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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Reference: Docket No. 50-285

SUBJECT: Startup Reports for Fort Calhoun Station Cycle 19

Pursuant to Fort Calhoun Station Technical Specification 5.9.1.a, Omaha Public Power District OPPD) provides the attached Cycle 19 Startup Testing Reports. The Cycle 19 reactor core at Fort Calhoun Station consists of 40 new fuel assemblies and 88 used fuel assemblies manufactured by Westinghouse Electric Corporation and 5 used fuel assemblies manufactured by ABB/Combustion Engineering. Cycle 19 represents the first operating cycle using Inconel mid-grids within the new Westinghouse fuel design.

The subject reports include a general description of the measured values obtained during Cycle 19 Low Power Physics Testing and Power Ascension Testing. Also included is a comparison of these measured values with the calculated design predictions. All test results showed good agreement with the predicted values.

Please contact me if you have any questions.

Sincerely,

S. K. Gambhir
Division Manager
Nuclear Operations

Attachment

TCM/tcm

c: E. W. Merschoff, NRC Regional Administrator, Region IV
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Winston & Strawn (w/o attachment)

IE26

FORT CALHOUN STATION
CYCLE 19
LOW POWER PHYSICS TEST REPORT
And
POWER ASCENSION REPORT

Conducted November 10 and 11, 1999

CYCLE 19 LOW POWER PHYSICS TEST REPORT

1. PURPOSE

The purpose of the Cycle 19 Low Power Physics Test (LPPT) was to obtain and confirm selected Cycle 19 core physics parameters. The physics parameters measured in the test included:

- All rods out (ARO) critical boron concentration,
- Isothermal temperature coefficient of reactivity,
- Control Element Assembly (CEA) shutdown and regulating group worths using the Rod Group Exchange Technique.

2. SUMMARY

Cycle 19 criticality was achieved at 1037 on November 10, 1999. Following criticality, zero-power physics testing was initiated to measure core physics parameters and validate the core design through comparison to predicted values. A summary of the primary results is described below:

Critical Boron Concentration (All Rods Out)	1552 ppm
Isothermal Temperature Coefficient of Reactivity	-0.02×10^{-4} Δρ/°F
Total Regulating and Shutdown Group Worth	5.76 %Δρ

3. DISCUSSION OF MEASUREMENTS

3.1 Approach to Criticality

Prior to the Cycle 19 approach to criticality, Shutdown Groups A and B were withdrawn to ARO, and the RCS was diluted to the Estimated Critical Condition (ECC) boron concentration for CEA Group 4 at 100 inches withdrawn. Additionally, Wide Range Channels A, B, and C were connected to scalar timers to provide count rates for use in determining the subcritical neutron multiplication.

3. DISCUSSION OF MEASUREMENTS (continued)

3.1 Approach to Criticality (continued)

The approach to criticality began by taking base count rates for each channel for use in the inverse count rate determination. The CEA Groups N, 1, 2, 3, and 4 were then withdrawn to various positions, taking the count rate for each channel to determine the inverse count rate and predict the point of criticality. Initial criticality was achieved at 3×10^{-4}% power at 1037 on November 10, 1999.

CEA Regulating Group 4 was adjusted to 25 inches withdrawn to maintain the reactor critical during stabilization and boron equalization between the pressurizer and the loop. The RCS was then borated to get CEA Group 4 near 100 inches withdrawn. After stabilization, the boron concentration was 1540 ppm with CEA Group 4 at about 98 inches withdrawn.

3.2 Zero Power Tests

Following Cycle 19 initial criticality, the reactivity computer was verified for correct operation. The following values of β and λ were set into the reactivity computer:

Group	β_{eff}	$\lambda(sec^{-1})$
1	0.000202	0.012778
2	0.001265	0.031643
3	0.001144	0.121707
4	0.002460	0.322723
5	0.000901	1.404599
6	0.000218	3.877156

$\beta_{total} = 0.0061899$

3.2.1 Validation of Power Range for Low Power Physics Testing and the All Rods Out Critical Boron Concentration Measurement

With the reactor at steady state after initial criticality, the boron concentration was 1540 ppm with Group 4 partially inserted. The remainder of Group 4 was withdrawn, increasing reactor power. When reactor power approached 10^{-1}%, the power increase was terminated. There were no indications that sensible heat production occurred below 1 x 10^{-1}%. Also, the signal-to-noise ratio was deemed to be acceptable down to near 10^{-4}% power. Therefore, the power range for the low power physics testing was defined as 2×10^{-4}% to 5×10^{-2}% power.

3. DISCUSSION OF MEASUREMENTS (continued)

3.2 Zero Power Tests (continued)

The ARO Critical Boron Concentration (CBC) was determined by first measuring the reactivity change caused by withdrawing the remainder of CEA Group 4 to determine the end of Group 4 reactivity worth. This reactivity worth was translated into the equivalent boron concentration and added to the measured CBC with CEA Group 4 partially inserted, resulting in the ARO CBC. Table 1 contains the measured and predicted ARO CBC along with other measured and predicted parameters.

3.2.2 Isothermal Temperature Coefficient of Reactivity (ITC) Measurement

The ITC was measured by first increasing the RCS inlet temperature by approximately 5°F, then decreasing the RCS inlet temperature by approximately 10°F, and then increasing the RCS inlet temperature by approximately 5°F. Table 1 contains the measured and predicted ITC values along with other measured and predicted parameters. The reported value is the average of the three measurements taken during the three temperature swings. Since the temperature swings moved equally about the initial temperature (~532°F), the value reported is a true ITC at HZP (~532°F) and no adjustment is needed. The Moderator Temperature Coefficient of Reactivity (MTC), which is equal to the ITC minus the Fuel Temperature Coefficient of Reactivity (FTC), was verified to be less than the $+0.5 \times 10^{-4}$ $\Delta\rho$/°F Technical Specification limit. The most positive measured MTC, including uncertainties, was calculated to be $+0.175 \times 10^{-4}$ $\Delta\rho$/°F, and is shown in Table 1.

3.2.3 Shutdown and Regulating CEA Group Worths

The CEA group worths were measured using the rod group exchange technique, where individual rod groups (i.e., test groups) were measured by swapping them with a reference group whose worth was determined by the boration-dilution method. The reference group was determined from predictions to be the CEA group with the most rod worth. Therefore, the worth of the test groups is a function of the measured worth of the reference group.

For this test, Group B was used as the reference group for Groups A, 1, 2, 3 and 4. Groups 1 and 3 were combined into one super group, and Groups 2 and 4 were combined into the other super group. A super group is a combination of two or more test groups into a more worthy rod group. Table 1 shows that all group worths, as well as the total worth of all CEA groups, were within the acceptance and review criteria for the test.

4. CONCLUSIONS

Test personnel have concluded that the Low Power Physics Test program conducted for Cycle 19 yielded results that are as accurate as can be expected within the limitations of reasonable reactor safety, prudent use of plant equipment, accuracy of available instrumentation, and reasonable expenditure of both time and money. The data collected during the Cycle 19 Low Power Physics Tests was analyzed by Nuclear Engineering – Reactor Physics and Reactor Engineering. The results of the Cycle 19 Low Power Physics Tests show excellent agreement with the 3-D SIMULATE-3 code predicted values, thus providing confirmation of the methods used in designing the Cycle 19 core and the associated safety analyses.

TABLE 1
CYCLE 19 COMPARISON OF PREDICTED AND MEASURED LOW POWER PHYSICS PARAMETERS
(Hot Zero Power, 2100 psia, 532°F)

ARO Critical Boron Concentration (ppm):

Prediction	Measurement	Predicted – Measured	Acceptance Criteria	Review Criteria
1512	1552	-40	±90 of predicted	±50 of predicted

Isothermal Temperature Coefficient (Δρ/°F):

Boron Conc. (ppm)	Temp. (°F)	Prediction (Δρ/°F)	Measurement (Δρ/°F)	Most Positive MTC(Δρ/°F)	Acceptance Criteria (Δρ/°F)	Review Criteria (Δρ/°F)
1538	532	-0.013×10^{-4}	-0.023×10^{-4}	$+0.175 \times 10^{-4}$	MTC Tech. Spec. Limit of $<+0.50 \times 10^{-4}$	$\pm 0.20 \times 10^{-4}$ of predicted

Rod Worth by Rod Group Exchange Technique:

Group	Predicted Worth (%Δρ)	Measured Worth (%Δρ)	Pred. – Meas. Worth (%Δρ)	Group B Position (Inches Withdrawn) Predicted	Group B Position (Inches Withdrawn) Measured	Acceptance Criteria** (%Δρ)	Review Criteria** (%Δρ)
1+3	1.25	1.20	0.05	82.5	85.0	1.09 to 1.47	1.09 to 1.47
2+4	1.48	1.49	-0.01	106	111.5	1.29 to 1.74	1.29 to 1.74
B	1.68	1.56*	0.12	N/A	N/A	1.53 to 1.86	1.53 to 1.86
A	1.56	1.51	0.05	113	115.0	1.36 to 1.83	1.36 to 1.83
Total	5.97	5.76	0.21			5.43 to 6.63	5.43 to 6.63

*Reference Group B was measured via boration-dilution method.
**Allowable range of measured worth given the predicted worth.

CYCLE 19 POWER ASCENSION REPORT

1. PURPOSE

The purposes of the Cycle 19 power ascension test program were to verify that the measured at-power core parameters were within the limits of the Technical Specifications and to compare selected measured parameters with the calculated/predicted values. The power ascension test program consisted of:

- Measurements of the following parameters at 58%, 75%, and 100% power:
  - Integrated Radial Peaking Factor (F_R^T),
  - Planar Radial Peaking Factor (F_{xy}^T),
  - Azimuthal Power Tilt (T_q).
- Determination of reactivity coefficients:
  - Measurement of Isothermal Temperature Coefficient of Reactivity (ITC),
  - Measurement of Power Coefficient of Reactivity (PC),
  - Calculation of Moderator Temperature Coefficient of Reactivity (MTC).
- Comparison of measured and predicted radial power distributions and calculation of the associated root mean square deviation (σ).
- Verification of the absence of gross power tilt by reviewing CECOR flux maps at low power conditions.

2. SUMMARY OF PRINCIPAL RESULTS

Cycle 19 commercial operation began at 1216 on November 11, 1999, when the turbine-generator was placed on-line. Power ascension subsequently began and was stopped upon reaching 96% power due to an unanticipated F_{xy}^T peaking limitation. No Technical Specification limit was exceeded. The subsequent investigation determined that an anomaly involving initial sensitivities of two incore detectors within the same incore instrument was the cause of this peaking limitation. Power ascension was resumed following resolution of this problem. The pertinent parameters measured during the power ascension testing program are summarized in Table 1 of this report.

3. DISCUSSION OF MEASUREMENTS AND RESULTS

3.1 Radial Peaking Factors

Measurements of F_R^T and F_{xy}^T using incore detector signals and CECOR calculations at 58%, 75%, and 100% power indicate that the integrated radial peaking factor, the planar radial peaking factor, and the excore and incore azimuthal power tilts (T_q^E and T_q^I) were within the limits of the Technical Specifications.

3.2 MTC, ITC, and PC

Tests were performed on November 28, 1999, to measure the ITC and PC. The results of this test are summarized in Continuing Physics Test Report (CPTP) No. 46. The 100% power MTC, including uncertainties, is within the Technical Specification limits.

3.3 Radial Power Distribution Comparison

Comparisons between the measured (CECOR) and calculated (SIMULATE) radial power distributions at 58%, 75%, and 100% power show that the root mean square values of σ are less than the 3% value required by the Technical Specifications.

3.4 Gross Power Tilt Check

In order to check for gross power tilts, a CECOR flux map was executed at 25% power. Assembly power comparisons of symmetric incore detector locations from the CECOR flux map revealed no evidence of gross power tilt and was well within the test acceptance criteria.

4. CONCLUSIONS

Radial peaking factors and azimuthal power tilts were measured at 58%, 75%, and 100% power and found to be within the Technical Specification limits. MTC measurements showed reasonable agreement with the calculated predictions using SIMULATE. Measurement of acceptable radial peaking factors and a MTC less than the Technical Specification limits demonstrate that the core is operating within the bounds of the safety analysis. Radial power distributions, measured at 58%, 75%, and 100% power exhibit reasonable agreement with those predicted by SIMULATE. The check for gross power tilt at 25% power demonstrated acceptable power distribution symmetry throughout the core. These results provide confirmation of the core design methodology used and demonstrate compliance with the Technical Specifications.

TABLE 1
PHYSICS PARAMETERS MEASURED DURING POWER ASCENSION TESTING PROGRAM

Parameter	Thermal Power (%)	Measured Value	Tech Spec Limit
F_R^T	58.0	1.752	≤1.817
F_{xy}^T	58.0	1.865	≤1.906
T_q^I	58.0	0.012	≤0.10*
T_q^E	58.0	0.017	≤0.10*
F_R^T	74.7	1.737	≤1.817
F_{xy}^T	74.7	1.847	≤1.906
T_q^I	74.7	0.010	≤0.10*
T_q^E	74.7	0.006	≤0.10*
PC	91.9	$-1.44 \times 10^{-4}\ \Delta\rho/\%$ pwr	None
ITC	91.9	$-0.88 \times 10^{-4}\ \Delta\rho/°F$	None
MTC	91.9	$-0.75 \times 10^{-4}\ \Delta\rho/°F$	$-3.5 \times 10^{-4}\ \Delta\rho/°F \le MTC \le +0.2 \times 10^{-4}\ \Delta\rho/°F$
MTC (Extrapolated)	100	$-0.87 \times 10^{-4}\ \Delta\rho/°F$	$-3.5 \times 10^{-4}\ \Delta\rho/°F \le MTC \le +0.2 \times 10^{-4}\ \Delta\rho/°F$
F_R^T	99.8	1.699	≤1.732
F_{xy}^T	99.8	1.778	≤1.816
T_q^I	99.8	0.012	≤0.10*
T_q^E	99.8	0.003	≤0.10*

* BASSS operable