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TO: Mr. Edson G. Case

FROM: Duke Power Company
Charlotte, North Carolina
William O. Parker, Jr.

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DESCRIPTION

Consists of additional info. concerning investigations into the cause of the Cycle 4 tilt..w/att table which provides a history of the core tilt indications observed as a function of core burnup and reactor power...

ENCLOSURE

1 ENCL

PLANT NAME: Oconee Unit No. 1
RJL 12/20/77 (4-P)+(1-P)

FOR ACTION/INFORMATION

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December 14, 1977

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U. S. NUCLEAR REGULATORY COMMISSION
Mail Section

Mr. Edson G. Case, Acting Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

RE: Oconee Unit 1
Docket No. 50-269

Dear Sir:

In letters dated October 4 and November 9, 1977, a core tilt condition was described which had been observed during the startup of the Oconee Cycle 4 core. Technical Specification amendments were issued by the Commission on November 23, 1977 to permit the full power operation of the core in an unrodded mode with a conservative limit on core power tilt. The purpose of this letter is to provide additional information concerning the investigations into the cause of the Cycle 4 tilt. The attached Table provides a history of the core tilt indications observed as a function of core burnup and reactor power.

A more indepth analysis of the Oconee 1, Cycle 3 core has been performed utilizing unprocessed incore detector signals. All failed detector locations were eliminated from this calculation to reduce any assymetry caused by substitution routines. This analysis indicated that a tilt of approximately 1.5% occurred from 150 EFPD throughout the duration of the cycle. This tilt was well within the Technical Specification limits and did not constitute any safety or operational problems during Cycle 3; hence, an indepth analysis was considered unnecessary at that time. Subsequent calculations have revealed that a high probability exists that the higher Cycle 4 tilt has resulted from the Cycle 3 tilt being magnified by the core shuffle scheme. The tilt in Cycle 3 would cause the fuel assemblies in the northwest quadrant of the core to receive a higher burnup than those in the southeast quadrant. During the refueling, fuel assemblies in the northwest and southeast quadrants were moved across the core into a region of higher importance (i.e., towards the center of the core). This shuffle pattern placed more reactive fuel assemblies (due to the burnup effect) in the northwest quadrant than in the southeast quadrant, thereby contributing to the quadrant tilt measured at the beginning of Cycle 4.

The following discussion is provided to explain the manner in which the burnup distribution is normally measured by the incore detector system.

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The segment and assembly burnups are calculated by the On-Line Computer using the following procedure:

(a) The raw signals generated by the rodium detectors in the flux environment are corrected to a value for an undepleted detector of nominal sensitivity.

(b) The corrected signals are converted to segment powers (1/7 of the axial height of any assembly) using a series of pre-calculated factors which convert the signals to power under a variety of core conditions. The calculated powers are then normalized to the core heat balance.

(c) The burnup for a segment is calculated by multiplying the calculated power by the time increment since the last calculations and adding this in a running sum.

$$B(1) = B(1-1)+P*\Delta t$$

where:

$B(1)$	= Burnup at time 1, MWD/MTU
$B(1-1)$	= Burnup at time 1-1, MWD/MTU
P	= Power generated in the segment, MW
Δt	= Delta time between 1-1 and 1, days (normally about 10 minutes)

Since the core tilt during Cycle 3 was exceedingly small, it was not considered in the design of Cycle 4. The burnup distributions for all cycles were computed on a quarter-core basis assuming symmetry about the core major axes. These computations were performed using B&W's version of the PDQ 07 Code in two energy groups with a pin by pin representation of the flux solution. The fuel depletion and isotopic changes are calculated using a system of equations patterned after those employed in the CINDER Program described in WAPD-TM-334 (August, 1962).

An operating limit more conservative than the Technical Specification limit is established on the allowable quadrant power tilt in order to account for the uncertainty in the tilt measurement. The accuracy of the incore detector system for tilt measurements may be described by defining the following terms:

Uncertainty. This terms refers to the potential for error in the measured value due to instrument error, signal noise, and calculational uncertainty.

Observability. This term refers to the potential for error in the measured value due to the limitations of measuring core power with an instrument system having a limited number of sensors distributed geometrically throughout the core.

The uncertainty is equal to 0.39 (percent quadrant power tilt). The observability is equal to 0.106 times the quadrant power tilt in percent. The total measurement uncertainty is thus equal to the sum of these terms. These terms are applied to the quadrant power tilt Technical Specification envelope to obtain an operating envelope within the Technical Specification envelope.

In order to alleviate the effects of quadrant tilt during the operation of Oconee 1, Cycle 4 and future cycles the core is being operated in a conservative manner in an unrodded mode. Additionally, the fuel shuffle procedure is being revised for future reloads to minimize the effects of a residual tilt from the previous cycle.

In order to gain a better understanding of this tilt phenomenon, additional investigations are in progress as follows:

(a) The computer study will be completed in which Oconee 1, Cycle 3 is depleted with a tilt. This will be used as input for Cycle 4, and the calculated zero power ejected rod worths and power tilts will be compared in detail with measured data.

(b) Investigations are currently in progress into the Cycle 3 plant operations that could potentially affect the Cycle 3 quadrant power tilt. Some steps in this investigation are:

(1) examine detailed incore detector data to determine axial level dependence of the tilt, tilt surface contour, and consistency of tilt behavior.

(2) Investigate plant operation during Cycle 3 to determine any anomalous behavior, other than tilt, which may have introduced a tilt in the core.

(3) Investigate Cycle 3 thermal hydraulic plant parameters in a similar manner.

(4) Examine data from other B&W plants to determine if similar behavior has occurred elsewhere.

(5) Perform computer studies of Cycle 3 to quantify the effect of various parameters on core tilt.

Further status reports will be submitted to the Commission as information becomes available.

Very truly yours,

William O. Parker Jr.
by WAH

William O. Parker, Jr.

MST:ge
Attachment

INCORE DETECTOR DATA
FOR
OCONEE 1 CYCLE 4 TILT

		Tilt (%)			
EFPD	% FP	WX	WY	YZ	ZW
0.0	15	5.66	1.26	-6.94	0.01
0.3	40	3.66	0.73	-5.14	0.76
1.0	40	3.81	0.84	-5.36	0.71
1.6	31	3.33	1.39	-4.99	0.28
3.5	40	2.88	0.69	-4.42	0.84
5.8	75	2.88	0.82	-3.86	0.16
6.4	75	2.87	0.84	-3.82	0.12
17.9	74	2.65	0.61	-3.12	0.14
28.4	99	2.30	0.46	-2.52	-0.23