.48	543.52	24.66
04:15	53.63	50.25	51.94	3.38	91.67	635.19	27.16
04:21	50.25	46.88	48.56	3.38	100.42	735.61	29.75
04:27	46.88	44.25	45.56	2.63	85.34	820.95	32.51
04:33	44.25	41.63	42.94	2.63	91.24	912.19	34.76
04:38	41.63	39.38	40.50	2.25	83.74	995.93	37.22
04:43	39.38	37.13	38.25	2.25	89.89	1085.83	39.95
04:49	37.13	34.88	36.00	2.25	94.54	1180.36	42.02
04:56	34.88	32.63	33.75	2.25	97.64	1278.00	43.40
05:02	32.63	30.38	31.50	2.25	99.61	1377.61	44.27
05:08	30.38	28.50	29.44	1.88	83.43	1461.04	44.50
05:13	28.50	26.63	27.56	1.88	83.15	1544.20	44.35
05:18	26.63	24.75	25.69	1.88	82.89	1627.09	44.21
05:24	24.75	22.88	23.81	1.88	77.72	1704.81	41.45
05:29	22.88	20.63	21.75	2.25	86.17	1790.98	38.30
05:35	20.63	18.38	19.50	2.25	76.01	1866.99	33.78
05:39	18.38	15.38	16.88	3.00	77.05	1944.04	25.68
05:43	15.38	12.00	13.69	3.38	66.11	2010.15	19.59
05:48	12.00	0.00	6.00	12.00	66.95	2077.10	5.58

Where:

DH = Change in height of rod group, inches
DP = Measured reactivity change, pcm
SUMDP = Total reactivity worth of rod group at final position
DP/DH = Differential reactivity worth of rod group at the average position

TABLE 8

MODERATOR TEMPERATURE COEFFICIENT (MEASURED)

BOL, HZP, Group C @ 80.0 Inches

Condition	MTC (PCM/Degree F)
Heatup No. 1	-0.21
Heatup No. 2	-0.26
Heatup No. 3	-0.39
Cooldown No. 1	-0.26
Cooldown No. 2	-0.39
Cooldown No. 3	-0.35
Average	-0.31

BOL, HZP, Group C @ 5.0 Inches

Condition	MTC (PCM/Degree F)
Heatup No. 1	-3.39
Heatup No. 2	-3.62
Heatup No. 3	-3.32
Cooldown No. 1	-3.40
Cooldown No. 2	-3.44
Cooldown No. 3	-3.60
Average	-3.46

TABLE 9

MODERATOR TEMPERATURE COEFFICIENT COMPARISONS
(PCM/°F)

Control Rod Position	Boron Concentration	Predicted	Measured	Corrected(1)	Difference
ARO	2108	-3.1	-.31(2)	-.27	+2.83
Group C In	1896	-6.8	-3.46(3)	-3.47	+3.33

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(1) Average of all measurements performed and corrected for control rod position to allow for direct comparison with predicted values.

(2) Group C @ 80.0 inches withdrawn.

(3) Group C @ 5.0 inches withdrawn.

TABLE 10

POWER PLUS XENON DEFECT DATA

Power	Mwt	Boron Concentration	Moderator Temperature	Rod Position
0.0%	0.0	2108 ppm	514.0°F	C @ 87.875"
63.6%	381.8	1687 ppm	513.0°F	C @ 80.750"
92.3%	554.0	1598 ppm	520.0°F	C @ 83.625

POWER PLUS XENON DEFECT RESULTS

Power	Predicted Defect	Measured Defect	Difference
63.6%	2944 pcm	3246 pcm	+10.3%
92.3%	3675 pcm	4058 pcm	+10.4%

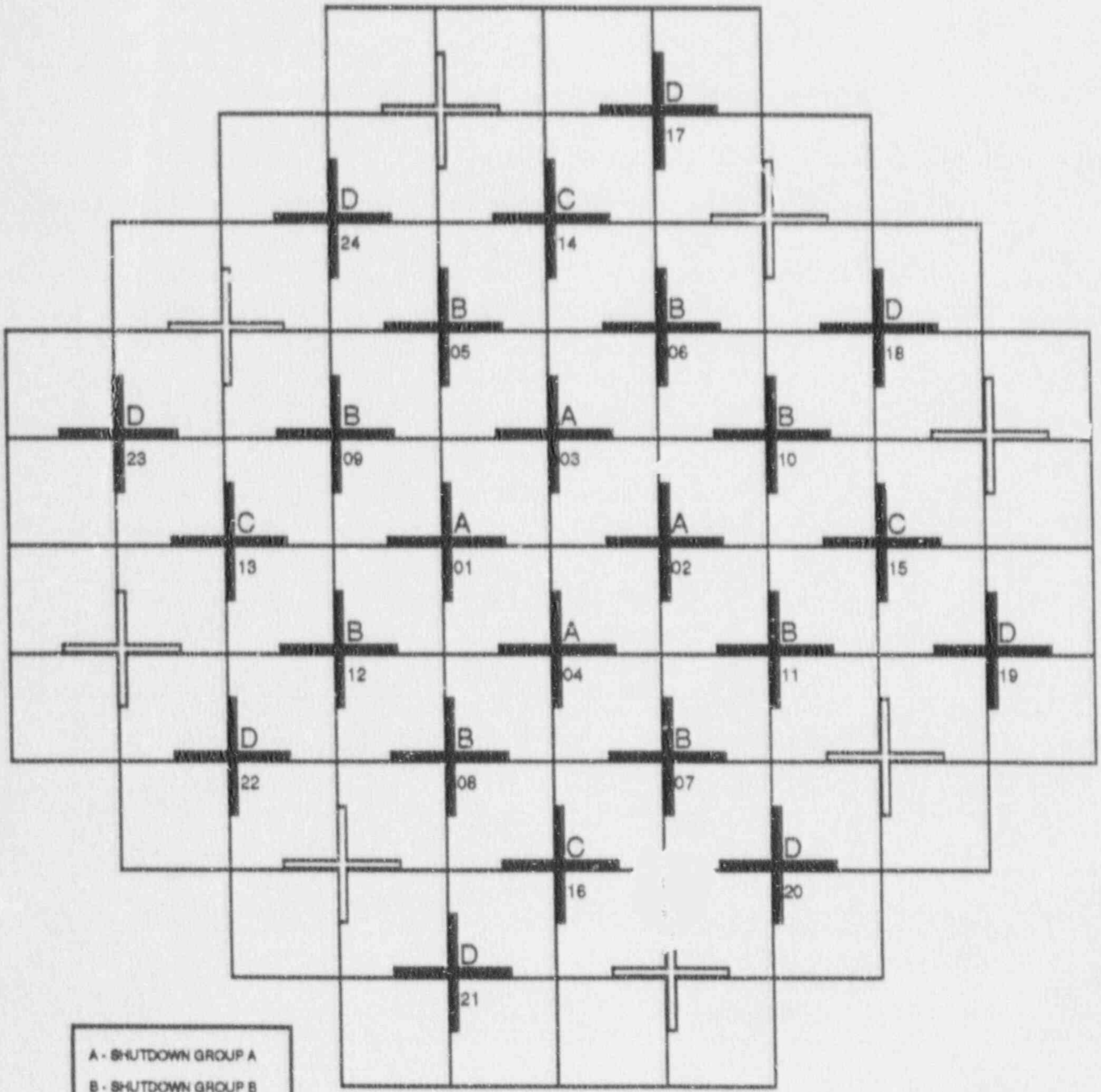
FIGURE 1

YANKEE CORE 21
BOL ASSEMBLY AVERAGE BURNUP

BURNUP (MWD/MTU)..... W/O OF ASSEMBLY * ...			0.	0.	0.	0.			
		0.	0.	10663.	0. 3.5	0.	0.		
	0.	0.	18344.	12868.	20551. 3.7	19420.	0.	0.	
0.	0.	19201.	12471.	11157.	13995.	13052.	18921.	0.	0.
0.	0. 3.5	20036. 3.7	13773.	18945.	19122.	10947.	13065.	10609.	0.
0.	11144.	12958.	10581.	18968.	18943.	13982.	19937. 3.7	0. 3.5	0.
0.	0.	19109.	12936.	13383.	11087.	12763.	18750.	0.	0.
	0.	0.	19433.	20529. 3.7	12657.	18607.	0.	0.	
		0.	0.	0. 3.5	10940.	0.	0.		
			0.	0.	0.	0.			

* 3.9 W/O UNLESS OTHERWISE INDICATED

FIGURE 2
YANKEE CORE 21
CONTROL ROD GROUP IDENTIFICATION



A - SHUTDOWN GROUP A
B - SHUTDOWN GROUP B
C - CONTROLLING GROUP C
D - SHUTDOWN GROUP D
N - CONTROL ROD ID

FIGURE 3
Yankee Rowe Core 21
Group C Differential Worth

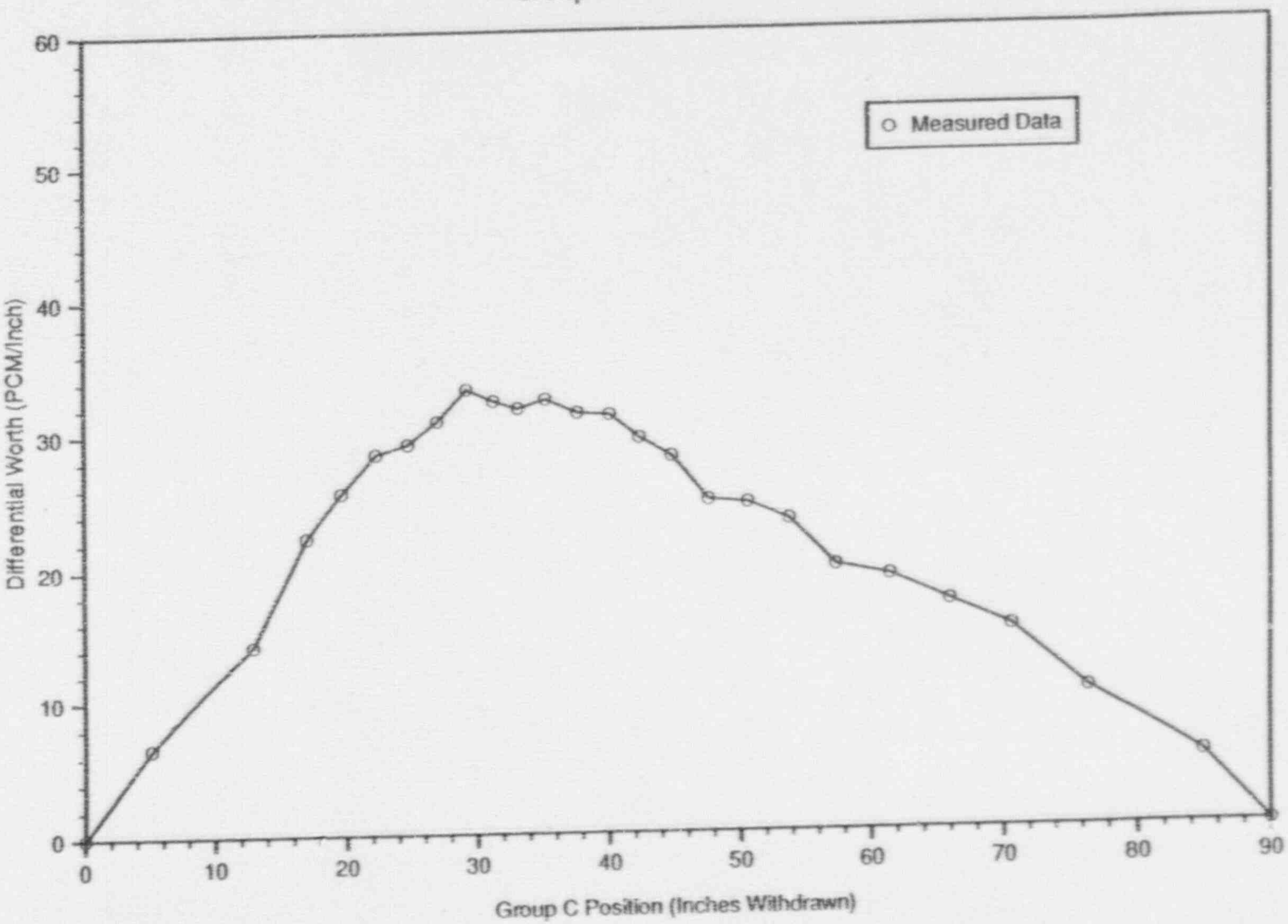


FIGURE 4
Yankee Rowe Core 21
Group C Integral Worth

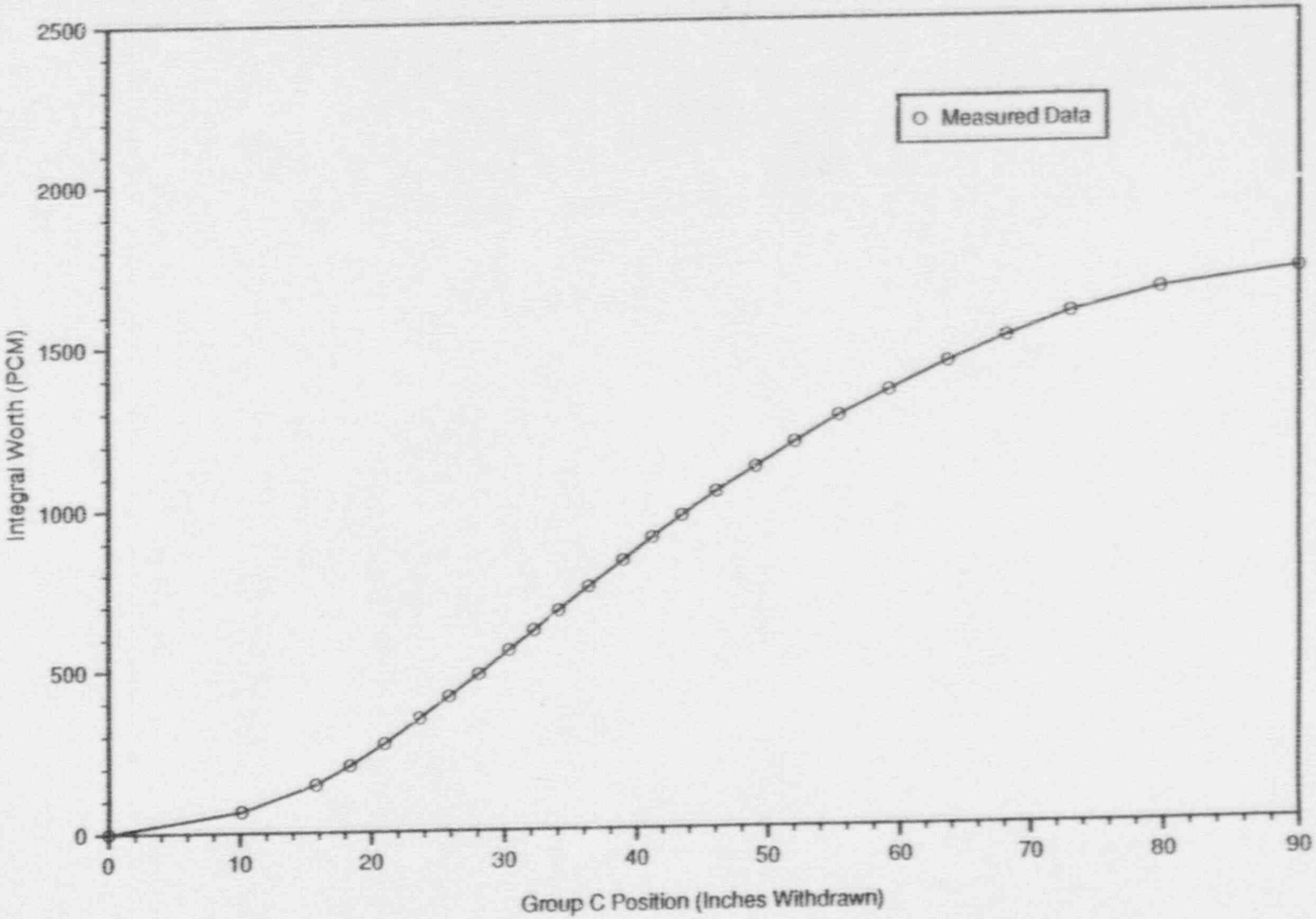


FIGURE 5
Yankee Rowe Core 21
Group A Differential Worth

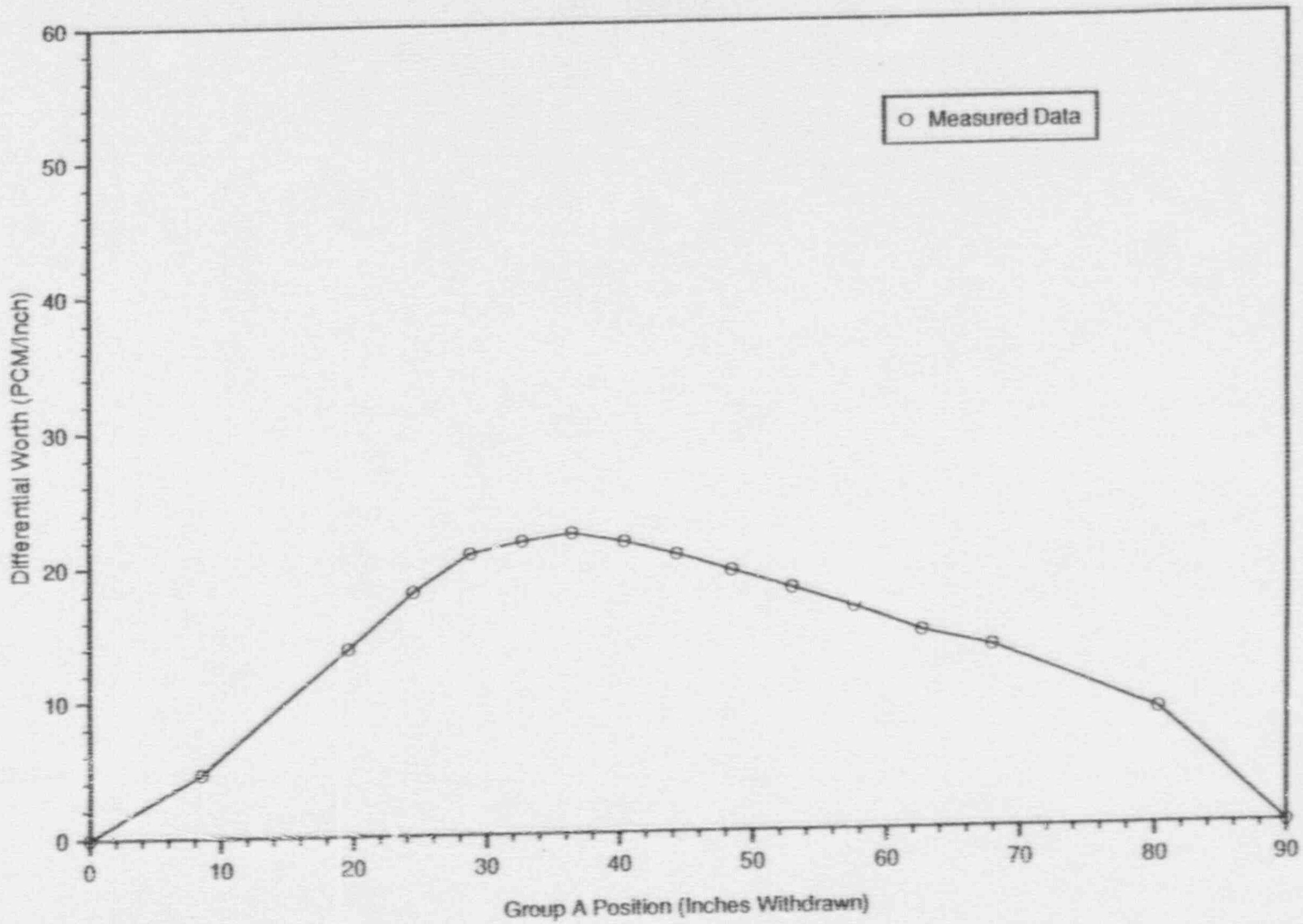


FIGURE 6
Yankee Rowe Core 21
Group A Integral Worth

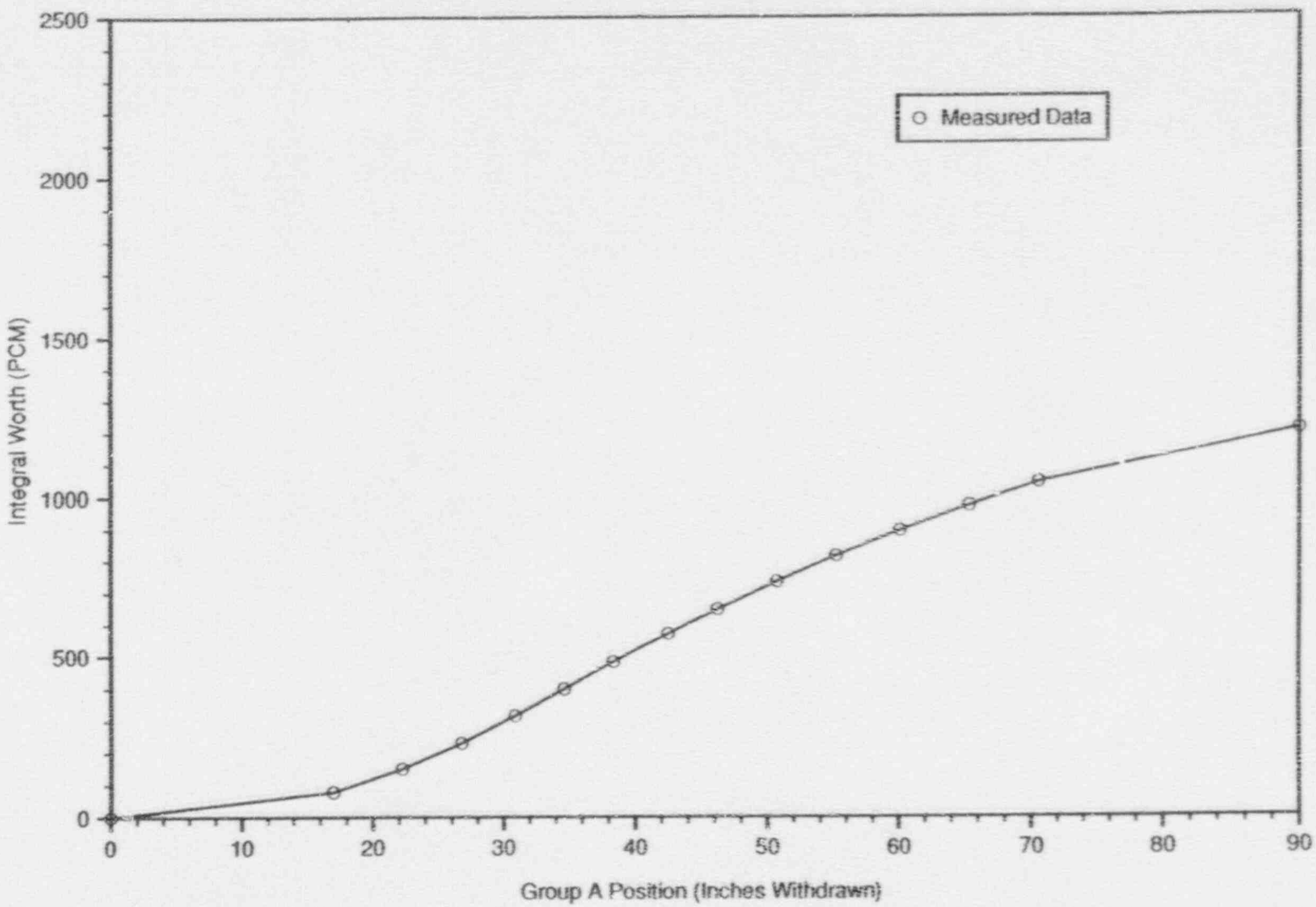


FIGURE 7
Yankee Rowe Core 21
Group B Differential Worth

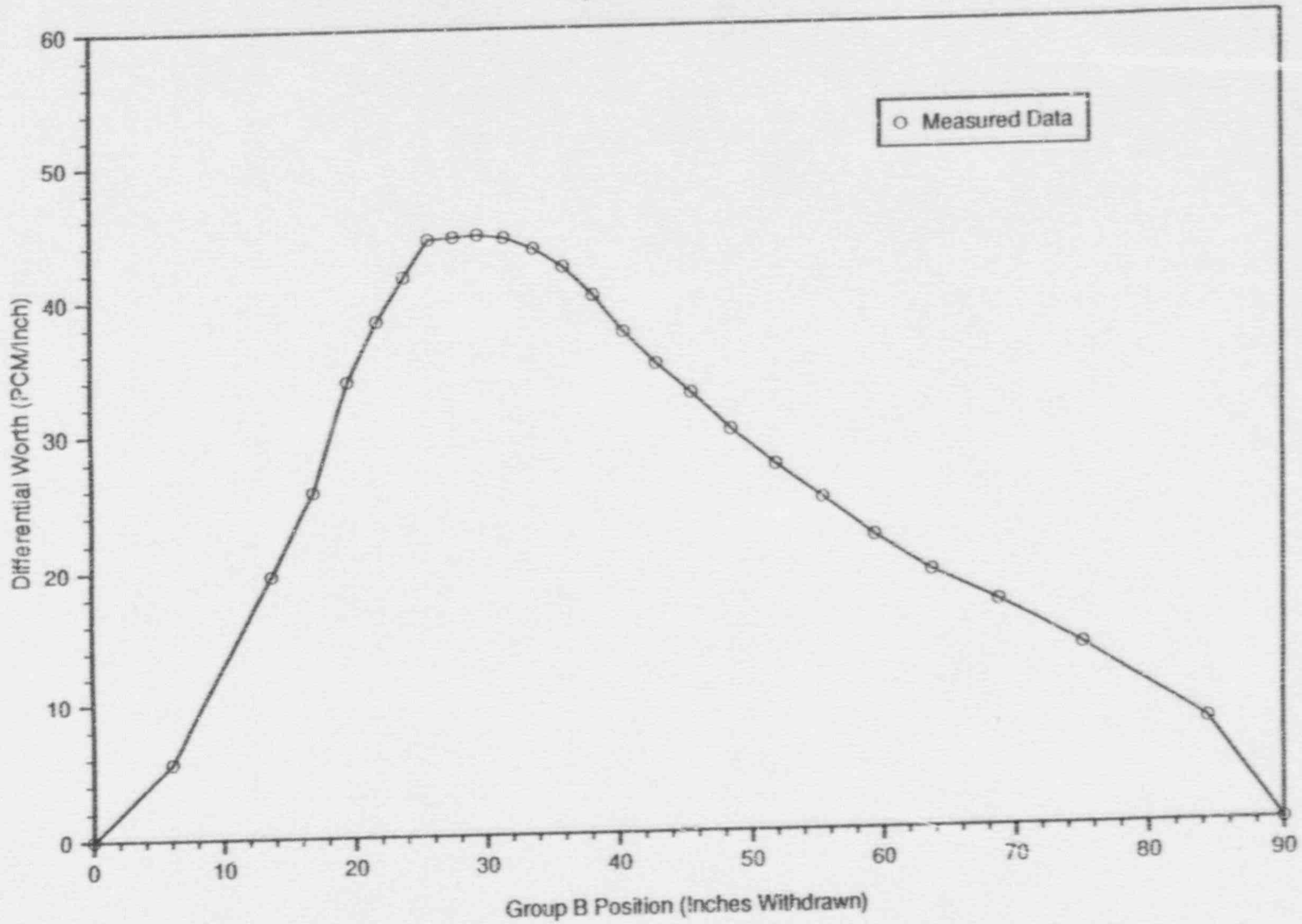


FIGURE 8
Yankee Rowe Core 21
Group B Integral Worth

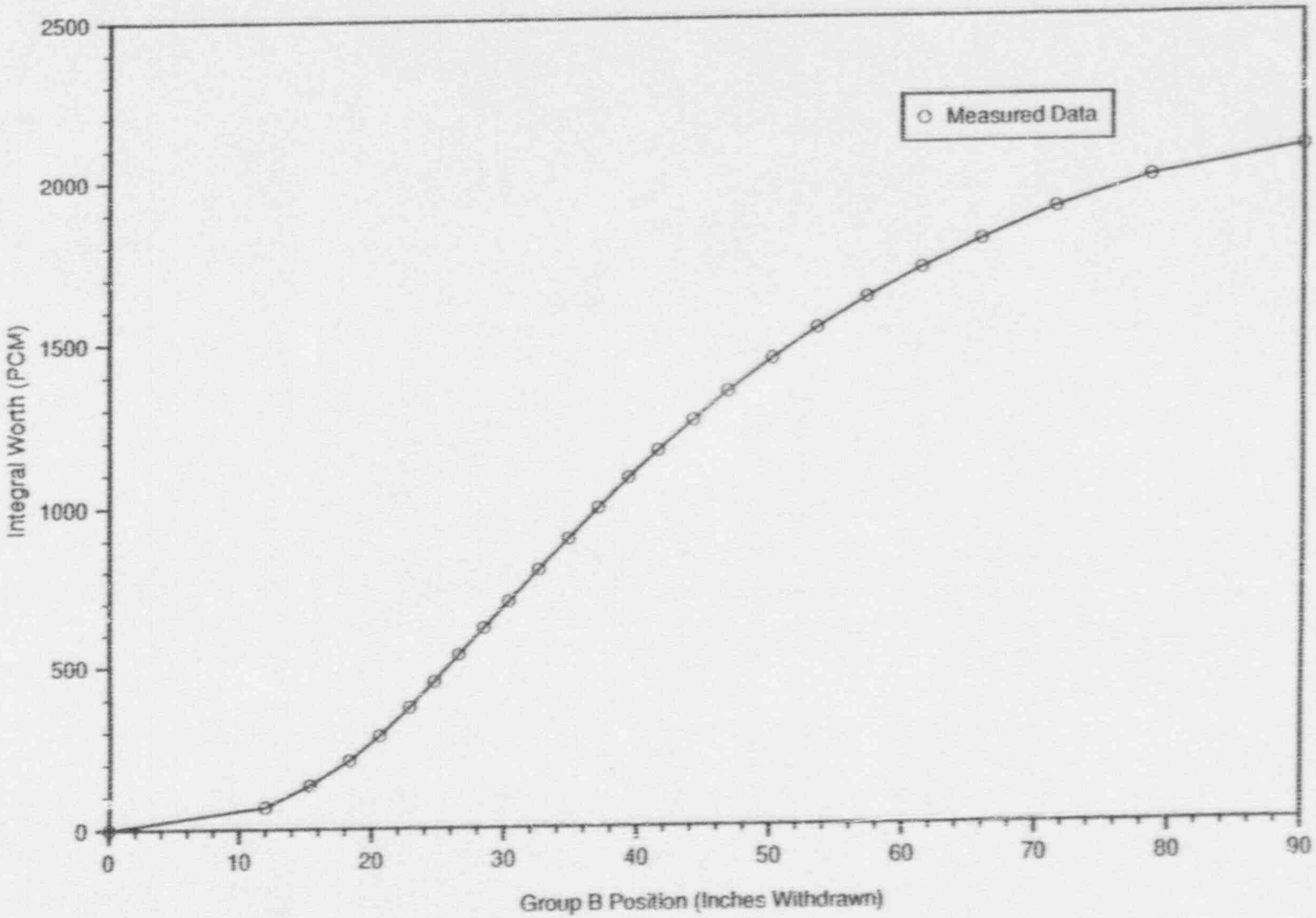
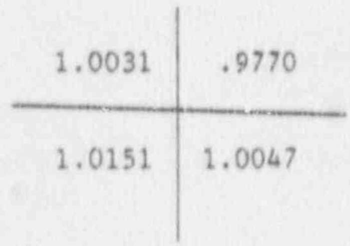


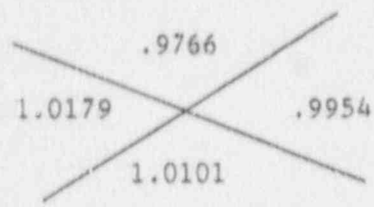
FIGURE 9

GROSS QUADRANT TILT
INCORE RUN YR-21-002
150 MWT, GROUP C @ 64.25 INCHES

STANDARD ORIENTATION



DIRECTIONAL ORIENTATION



Maximum Value = 2.34%

Acceptance Criteria = ± 5.0%

FIGURE 10

INCORE RUN YR-21-004
381.8 MWT GROUP C AT 80.000 INCHES 50. MWD/MTU

COMPARISON OF MEASURED AND PREDICTED SIGNALS

MEASURED SIGNAL........
PREDICTED SIGNAL........
% DIFFERENCE...............

				.739 .755 -2.2					
					1.241 1.281 -3.1				
			1.068 1.073 -.5						
		.968 .966 .2		1.043 1.020 2.2					
			1.004 .977 2.8				1.022 1.022 .0		
		1.120 1.099 1.9							
					1.033 1.019 1.3		.966 .967 -.1		
						.985 .993 -.9			
					.813 .828 -1.9				

AVERAGE ABSOLUTE DIFFERENCE BETWEEN
MEASURED AND PREDICTED IS 1.420 PERCENT

RMS ERROR IS 1.749

FIGURE 11

SUMMARY OF INCORE RESULTS
YR-21-004
381.8 MWT, 50 MWD/MTU

	FRESH FUEL	RECYCLED FUEL
Fq (Measured)	2.376	2.309
Fq (Limit)	4.337	4.337
% Margin to Limit	45.2	46.8
FΔH (Measured)	1.573	1.535
FΔH (Limit)	1.931	1.931
% Margin to Limit	18.5	20.5
LHGR (kW/ft) (Measured)	6.443	6.262
LHGR (kW/ft) (Limit)	9.545	11.178
% Margin to Limit	32.5	44.0

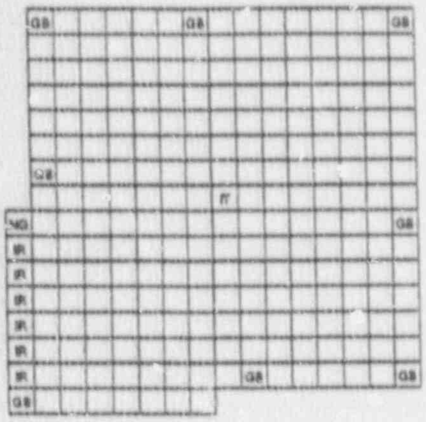
FIGURE 12
YANKEE CORE 21
CORE LOCATIONS OF MODIFIED ASSEMBLIES

			1 A-1 (7)	2	3	4			
		5 A-1 (7)	6	7 A-1 (7)	8	9	10		
	11 A-1 (7)	12	13	14 B-1 (12)	15	16	17	18	
19 A-1 (7)	20	21	22	23 A-2 (7)	24 B-3 (7*)	25 A-2 (7)	26	27	28
29 B-2 (6)	30	31	32	33	34	35 B-1 (12)	36 A-1 (7)	37	38
39 A-1 (7)	40 B-1 (12)	41 A-2 (7)	42	43	44	45 A-1 (7)	46	47	48
49 B-1 (12)	50	51	52 A-1 (7)	53	54 A-1 (7)	55 B-1 (12)	56	57	58 A-2 (7)
	59 B-1 (12)	60	61	62	63	64	65	66 A-2 (7)	
		67 B-1 (12)	68	69	70 A-2 (7)	71	72 A-2 (7)		
			73 B-1 (12)	74 A-2 (7)	75 B-3 (6)	76 A-2 (7)	ASSEMBLY NUMBER ASSEMBLY TYPE # OF REPLACED RODS		

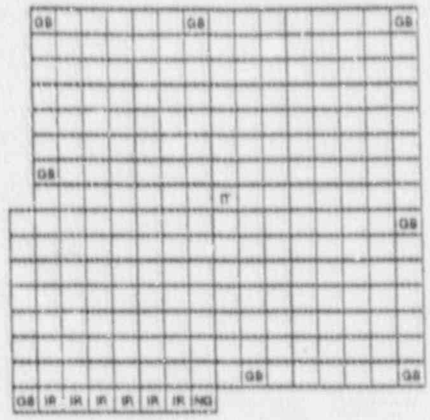
* Contains one reconstituted fuel rod

FIGURE 13
YANKEE CORE 21
LATTICE LOCATIONS OF INERT RODS AND NEW GUIDE BARS

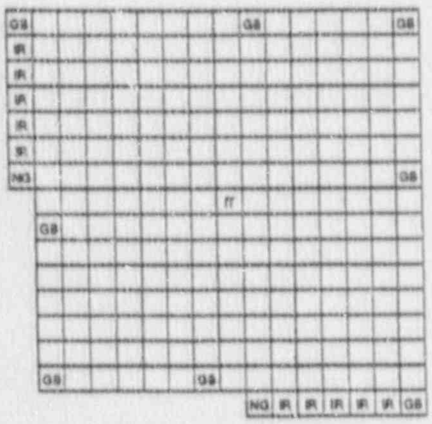
YANKEE ASSEMBLY TYPE A-1



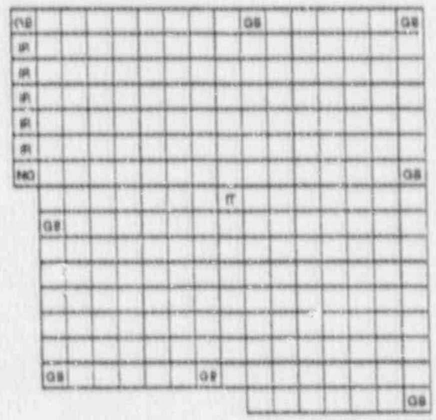
YANKEE ASSEMBLY TYPE A-2



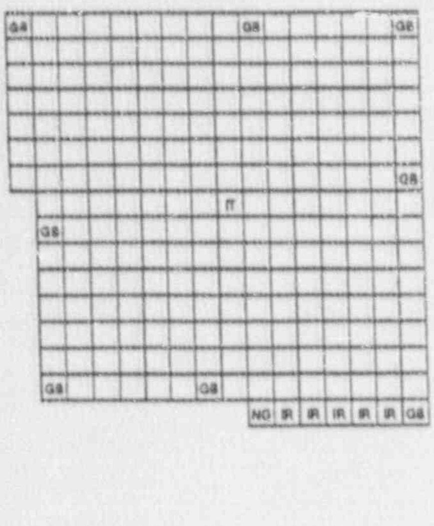
YANKEE ASSEMBLY TYPE B-1



YANKEE ASSEMBLY TYPE B-2



YANKEE ASSEMBLY TYPE B-3



IT - INSTRUMENTATION TUBE

GB - GUIDE BAR

NG - NEW GUIDE BAR

IR - INERT ROD

VI. REFERENCES

1. YAEC-1731, "Yankee Nuclear Power Station Core 21 Performance Analysis."

2. Internal Memo, R. C. Paulson to K. J. Heider, "Yankee Core 21 Startup Physics Data", RP 90-219, July 24, 1990.

3. Plant Refueling and Inspection Procedures: OP-1700, 1704, 1705, and 1706.

4. Physics Test Procedures: OP-1701, 1702.

5. Internal Memo, R. C. Paulson to Distribution, "Analysis of Incore Traces YR-21-002 through YR-21-007," RP 90-338, November 29, 1990.