DUKE POWER COMPANY
OCONEE NUCLEAR STATION
UNIT 1

STARTUP PHYSICS TEST PROGRAM

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The Startup Physics Test Program for Oconee Nuclear Station is structured to provide assurance that the installed reactor core conforms to the design core. This document provides the minimum test program which will be conducted on each Oconee unit. Additional tests may be performed during a specific startup test program as conditions warrant. However in all cases, the following tests will be performed:

1. Pre-critical Test Phase
   a. Rod Drop Time

2. Zero-Power Physics Test Phase
   a. Critical Boron Concentration
   b. Moderator Temperature Coefficient
   c. Control Rod Worth
   d. Core Symmetry

3. Power Escalation Test Phase
   a. 40% Power Distribution
   b. 100% Power Distribution

In addition to the above tests, which comprise the basic Startup Physics Test Program, a separate test, the reactivity anomaly check, is performed approximately each 10 EFPD, during steady-state operation, at equilibrium conditions pursuant to Technical Specification 4.10. This procedure is used to verify that the measured all-rods-out hot full power critical boron concentration is in agreement with the predicted value. The test conditions, procedure descriptions, acceptance criteria and review requirements for each of the above are provided in this document.

For all of these tests, specific acceptance criteria are provided. Upon completion of each test, the results are reviewed by a designated individual. If the results meet the specific acceptance criteria, then the test is considered to be satisfactorily completed. However, if the results exceed the specific acceptance criteria, an extensive review is performed by cognizant engineers from within Duke Power or from outside organizations, as appropriate, to identify and correct the cause of the discrepancy. Continuation of the test program, including any power escalations, will be dependent upon satisfacotry resolution of any unacceptable test result. The on-site Technical Review Committee will approve actions under the conditions stated for each test.

ROD DROP TIME

CONDITIONS:

HSD, 532°F, 2155 psig, full reactor coolant flow.

PROCEDURE:

The rod drop time for each full-length control rod assembly (CRA) to fall from the fully withdrawn position to the 75% inserted position is measured. The plant process computer is used to record the time interval between initiation and termination of the event. The test may be performed either by dropping all full-length CRA's simultaneously from the fully withdrawn position, or by dropping one full length CRA group at a time and measuring the drop times for each individual group. In either case, the computer records the drop time of each CRA individually.

The accuracy of the measurement of rod drop time is performed by the computer is approximately ± 0.005 sec.

The results are reviewed by the Test Coordinator and compared with the acceptance criteria, 1.60 sec.

FOLLOW UP ACTIONS:

If any rod drop time exceeds 1.66 sec., then the results will be reviewed by cognizant design engineers to determine the appropriate corrective actions and the actions specified by Technical Specifications 3.5 and 4.7 will be taken.

If any measured rod drop time is greater than the acceptance criteria, then the results will be reviewed by cognizant design engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed prior to 100% FP.

CRITICAL BORON CONCENTRATION

CONDITIONS:

HZP, 532^{o}F, 2155 psig, full reactor coolant flow.

PROCEDURE:

Critical boron concentration measurement is taken at the "all-rods-out" configuration.

The "all-rods-out" critical boron concentration is measured by borating the Reactor Coolant System to achieve a just-critical condition with control rod Groups 1-6 fully withdrawn, Group 7 as close as practical to fully withdrawn and Group 8 at the nominal design position. The boron concentration in the Reactor Coolant System is then allowed to come to equilibrium, and a sample is taken and analyzed to determine the critical boron concentration. Since it is not practical to establish equilibrium critical conditions with Group 7 fully withdrawn, the small amount of inserted worth of Group 7 is measured by withdrawing the group and measuring its worth by use of the reactivity calculator. This reactivity value is then used to adjust the boron concentration to obtain the measured all-rods-out boron concentration.

The uncertainty associated with these measurements is less than 20 ppm B.

The results are reviewed by the Test Coordinator and compared with the predicted boron concentrations. If the difference between the measured and predicted values does not exceed 50 ppm B, the results are acceptable.

FOLLOW UP ACTIONS:

If the difference between measured and predicted critical boron concentration is greater than 100 ppm B, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results and recommended actions approved by the on-site Technical Review Committee prior to exceeding 5% FP.

If the acceptance criteria is not met, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results and recommended corrective actions approved by the Technical Review Committee prior to 100% FP.

MODERATOR TEMPERATURE COEFFICIENT

CONDITIONS:

HZP, 532^{o}F, 2155 psig, full reactor coolant flow.

PROCEDURE:

The moderator temperature coefficient (MTC) test begins with the reactor at equilibrium critical conditions. The test is performed by executing a change in reactor coolant average temperature of either plus or minus 5 degrees and establishing the reactor at the upper or lower temperature plateau while data is taken. The change in reactivity associated with this maneuver is compensated for by control rod movement. After data is taken at the first temperature plateau, reactor coolant temperature is changed to the opposite plateau, either 5 degrees above or below the nominal average coolant temperature, by executing a 10^{o}F temperature ramp from the first plateau to the second. Changes in reactivity associated with this temperature transient from the first or second temperature plateaus are recorded by the reactivity calculation. The overall temperature coefficient is then calculated by dividing the change in reactivity between the first and second temperature plateaus by the change in temperature between the first and second temperature plateaus. This overall temperature coefficient is corrected for the contribution of the isothermal doppler coefficient of reactivity to give the moderator coefficient of reactivity.

The Reactor Coolant System's average temperature values are obtained by taking the average of hot and cold leg RTD readings. The hold time at each temperature plateau during the test is approximately five minutes.

The measurement uncertainty associated with this measured value varies as a function of the magnitude of the temperature coefficient itself. In all cases within or near the acceptable range of temperature coefficient values, the error is less than $\pm$ 6.0 x 10^{-6} $\Delta k/k/^{o}F$.

The results are reviewed by the Test Coordinator and compared with the predicted MTC. If the difference between the measured and predicted values does not exceed 0.3 x 10^{-4} $\Delta k/k/^{o}F$, then the results are acceptable.

FOLLOW UP ACTIONS:

If the measured maximum positive MTC exceeds 0.5 x 10^{-4} $\Delta k/k/^{o}F$, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results and recommended actions approved by the on-site Technical Review Committee prior to exceeding 5% FP.

If the acceptance criteria is exceeded, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results as well as recommended corrective actions approved by the on-site Technical Review Committee prior to 100% FP.

CONTROL ROD WORTH

CONDITIONS:

HZP, 532°F, 2155 psig, full reactor coolant flow.

PROCEDURE:

The measurements of regulating group rod worths begin from a critical steady state condition with all regulating groups withdrawn as far as possible (i.e. Group 7 between 93% and 100% withdrawn). From this point a boron concentration necessary to deborate control rod Groups 7 and 6 to 0% withdrawn and Group 5 to approximately 10% withdrawn is calculated. The deboration is commenced, and chemistry sampling is initiated on a thirty minute frequency. The resulting reactivity change during deboration is compensated for by discrete insertion of control rods in steps of approximately 600 μρ with these reactivity insertions being recorded by the reactimiter calculation. Differential rod worths for these insertions are then calculated by dividing the difference in reactivity for each insertion by the difference in control rod position, and integral worths are calculated by summing the differential worths for each group.

The results are reviewed by the Test Coordinator and compared with the predicted group worths. If the difference between the measured and predicted individual rod group worths does not exceed 15%, and the difference between the measured and predicted total worth of rod Groups 5, 6 and 7 does not exceed 10%, then the results are acceptable.

FOLLOW UP ACTIONS:

If the difference between the measured and predicted total worth of rod groups exceeds 10%, then, following calculation of the minimum rod position for which the worth of the control rods withdrawn would equal 1% ΔK/k, additional rod group worths will be measured. The worths of safety rod groups will be measured in sequence from Group 4 to Group 1, until either the difference between the measured and predicted total worth of all rod groups measured does not exceed 10%, or the minimum rod position calculated above is reached in which case additional testing will be performed. The results will be reviewed by cognizant engineers to determine the appropriate additional corrective actions required to resolve the discrepancy. This review will be completed and the results as well as the recommended actions approved by the on-site Technical Review Committee prior to exceeding 5% FP.

If the difference between the measured and predicted individual rod groups worths exceeds 15%, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy.

CORE SYMMETRY

CONDITIONS:

HZP, 532^{o}F, 2155 psig, full reactor coolant flow.

PROCEDURE:

The core symmetry check is performed with a minimum of four symmetric control rod assemblies (CRA's). One CRA is swapping against Group 5, and the worth is determined by observing the required motion of Group 5. The rods are then restored to their original positions, in order to verify that no significant reactivity changes have occurred. The procedure is repeated for each of the other CRA's. The measured worths for each individual CRA are then averaged and the individual values compared to the average value to obtain an indication of core symmetry at zero power.

The deviation between individual CRA worth and average CRA worth is calculated as follows:

$$\% \text{ Deviation} = \frac{\begin{pmatrix}\text{Average worth of} \\ \text{symmetric set}\end{pmatrix} - \begin{pmatrix}\text{Individual} \\ \text{CRA worth}\end{pmatrix}}{\begin{pmatrix}\text{Average worth of} \\ \text{symmetric set}\end{pmatrix}} \times 100$$

The results are reviewed by the Test Coordinator and if the deviation for each individual rod does not exceed 20%, then the results are acceptable.

FOLLOW UP ACTIONS:

If any individual CRA worth exceeds the average CRA worth by 35%, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the recommended actions approved by the on-site Technical Review Committee prior to exceeding 5% FP.

If the acceptance criteria is exceeded, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results and recommended corrective actions approved by the on-site Technical Review Committee prior to 100% FP.

40% POWER DISTRIBUTION

CONDITIONS:

40% FP, 580^{o}F, 2155 psig, full reactor coolant flow.

PROCEDURE:

Once the unit has attained 40% FP, the output of the plant process computer reactor calculations program is analyzed. This program processes the signals from fixed incore detectors and provides a relative core power distribution as output. The incore detector outputs are checked, in order to identify malfunctioning detectors. After these have been eliminated, the radial and total peaking factors obtained from the process computer are compared with the values calculated as a part of the reload design process on an eight-core basis. For those eight-core locations which have more than one symmetric instrumented location, instrument signals are averaged for comparison with design peaking values.

Independent of this comparison with design values, the measured core power distribution values are used to calculate maximum linear heat rate valves for comparison with Technical Specification limits. No averaging is performed, so that the limiting valve will come from the highest individual detector output for the entire core. This output is adjusted for axial local peaking, radial local peaking, hot channel factor, nuclear uncertainty and power uncertainty. This adjusted value is then used for comparison with the specified limits.

The measurement uncertainty for radial peak is less than 5% and for a total peak is less than 7.5%. The uncertainties are taken care of in the case of the maximum linear heat rate comparison by the application of adjustment factors to conservatively account for the individual sources of error, so that the result which is compared against Technical Specification Power limits is a conservatively high value.

The results are reviewed by the Test Coordinator. If the highest measured radial peaking factor does not exceed the highest predicted radial peaking factor by more than 8.0% of the highest measured radial peaking factor, and if the highest measured total peaking factor does not exceed the highest predicted total peaking factor by more than 12% of the highest measured total peaking factor and if such peaks occur in one of the three highest predicted locations then the results are acceptable.

If any observed parameter exceeds its specified value in the Technical Specifications, actions will be taken as required by the Technical Specifications.

FOLLOW UP ACTIONS:

If the adjusted maximum linear heat rate value exceeds the LOCA limiting heat rate specified in the Technical Specifications, reactor power will be reduced to a power level such that the adjusted maximum linear heat rate value is less than the specified value. The results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the recommended action approved by the on-site Technical Review Committee prior to any further escalation of power.

If the acceptance criteria is exceeded, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the results and recommended corrective actions approved by the on-site Technical Review Committee prior to 100% FP.

100% POWER DISTRIBUTION

CONDITIONS:

100% FP, 580°F, 2155 psig, full reactor coolant flow.

PROCEDURE:

Once the unit has stabilized at 100% FP, the output of the plant process computer reactor calculation program is analyzed. This program processes the signals from fixed incore detectors and provided a relative core power distribution as output. The incore detector outputs are checked, in order to identify malfunctioning detectors. After these have been eliminated, the radial and total peaking factors obtained from the process computer are compared with the values calculated as part of the reload design process on an eight-core basis. For those eight-core locations which have more than one symmetric instrumented location, instrument signals are averaged for comparison with design peaking values.

Independent of this comparison with design values, the measured core power distribution values are used to calculate maximum linear heat rate values for comparison with Technical Specification limits. No averaging is performed, so that the limiting value will come from the highest individual detector output for the entire core. This output is adjusted for axial local peaking, radial local peaking, hot channel factor, nuclear uncertainty and power uncertainty. This adjusted value is then used for comparison with the specified limits.

The measurement uncertainty for radial peak is less than 5% and for total peak is less than 7.5%. The uncertainties are taken care of in the case of the maximum linear heat rate comparison by the application of adjustment factors to conservatively account for the individual sources of error, so that the result which is compared against Technical Specification power limits is a conservatively high value.

The results are reviewed by the Test Coordinator. If the highest measured radial peaking factor does not exceed the highest predicted radial peaking factor by more than 5.0% of the highest measured radial peaking factor, and if the highest measured total peaking factor does not exceed the highest predicted total peaking factor by more than 7.5% of the highest measured total peaking factor and if such peaks occur in one of the three highest predicted locations, then the results are acceptable.

If any observed parameter exceeds its specified values in the Technical Specifications, actions will be taken as required by the Technical Specifications.

FOLLOW UP ACTIONS:

If the adjusted maximum linear heat rate value exceeds the LOCA limiting heat rate specified in the Technical Specifications, reactor power will be reduced to a power level such that the adjusted maximum linear heat rate value is less than the specified value. The results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy. This review will be completed and the recommended actions approved by the on-site Technical Review Committee prior to any further escalation of power.

If the acceptance criteria is exceeded, the results will be reviewed by cognizant engineers to determine the appropriate corrective actions required to resolve the discrepancy.. This review will be completed and the results and recommended corrective actions approved by the on-site Technical Review Committee prior to 100% FP.

REACTIVITY ANOMALY

CONDITIONS:

HFP, 580°F, 2155 psig, full reactor coolant flow.

PROCEDURE:

As a part of the periodic testing program and separate from the startup testing program, the all rods out critical boron concentration at power is checked against normalized predicted values approximately each 10 EFPD of steady-state operation. With the reactor at steady-state conditions, as near as practical to full-power rods out conditions, a sample of reactor coolant is taken and analyzed for boron concentration. This value of boron concentration is then adjusted to account for the reactivity worth of regulating rods in the core at the time of the measurement, and any other minor variations from design conditions.

The results are reviewed on-site by the cognizant Performance Engineer and are compared with the normalized predicted all-rods-out boron concentration for the time in the cycle at which the measurement was taken. If the difference between the measured and predicted values does not exceed 50 ppm the results are acceptable.

FOLLOW UP ACTIONS:

If the difference between measured and predicted all-rods-out boron concentration is greater than 100 ppm B, then the results will be reviewed by cognizant engineers to determine the approproate corrective actions required to resolve the discrepancy pursuant to Technical Specification 4.10.