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FACIL:50-269 Oconee Nuclear Station, Unit 1, Duke Power Co. 05000269

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SUBJECT: Forwards addl info re reactivity anomaly that occurred at 97.4 effective full power days of operation during Cycle 6, per 801016 ltr.Ref RO 269/80-23.

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VICE PRESIDENT
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November 20, 1980

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Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. R. W. Reid, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station
Docket No. 50-269
Unit 1 Reactivity Anomaly

Dear Sir:

In response to your letter of October 16, 1980, requesting additional information regarding the reactivity anomaly that occurred at Oconee Unit 1 at 97.4 effective full power days of operation during Cycle 6, please find attached the requested information.

Very truly yours,

William O. Parker, Jr.

JLJ:scs
Attachment

A001 5/1

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ATTACHMENT

DUKE POWER COMPANY
OCONEE NUCLEAR STATION

Oconee Unit 1 Reactivity Anomaly

Responses to NRC Questions
of
October 16, 1980

Question 1

Provide the predicted boron letdown curve and the measurements of critical boron concentration for Cycle 6 for both zero and full power.

Response

The predicted and measured hot full power "All Rods Out" (ARO) boron concentrations through the time of the occurrence are provided in Figure 1-1. The reference conditions for the predicted curve are:

- hot full power

- equilibrium xenon and samarium

- control rod groups 1-8 @ 100% wd

- curve normalized to BOC measured values (i.e., curve is shifted, shape is unchanged)

Following the beginning of cycle startup on Oconee 1 it was learned that a reactor shutdown was scheduled for repair of RCP 1B1 and implementation of the "Crystal River ICS Modification." It was therefore decided to obtain criticality data as the reactor shut down before normalizing the core excess reactivity curve to beginning of cycle "all rods out" boron concentration results from the Zero Power Physics Test. This shutdown was delayed because of system load requirements, but criticality data was obtained when the reactor was brought to hot standby at about 50 EFPD. Based on this data and the beginning of cycle results (which showed 0.70 and 0.42% ΔK/K core excess reactivity offsets, respectively) the core excess reactivity curve was offset downward by 0.55% ΔK/K per approved station procedure. It now appears that the hot standby data was inaccurate, as the actual required reduction to the core excess reactivity curve at that burnup would have been about 0.3% ΔK/K.

A re-analysis of the hot standby data showed no errors in recorded boron concentration, rod position, xenon worth, or the normalization technique. It is concluded the boron sample results used for this calculation must have been in error.

Figure 1-2 is a plot of the predicted and "measured" ARO boron concentrations at hot zero power (HZP). No actual measurements of HZP ARO boron concentration are made; the plotted values are calculated from criticality data obtained during all startups of Oconee 1 Cycle 6. Since these criticalities occurred at widely varying core conditions generally not near the reference conditions (listed below), there is considerable uncertainty in the plotted results. The reference conditions for the predicted curve are as follows:

- hot zero power

- no xenon, equilibrium samarium

- control rod groups 1-7 @ 100% wd, group 8 @ 37.5% wd

- curve not normalized

Question 2

A component of the reactivity anomaly was the underprediction of the core excess reactivity which was based on BOC measurements. Explain why there is a slope change in the excess reactivity curve. Include the originally predicted curve and the revised curve. Why was this not a problem in previous cycles of this or similar reactors?

Response

Oconee 1, Cycle 6 is a lump burnable poison (LBP) cycle. Previous cycles did not contain LBP's. From information gathered from B&W plants having LPB cycles, B&W adjusted the HZP, BOC, AROCBC to account for the differences between the predicted and measured AROCBC. The correction factor is a function of initial LPB loading and decreases with LBP burnup. The correction appears to produce more accurate AROCBC predictions at BOC since B&W plant startups have been within a few ppm of the predicted HZP BOC AROCBC with the correction factor. This LBP correction factor, if applied, would have a decreasing value with burnup becoming essentially zero at approximately 100 EFPD, when the LBP is substantially depleted. Therefore, the burnup dependent LBP correction factor results in a modified scope of the corrected core excess reactivity curve for the 0-100 EFPD portion of the fuel cycle.

However, the functional dependence of the LBP correction on burnup is not fully established. After the Oconee 1 Cycle 6 core physics data was generated, B&W became aware that a correction should be made to the slope of the predicted critical boron concentration (i.e., core excess reactivity) versus burnup curve for the first 100 EFPD of operation. This change was needed because of new information concerning the burnup dependency of the LBP correction factor. This information was not forwarded to Duke; as a result the normalization to beginning of cycle measured data of the core excess reactivity curve in the Reactivity Balance Procedure introduced an error that increased with burnup to a maximum of 0.32% ΔK/K at 100 EFPD. The core burnup at the time the reactivity anomaly was observed was 97.4 EFPD--virtually all of the 0.32% ΔK/K error was present.

To confirm that the slope of the original predicted critical boron concentration curve was in error as B&W stated, the results of "all rods out" boron concentration at power measurements were evaluated. As shown on Figure 1-1, a least squares fitted line through the measured data points does have a different slope than was predicted.

Figure 2-1 is a plot of the original predicted and adjusted (i.e., slope changed) HZP ARO boron curves. These are analagous to the requested core excess reactivity curves.

Question 3

Given the reactivity anomaly of 1.3% at hot zero power, what would the reactivity anomaly be at cold shutdown conditions? Justify your response.

Response

The best estimate of the anomaly is 1.2% ΔK/K relative to the data in the Oconee Station procedure at the time of the incident. The anomaly relative to B&W predicted data is ∿ 0.9% ΔK/K. Of this anomaly ∿ 0.4% ΔK/K has been determined to be in the difference between predicted and measured control rod worth curve shapes (not in total control rod worth). If all the remaining anomaly is considered to be in the core excess reactivity, the core would be ∿ 0.5% ΔK/K more reactive than predicted at HZP.

B&W predicted data is used to calculate shutdown margins at cold conditions. (Following this incident, adjustments were made to the shutdown margin calculations to assure conservatism in light of the anomaly.) At 97 Effective Full Power Days (EFPD), core excess reactivity is predicted to increase by a factor of 1.36 as core temperature decreases from 532°F to 68°F. If the ∿ 0.5% ΔK/K anomaly in core excess reactivity is assumed to vary in the same manner, the core would be ∿ 1.36 x 0.5 ≃ 0.7% ΔK/K (56 ppm) more reactive than predicted. This is well within the margin of conservatism used for shutdown margin calculations at cold conditions and hence the minimum shutdown margin of 1% would have been available.

It is to be noted that an anomaly at HZP would not necessarily indicate that an anomaly would exist at cold conditions because separate computer codes are used to generate hot and cold physics data.

Question 4

Using the reactivity anomaly from Question 3, re-do the analysis of the boron dilution accident from drained-down condition at approximately 100°F.

Response

As discussed in the response to Question 3, the minimum required 1% shutdown margin at cold condition was not compromised. Therefore, the FSAR boron dilution accident is not affected.

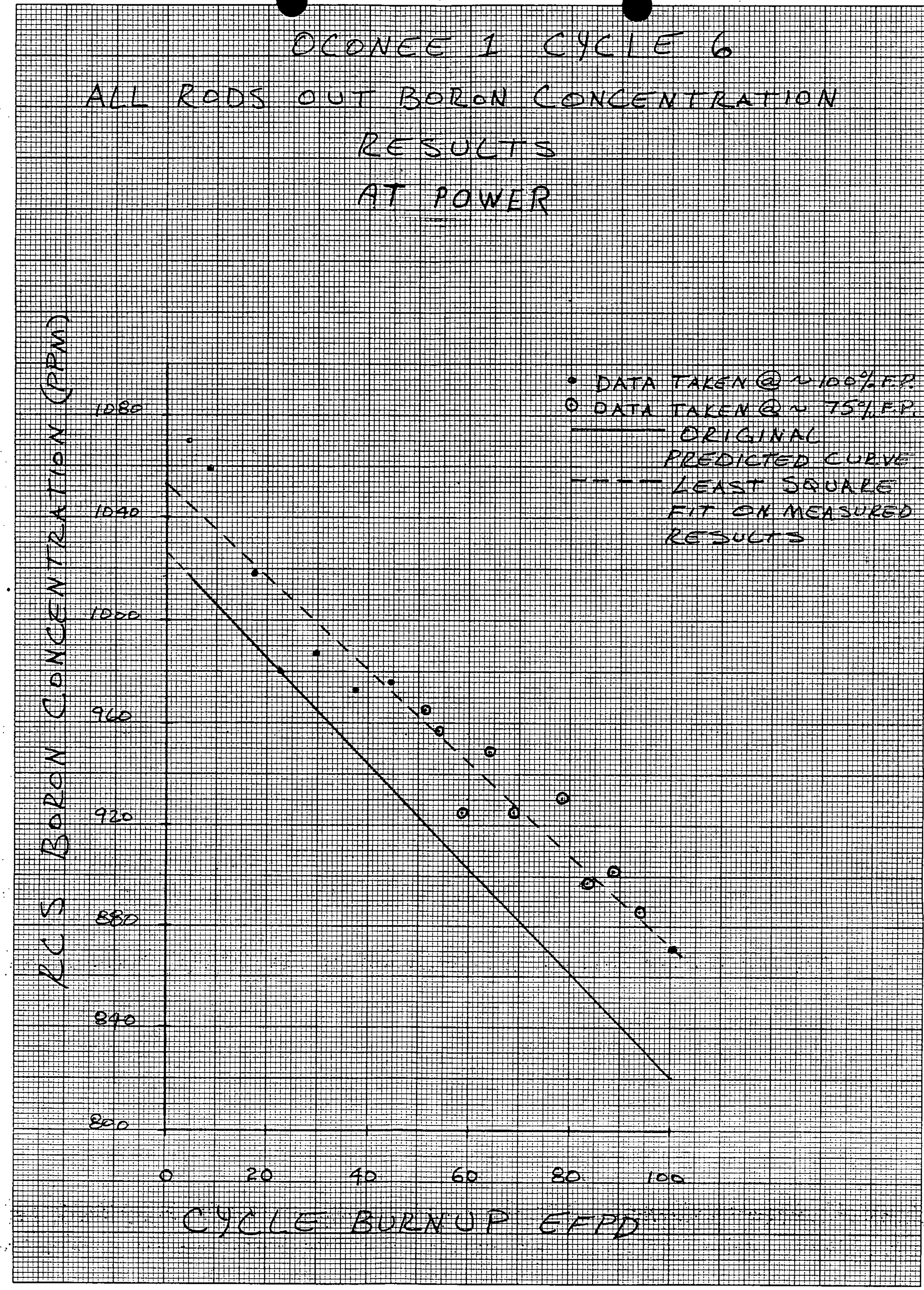

OCONEE 1 CYCLE 6
ALL RODS OUT BORON CONCENTRATION RESULTS
AT POWER
• DATA TAKEN @ ~100% F.P.
⊙ DATA TAKEN @ ~ 75% F.P.
ORIGINAL PREDICTED CURVE
LEAST SQUARE FIT ON MEASURED RESULTS
RCS BORON CONCENTRATION (PPM)
1080
1040
1000
960
920
880
840
800
0
20
40
60
80
100
CYCLE BURNUP EFPD

Figure 1-1

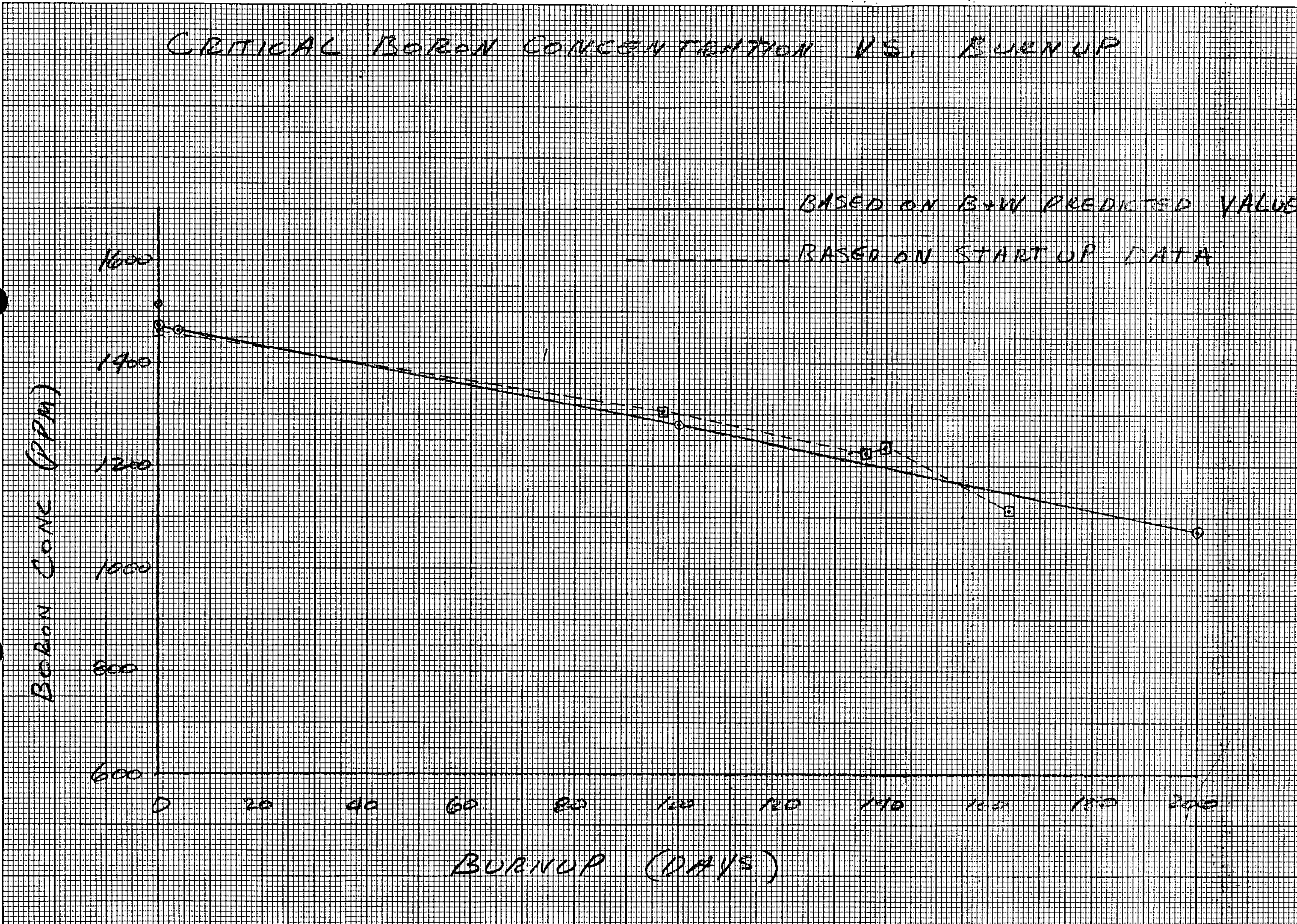
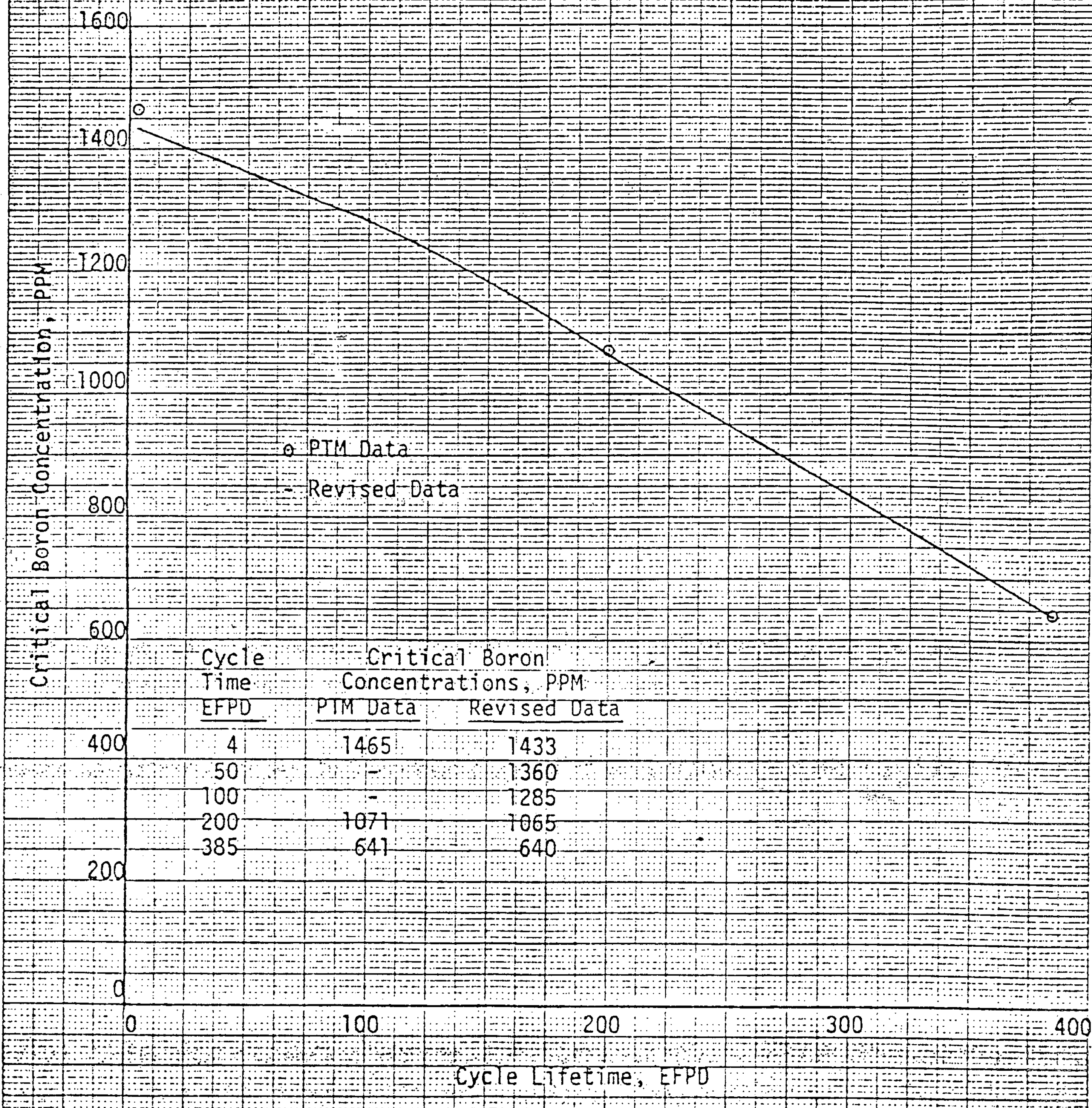

CRITICAL BORON CONCENTRATION VS. BURNUP
BASED ON B+W PREDICTED VALUES
BASED ON STARTUP DATA
BORON CONC (PPM)
1600
1400
1200
1000
800
600
0
20
40
60
80
100
120
140
160
180
200
BURNUP (DAYS)

Figure 1-2

Oconee I Cycle 6 off 300 EFPD Cycle 5

Critical Boron Concentration vs. Cycle Lifetime

HZP, No Xenon, HFP Sm, Banks 1-7 Out, Bank 8 Inserted



Cycle Time EFPD	Critical Boron Concentrations, PPM PTM Data	Revised Data
4	1465	1433
50	-	1360
100	-	1285
200	1071	1065
385	641	640

Figure 2-1