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AN OPTIMIZED FFTF ACCEPTANCE
TEST PROGRAM COVERING
PHASES III, IV, & V

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AN OPTIMIZED FFTF ACCEPTANCE TEST PROGRAM
COVERING PHASES III, IV, AND V

MARCH 1977

Report by
FTTF Project

HANFORD ENGINEERING DEVELOPMENT LABORATORY
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SECTION I

INTRODUCTION AND SUMMARY

A detailed review of Phases III, IV, and V, of the FFTF Acceptance Test Program has been completed. The purpose of this review was to formulate that test sequence which not only meets requirements for safe, reliable and useful operation of the plant, but also results in the earliest prudent demonstration of full-power performance. A test sequence based on the underlying assumption that sodium flows into the secondary sodium storage tank (T-44) no later than August 31, 1978 is described in detail in Section II. A time-scale which allows extra time to put systems and equipment into operation the first time, debugging, and learning how to operate most effectively has been superimposed on the test sequence. Time is not included for major equipment malfunctions.

This test plan provides the basis for coordinating the many and varied activities and interfaces necessary for successful and timely execution of the FFTF Acceptance Test Program. In this report, the need dates have been identified for presently scheduled test articles and standard core components. Requirements for delivery of fuel assemblies to the FFTF Site have been formulated. Requirements for safeguards and security in the 400 Area have been assessed, and the test plan meets those requirements of the Safeguards and Security Plan for the 400 Area. Release points during the test program for both HEDL and ERDA review are shown. This ATP is the plan that the FFTF Project will use to guide future activities in Phases III, IV, and V. It shows that initial criticality will be achieved by August, 1979, with a full-power demonstration run occurring by October, 1979. Detailed schedules for turnover of plant systems and subsystems to support this plan, including a critical path schedule with resource requirements, will be made by separate correspondence.

This test plan is the culmination of many months of effort to optimize the ATP so as to achieve full power at the earliest possible date consistent with requirements for safety and reliability. Earlier steps in the evolution of this program raised a number of substantive issues. This program provides resolution to the open items as detailed in Section II.K of this report.

In the first stages of this present review, a variety of alternate test sequences were examined including complete dry loading of the core, partial dry loading, complete wet loading of the core early in the test sequence and partial early wet loading. After

extensive review it became clear that none of these schemes contributed toward the objective of early full power demonstration while having an adverse impact on construction and testing activities. The HEDL position is that the test sequence defined in this report is optimum for achieving the objectives for startup and initial operation of the FFTF plant.

During this review, a number of possible alternates to the fuel loading portion of the ATP were examined. However, the number of viable alternates is dependent upon both the requirements for filtration of the primary sodium and the necessity of providing the greatest potential to the project of achieving full flow in the primary system at the earliest date. From present information available on the SCA performance, it is not possible to rule out the contingency that the SCA's will accumulate sufficient debris from the primary sodium system to result in loss of full flow capability.

This loss of full flow could occur in two distinctly different ways. Full flow capability through the SCA's could be lost during the first few minutes or hours of sodium flow, or flow capability could be gradually reduced over a period of many days or weeks. In the former case, the system would have to be cleaned so that the full flow tests could be carried out. In the latter case, depending on the specific indications of change in flow rates and pressure drops, either the non-nuclear tests could be completed at some reduced flow rates and temperatures, or the system could be judged to require further cleaning.

At the present time, available measurements and tests on the FFTF filters, and from other reactor startups, do not establish confidence that the SCA's will permit the required full sodium flow throughout the course of the non-nuclear test program. Accordingly, FFTF Engineering has embarked on a limited series of tests designed to provide additional data needed for evaluation of filter performance under FFTF startup conditions. From these results and concurrent studies of time and resources required to change or modify the present SCA's FFTF Engineering will recommend, through separate correspondence, a course of action for treatment of the SCA's before and during the test program. The recommendation will consider both (1) leaving the SCA's in place, and (2) modifying or replacing the SCA's in order to achieve the necessary cleaning of the system with an acceptable impact on the test program.

The ATP calls for completion of the non-nuclear tests and establishment of required safety systems prior to loading fuel into the reactor vessel.

The plan for handling fuel assemblies and other core components during the initial core loading process utilizes the basic fuel handling equipment, but omits the need for the Bottom Loading Transfer Cask (BLTC). Additionally, special grapple/crane handling procedures may be used for early through-the-head transfers involving PIOTA's and Closed Loop Jumper Assemblies (CLJA) at times when

radiation streaming is not a consideration. The first planned need for the IEM cell is to handle the Low Power Characterizer assemblies after irradiation in the reactor, shortly after the first power demonstration run has been completed. Unforeseen radioactive repair or maintenance could also require use of the IEM cell.

The alternate fuel loading schemes that were considered--and subsequently discarded--are briefly described in Appendix 1.

SECTION II.A

FFTF ACCEPTANCE TEST PROGRAM

SUMMARY OF TEST OPERATIONS BY TEST PERIODS

<u>Test Period</u>	<u>Time Estimate (Shifts)</u>	<u>Tests Performed</u>
1	360	Fill all sodium systems.
2	6	Heat plant from 350 to 400 ⁰ F.
3	30	Sodium flow tests at 400 ⁰ F - non-nuclear.
4	120	Install control rods and test refueling system.
5	30	Test control rod drive systems.
6	48	Heat plant to maximum isothermal system temperature (MIST).
7	36	Functional tests at MIST - non-nuclear.
8	33	Cooldown to 400 ⁰ F and plant testing at 400 ⁰ F.
9	48	Thermal cycling of sodium systems, DHX heat loss measurements and flowmeter calibrations by pulsed-neutron technique.
10	30	Natural circulation tests on HTS secondary.
11	120	Inspect welds on sodium piping and prepare plant for power operation. Load non-fueled core components and FOTA's.
12	180	Core loading, initial criticality, final core adjustments and preliminary low power reactivity measurements.
13	63	Conduct very low power and low power (active) reactor characterizations using IRT.
14	12	Remove In-Reactor Thimble.
15	6	Zero power testing - prepare for power operation.
16	39	Ascent to 100% power and 48 hour demonstration run.
17	6	Power descent and testing under shutdown conditions.

<u>Test Period</u>	<u>Time Estimate (Shifts)</u>	<u>Tests Performed</u>
18	20	Reactor Characterization - low power. Install and irradiate.
19	20	Remove characterizers, install gas tag capsules and no-flow assemblies (NFA).
20	51	Changeout low power characterizers in IEM cell and install high power characterizers and conduct tests.
20A	6*	Conduct non-nuclear tests.
20B	25*	Natural circulation test - steady state.
20C	20*	Reactivity assessments following full power demonstration run.
21	33	Conduct 8-day irradiation at full power for characterization and plant tests.
22	25	Final core adjustment and plant repairs.
23	58	Finish test program - <ul style="list-style-type: none"> • Drain verification • Natural circulation - scrams • Two loop operation • Operation in isolated DHX
24	15	Install CLIRA's
25	90	Nuclear test program on Closed Loops
26	8	Install Materials Open Test Assembly (MOTA)
<hr/>		
TOTAL	1487	(16.5 months) from first sodium in plant to end of Acceptance Test Program
	1155	(12.8 months) to first full power operation.

NOTE: During the ATP, three shifts/day and seven days/week are assumed.

* These times are included in the time span for T-20.

SECTION II. B

ACCEPTANCE TEST PROGRAM

TEST INDEX

<u>Test Number</u>	<u>Test Title</u>	<u>Test Periods</u>
32-2A094	Reactor Equipment Surveillance and In-Service Inspection at 400° F	T-1, 11
31-3A004	LLFM Test with Sodium in Reactor	T-4, 7
31-3A005	Vibration Testing of Reactor Components	T-3, 4, 6, 7
31-3A006	Nuclear Control System Functional Test	T-5, 7, 8
31-3A007	Flow Mapping at Reactor Core Outlet	T-3, 6, 7, 15, 20A
31-3A008	Calibration of LLFM and Special Flux Monitoring Equipment	T-11
41-3A012	IVHM Functional Testing in Sodium	T-3, 4
41-3B013	IDS Operational Test	T-1 through 8
41-3C014	Sodium Removal Station	As available by T-19
41-3B015	Fuel Handling System Operational Check in Sodium	T-4
51-3A018	HTS Natural Circulation Test	T-10
00-3A021	Sodium Fill and Initial Circulation of Primary Systems (Includes IDS)	T-1
00-3A022	Sodium Fill and Initial Circulation of Secondary Systems	T-1
00-3A023	Plant Operation at Refueling Temperature (400° F)	T-2, 3, 4, 5, 8, 10, 11
00-3A024	Plant Heatup and Cooldown	T-6, 8, 9,
51-3A025	Primary HTS Drain Verification	T-1, 11, 23
00-3A026	Plant Operation at Maximum Isothermal System Temperature	T-7
81-3B037	IDS, Primary Sodium Storage and NaK/IDS Systems Hot Functional Test	T-1 through 8
81-3C039	Fill and Initial Circulation of NaK Systems	T-1

<u>Test Number</u>	<u>Test Title</u>	<u>Test Periods</u>
82-3C044	Nitrogen System	T-11
85-3C045	Sodium Sampling and Monitoring System	T-1 through 8
51-3A050	HTS Dimensional Survey	T-3, 7
00-3C053	Auxiliary Heat Removal System Performance and Balancing Test	T-1 through 9
00-3A055	Effects of Plant Noise on Instrument Performance	T-4
00-3C056	Overall Systems Response to Loss of BPA and 300 Area Electrical Power	T-8
31-3A060	Instrument Tree Functional Test in Sodium	T-4
90-3A063	Reactor Plant Control System Operational Test with Sodium	T-3
41-3B065	Grid Spaced Fuel Pin Removal	As available
51-3A066	Primary and Secondary HTS Inspection	T-11
94-3B071	Fuel Failure Monitoring In-Core Gas Release Test	T-20A
31-4A001	Initial Fuel Loading, First Criticality and Low Power Reactivity Measurements	T-12, 20C
00-5C001	Auxiliary Heat Removal System Performance and Rebalance Test	T-16, 21
31-5A002	Neutron Spectra, Reaction Rates and Gamma Heating Measurements at High Power	T-12, 13, 18, 20, 21
31-5A003	Power Coefficient Measurement	T-16
31-5A004	Measurement of Reactor Stability	T-16
51-5A008	HTS Natural Circulation Tests	T-20B, 23
90-5A015	Reactor Plant Control System Operational Test	T-16
00-5A019	Reactor Power Scram Tests	T-16, 21
00-5A020	Power Ascension and Operation	T-13 through 16 and 18 thru 26

<u>Test Number</u>	<u>Test Title</u>	<u>Test Periods</u>
00-5A023	Reactivity Surveillance Procedure Calibration Checks	T-16
00-5B024	Airborne Noise Measurement	T-21
00-5B025	Shielding Surveys	T-12, 16, 21, 25
00-5A026	Power Descent and Plant Shutdown	T-17
00-5A027	Checkout of Two-Loop Operation	T-23
00-5A028	Operation with Isolated DHX Module	T-23
31-5A029	Vibration Testing of Reactor Components	T-15, 16
61-5B101	Initial CLS Startup and Performance Verification	T-25
61-5B103	Primary Closed Loop System Failure Evaluation	T-25
61-5B105	DHX Closed Loop System Failure Evaluation	T-25
61-5B106	Closed Loop System Power Failure Evaluation	T-25

SECTION II.C

TEST PERIOD T-1

Purpose: Fill all sodium and NaK systems.

Time Estimate: 360 Shifts

Plant Control: Systems inerted and preheated to 350° F (Phase II tests 2C069 and 2A095)

Tests Conducted:

- 00-3A021 - Sodium Fill and Initial Circulation of Primary Systems (Includes IDS)
- 00-3A022 - Sodium Fill and Initial Circulation of Secondary Systems
- 32-2A094 - Reactor Equipment Surveillance and In-Service Inspection at 400° F
- 51-2A098 - HTS Dimensional Survey at 400° F with No Sodium
- 51-3A025-1 - Primary HTS Drain Verification
- Core Component Handling Event 2
 - Remove Argon Inlet Assemblies
 - Install VOTA, IRT, and ICSA plus a PIOTA

Concurrent Tests:

- 00-3C053 - Auxiliary Heat Removal System Performance and Balancing Tests

This test starts as preheat of the plant is initiated and continues through Test Period T-9 as heat loads in the plant are changed.
- 41-3B013 - IDS Operational Test

This mechanical test of the IDS core basket mechanism should be conducted concurrently with the IDS hot functional tests (3B037) at appropriate test conditions. Complete this test by T-8.
- 81-3B037 - IDS and NaK/IDS System Hot Functional Test

Conduct these hot functional tests on a time-available basis during the period T-1 through T-8. Coordinate with Test 3B013.

85-3C045 - Sodium Sampling and Monitoring System

This test starts during T-1 and continues through T-8, testing System 85 under all plant conditions established during the Phase III Acceptance Test Program.

Test Sequence:

1. Prerequisite - 81-3C039 - Fill and Initial Circulation of NaK Systems must be completed prior to starting preheat of the interfacing sodium systems, and should be completed before start of Test Period T-1.
2. Preheat and fill sodium systems. This operation is to be conducted sequentially, starting with T-44 generally proceeding as follows:
 - Secondary Process Loop #3
 - Secondary Loop #3
 - The other two secondary loops and their process loops
 - T-43
 - IDS and its auxiliary systems
 - T-42
 - Primary process loops
 - Reactor vessel and one primary loop
 - The other two primary loops
3. Conduct dimensional surveys of HTS system per T-2A098 after systems are preheated to 400° F, but before filling with sodium. Systems are to be cooled to 350° F for sodium fill. Do these tests sequentially as sections of the system are ready, and in the order needed to support Step 2 above.
4. Conduct SISI test per T-2A094 after the reactor vessel is preheated. This test should work around other activities in this Test Period.
5. Demonstrate primary loop drain initiation per TS-3A025-1 (Paragraph 2.1) at appropriate time during fill of the primary system.
6. Conduct concurrent tests (3C053, 3B013, 3B037, and 3C045) as required.
7. At the conclusion of this test period, all liquid metal systems should be filled and circulating at 350° F. The main systems should be on Pony Motor flow.

Comments:

1. The primary side of the IHX's must be inerted prior to filling of the interfacing secondary system with sodium.
2. If system turnover dates on the primary systems are delayed, it may be possible to complete sodium flow tests on the secondary loop during this Test Period and get an early start on the time-consuming secondary filter removal operations.
3. Sodium fill and hot functional tests of the sodium systems is conducted with air in the primary heat transport system cells (rather than nitrogen). An initial safety assessment supports this plan. However, HEDL will continue to study the plant safety aspects of this plan in greater detail. It may prove necessary to inert some of the cells for part of the test program, requiring additional time for inerting and deinerting.

TEST PERIOD T-2

Purpose: Heat Primary and Secondary Sodium Systems to 400° F.

Time Estimate: 6 Shifts

Plant Control:

00-3A023 - Plant Operation at Refueling Temperature

System Temperature: 350-400° F Isothermal

System Flow: Pony Motors

Tests Conducted:

00-3A023 - Plant Operation at Refueling Temperature

Concurrent Tests:

85-3C045 - Sodium Sampling and Monitoring System -
T-1 through T-8

41-3B013 - IDS Operational Test - T-1 through T-8.

00-3C053 - Auxiliary Heat Removal System Performance and
Balancing Test T-1 through T-9.

81-3B037 - IDS and IDS/NaK System Hot Functional Test -
T-1 through T-8

Test Sequence:

1. Conduct Paragraph 2.1 of TS-00-3A023 to heat plant from 350 to 400° F.
2. Conduct concurrent tests (3C045, 3B013, 3B037, and 3C053) as required.

TEST PERIOD T-3

Purpose: Sodium flow tests at 400° F. Initial startup of main sodium pumps.

Time Estimate: 30 Shifts

Plant Control:

00-3A023 - Plant Operation at Refueling Temperature

System Temperature: 400° F

System Flow: PM to 100 percent

Tests Conducted:

00-3A023 - Plant Operation at Refueling Temperature

- Ascent to 100 percent sodium flow rate - 50 rpm steps
- 24-hour run at full flow for system degas and pump run-in
- Pump coastdowns
- Starts/stops - check valve operation
- Operation of primary and secondary system isolation valves

31-3A005-1 - Vibration Testing of Reactor Components
Baseline information taken at appropriate plant conditions.

31-3A007-1 - Flow Mapping at Reactor Core Outlet
Baseline data taken at appropriate plant conditions and monitor performance of primary filters.

41-3A012-1 - IVHM Functional Testing in Sodium
Part 1 - Levelness tests

51-3A050-1 - HTS Dimensional Survey
Part 1 - Tests after sodium fill at 400° F

90-3A063 - Reactor Plant Control System Operational Test in Sodium

Concurrent Tests:

- 41-3B013 - IDS Operational Test - T-1 through T-8.
- 85-3C045 - Sodium Sampling and Monitoring - T-1 through T-8.
- 00-3C053 - Auxiliary Heat Removal System - T-1 through T-9.
- 81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8.

Test Sequence:

1. Establish plant conditions with all pumps running at minimum control speed (about 50%).
2. Increase pump speed in 50 rpm increments per T-3A023.
3. Conduct pump control tests per T-90-3A063 at appropriate plant conditions.
4. Record data for vibration tests (3A005) and the flow mapping tests (3A007) at flow rates as established by the Test Specifications.
5. Complete the levelness tests of the three In-Vessel Handling Machines per T-41-3A012.
6. Conduct dimensional survey per T-3A050-1 throughout T-3, can carry over into T-4 if necessary.
7. Conduct concurrent tests (3B013, 3B037, 3C045 and 3C053) as required.

Comments:

During this test, particulate burden in the primary system will collect in the temporary filters installed in the simulated core assemblies (SCA). This will cause the flow impedance of the filters to increase. The pressure drop across the clean SCA's is about 130 psi at rated operating conditions. An increase of about 15 psi will require that pump speed be reduced in order to stay within the permissible operating range of the pumps.

Data from SEFOR and FERMI indicate that the filters may acquire a burden sufficient to prevent further operation of the system at 100 percent flow rate, which would prevent continuation of the non-nuclear test program. Through a separate study, a strategy will be developed to cope with this concern.

TEST PERIOD T-4

Purpose: Install Control Rods and Test Refueling System

Time Estimate: 120 Shifts

Plant Control:

00-3A023-3 - Plant Operation at Refueling Temperature

System Temperature: 400° F Isothermal

System Flow: Pony Motors

Tests Conducted:

31-3A004-1 - LLFM Test with Sodium in Reactor

31-3A005-2 - Vibration Testing of Reactor Components

41-3A012-2 - IVHM Functional Testing in Sodium

41-3B015 - Fuel Handling System Operational Check in Sodium

00-3A055 - Effects of Plant Noise on Instrument Performance

31-3A060 - Instrument Tree Functional Test in Sodium

Core Component Handling Event 3

- Install all nine control rods

Concurrent Tests:

85-3C045 - Sodium Sampling and Monitoring - T-1 through T-8

00-3C053 - Auxiliary Heat Removal System - T-1 through T-9

41-3B013 - IDS Operational Test - T-1 through T-8.

81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8.

Secondary Filters - Start removal of filters in all three secondary systems. Complete by end of T-5.

Test Sequence:

1. Shift reactor plant into refueling mode performing requisite tests on IVHM and the IT per T-41-3A012-2 and T-31-3A060.

2. Conduct vibration test with the Instrument Tree parked per T-31-3A005-2.
3. Install all nine control rods, completing requirements of T-41-3B015.
4. Complete T-00-3A055, Effects of Plant Noise on Instrument Performance, at appropriate times as the fuel handling equipment is operated for other tests.
5. Conduct T-31-3A004-1, LLFM Test with Sodium in Reactor, during this Test Period as conditions permit. LLFM-2, which has vibration sensors installed, should be tested during T-11.
6. Park the IVHM's, move the instrument trees over the core, and connect the control rods.
7. Conduct tests on IDS per 3B013 and 3B037 as time permits.

Comments:

Installation of the three control rods in the first sector and one in each of the other sectors constitutes the test of the fuel handling system per 41-3B015.

This test sequence allows over 7 weeks for the removal of the secondary filters concurrent with "main-line" test program activities. This should permit the filter removal operation to be conducted without delay to the test program.

TEST PERIOD T-5

Purpose: Test Control Rod Drive Systems

Time Estimate: 30 Shifts

Plant Control:

00-3A023-4 - Plant Operation at Refueling Temperature

Temperature: 400° F Isothermal

Flow Rate: Pony Motor to 100 percent

Tests Conducted:

31-3A006-1 - Nuclear Control System Functional Test

Concurrent Tests:

85-3C045 - Sodium Sampling and Monitoring - T-1 through T-8

00-3C053 - Auxiliary Heat Removal System - T-1 through T-9

41-3B013 - IDS Operational Test - T-1 through T-8

81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8

Secondary Filters - Removal from system - T-4 through T-5

Test Sequence:

1. Conduct tests of control rod systems per TS-31-3A006-1.
2. Conduct tests on IDS systems per 3B013 and 3B037 as time permits.

TEST PERIOD T-6

Purpose: Heat-up to Maximum Isothermal System Temperature (MIST) (MIST is defined as 800° F or the temperature at which the plant heatup rate drops to 1° F per hour, whichever is lower).

Time Estimate: 48 Shifts

Plant Control:

00-3A024-1 - Plant Heatup and Cooldown

Temperature: 400° F to MIST

Flow rate: Pony Motor to 100 percent

Tests Conducted:

00-3A024-1 - Plant Heatup and Cooldown
Paragraph 2.1, IHX Support Flange Heatup
2.2, Initial Heatup to MIST

31-3A005-3 - Vibration Tests

31-3A007-2 - Flow Mapping

Concurrent Tests:

85-3C045 - Sodium Sampling and Monitoring - T-1 through T-8

00-3C053 - Auxiliary Heat Removal System - T-1 through T-9

41-3B013 - IDS Operational Test - T-1 through T-8.

81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8

Test Sequence:

1. Heatup plant to MIST and conduct tests per TS-00-3A024-1, Paragraph 2.1 and 2.2.
2. Conduct tests on sodium sampling system per TS-85-3C045 as required during heatup of plant.
3. Conduct tests on the auxiliary heat removal system per TS-00-3C053 as required during plant heatup.

4. Conduct vibration tests per 31-3A005.
5. Conduct tests on IDS systems per 3B013 and 3B037 as time permits.
6. Conduct flow mapping tests per 3A007 to monitor performance of SCA filters.

TEST PERIOD T-7

Purpose: Functional Tests at Maximum Isothermal System Temperature (MIST)

Time Estimate: 36 Shifts

Plant Control:

00-3A026-1 - Plant Operation at Maximum Isothermal System Temperature

Temperature: MIST

Flow Rate: 0 to 100 percent

Tests Conducted:

31-3A004-2 - LLFM Test with Sodium in Reactor

31-3A005-4 - Vibration Testing of Reactor Components

31-3A007-3 - Flow Mapping at Reactor Core Outlet

31-3A006-3 - Nuclear Control System Functional Test

00-3A026 - Plant Operation at MIST

- 100 hour soak
- Pump coastdown tests

51-3A050-2 - HTS Dimensional Survey

Concurrent Tests:

85-3C045. - Sodium Sampling and Monitoring - T-1 through T-8

00-3C053 - Auxiliary Heat Removal System - T-1 through T-9

41-3B013 - IDS Operational Test - T-1 through T-8

81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8

Test Sequence:

1. Conduct 100-hour soak at MIST

2. Conduct dimensional survey per T-51-3A050-2 including:
 - Measurements of pipe movement
 - Observations for interferences
 - Observations of thermal insulation to look for gaps and hot spots.

Start these observations during Step 1 and continue as required.

3. Conduct Control Rod System Tests per T-31-3A006-3 concurrent with Step 1.
4. Conduct test of LLFM drive system per T-31-3A004-2 concurrent with Step 1.
5. Conduct flow mapping tests per T-31-3A005-4 and vibration tests per T-31-3A007-2 concurrently at conclusion of Step 1.
6. Conduct pump coastdown tests per T-00-3A026-1.
7. Conduct tests of sodium sampling system per T-85-3C045 as required.
8. Conduct tests of heat removal system per T-00-3C053 as required.
9. Conduct tests on IDS systems per 3B013 and 3B037 as time permits.

TEST PERIOD T-8

Purpose: Cooldown to 400° F and Plant Testing at 400° F.

Time Estimate: 33 Shifts

Plant Control:

00-3A023-5 - Plant Operation at Refueling Temperature

Temperature: MIST to 400° F

Flow Rate: 0 to 100 percent

Tests Conducted:

00-3A024-2 - Plant Heatup and Cooldown

31-3A006-3 - Nuclear Control System Functional Test

00-3A023-5 - Plant Operation at Refueling Temperature

- Pump coastdown tests

00-3C056 - Overall System Response to Loss to BPA and 300 Area Electrical Power.

Concurrent Tests:

41-3B013 - IDS Operational Test - T-1 through T-8

81-3B037 - IDS and NaK/IDS Hot Functional Test - T-1 through T-8

00-3C053 - Auxiliary Heat Removal System - T-1 through T-9

85-3C045 - Sodium Sampling and Monitoring - T-1 through T-8

Test Sequence:

1. Cool plant from MIST to 400° F per T-00-3A024-2.
2. Conduct tests of nuclear control system per T-31-3A006-3.
3. Conduct pump coastdown tests per T-00-3A023-5.
4. Conduct Loss-of-Electrical-Power Test per T-00-3C056.
5. Conduct tests of heat removal systems per T-00-3C053 as required.
6. Conduct tests of IDS systems per 3B013 and 3B037 as time permits.

TEST PERIOD T-9

Purpose: Thermal cycle the plant - two heatups and two cooldowns. Conduct DHX heat loss tests and pulsed-neutron flowmeter calibrations.

Time Estimate: 48 Shifts

Plant Control:

00-3A024-3 - Plant Heatup and Cooldown

Temperature: 400° F to MIST

Flow Rate: 0 to 100 percent

Tests Conducted:

00-3A024-3 - Plant Heatup and Cooldown

- Heatup and cooldown cycles
- Integrity test (pressurization)
- DHX heat loss tests at 400, 500, and 600° F
- Flowmeter calibrations by pulsed-neutron flowmeter
 - Primary - 400, 615, 700° F and reverse flow at 400° F.
 - Secondary - 400, 515, and 615° F

Concurrent Tests:

00-3C053 - Auxiliary Heat Removal System T-1 through T-9

Test Sequence:

1. Heat plant to MIST.
2. Cool system to 700° F.
3. Calibrate all primary and secondary flowmeters by pulsed-neutron technique.
4. Cool system to 615° F.
5. Calibrate primary and secondary flowmeters by P/N technique.
6. Cool system to 515° F.
7. Calibrate secondary flowmeters by P/N technique.

8. Cool plant to 400⁰ F.
9. Calibrate primary and secondary flowmeters by P/N technique, include reverse flow on primary flowmeters.
10. Measure DHX heat loss at 400⁰ F.
11. Heat plant to 500⁰ F.
12. Measure DHX heat loss at 500⁰ F.
13. Heat plant to 600⁰ F.
14. Measure DHX heat loss at 600⁰ F.
15. Heat plant to MIST.
16. Pressurize primary system per T-00-3A024 for integrity test.
17. Cool plant to 400⁰ F.

○ Step in Test Sequence

TEST PERIOD T-10

Purpose: Perform natural circulation test of secondary system

Time Estimate: 30 Shifts

Plant Control:

00-3A023-6 - Plant Control at Refueling Temperature

Temperature: 400 - 600⁰ F

Flow Rate: 0 to 100 percent

Tests Conducted:

51-3A018 - HTS Natural Circulation Tests

Concurrent Tests:

None

Test Sequence:

Conduct natural circulation tests per T-51-3A018. Complete all tests.

TEST PERIOD T-11

Purpose: Inspect welds in sodium systems and prepare plant for power operation

Time Estimate: 120 Shifts

Plant Control:

00-3A023-7 - Plant Operation at Refueling Temperature

Temperature: 400° F

Flow Rate: Pony Motor

Tests Conducted:

32-2A094-2 - Reactor Equipment Surveillance and In-Service Inspection at 400° F.

82-3C044 - Nitrogen System

51-3A066 - Primary and Secondary HTS Inspection

00-3A025 - Primary HTS Drain Verification

31-3A008 - Calibration of LLFM and Special Flux Monitoring Equipment

Core Component Handling Event 4

- Core Loading, Non-fueled components and FOTA's

Concurrent Tests:

Prepare plant for power operation:

- Remove vibration sensors from LLFM-2 and IT-2, and install normal instrumentation
- Install and seal all floor plugs
- Start readiness review for power operation - continue through T-14
- Repair plant deficiencies - continue through T-14 if needed.

Test Sequence:

1. Remove insulation and inspect selected welds on sodium systems per T-51-3A066. Restore insulation. This test should be completed as early as possible in order that inerting of the HTS cells can be initiated.
2. Conduct SISI inspections per T-32-2A094-2 concurrently with Step 1.
3. Install and seal floor plugs and inert cells per T-82-3C044 as soon as activities in Steps 1 and 2 permit.
4. Calibrate LLFM's per 31-3A008 and make ready for core loading.
5. Install Startup Chambers in IRT and make ready for core loading.
6. Start readiness review for power operation. Continue through T-14.
7. Repair plant deficiencies concurrent with other activities. Continue through T-14 if necessary.
8. Complete testing requirements of TS-3A025, (1) Circulation at Minimum Safe Level and (2) Primary Loop Syphon Break Demonstration. These tests should be conducted concurrently with the weld inspections in Step 1.
9. Shift plant into refueling mode (all 3 sectors) and load non-fueled core components and FOTA's, Event 4.

Comments:

The tests identified in Step 8 above cannot be conducted with meaningful results until after the systems have been operated at high flowrates to remove all gas pockets from the system. The tests can be conducted in T-11 concurrently with the weld inspections, without extending the test time and without jeopardizing the plant.

TEST PERIOD T-12

Purpose: Core Loading, Initial Criticality, Final Core Adjustments and Preliminary Low Power Reactivity Measurements.

Time Estimate: 180 Shifts

Plant Control:

31-4A001-1 - Initial Fuel Loading, First Criticality and Low Power Reactivity Measurements

Temperature: 400° F

Flow Rate: Pony Motor

Tests Conducted:

31-4A001-1 - Initial Fuel Loading, First Criticality and Low Power Reactivity Measurements, Paragraphs 2.1, Core Loading Plan, and 2.2., Reactivity Assessments Preceding the Full Power Demonstration Run.

31-5A002 - Reactor Characterization, Paragraph 2.1.1, Compton-Recoil Gamma Spectrometry, Paragraph 2.1.2, Proton-Recoil Neutron Spectrometry

00-5B025 - Shielding Surveys

Core Component Handling Event 4

- Core Loading

Test Sequence:

1. Load reactor core by tri-sectors per Core Loading Plan, TS-31-4A001, Paragraph 2.1.
2. Establish criticality per Core Loading Plan, TS-31-4A001, Paragraph 2.1.
3. Remove startup chambers from IRT and install instrumentation for Compton-Recoil Gamma Spectrometry.
4. Complete core loading to final configuration for full power operation (except that IRT must be removed later), per Core Loading Plan, TS-31-4A001, Paragraph 2.1.

5. Conduct characterization measurements per T-31-5A002 concurrently with Step 4.
 - Paragraph 2.1.1, Compton Recoil Gamma Spectrometry
 - Paragraph 2.1.2, Proton Recoil Neutron Spectrometry
6. Reinstall startup chambers in the IRT.
7. Complete reactivity assessments per T-31-4A001, Paragraph 2.2, Reactivity Assessments Preceding Full Power Demonstration Run.

Comments:

1. Start of fuel loading is a formal release point for both ERDA and HEDL.

TEST PERIOD T-13

Purpose: Conduct Very Low Power and Low Power (active) reactor characterizations.

Time Estimate: 63 Shifts (see Comment)

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400° Isothermal

Flow Rate: PM to 75 percent

Tests Conducted:

31-5A002 - Reactor Characterizations
Paragraph 2.1.3, ⁶Li Neutron Spectroscopy
Paragraph 2.1.4, TLD Irradiations
Paragraph 2.1.5, Passive Neutron Spectrum Measurements
Paragraph 2.1.6, Absolute Fission Rates
Paragraph 2.1.7, Axial Fission Rate Traverses
Paragraph 2.1.8, Gamma Ion-Chamber and Calorimetric Traverse
Paragraph 2.2.1, Low Power Irradiation insert in IRT

Concurrent Tests:

Readiness Review for power operation, T-11 through T-14

Repair plant deficiencies, T-11 through T-14 as needed.

Test Sequence:

1. Establish conditions for tests per 00-5A020.
2. Conduct VLP experiments per T-31-5A002, Paragraph 2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7, and 2.1.8.
3. Conduct the LP active experiment per T-31-5A002 Paragraph 2.2.1. Plant flow rate should be 75 percent for this test (four mw reactor power).
4. Remove all instrumentation from the IRT.

Comment:

50% contingency was added

TEST PERIOD T-14

Purpose: Remove In-Reactor Thimble (IRT)

Time Estimate: 12 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation. Operate at refueling condition per PN-07.

Temperature: 400° Isothermal

Flow Rate: Pony Motor

Tests Conducted:

No tests.

- Core Component Handling Event 5
- Remove IRT
- Install in-core shim (installed in IVS during Event 4)
- Install Closed Loop Jumper Assembly (CLJA)

Concurrent Tests:

Readiness Review for power operation, T-11 through T-14

Repair plant deficiencies, T-11 through T-14 as needed

Test Sequence:

N/A

TEST PERIOD T-15

Purpose: Zero Power Testing

Time Estimate: 6 Shifts

Plant Control:

00-5A020 - Power Ascension and Reactor Operation

Temperature: 400° F Isothermal

Flow Rate: Pony Motor to 100 percent (or zero flow to 100 percent)

Tests Conducted:

00-5A020 - Establish and Maintain Plant Conditions for Tests

31-5A029 - Vibration Testing of Reactor Components
Vibration measurement - three-loop operation at
400° F - core subcritical

31-3A007 - Flow Mapping at Reactor Core Outlet - Final flow
mapping on actual core configuration for power operation

Concurrent Tests:

None

Test Sequence:

1. Establish initial conditions for test per T-00-5A020.
2. Take zero flow reference point for vibration test and flow mapping.
3. Increase pump speed and take data per T-00-5A020. Concurrently, complete requirements for vibration tests (5A029) and flow mapping (3A007) as required flow rates are established.
4. Complete preoperational requirements of T-00-5A020.
5. Return plant to 400° F at pony motor flow and proceed to power operation in T-16.

Comments:

The following recommendations still apply:

1. Thermal equilibrium of pump motor bearing temperatures, seal/bearing lubricant temperature, and rheostat electrolyte temperatures shall be established and full data taken only at the following major hold points: PM, 50 percent, 75 percent, and 100 percent of design flow rate. This is consistent with requirements for the vibration tests.
2. Delete the requirement to establish equilibrium HTS cell temperature from this test. This would be redundant with Phase 3 tests. The potential problems with HTS cell temperature will be uncovered in the ascension to power (T-16).
3. Raise pump flow in 5 percent increments. At all points other than those in Paragraph 1 above, hold only briefly (15 minutes), recording limited data such as flow and pressure and noting any usual operating conditions.

TEST PERIOD T-16

Purpose: Raise system to power standby condition (515° F); increase power to 100 percent, conducting tests at specified hold points; conduct 48-hour demonstration run at full power; conduct system tests under operating conditions.

Time Estimate: 39 Shifts (33 Shifts to full power)

Plant Control:

00-5A020 - Power ascension and operation

Temperature: 400° F Isothermal

Power - Cold Leg = 400 to 680° F

Hot Leg = 400 to 938° F

Flow Rate: Pony Motor to 100 percent

Tests Conducted:

00-5A020 - PN-01 Precritical checkout
PN-02 Increase to power standby condition (515° F)
PN-03 Increase power level to 100 percent

- Reactor plant performance data
- Calorimetric tests and adjustments
- In-core flow and temperature distribution

00-5C001 - H&V Balancing Test

31-5A003 - Power Coefficient Measurement

31-5A004 - Measurement of Reactor Stability

90-5A015 - Reactor Plant Control System Operational Test

00-5A019 - Reactor Power Scram Tests

00-5A023 - Reactivity Surveillance Procedure Calibration Checks

00-5A025 - Shielding Survey

31-5A029 - Vibration Testing of Reactor Components

Concurrent Tests:

None

Test Sequence:

1. Conduct precritical checkout (PN-01). Do as much of this as possible during last part of T-15.
2. Conduct ascent to power standby condition per PN-02.
3. Increase reactor power to 100% per PN-03. Conduct tests as outlined in the test matrix shown below. The power steps should be held as long as required to obtain the required data and to assure that no unusual operating characteristics are occurring. During this first power ascension, a specifically designated task force should review the data taken at each of the major and minor hold points to assure that reactor and plant performance is satisfactory and that reactor power can safely be increased. Formal approval should be given by this task force at each major hold point before continuation of the power ascent.
4. It is recommended that the requirement to take data at the 35 percent hold point be added to 5A015 - Reactor Plant Control System Operational Test. Time should be available to conduct the test and the data is needed for a complete evaluation of plant performance at this major hold point.
5. This ascent to full power and two-day operation at full power constitutes the first useful "irradiation testing" in the FFTF. Therefore, all routine irradiation history record keeping shall be initiated at the beginning of this power ascent.
6. After completion of all required data at the major hold point of 35 percent power, conduct a normal scram per 5A019. While conducting a required test, the operating crew will gain experience with the plant during scram conditions while system temperatures are somewhat below full-power levels.
7. Return plant to 35 percent power as rapidly as possible per normal operating procedure (PI-10 and PN-09).
8. Repeat recording of plant and reactor data at 35 percent power level and proceed with power ascent.
9. Conduct shielding surveys during the power ascent at appropriate times to assure safe operation of the plant, to uncover gross problems and to take corrective actions to protect operating personnel. The final survey and shielding test per 5A025 will be conducted during the 8-day demonstration run in T-21.

10. Throughout the power ascent, sodium system and cover gas chemistry must be monitored carefully, using normal operating procedures. The first power ascension is a critical time as the system becomes conditioned at the higher temperatures. The most interesting periods will be when fuel cladding temperatures approach 900° F (about 75 percent power). It is essential that system chemistry be kept within normal limits, and it may be necessary to hold at some power levels while plugging temperatures are reduced. The first time the system temperature approaches 900° F, chemical changes take place that frequently result in a significantly increased plugging temperature (potentially out of limit); special operating restrictions will be in effect to cope with this situation to avoid either damage to the system or undue delay to the test program.

11. Proceed to T-17 for power descent.

Comments:

A HEDL readiness review will be conducted and a release given before this Test Period can be initiated. Formal ERDA releases are required for (1) start of low power testing and (2) power ascension.

TEST MATRIX - FIRST POWER ASCENT (TEST PERIOD T-15)

	TEST	5	10	15	20	25	30	35	POWER LEVEL - PERCENT											75	80	85	90	95	100
		40	45	50	55	60	65	70																	
REACTOR PLANT PARAMETERS	5A 020	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
CALORIMETRIC TEST & ADJUSTMENT	5A 020		X					X										X		X					
POWER COEFFICIENT	5A 003		X		X		X	X		X		X		X		X		X	X	X					
REACTOR STABILITY	5A 004		X		X		X	X		X		X		X		X		X	X	X					
REACTIVITY SURVEILLANCE PROCEDURE	5A 023		X					X				X		X		X		X	X	X					
IN-CORE FLOW/TEMPERATURE	5A 020		X					X								X				X					
REACTOR PLANT CONTROL	5A 015		X	→ X				X			X					X				X					
VIBRATION TEST	5A 029	X	X					X			X					X		X	X	X					

TEST PERIOD T-17

Purpose: Power descent from 100 percent and testing under shutdown conditions.

Time Estimate: 6 Shifts

Plant Control:

00-5A026 - Power Descent and Plant Shutdown

Temperature: Cold Leg - 680° to 400° F
Hot Leg - 938° to 400° F

Flow Rate: 100 percent to PM

Tests Conducted:

00-5A026 - Power Descent and Plant Shutdown

- Reduce power to 5 percent per PN-05
- Conduct physics tests per PN-05 (Paragraph 4.2.2.5)
- Operate at Hot Standby per PN-08

Test Sequence:

1. Reduce power to 5 percent per PN-05.
2. Perform physics tests per PN-05 through Section E.
3. Perform tests at Hot Standby per PN-08.
4. Cool plant to refueling condition.

Comments:

Summary of tests required by 5A026:

<u>Requirement</u>	<u>Where Done</u>
Power descent, PN-05	T-17
Operation at Hot Standby, PN-08	T-17
Plant operation at refueling cond., PN-07	T-18

TEST PERIOD T-18

Purpose: Low Power (LP) Reactor Characterization - Install and Irradiate Characterizers

Time Estimate: 20 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: Cold Leg = 400° F, Hot Leg = about 404° F

Flow Rate: Pony motors to 75 percent

Tests Conducted:

00-5A020 - Establish and maintain plant operating conditions required for test.

31-5A002 - Reactor Characterization
Conduct LP irradiation of 11 core characterizers.
The following tests from the Reactor Characterization Plan are included in these irradiations:

RCP Para.	3.1.5	Passive Isotopic Fission Rate Distribution
	3.1.6	Fuel Fission Rate Distribution
	3.2	Non-Fission Reaction Rates
	3.3.3.2	Neutron Flux Spectra in Experimental Regions of Core (passive irradiation)
	3.3.3.4	Perturbing Effects of Spectral Sensor Package and Holder
	3.4.3.5	Gamma Dose - Ionization (in IRT)
	3.8	Fission Product Yields
	3.9	Capture-to-Fission Ratio

Core Component Handling Event 6

Test Sequence:

1. Establish refueling condition per PN-07.
2. Install 11 characterizers in core, all in one trisector per TS-5A002. Store the replaced elements in in-vessel storage.
3. Increase flow rate to 75 percent.
4. Conduct modified PN-01 and PN-02 checkouts sufficient to permit operation at the Low Power condition (about 4 MW).

5. Establish required power level (about 4MW) as rapidly as possible and hold for 24 hours. Terminate with manual scram.
6. Establish refueling conditions.

Comments:

The low power irradiation is conducted with a sodium flow rate of 75 percent. This is a change over the recommendation in the Core Characterization Plan which stated that the test should be conducted at pony motor flow. Conducting the test at 75% flow rate will significantly improve temperature control in the main Heat Transport System which will result in a steadier power level for the irradiation.

TEST PERIOD T-19

Purpose: Remove Low Power Characterizers and install gas tag capsules and No Flow Assemblies (NFA's).

Time Estimate: 20 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400° F

Flow Rate: Pony motor

Tests Conducted:

Core component Handling Event 7

- Remove 11 Characterizers
- Install two gas tag capsules in SCA's (for TS-94-3B071)
- Install three No Flow Assemblies (for TS-31-3A007)

Test Sequence:

1. Remove 11 characterizers and replace with original elements from in-vessel storage. Characterizers must immediately go to IEM cell for removal of passive sensors. New passive sensors will be installed and the characterizers will be stored for the High Power Reactor Characterization irradiation in T-21.
2. Install original components from IVS as characterizers are removed except install:
 - Two SCA's containing gas tag capsules per TS-94-3B071
 - Three No Flow Assemblies per TS-31-3A007.
3. Secure core and reactor vessel sufficiently for the non-nuclear operation required for T-20A.

TEST PERIOD T-20

Purpose: Reconstitute characterizers in IEM cell, conduct test on pins in IEM cell, and install high power characterizers in reactor. Conduct tests 20A, 20B, 20C.

Time Estimate: 51 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400° F to 600° F

Flow Rate: Natural circulation to 100 percent

Tests Conducted:

31-5A002 - Reactor Characterization
Remove irradiated pins from LP Characterizers, conduct tests on pins, install HP pins in characterizers.

Core Component Handling Events 8, 9, and 10

Concurrent Tests:

Concurrent with the work in the IEM cell the following Test Periods are conducted:

T-20A - Conduct Non-Nuclear Tests

T-20B - Natural Circulation Tests - Steady State

T-20C - Reactivity Assessments following full-power demonstration run.

Test Sequence:

1. As Low Power Characterizers are transferred to IEM cell:
 - A. Remove top of subassembly
 - B. Remove characterizer pins
 - C. Install new characterizer pins
 - D. Install top of subassembly
 - E. Requalify subassembly for reactor service
 - F. Store in IDS until time for installation in reactor

2. Perform sodium removal operations on pins as required.
3. Conduct tests on individual pins as required.
4. Package pins for shipment to 300 Area.
5. Install the reconstituted characterizers (now High-Power) in the reactor in locations defined in 31-5A002, (See Event 10).
6. Conduct plant repairs or modifications as needed in time available.

TEST PERIOD T-20A

Purpose: Conduct Non-Nuclear Tests

- Gas tag release
- Effects of blocked subassemblies on core flow-meter readings

Time Estimate: 6 Shifts (see Comment 1)

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400 to 600⁰ F

Flow Rate: PM to 100 percent

Tests Conducted:

31-3A007 - Flow Mapping at Reactor Core Outlet

- Effect of blocked subassemblies on core flowmeter readings

94-3B071 - Fuel Failure Monitoring In-Core Gas Release Test

Test Sequence:

1. Conduct flow mapping with NFA's per 3A007.
2. Conduct gas release test per 3B071. This involves heating the plant to about 600⁰ F (non-nuclear). At two selected temperatures solder seals in the gas tag capsules will melt out, releasing Xe-Kr mixtures and exercising the entire fuel failure detection and location system.

Comments:

1. This time is concurrent with the 51 shifts defined for T-20.

TEST PERIOD T-20B

Purpose: Conduct natural circulation tests.

Time Estimate: 25 Shifts (See Comment 1)

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: Cold Leg - 400° to 500° F, Hot Leg = 400° to 758° F

Flow Rate: Natural circulation to PM

Tests Conducted:

51-5A008 - HTS Natural Circulation Tests -
Steady-state natural circulation test only.

Core Component Handling Event 8

Test Sequence:

1. Remove gas-tag capsules and No-Flow assemblies and restore reactor to operational readiness (See Event 8).
2. Conduct the steady-state natural circulation test as defined in Test Specification 5A008. This requires that control circuits, interlocks and limit switches be temporarily modified to permit the reactor plant to operate up to about 10 percent power under pony motor and natural circulation flow rates in both the primary and secondary Heat Transport Systems.
3. Restore Plant Protective System (PPS) to normal.

Comments:

1. This time is concurrent with the 51 Shifts defined for T-20.

TEST PERIOD T-20C

Purpose: Perform reactivity assessments following full power demonstration run.

Time Estimate: 20 Shifts (See Comment 1)

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400⁰ F

Flow rate: Pony motor

Tests Conducted:

31-4A001 - Initial Fuel Loading, First Criticality and Low Power Reactivity Measurements

- Paragraph 2.3, Reactivity Assessments following the Full Power Demonstration Run

Core Component Handling Event 9

Test Sequence:

1. Perform Maximum Primary and Secondary Rod Worth Measurements in a Tilted Flux per TS-4A001, Paragraph 2.3.1.
2. Perform relative worth measurements by subassembly replacement per TS-4A001, Paragraph 2.3.2. These component substitutions are described in Core Component Handling Event 9.
 - A. Insert ICSA in place of an inner driver. Return original component after measurement.
 - B. Insert Peripheral Shim Assembly in place of a radial reflector. Return original component after measurement.
 - C. Insert a Blanket Test Assembly (WB018) in place of a radial reflector (2708). Leave Blanket Test Assembly installed and remove the radial reflector from the reflector vessel.
3. Make secondary bank worth measurements per T-4A001, Paragraph 2.3.3.

Comments:

1. This time is concurrent with the 51 Shifts defined for T-20.

TEST PERIOD T-21

Purpose: Conduct 8-day run at full power to irradiate characterizers and conduct plant tests.

Time Estimate: 33 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: Cold Leg = 400 to 680° F, Hot Leg = 400 to 938° F

Flow Rate: Pony motor to 100 percent

Tests Conducted:

- 00-5A020
 - PN-01 Precritical checkout
 - PN-02 Increase to power standby condition
 - PN-03 Increase power level to 100 percent at maximum rate of increase.
- 31-5A002
 - Reactor Characterization
 - Neutron spectra, reaction rates, and gamma heating measurements
 - High power characterization
- 00-5C001
 - Heating and ventilating system balancing test
- 00-5A019
 - Reactor power scram tests
- 00-5B024
 - Airborne noise survey
- 00-5B025
 - Shielding Survey

Test Sequence:

1. Conduct PN-01, precritical checkout. Do as much of this as possible during the last part of T-20.
2. Conduct ascent to power standby condition per PN-02.
3. Increase power to the 100 percent level at the maximum rate of increase permitted by the normal operating procedure.

4. Record plant performance data per 5A020 and PN-04.
5. Conduct H&V balancing test during heatup and throughout the demonstration run.
6. Conduct the airborne noise surveys at appropriate times throughout the run.
7. Conduct the shielding survey at appropriate times throughout the run. The final surveys should be made during the last four days of the run, after the primary sodium is fully activated.
8. End the run with a normal scram from full power per 5A019.
9. Establish refueling condition.

TEST PERIOD T-22

Purpose: Final core adjustment and plant repairs

Time Estimate: 25 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400° F

Flow Rate: Pony motor.

Tests Conducted:

Core Component Handling Event 11

- Remove 13 High Power Characterizers (maximum speed required)
- Install original components and one new Driver Fuel Assembly
- Install Absorber Open Test Assembly, AOTA, -HA006 in 2610.
- Install Vented B₄C Test Assembly HA003 in 3709.
- Install test assemblies as follows:
 - 1 HEDL Advanced Oxide in Row 4
 - 1 CE Carbide in Row 4
 - 1 HEDL Modified Wire Wrap in Row 5
 - 1 HEDL Modified Wire Wrap in Row 6
 - 2 Highly Enriched Fuel Assemblies (HEFA) in proximity instrumented Row 7.
 - 1 Improved Control Element in Row 5 control rod position.

Test Sequence:

1. Shift plant into refueling mode.
2. Perform transfers as detailed in Event 11.
3. Transform plant to operational mode.
4. Perform any needed plant repairs concurrently with above activities.

TEST PERIOD T-23

Purpose: Complete test program

Time Estimate: 58 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: Cold Leg = 400 to 680⁰ F, Hot Leg = 400 to 938⁰ F

Flow Rate: PM to 100 percent

Tests Conducted:

51-3A025-2 - Primary HTS Drain Verification
Paragraph 2.2, Complete Drain of HTS Primary Loop

51-5A008-2 - HTS Natural Circulation Tests
Scram to natural circulation from:

1. 75 percent power at 75 percent flow
2. 100 percent power at 100 percent flow

00-5A027 - Checkout of Two-Loop Operation
- Include sodium circulation with pumps at operating speed on two loops

00-5A028 - Operation with Isolated DHX Module

Test Sequence:

1. Conduct drain verification test per 3A025-2.
2. Conduct natural circulation scram test from 75% power per 5A018-2.
3. Conduct Isolated DHX Test per 5A028.
4. Conduct two loop operation tests per 5A027.
5. Conduct natural circulation scram test from 100% power per 5A018-2.
6. Return plant to refueling condition.

TEST PERIOD T-24

Purpose: Install two Closed Loop In-Reactor Assemblies (CLIRA)

Time Estimate: 15 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400⁰ F.

Flow Rate: Pony motor

Tests Conducted:

Core Component Handling Event 12

- Install CLIRA's in 3202 and 3406

Test Sequence:

1. Shift plant into refueling mode.- Sector 3.
2. Remove ICSA's and CLJA's from 3202 and 3406.
3. Install CLIRA's.
4. Shift plant to operational mode.

Comment:

If the closed loop systems are not ready to proceed with CLIRA installation and nuclear testing at this point in the test program, the option exists to delay T-24 and T-25 and go directly to T-26.

TEST PERIOD T-25

Purpose: Nuclear Test Program on Closed Loops

Time Estimate: 90 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: Cold Leg = 400 to 680° F, Hot Leg = 400 to 938° F

Flow Rate: Pony motor to 100 percent

Tests Conducted:

61-5B101 - Initial CLS Startup and Performance Verification

61-5B103 - Primary Closed Loop System Failure Evaluation

61-5B105 - DHX Closed Loop System Failure Evaluation

61-5B106 - Closed Loop System Power Failure Evaluation

00-5B025 - Shielding Survey

Test Sequence:

1. Conduct Nuclear Test Program for closed loops in accordance with above listed Test Specifications.

Comments:

The non-nuclear test program on the two closed loops must be completed prior to this Test Period.

The non-nuclear CLS tests should be coordinated with the previously detailed main plant test program so that they can be completed at this point in time with minimum impact on the plant.

TEST PERIOD T-26

Purpose: Install the Materials Open Test Assembly (MOTA)

Time Estimate: 8 Shifts

Plant Control:

00-5A020 - Power Ascension and Operation

Temperature: 400⁰ F

Flow Rate: Pony motor

Tests Conducted:

Core Component Handling Event 13

Test Sequence:

1. Transform plant to refueling mode, Sector 1.
2. Remove ICSA and PIOTA from 1406.
3. Install MOTA in 1406.
4. Transform plant to operational mode.

Comments:

1. The MOTA is to be installed after all testing is completed and plant is ready for steady operation at full power.
2. This completes the Acceptance Test Program.

SECTION II.D

CORE COMPONENT HANDLING EVENTS

FFTF ACCEPTANCE TEST PROGRAM PHASES III, IV, AND V

<u>Event</u>	<u>Phase Test Period</u>	<u>Remove</u>	<u>Install</u>
<u>1. Install Argon Inlet Assemblies (AIA)</u>			
	II	3 SCA - Type II	3 AIA preheat tubes in 1610, 1406, 3202
<u>2. Remove Argon Inlet Assemblies</u>			
	III T-1	3 AIA preheat tubes 1610, 1406, 3202	1 VOTA (XM017) in 1610 1 IRT in 3202 1 ICSA - PIOTA in 1406
<u>Fill all Systems with Sodium - Start Flow</u>			
<u>3. Install Control Rods</u>			
	III T-4	9 SCA - Type I	9 Control Rods
<u>4. Core Loading</u>			
	IV	4 SCA Type II - 1404, 2404, 2202, 3404	4 ICSA in 1404, 2404, 2202, 3404
	T-11, 12 (Start installing non-fueled com- ponents and FOTA's during T-11).	2 Reflector Assemblies 2812, 2901	4 Material Surveillance Assemblies HMO13 - 2812 HMO14 - 2901 HMO15 - IVS HMO16 - IVS
		4 SCA - Type II - PIOTA's 3406, 2610, 1202, 3610	1 ICSA-CLJA - 3406 1 Fixed Absorber - PIOTA - 2610 1 FOTA HF011 - 1202 1 FOTA HF012 - 3610
		71 SCA Type II - (all remaining) 1 PIOTA - 2406	67 Driver Fuel 4 Grid Spaced Drivers GF001 - 2303 GF002 - N507 WF004 - 3301 WF005 - 3508 1 PIOTA - 2406 1 ICSA in CCP-FTP Sector 3 for use in Event 5

<u>Event</u>	<u>Phase Test Period</u>	<u>Remove</u>	<u>Install</u>
			1 W-ARD Blanket Test Assembly, WB018
			1 ICSA
			1 Peripheral Shim Assembly
			The three items above into IVS for later use during T-19 per 4A001.

Complete Non-Nuclear Test Program - Criticality Established

5. Remove In-Reactor Thimble (IRT)

V	1 IRT - 3202	1 ICSA - CLJA - 3202
T-14		Transfer from FTP - See Event 4

First Ascent to Full Power

6. Install Low Power Characterizers

V	6 Driver fuel	11 Characterizers
T-18	1 ICSA - 2404	HF021 - 2101
	4 Reflectors	HF022 - 2304
		HF023 - 2405
	Retain all items	HF024 - 2507
	in IVS for rein-	HF025 - 2606
	sertion to original	HF026 - 2608
	core positions.	HS027 - 2404
		HR028 - 2711
		HR029 - 2707
		HR030 - 2811
		HR031 - 2909

Low Power Irradiation - 4 mw for 24 Hours

7. Remove Characterizers - Install Tests

V	11 Characterizers	11 Original Core Components
T-19		from IVS - See Event 6

<u>Event</u>	<u>Phase/ Test Period</u>	<u>Remove</u>	<u>Install</u>
		2 Driver Fuel - Retain in IVS - positions defined in 3B-071	2 SCA's Containing Gas tag capsules (TP-94-3B071)
		3 Driver fuel (or ICSA) retain in IVS - positions defined in TP-31-3A007	3 No Flow Assemblies - per TP-31-3A007

Conduct Non-Nuclear Tests

8. Remove Tests - Install Original Core Components

V T-20B	2 SCA's containing gas tag capsules - see Event 7.	5 Original Core Components from IVS - See Event 7.
	3 No-Flow Assemblies - see Event 7.	

Conduct Steady State Natural Circulation Tests

9. Reactivity Assessments by Component Substitution

Selected core components are interchanged with the Blanket Test Assembly, ICSA, and Peripheral Shim Assembly from IVS (see Event 4) for comparative reactivity measurements per 31-4A001. Installation of the Blanket Test Assembly is permanent, the other two original components are returned to the core.

V T-20C	1 Radial Reflector - 2708	1 Blanket Test Assembly, WB018 - 2708
	1 ICSA from IVS	
	1 Peripheral Shim from IVS	

Above three items removed from reactor after test.

<u>Event</u>	<u>Phase</u> <u>Test Period</u>	<u>Remove</u>	<u>Install</u>
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10. Install High Power Characterizers

V	6 Driver fuel	13 Characterizers
T-20	1 ICSA - 2404	HF021 - 2101
	4 Reflectors	HF022 - 2201
		HF023 - 2402
	Retain 10 in IVS	HF024 - 2503
	Remove 1 Driver fuel	HF025 - 2506
	for examination	HF026 - 2603
		HS027 - 2404
		HR028 - 2704
		HR029 - 2808
		HR030 - 2804
		HR031 - 2909
		2 in IVS

High Power Irradiation - 100% for 8 Days

11. Remove Characterizers - Adjust Core

V	13 High Power	10 Core Components from
T-22	Characterizers	IVS - return to original
	(two from IVS)	core locations - (see
		Event 9)
	1 Reflector Assembly	1 AOTA - HA006 in 2610
	from 3709	
	2 Reflectors - Row 7	1 Vented B ₄ C Test Assembly
	Proximity Inst.	HA003 in 3709
	position (possibly	4 Test Assemblies
	characterizer position)	
	4 Driver Fuel Assemblies	1 HEDL Advanced
		Oxide Row 4
	1 Control Rod - Row 5	1 CE Carbide Test -
		Row 4
	1 Fixed Absorber and	1 HEDL Modified Wire
	PIOTA - 2610	Wrap - Row 5
		1 HEDL Modified Wire
		Wrap - Row 6
		1 HEDL - Radionuclide Trap
		Test
		2 Highly Enriched Fuel Assemblies
		(HEFA) - in proximity instru-
		mented Row 7 positions
		1 Improved Control Element
		in Row 5 CR Position

<u>Event</u>	<u>Phase/ Test Period</u>	<u>Remove</u>	<u>Install</u>
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Complete Test Program - Main Plant

12. Install Closed Loop In-Reactor Assemblies (CLIRA)

V	2 ICSA - CLJA	2 CLIRA's - 3202, 3406
T-24	3202, 3406	

Complete Nuclear Test Program for Closed Loops

13. Install Materials Open Test Assembly

V	1 ICSA - PIOTA 1406	1 MOTA - 1406
T-26		

End of Acceptance Test Program

SECTION II.E

SECTION II.F

FTR CORE MAP
TEST LOCATIONS

SECTION II.G

FUEL HANDLING STEPS

The fuel handling sequence for the initial core loading reflects a balance between the need to attain full power at the earliest possible time and the requirements for safe, reliable operations which fit into the overall FFTF Acceptance Test Program (ATP). The loading plan utilizes the basic fuel handling equipment, but omits the need for the Bottom Loading Transfer Cask (BLTC) by taking advantage of the fact that the Core Component Pots (CCP) are not yet under sodium. Additionally, since radiation streaming from the core is not a consideration, a special grapple is used to enable the Polar Crane (PC) to remove and replace Post Irradiation Open Test Assembly (PIOTA) stalks as well as insert Closed Loop Jumper Assembly (CLJA) stalks directly into test locations through the Reactor Vessel (RV) head. This departure from the normal fuel handling sequence occurs in only a few locations and minimizes the number of CCP-to-test assembly grapple changeouts of the Closed Loop Ex-Vessel Machine (CLEM). Initial movement of fuel into the Reactor Containment Building (RCB) will commence as soon as the Interim Decay Storage (IDS) tank is sodium filled and ready to receive fuel for hot storage; initial movement of fuel into the RV will commence upon completion of the filtering of the primary plant sodium. The plan provides flexibility to accommodate unforeseen delays in IDS or RV fuel processing by allowing fuel loading directly from the Core Component Conditioning Station - South (CCCS-S) to the RV or loading from CCCS-S into IDS in which conditioned, sodium-wetted fuel assemblies are accumulated until the RV is ready to receive fuel assemblies.

The plant is shifted into the refueling mode two or four separate times. The option to be followed depends on the length of time required to complete primary plant sodium filtering. The refueling periods are described in general terms below:

- A. Upon completion of primary plant inert and preheat operations, the three Argon Inlet Assemblies (AIA) and one outlet assembly are removed and one In-Reactor Thimble (IRT), one non-fuel Vibration Open Test Assembly (VOTA), one In-Core Shim Assembly (ICSA)/PIOTA and one Fuel Transfer Port (FTP) shield plug are inserted.
- B. Install and mechanically test control rods after completion of the flow tests. This is accomplished during plant down time to accommodate secondary loop filter removal.
- C. Install all non-fuel core components and test assemblies plus two Fuel Open Test Assemblies (FOTA).
- D. Load all fuel assemblies through initial criticality and first full power.

The fuel handling sequence for initial core loading is described in more specific detail as developed below:

1. Receive CCP's, core components and test assemblies in RCB via the equipment airlock. Normally, the vehicle used for traffic through the airlock is the Multi-Purpose Rail Transporter (MPRT). It appears that the MPRT will be available for service at the time of core loading, and therefore, should be used. If it should not be serviceable when needed, alternate methods such as pulling a truck through the airlock with an electric vehicle, or even driving the truck through, can be readily improvised.
2. Receipt inspect.
3. Insert a CCP into the CCCS-S, then a core component into the CCP using the polar crane; for test assemblies, attach the grapple adapter and insert into the Test Assembly Conditioning Station (TACS).
4. Inert and preheat.

At this point, a choice is made between two courses of action - either 5, 6, and 7; or 5, 6, 7, 8, 9, and 10, as described below:

- either 5. Inert transfer a CCP containing the core component from CCCS-S to the RV-FTP using CLEM; leave test assemblies in TACS for hot hold or inert storage with subsequent direct transfer between TACS and RV-Test Transfer Port (TTP) using CLEM or a special grapple for PIOTA/CLJA.
- and 6. The In-Vessel Handling Machine (IVHM) removes the core component from the CCP, identifies it, and inserts it into the proper core location; IVHM removes a Simulated Core Assembly (SCA) from the core and inserts it into the waiting CCP.
- and 7. CLEM transfers the sodium filled CCP containing the SCA from the FTP to IDS for storage, then returns to CCCS-S to start the cycle anew.
- or 5. Inert transfer a CCP containing the core component from CCCS-S to IDS for sodium wetting and storage using the Closed Loop Ex-Vessel Machines (CLEM); leave test assemblies in TACS for hot hold or inert storage with subsequent direct transfer between TACS and RV - Test Transfer Port (TTP) using CLEM or a special grapple for PIOTA/CLJA.
- and 6. Repeat sequence until full core loading is in IDS and TACS.
- and 7. When the RV is ready to receive fuel, inert transfer a sodium filled CCP containing a core component from IDS to the RV-FTP, using CLEM.

SECTION II.H

FUEL HANDLING SYSTEMS REQUIRED

All normal fuel handling equipment must be available to support initial full power, with the exception of the BLTC and IEM cell. Additionally, a special grapple which enables the Polar Crane to handle inerted PIOTA's and CLJA's is required, along with a bagging technique to minimize air contact with TACS and RV argon cover gases and the inerted component. Fuel handling equipment required for the initial core loading is listed below:

1. Fuel assembly shipping containers for use between the 308 Building and Reactor Containment Building (RCB) offloading area at FFTF.
2. Test assembly shipping containers for use between the 308 Building and the RCB.
3. A vehicle to transfer fuel (as well as test) assembly shipping containers between the 300 Area storage and 400 Area receiving at the rate of three to four per three-shift working day, depending on whether the fuel assemblies are processed directly into the core or into IDS for interim storage.
4. A separate vehicle to transfer CCP's from storage to the RSB in batches suitable to at least match incoming fuel assembly quantities.
5. RSB overhead 100 ton crane for transferring assemblies.
6. Jib crane, 10 ton, for transferring CCP's and fuel assembly shipping containers from the MPRT to the RCB floor.
7. Polar crane, 20 ton, for transferring AIA's, test assemblies, PIOTA's, CLJA's and the IRT between shipping containers, TACS and RV-TTP; for moving the Plug Handling Fixture (PHF) between the refueling stations and shield plug storage; for transferring CCP's and fuel assemblies from shipping containers to CCCS-S.
8. CLEM for transferring inert/preheated CCP/core components between CCCS-S, IDS, and RV-FTP (using the long grapple); for transferring test assemblies, PIOTA's, CLJA's, AIA's, and IRT between TACS and RV-TTP's (using the short grapple).
9. CCCS-S to inert/preheat CCP/core component combinations. Hot gas flow will be around the outside of the CCP rather than through the fuel assembly.

10. TACS to inert/preheat and store test assemblies, PIOTA's, and CLJA's and one CLEM grapple. CLEM grapple changeout will be accomplished in a modified TACS cell, using a bagging technique.
11. Shield Plug Storage Station No. 1 (SPSS-1) to inert-store refueling shield plugs from CCCS, TACS, IDS and TTP seal plug; Shield Plug Storage Station No. 2 (SPSS-2) to inert-store the FTP shield plugs.
12. Floor Valves (FV) to provide the refueling access seal and shield to IDS, CCCS, TACS, RV-FTP, and RV-TTP ports (quantity five required); FV adapters for IDS, CCCS, and TACS.
13. FTP adapters to provide refueling access to the RV fuel transfer ports (quantity two required).
14. TTP adapter to provide refueling access to the RV test transfer ports (quantity one required).
15. PHF to inert-transfer shield plugs between RV-FTP, IDS, CCCS, TACS, and storage in SPSS-1 and -2.
16. Loop Preparation Equipment (LPE) for securing and opening test assemblies, PIOTA's, CLJA, and IRT; control rod latch/unlatch tooling (including Disassembly Actuating Tools - DAT).
17. Crane grapple NIH-3 for handling core components.
18. Crane grapple NIH-4 for handling CCP's.
19. IDS for storage of SCA's in sodium-filled CCP's from RV and storage of new fuel assemblies in CCP's prior to RV installation.
20. Special loading crane grapple for latching PIOTA's and CLJA's along with necessary bagging to permit an inert removal and transfer between TACS and RV-TTP.
21. Special long loading grapple for latching ICSA's and placement into RV test location upon removal of an AIA.
22. IVHM's to load core (three required).
23. IT's to provide assembly backup holddown and primary sodium flow data (three required).

Core and test components required for initial full power loading are listed below. A total of 105 components are used, with 91 remaining in the core, 2 CLJA's and 3 PIOTA's providing holddown

and 1 blanket, 1 fixed absorber, and 2 material surveillance assemblies going into IVS, with 5 others being removed after use.

1. Three AIA's are used to provide RV inert-preheat and are then removed to TACS for storage.
2. One IRT to provide startup physics data, then removed to TACS for storage.
3. One non-fuel Vibration Open Test Assembly (VOTA) to provide startup sodium flow vibration data.
4. Nine control rods for operational nuclear control.
5. Eight non-fuel ICSA (two are temporarily stored in In-Vessel Storage [IVS]) for later use.
6. Two fixed absorber assemblies (one is temporarily stored in IVS) for nuclear control and testing.
7. One blanket assembly into IVS for future test use.
8. Four material surveillance assemblies (two replace reflector assemblies and two are placed in IVS for long term storage).
9. Three PIOTA's for core component holddown and sodium flow monitoring.
10. Two CLJA's for core component holddown and to allow Closed Loop flow testing bypass.
11. Two FOTA's into test locations for long term testing.
12. Sixty-seven driver fuel assemblies, plus four grid-spaced drivers which provide for two fuel enrichment types and three orifice types.

After first full power, the core characterizers and some test assemblies will be cycled through the RV to complete the ATP.

SECTION II.I

TEST ASSEMBLY NEED DATES

<u>Test Assembly</u>	<u>Site Need Date</u>	<u>Backup Plan</u>
AIA Preheat Tubes	Aug 1978	Must have
VOTA-XM017	Sept 1978	Install ICSA and PIOTA
In-Reactor Thimble (IRT)	Sept 1978	Must have - Could be installed as late as May 1979, but would cause extra handling operations
Closed Loop Jumper Assembly (CLJA)	(1) Apr 1979 (2) Jun 1979	Install PIOTA's - would impact Closed Loop testing
Fueled Open Test Assemblies (FOTA's) - HF-011 and HF-012	Apr 1979	Install Driver fuel plus PIOTA's. FOTA's to be installed when ready Dec 1979 (T-24) or later.
W-ARD Blanket Test Assembly WB-018	Apr 1979	Leave present reflector in place - Install when avail- able - Dec 1979 (T-24) or later.
Material Surveillance Assemblies (MSA) HM-013, 014, 015, 016	Apr 1979	Leave present reflectors in place - Install when avail- able - Dec 1979 (T-24) or later.
Grid Spaced Driver Fuel GF-001, GF-002, WF-004, WF-005	May 1979	Install during core loading if available - if not, install driver fuel. GSDA's can be installed when available Dec 1979 (T-24) or later.
Characterizer Assemblies*	Aug 1979	Delay Reactor Characterization program - will not be able to obtain data on relatively clean core.
SCA's (2) with Gas Tag Capsules (Test 3B071)	Aug 1979	Reschedule test
No Flow Assemblies	Aug 1979	Now available

<u>Test Assembly</u>	<u>Site Need Date</u>	<u>Backup Plan</u>
Absorber Open Test Assembly (AOTA) - HA006	Nov 1979	Leave fixed absorber (2610) in place until AOTA is ready - Install AOTA when available.
Vented B ₄ C Assembly HA-003	Nov 1979	Leave present reflector (3709) in place until assembly is ready - reschedule insertion date.
<u>Test Assemblies</u> HEDL Advance Oxide CE Carbide HEDL Modified Wire Wrap (2) Highly Enriched Fuel Assemblies (2) Improved Control Element	Nov 1979	Leave present core component in place - reschedule insertion of new test assembly
CLIRA's (2)	Nov 1979	Leave present component in place. Reschedule insertion of CLIRA. Delay nuclear testing of Closed Loop Systems.
Material Open Test Assembly (MOTA)	Dec 1979	Leave ICSA in position 1408. Reschedule insertion of MOTA.

*Shipping containers for core characterizers are required on this date. 13 containers are required to be used for low power, then recycled for use with high power characterizer sensor pins.

SECTION II.J

RELEASE POINTS

Release points have been identified both by HEDL and by ERDA. These release points are enumerated below:

HEDL

The HEDL Safeguards Subcouncil has formulated a plan of action whose key element is a review of the readiness to proceed with each of four major events. A judgment concerning readiness will be made by the subcouncil prior to each event, and this judgment will be recorded in a Readiness Memorandum. The four major events are:

1. Start of sodium fill procedure;
2. Initial fuel loading and criticality;
3. Initial high power operation;
4. Beneficial irradiation testing.

Further, the HEDL Safety Analysis Department is chartered to make concurrent and independent reviews of readiness. The Safety Analysis release points are the same as those cited above.

ERDA

ERDA has identified the following five hold points of the FFTF Startup Sequence. Concurrence is required to proceed beyond these points. The hold points are enumerated below:

1. Start of Preheat - FFTFPO internal Readiness Review;
2. Start of Sodium Fill - ERDA Approval;
3. Initial Fuel Load - ERDA Approval and Operating Authorization;
4. Low Power Testing - FFTFPO internal Readiness Review;
5. Power Ascension - FFTFPO internal Readiness Review.

The Operating Authorization noted above is a formal HEDL request to FFTFPO for this authorization, whose final approval is granted by the Assistant Administrator for Nuclear Energy.

RESOLUTION OF OPEN ITEMS

The Acceptance Test Program, as presented in this report, reflects many months of effort to develop a test program that will achieve a full-power demonstration run on the FFTF at the earliest possible date consistent with safety and reliability of the plant.

Since the issuance of these initial test programs, intensive dialog has occurred within HEDL and between HEDL and FFTFPO to assure that necessary test requirements were properly conducted and the test requirements affecting the safety and reliability of the plant were effectively and expeditiously conducted. Test requirements that do not meet this need are conducted after the first power demonstration run.

A number of open items developed in the course of optimizing the test program toward early plant operation. A summary of the status of the items follows:

1. Secondary HTS System Filters - Removal Early in the Test Program

Resolved. The present test sequence shows the secondary filters removed at the earliest possible time, immediately after the first sodium flow tests. A time period of 7 weeks is available to complete this task without delaying the test program. In the event that parts of the primary system are delayed, the secondary systems may be operated early, allowing for an even earlier start on the filter removal.

2. No Flow Assemblies - Defer until after the Power Demonstration Run

Done. This test is shown in Test Period 20A.

3. Simulated Core Assemblies - Examination of Filter Burden

The requirement that the SCA's be examined for filter burden has been eliminated as a test requirement.

4. Test of the Fuel Failure Monitoring System by Gas-Tag Release - Defer until after the Power Demonstration Run

Done. This test is now shown in Test Period 20A.

5. Reactivity Assessments by Interchanging of Core Components -
Need for the Tests

These tests are now shown after the power demonstration run in Test Period 20C.

6. Core Component Manipulations prior to Full Power Operation -
Minimize

Core component manipulation prior to the power demonstration run have been reduced to a minimum. In general, test assemblies are not installed until after the power demonstration run unless they are needed for the test program, such as the VOTA and the FOTA's.

Some test assemblies such as the Grid-Spaced Drivers are installed during the core loading because they are as easy to put in as any other component that could be installed, present negligible risk of delaying the program, and it would be wasteful of driver fuel to do otherwise. If the test assemblies are not available, reference fuel or other standard core components can be installed in their place.

7. Core Loading Plan - Simplify and Reduce the Number of Rod Pulls

The present core loading plan as presented in this test program has been greatly simplified and represents a minimum number of rod pulls consistent with nuclear safety. In the assymetric loading, each sector is fully loaded and the control rods connected, permitting the rods in that sector to be operated as loading continues in the next sector. In loading of the final sector, the rods are connected at the estimated critical loading (about 8 subassemblies short in the sixth row) and the critical measurements are made. Then loading of that sector is completed and the preliminary reactivity assessments are made.

8. Low Power Characterization - Delay until after Full Power Operation

Done. Now shown in Test Period T-18.

9. High Power Characterization - Add One Characterizer in In-Vessel Storage

Done. There are now two characterizers in IVS for the high power irradiation.

SECTION III

IMPACT OF THE TEST PROGRAM

SECTION III.A.

IMPACT OF PLAN ON SECURITY AND CONSTRUCTION REQUIREMENTS

The safeguards and security requirements at the FFTF Site will be met by the implementation of the Westinghouse Hanford Company Safeguards and Security Plan for the 400 Area. In summary, the plan calls for the following:

1. An outer perimeter fence around the facilities.
2. An inner fence around the FFTF Containment building, the DHX structures, water storage tanks, and the ethylene-glycol equipment pad. This fence defines the Protected Area.
3. A guard station for access to the Protected Area. This station will contain metal, explosive, and SNM detectors as well as means to identify authorized personnel, search all packages and detain suspect personnel.
4. Telephone and radio links between guard stations, central alarm stations, other onsite security forces and offsite response units will be established.
5. Area lighting.
6. An alarm and monitoring system such that all alarms must annunciate in a continuously manned central alarm station and in at least one other continuously manned station, and all emergency exits in the Protected Area shall be alarmed.
7. A method of controlling access inside the Protected Area.
8. Protection within the Protected Area of vital areas which contain equipment or services essential to plant safety, security and/or emergency operations.

The capability to accomplish these security measures is targeted to be in place by August, 1978.

The security plan requires that anyone who is issued a badge-card for access into the FFTF buildings must have an L-clearance or higher.

If non-cleared construction personnel remain on the FFTF Site at the time of fuel movement into containment, and if they require access to the FFTF buildings, the workers would either be escorted by L-cleared personnel; or construction workers would have to possess an L-clearance.

If neither of these alternatives is practical, a backup security plan would be imposed until either the construction workers were gone from the FFTF Site or until fuel loading into the reactor vessel was completed. The key point of this backup plan would require continuous surveillance of fuel by two appropriately cleared personnel until the fuel was loaded into either IDS or the RV. In addition, the backup security plan would consist of roped-off areas on the main floor of containment within which the fuel would be unloaded and transported either to IDS or to the reactor vessel. An armed guard - standing a continuous watch - would control access into this roped-off area. An additional armed guard would control access to the head compartment. Further, a picture badge identification system would be used for all Site personnel, and at the point of entry into the FFTF Area, all hand-carried packages would be searched.

SECTION III.B

REQUIREMENTS FOR DELIVERING CORE ASSEMBLIES AND TEST ARTICLES TO THE FFTF SITE

Fuel and test assemblies will be ordered from the 300 Area storage by the Reactor Components Handling Manager on a schedule consistent with the capabilities of the fuel handling equipment to process them into the RV. Four assemblies per day will be required for delivery to the FFTF Site.

It is anticipated that each incoming assembly will require about 1.5 shifts to process. This is on-line time and assumes CCCS inert-preheating has been accomplished. The loading time includes CLEM mating with CCCS, removal of the CCP containing the fuel assembly and transport to the RV, mating and depositing them into the FTP, waiting until the IVHM removes the fuel assembly and replaces it with an SCA, removing the CCP containing an SCA, transport to IDS, mating and depositing the CCP, moving to CCCS and mating to begin the 1.5 shift cycle again. Test assemblies will take approximately the same time to process via TACS. For 91 core locations, plus 5 PIOTA/CLJA, it will take approximately 48 three shift days to load the core at 2 assemblies/day or 24 three shift days to load the core at 4 assemblies/day. Present estimates are that if the fuel is loaded through CCCS into the reactor vessel, two assemblies per day can be loaded, while if the loading is through IDS, four assemblies per day can be loaded. Additional time is required for IT movement, control rod latching and withdrawal, and other events associated with the approach to critical and full power. To avoid delays in the fueling schedule caused by unforeseen interruptions in core delivery, present plans are to be formulated based on a delivery to the FFTF Site of 4 assemblies/day.

SECTION III.C

IMPACT ON THE IEM CELL

The only need for the IEM cell during the ATP is to support the core characterization program. The IEM cell is not needed to support the initial full power demonstration. After the first full power demonstration, low power core characterizer assemblies are loaded into the core (six fueled and five non-fueled assemblies). These are irradiated for one day at one percent power to activate passive sensors contained in special pins. The assemblies are removed from the RV, partially disassembled in the IEM cell and the pins removed for immediate shipment to offsite counting facilities. This removal from the RV begins approximately 26 shifts from the conclusion of the full power demonstration run. The assemblies are reconstituted with new sensor pins and are now designated high power core characterizer assemblies. These are loaded into the core and are irradiated for eight days at full power. The special pins are again removed from the characterizer assemblies in the IEM cell, gamma scanned and then shipped offsite. The remaining parts of the assemblies are packaged for shipment out of the IEM cell. The characterizer assemblies employ a removable handling socket with special pins which can be withdrawn out of the top of the assembly. Two additional assemblies are in IVS at high power.

Processing of the characterizer assemblies through the IEM cell consists of the following operations:

- A. Receive the assembly from CLEM in a sodium filled core component pot.
- B. Transfer the assembly in the core component pot to the receiving station.
- C. Remove the assembly from the core component pot.
- D. Transfer the fuel assembly or the non-fuel assembly to the disassembly/reassembly station (D/RS) for installation into a special, heated, sodium filled pot with just the handling socket exposed.
- E. Remove the handling socket to expose the sensor pins (9-13) for fuel assemblies or 6-7 for non-fuel assemblies).
- F. Remove these special pins and replace with new sensor pins.
- G. Package all the removed sensor pins from one assembly in the same shipping container and immediately transfer from the IEM cell. Gamma scanning in the IEM cell of selected pins after the full power run is required. Sodium will not be removed from the non-fuel pins prior to packaging since the pins can be safely handled in the 300 Area hot cells with the small amount of residual sodium remaining in the "drip-dry" condition.

- H. Replace the handling socket on the characterizer assembly, and then return the assembly to the reactor for subsequent irradiation, following any required inspection and/or pull test, flow test, etc.

Two assemblies may be simultaneously processed through the IEM cell at any one time; since, one would be in the sodium removal station while the other is in the D/RS.

IEM cell equipment which is required to support the core characterizer program is shown below:

<u>AMCO Ident. No.</u>	<u>Equipment</u>
15	CCP receiving container
17	CCP storage container
18A	CCP grapple
18B	Fuel assembly grapple
21	Contaminated gas suction manifold
22	Equipment and personnel airlock
26	Multipurpose elevator
35	Core component disassembly/reassembly station
42, 42B, & 42C	Gamma scanning port pin positioner
45	Cell ceiling valve
46 & 47B	Bridge cranes, 1 ton and 5 ton
48	Viewing windows
49	Periscopes at disassembly/reassembly station
50B & 51	Wall and Pedestal Mounted manipulators
53	Closed circuit TV system
54	Lighting
55	Binocular mounts
59	Work tables
66	Grapple storage rack

<u>AMCO Ident. No.</u>	<u>Equipment</u>
71	Master-slave manipulator (light duty)
73	Electrical power and controls plug
74	Maintenance turntable
90	Special service plug
91	Small tool transfer lock
92	Cell atmosphere filter frames (remote)
95	Cell electrical power and control equipment
98	Fuel pin shipping container (offsite)
99	Equipment mounting bracket (remote)
106	Remote impact wrench
109	Fuel pin handling equipment
110	Fuel pin end fitting
116A, B	Fuel pin container/transfer stand
119	Equipment pressurization and purge system
126	Fuel pin removal/insertion equipment
129	Handling socket removal/installation equipment
130	Sodium filled holding pot
136	Fuel pin ID fixture
141	Small tool storage fixture

ITEM Cell Equipment Checkouts. Prior to use, the ITEM cell equipment checkouts will have been completed (including vault shielding and leak tests) as well as the required grooming and alignment.

Reconstitution of the Reactor Characterizers.

Reconstituting the fueled characterizers between low power and high power operation calls for complete sodium removal in the Sodium Removal Station (Ident 89), and flow testing in the Core Component Measuring Fixture (Ident 41). It is not necessary that this be done.

The fueled assemblies can be rebuilt in the same way that the reflector assemblies are handled, i.e., in the open pot of molten sodium, and the pins can be shipped to the 300 area hot cells in the "drip-dry" condition. The small amount of sodium remaining on the pins in this condition will require additional operations in the hot cells, but can be handled without undue difficulty.

To process all six fueled characterizers through the sodium removal process forces an early demonstration of the reuse of cleaned fuel pins at a very early stage in the life of the reactor. Prudence would dictate that this experiment be done on a smaller scale to build up confidence rather than to reuse 1200 reference fuel pins on the first try, and risk cladding failures.

As it is not yet clear that the low power characterizers must go through the sodium removal process, or even that they should be permitted to, the Sodium Removal Station (Ident 89) has not been included in the above list of IEM cell equipment needed to support the characterizer program. Similarly, the Core Component Measuring Fixture (Ident 41) has not been included. In order to reuse a fuel assembly in the reactor, current SDD requirements call for a flow test. This cannot be done in a meaningful manner unless the assembly has been completely cleaned of all residual sodium. Thus it will be necessary to obtain an exception to this requirement in order to reuse the characterizers without the flow test.

APPENDIX 1

ALTERNATE CORE LOADING OPTIONS CONSIDERED

The recommended initial core loading sequence provides the best balance between safety, reliability, flexibility, and schedule considerations. This conclusion is based on comparative evaluations made on several alternate core loading options. Basic guidelines in formulating and judging these options were:

1. Safety - loading must be safe from nuclear as well as mechanical and personnel viewpoints.
2. Reliability - the method must provide a high degree of confidence of being successfully completed on the proposed schedule, with backup options available where possible; use of special procedures or tooling should be minimized.
3. Schedule - loading should be completed so as to allow first full power to be achieved at the earliest date; also, fuel loading must not significantly impact construction progress; loading must mesh with the ATP sequence in a logical and achievable manner (e.g., all required systems must be functional, sodium filtering must be accomplished, basic physics testing requirements must be accommodated, etc.)
4. SCA handling restriction - IVHM must deposit SCA's into a CCP upon removal from the core due to the potential for hangup of the protruding alignment nuts (i.e., unmodified SCA's may not be stored in IVS or returned to the core).
5. Inerting - transfers to/from sodium filled vessels must be accomplished in an inert environment; incoming components must be inerted before insertion into sodium.
6. Thermal shock - preheating of incoming components to the refueling sodium temperature is desirable, but not mandatory.

Alternate loading schemes investigated ran all the way from complete core loading into the dry vessel prior to inerting and sodium fill of the RV to the full refueling sequence to be followed during the normal FFTF refueling. A brief discussion of the principal viable options follow:

- A. Dry load RV - All core components would be loaded into the RV prior to sodium fill; the core would be loaded out to Row 4, including all nine control rods and test assemblies, with the remainder of the fuel loaded into In-Vessel Storage (IVS).

Advantages: No ex-vessel fuel handling equipment is required to be available to load the RV; potential for early criticality.

Disadvantages: Early fuel loading impacts physical security and construction; only partial primary plant sodium filtering is achieved; alignment-indexing problems over the FTP using the polar crane are significant; potential for damage of a fuel assembly while inserting it into the FTP exists; special tools* and techniques would be required for the dry loading; CLEM is subsequently required to transfer a sodium-filled CCP/SCA to IDS for each fuel assembly moved from IVS during approach to criticality and first full power (total of 45 assemblies); additional fuel handling steps are required; significant FSAR modifications would be required.

- B. Dry load IDS - All CCP/core components would be loaded into IDS prior to sodium fill of IDS; test assemblies are loaded into TACS for conditioning; CLEM subsequently loads the sodium filled RV from IDS and TACS and deposits out-going CCP/SCA's into IDS.

Advantages: IDS can be preloaded; CCCS is not required; full filtering of RV sodium is provided; potential for earlier criticality.

Disadvantages: IDS rotating basket has not been operated in hot sodium prior to receiving the full core load; IDS sodium cleanup has not occurred prior to receiving new fuel; early introduction of fuel into the RCB impacts physical security and construction.

- C. Use polar crane/bagging technique - All core components would be loaded directly into the sodium filled RV from the shipping containers by means of a special long loading grapple and bagging technique; SCA's would be transferred from the RV to outgoing shipping containers.

Advantages: No ex-vessel fuel handling machines are required to be available to load the RV; potential for earlier criticality; SCA's would be removed from RCB concurrent with incoming fuel; SCA's and fuel would be handled directly without a sodium filled CCP.

Disadvantages: Alignment-indexing over the FTP using the polar crane is a problem; time to load a core component will be equal to or greater than that required using CLEM; potential for damage of a fuel assembly while inserting it into the FTP exists; inert bagging operation

*Special tools for inserting core components into the reactor using the polar crane will need to be designed and developed to implement this plan.

over the 350° F RV sodium at the open FTP has a potential for personnel and mechanical safety problems; a special loading grapple must function in air after having been wetted in RV sodium to pick up the new fuel assembly; neither preheating nor inerting of incoming assemblies is provided; potential for hangup of the protruding nuts of an outgoing SCA on the CCP exists; outgoing sodium wetted SCA's would retain some sodium in each filter assembly which would necessitate inert SCA handling; all fuel handling operations are in series, including truck transfer from the 300 Area.

- D. Equilibrium Core Loading Sequence - Empty CCP's are conditioned and inserted into the sodium filled IDS using CLEM; core components are conditioned and inserted into the CCP's in IDS using BLTC; test assemblies are loaded into TACS for conditioning; CLEM subsequently loads the sodium filled RV from IDS and TACS and deposits outgoing CCP/SCA's into IDS.

Advantages: All fuel handling equipment will be operated as designed, using standard procedures; no special tooling or techniques are required; full filtering of IDS and RV sodium is provided; IDS acts as an accumulator in the loading sequence and fuel can be inserted concurrent with CLEM operations in loading the RV.

Disadvantages: Two loading operations required are: transferring a CCP into IDS, and installing a core component into the CCP; BLTC and IEM cell must be operational before the initial core loading; frequent CLEM grapple change-outs in the IEM cell are necessary to unload and load all test locations; there is little potential for achieving early criticality.

- E. Special Features - Several ideas were evaluated which could be used with the different core loading sequences.

1. Drainable CCP's - Special CCP's with drain holes would be used (or drill holes in a limited number of existing CCP's) to enable the CCP/SCA coming from the RV to be deposited into CCCS-S, or a dry IDS, where the SCA would immediately be removed, bagged and shipped out of the RCB. The sodium wetted modified CCP could be used again with an incoming core component or removed for cleaning prior to reuse.

Advantages: SCA's would be removed from the RCB; IDS would not be required to be sodium filled for storage of sodium fill CCP/SCA's.

Disadvantages: Congestion at CCCS-S/IDS would occur as incoming fuel assemblies and outgoing SCA's are simultaneously processed at the same location; CCCS-S would potentially become sodium contaminated from the sodium wetted CCP's; added expense to procure special CCP's or replacement units; special sodium cleaning area for the CCP's would have to be provided or a risk of sodium oxide carry-over back into the RV sodium accepted.

2. Loading of Two Sectors Concurrently - CLEM would load a CCP/fuel assembly into the RV-FTP of one sector while the IVHM in a second sector is inserting an SCA into a waiting CCP; CLEM disengages from the first sector and mates with the second sector RV-FTP to remove the waiting CCP/SCA. Move it to IDS where a new CCP/fuel assembly is obtained for insertion into the second RV-FTP; the IVHM in the first sector is simultaneously loading the fuel assembly into the core and removing an SCA for insertion into the empty CCP.

Advantages: Core loading can be accomplished faster than single sector loading since CLEM does not idly wait for 4-5 hours while IVHM unloads/loads the CCP.

Disadvantages: A very important physics data point obtained from IRT count rates with one sector fully loaded and its three control rods in/out is not available; extra motions are required of CLEM since it moves empty between the first and second sectors; strict accountability of two fuel loading operations must be simultaneously maintained; interlocks between CLEM and IVHM which prevent the grapple from being lowered into the RV when IVHM is working must be overridden.