13.10 REFUELING TEST PROGRAM

This section presents a general description of the testing currently performed following each refueling outage at Browns Ferry. The tests described in this section are similar to those in Section 13.5, Startup and Power Test Program. Some of the initial startup tests need only be performed once in a plant's lifetime and are therefore not repeated. Due to the plant surveillance program, improved maintenance method, and greater operational experience, several of the tests were deleted or modified. Currently tests described in Sections 13.10.2.1 through 13.10.2.6 are performed each cycle. Other tests are often performed since they provide an efficient method of controlling and scheduling activities during the startup. These include tests described in Sections 13.10.2.7 through 13.10.2.10.

13.10.1 Program Description and Objectives

The tests comprising the Refueling Test Program are conducted to demonstrate that overall plant or system performance is acceptable based on established design criteria and/or is consistent with previous operating history. The Refueling Test Program may be broadly divided into three phases:

Phase I : Open Vessel,
Phase II : Heat-up to 55% power,
Phase III : 55% Power to 100% power

Some individual tests are more restrictive and specify the power level at which they must be performed while others are equally valid for more than one phase.

13.10.2 Test Purpose, Description, and Acceptance Criteria

13.10.2.1 Fuel Loading

Purpose

This test safely and efficiently loads fuel to full core size.

Description

Two types of core reload are possible. One is a complete core unload, where all fuel bundles are removed from the core during unloading and the other is an in-core shuffle where spent fuel is expelled, reusable fuel is relocated and fresh fuel is loaded. After loading, a core verification is performed to ensure proper loading configuration.

Criteria

The core must be altered to exactly reflect the final design configuration while maintaining subcriticality.

13.10.2.2 Full Core Shutdown Margin

Purpose

This test verifies that the reactor will remain subcritical throughout the cycle with any single control rod withdrawn and all other control rods fully inserted.

Description

After core loading is complete, the shutdown margin (SDM) is demonstrated to be at least 0.38 percent $\Delta K/K$ throughout the upcoming cycle with the analytically determined strongest rod withdrawn. SDM is calculated by evaluating core reactivity after achieving criticality. The actual amount of rods withdrawn are compared to the predicted amount to verify that 0.38 percent $\Delta K/K$ or better margin is available. An open vessel SDM demonstration can be performed by pulling rods equivalent to 0.38 percent Δ K/K (plus the worth of the strongest rod) and proving subcriticality.

Acceptance Criteria

Level 1: The SDM of the fully loaded core must be calculated to remain at least 0.38 percent $\Delta K/K$, with the analytically determined strongest rod fully withdrawn, at any point in the upcoming cycle.

Level 2: Criticality should occur within ± 1 percent ΔK of the predicted critical rod configuration.

13.10.2.3 Control Rod Drive System

Purpose

This test demonstrates that the CRD system is operating properly and is capable of meeting its normal and emergency functions.

Description

This test is separated into the testing done at zero psig and the testing done at greater than 800 psig. Following maintenance on a control rod, that rod is functionally checked by stroking it to full length. While the rod is being stroked, a visual check of the RPIS position indication is made; and, upon reaching the end of travel the coupling is checked for over travel. After fuel loading is finished, the functional/position indication check and the coupling check are performed for each rod. Additionally, friction testing is performed as a diagnostic tool on suspected problem rods. Sometime after reaching rated pressure but before 40 percent power, all CRD's are scram timed and the LPRM hookup to the process computer is verified by observing LPRM response to control rod motion.

Acceptance Criteria

Level 1

1. Each CRD must have a normal withdraw speed of less than or equal to 3.6 inches per second, indicated by a full 12-foot stroke time of no less than 40 seconds.

2. The control rod scram insertion times must be within the limiting conditions for operations specified in Technical Specifications.

Level 2

1. Each CRD must have a nominal insert or withdraw speed of 3.0 $\pm$ .6 inches per second, indicated by a full 12-foot stroke time between 40 and 60 seconds.

2. With response to the control rod drive friction tests, if the differential pressure variation exceeds 15 psid for a continuous drive in, a settling test may be performed, in which case, the differential settling pressure should not be less than 30 psid nor should it vary by more than 10 psid over a full stroke.

3. Proper LPRM connections shall be verified and adjustments made to provide proper inputs to the process computer.

13.10.2.4 Process Computer

Purpose

This test verifies the capability of the process computer to monitor plant conditions and to evaluate core performance parameters.

Description

Phase I

Following completion of the Cycle NSSS data installation the NSSS data will be verified for accuracy and proper location in the computer memory.

Phase II

1. After reaching 10 percent power but before reaching 23 percent power, the core thermal power calculated by the process computer will be compared to a detailed manual heat balance.

2. The thermal limits for minimum critical power ratio (MCPR), maximum average planar linear heat generation rate (MAPLHGR), and maximum linear heat generation rate (LHGR) are compared to a qualified backup method.

Phase III

The testing done for Phase II.2 is repeated after calibrating the LPRMs.

<u>Criteria</u>

Level 1

Not applicable.

Level 2

Core Monitoring Software System (CMSS) core performance monitoring is considered operational when:

1. The location and value of the MCPR as calculated by the process computer are in the same location and within 2 percent of the MCPR as determined by any offline computer system qualified; or,

2. If the MCPR, as determined by the process computer, is in a different location than that determined by any offline computer system qualified, the values calculated for CPR by the two methods shall agree to within 2 percent for each fuel assembly.

13.10.2.5 <u>Core Power Distributions</u>

<u>Purpose</u>

This test confirms the reproducibility of the TIP system readings, determines the core power distribution and checks the core power symmetry.

Description

The core must be in an octant symmetric rod pattern to perform these tests.

For Global Nuclear Fuel Analyzed Cores: At least two full TIP sets will be run in order to measure the TIP uncertainty. The data from these TIP sets will be compared statistically to determine total TIP uncertainty. At the beginning of each operating cycle, TIP set data is used to calibrate the LPRMs prior to reaching 100 percent power (performed separately from Refueling Test Program). This activity also satisfies Technical Specifications Surveillance Requirement 3.3.1.1.7. In addition, TIP data and CMSS data taken after TIP sets will be analyzed to determine TIP asymmetry and core power symmetry. One of the TIP sets must be taken at > 75 percent power level and it is recommended that neither TIP set be taken below 50 percent power.

For Framatome-ANP Analyzed Cores: The radial bundle power uncertainty is a key component of the MCPR Safety Limit methodology. A TIP asymmetry test is performed at startup to confirm that the actual integral TIP response uncertainties are consistent with expected internal TIP uncertainties. The test performed is the Chi-Squared test for Symmetric Integral TIP Measurements described in EMF-2508, “POWERPLEX®-III Core Monitoring Software System - Operational Comparison Test Procedure.” Failure of the test does not necessarily indicate a lack of consistency but is cause for further investigation and may require a repeat of the test.

Acceptance Criteria

Level 1

Not applicable.

Level 2

For GNF Analyzed Cores:

1. The total TIP uncertainty shall be less than 6.0 percent. This total TIP uncertainty will be obtained by averaging the total uncertainty for all data sets obtained. A minimum of two data sets is sufficient for determination of the total TIP uncertainty. The 6.0 percent represents the limiting uncertainty for which the present MCPR safety limit is valid. If this 6.0 percent uncertainty is exceeded, a detailed analysis will be made and possibly additional data sets will be taken.

2. The gross check of the TIP signal symmetry should yield a maximum deviation between symmetrically located pairs of less than 25 percent. If this criterion cannot be met, the cause of the asymmetry should be investigated.

For FANP Analyzed Cores:

1. The acceptance criteria are dependent upon the available number of symmetric TIP pairs. For a full set of TIPs, there are 19 pairs. The Chi-squared value for 19 pairs of TIPs should be less than 36.19.

2. For tests with fewer symmetric TIP pairs equivalent criteria are defined in EMF-2508.

13.10.2.6 APRM Calibration

Purpose

This test calibrates the Average Power Range Monitor System. The test is only applicable below the power level of Technical Specification Surveillance Requirement 3.3.1.1.2.

Description

Before there is sufficient feedwater flow to obtain an accurate heat balance, the APRMs are calibrated to a core thermal power determined either by a constant heatup rate balance or by a bypass valve comparison. APRMs will be calibrated using a heat balance after feedwater flow becomes reliable.

Criteria

Level 1

(Units 2 and 3)
At least three of the four APRMs must be calibrated to read greater than or equal to the actual thermal power.

(Unit 1 only)
At least two APRMs in each RPS channel must be calibrated to read greater than or equal to the actual thermal power.

Level 2

If the level 1 criterion is satisfied, then the APRM channels are considered to be reading accurately if they do not read more than 7 percent greater than the actual core thermal power.

13.10.2.7 Pressure Regulation

Purpose

This test demonstrates: (a) smooth pressure control during transients induced in pressure by the pressure control system, and (b) smooth pressure control transition between control valves and bypass valves. These tests will be performed in both Reactor Pressure control and Header Pressure control to ensure expected control response in either mode.

Description

A pressure setpoint bias will be introduced (both increased and decreased) to produce step changes in pressure and the response of the system will be measured. These tests will be performed.

1) Off-line to test bypass valve ability to control the transient.

2) On-line with control valve position limit set so that control valves alone with control the transients.

3) On-line with control valve position limit set to test bypass valve capability to handle the excess transients.

Criteria

Level 1

The decay ratio must be less than 1.0 for each process variable that exhibits oscillatory response to pressure control system changes.

Level 2

1. In all tests, the decay ratio is expected to be ≤ 0.25 for each process variable that exhibits oscillatory response to pressure control system changes when the plant is operating above the lower limit of the master flow controller.

2. Pressure control deadband, delay, etc., shall be small enough that steady state limit cycles, if any, shall produce variations in turbine steam flow no larger than those specified in the following table.

Percent of Full Power	Percent of Rated Flow
90 - 100	± 0.5
70 - 90	± 1.5 to ± 0.5
70 and below	± 1.5

3. Following each pressure setpoint bias change (2 to 10 psi), the time between the setpoint bias change and the occurrence of the pressure peak shall be 10 seconds or less. The peak neutron flux and peak vessel pressure should remain below scram setting by 7.5 percent and 10 psi, respectively for pressure setpoint changes ≤ 5 psid.

13.10.2.8 Feedwater System

Purpose

This test demonstrates that the components of the feedwater control system satisfactorily control reactor water level.

Description

To provide an observable feedwater system and reactor response, two methods are used to initiate test disturbances. The first is to change the input level setpoint about 4 to 6 inches. The second is to change one pump flow approximately 10 percent in the manual mode. The remaining pumps are in automatic mode to control reactor water level. Both one element and three element modes of level control will be tested. Tests are to be performed between 55 percent and 70 percent of rated power.

Acceptance Criteria

Level 1

The decay ratio must be less than 1 for each process variable that exhibits oscillatory response to feedwater system changes.

Level 2

1. The decay ratio of an oscillatory control loop mode must be ≤ 0.25 for each process variable that exhibits oscillatory response to feedwater system changes where the unit is operating above the lower limit setting of the master flow controller.

2. The transient response of each feedwater pump to a 10 percent flow demand input change, as measured by the turbine speed and flow recorder outputs shall be as follows:

a. Time to 10 percent of demand should be 1.1 seconds and must be less than or equal to 2.2 seconds.

b. Time from 10 percent to 90 percent of demand should be 1.9 seconds and must be less than or equal to 2.5 seconds.

c. Settling time to within ± 5 percent of the final value should be 14 seconds.

d. Peak overshoot should be equal to or less than 15 percent of demand.

13.10.2.9 Recirculation Motor-Generator (M-G) Set Control

Purpose

This test demonstrates that the recirculation speed control system can satisfactorily perform its function by comparing transient test results against system criteria.

Description

Pre-heatup tests are performed to test individual components and make other preparations for the tests at power. Once the unit has reached the 100 percent rated core flow point, several small step changes to M-G set speed will be made and applicable data recorded.

Acceptance Criteria

Level 1

The decay ratio must be less than 1.0 for each process variable that exhibits oscillatory response to recirculation system changes.

Level 2

When the unit is operating above the lower limit of the master manual limiter, the decay ratio of any oscillatory control loop mode must be ≤ 0.25 for each process variable that exhibits oscillatory response to recirculation system changes.

13.10.2.10 Drywell Atmosphere Cooling System

Purpose

This test verifies the ability of the drywell atmosphere cooling system to maintain design conditions in the drywell during operating conditions.

Description

The drywell atmosphere cooling system will be placed in operation and its ability to maintain normal operating temperatures inside the drywell is verified. For this test, 8 of 10 fans (and associated coils) are on, thereby demonstrating ≥ 25 percent standby heat removal capability.

Acceptance Criteria

Level 1

Not applicable.

Level 2

1. Deleted.

2. Deleted.

3. The drywell cooling system shall maintain the bulk volumetric average temperature in the drywell below design values during normal operation.