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Information Processing

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for U.S. Nuclear Regulatory Commission

REACTIVITY INITIATED ACCIDENT TEST SERIES
TEST RIA 1-4
EXPERIMENT OPERATING SPECIFICATION

C.J. STANLEY Z.R. MARTINSON

JUNE 1979

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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TEST RIA 1-4

EXPERIMENT OPERATING SPECIFICATION

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THERMAL FUELS BEHAVIOR PROGRAM
EG&G IDAHO, INC.

EG&G Idaho, Inc.

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TFBP-TR-323

REACTIVITY INITIATED ACCIDENT TEST SERIES

TEST RIA 1-4

EXPERIMENT OPERATING SPECIFICATION

June 1979

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1. INTRODUCTION

This document describes the experiment operating specifications for the Reactivity Initiated Accident (RIA) Test RIA 1-4 to be conducted in the Power Burst Facility (PBF) at the Idaho National Engineering Laboratory as part of the Nuclear Regulatory Commission's Fuel Behavior Program[1]. The overall experiment requirements and objectives for the RIA Test Series are described in the RIA Experiment Requirements Document[2] while the experiment specifications for Test RIA 1-4 are described in the Test RIA 1-4 Experiment Specification Document[3]. RIA Test Series I objectives are to provide data for the evaluation and possible revision of current nuclear reactor licensing criteria regarding hypothetical control rod drop or ejection accidents in commercial nuclear power plants. These experiments will also provide fuel performance data during a RIA event for model development and assessment purposes. The most severe RIA is the postulated boiling water reactor (BWR) control rod drop during reactor startup, therefore the Series I tests are being conducted at coolant conditions (pressure, temperature, and flow rate) that are typical of hot-startup conditions in commercial BWRs. A specific objective of the test is to provide information pertaining to core coolability and coolant channel integrity following a RIA event at an energy insertion equivalent to the present licensing criteria of 280 cal/g.

Test RIA 1-4 will consist of a 3x3 array of preirradiated fuel rods. The nine fuel rods will be 5.7 wt% enriched UO_2, zircaloy-4 clad, Westinghouse MAPI rods irradiated to an average burnup of approximately 5250 MWd/t in the SAXTON pressurized water reactor.

The test sequence will begin with steady state power operation to condition the fuel and establish a short-lived fission gas inventory and determine the fuel rod power calibration. The test train will be removed from the in-pile tube (IPT) and one of the fuel rods replaced. The eight aluminum-cobalt shroud flux wires will be replaced with 100% cobalt flux wires. The PBF core flux wires will

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also be replaced. Several trial power bursts will be performed with the test train out of the IPT at various reactor periods to verify the reactor period which is required to provide the desired energy deposition of 280 cal/g UO_2 for the actual power burst. The test train will be reinserted into the IPT and the actual power burst for Test RIA 1-4 will be conducted. The IPT loop will be cooled down and depressurized, thus terminating the test sequence.

The nine-rod bundle of test rods is expected to be highly oxidized with a high probability of fuel rod failure and flow blockage of the assembly. The test assembly will be transported to the hot cells for disassembly and postirradiation examination.

Section 2 of this document describes the fuel rods, flow shroud, test assembly and instrumentation. Section 3 presents the operating procedures for the conduct of Test RIA 1-4. Section 4 presents the data acquisition and reduction requirements for test conduct and posttest analyses. The posttest operations support requirements are presented in Section 5 and the outline for the postirradiation examination requirements is presented in Section 6. The instrumentation status checklists are contained in Appendix A.

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2. EXPERIMENT DESIGN

Test RIA 1-4 will consist of a nine-rod bundle of test rods made up of previously irradiated MAPI fuel rods contained within a zircaloy flow shroud. Grid spacers will maintain a 3x3 rod array (see Figure 1). A support structure will center the rod bundle and flow shroud inside the PBF IPT. The test train instrumentation will also be attached to the support structure. Specifications for the fuel rods, grid spacers, flow shroud, support structure, and instrumentation are presented in this section.

2.1 Fuel Rods and Flow Shroud

A total of ten 5.7 wt% enriched unopened MAPI fuel rods previously irradiated to an average burnup of approximately 5250 MWd/t will be used in Test RIA 1-4. The nine fuel rods in the 3x3 array for the power calibration and conditioning phase are designated as Rods 804-1, 804-10, 804-3, 804-4, 804-5, 804-6, 804-7, 804-8, 804-9. The tenth rod designated 804-2, will be used as a replacement for [illegible] 10 in the bundle after the power calibration and conditioning tes[illegible]se is completed. The specific information on rod designations, fuel enrichment, average burnup, internal gas composition and internal pressure for each of the rods is presented in Table I. The as-fabricated nominal design characteristics of these fuel rods are given in Table II. Fuel Rods 804-1, 804-5 and 804-6 are instrumented with two cladding thermocouples each, as described in Subsection 2.3.

The nine-rod bundle of test rods is positioned within a zircaloy flow shroud (see Figure 1). The fuel rods are positioned in the flow shroud by a series of four grid spacers with a rod-to-rod pitch of 14.3 mm. The grid spacers are centered at 15, 320, 625, and 930 mm above the bottom of the fuel region.

2.2 Test Assembly

The test rod bundle, flow shroud and associated instrumentation are held in place in the IPT of the PBF by a suppor[illegible] structure

TABLE I

SPECIFICATIONS FOR INDIVIDUAL FUEL RODS FOR TEST RIA 1-4

Rod Number	Original Westinghouse Number	Fuel Enrichment (wt% 235 U)	Average Burnup (MWd/t)	Original 235 U Weight g/rod	Backfill Gas Composition	Backfill Pressure (MPa)
804-1	M-15	5.7	5110	27.0	Air	0.103
804-2	M-29	5.7	4950	27.0	Air	0.103
804-3	M-17	5.7	4770	27.0	Air	0.103
804-4	M-19	5.7	5610	27.0	Air	0.103
804-5	M-62	5.7	5450	27.0	Air	0.103
804-6	M-24	5.7	5150	27.0	Air	0.103
804-7	M-38	5.7	5050	27.0	Air	0.103
804-8	M-39	5.7	5550	27.0	Air	0.103
804-9	M-61	5.7	5650	27.0	Air	0.103
804-10	M-15	5.7	4560	27.0	Air	0.103

TABLE II

NOMINAL DESIGN CHARACTERISTICS FOR TEST RIA 1-4 FUEL RODS

Characteristic [a]	MAPI
Fuel	
Material	UO_2
Pellet OD (mm)	8.59
Pellet length (mm)	15.2
Pellet enrichment (wt%)	5.7
Density (% TD)[b]	94
Fuel stack length (m)	0.914
End configuration	dished
Cladding	
Material	zircaloy-4
Tube OD (mm)	9.99
Tube wall thickness (mm minimum)	0.572
Yield strength (MPa)	570
Ultimate strength (MPa)	700
Fuel Rod	
Gas plenum length (mm)	45.7
Insulator pellets	none

a. Data are preirradiation values.
b. Theoretical density (TD) of UO_2 (10.97 g/cm^3).

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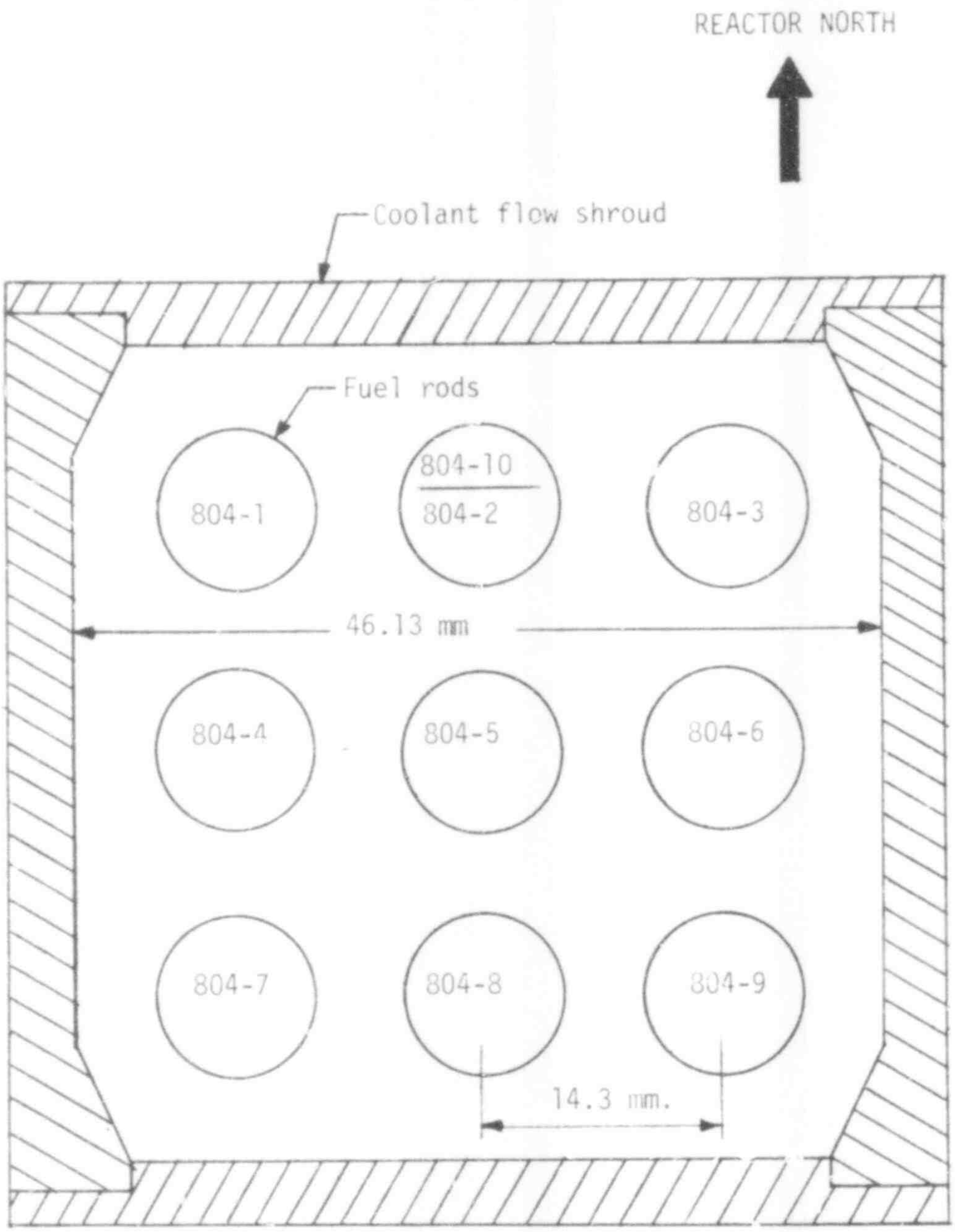

Fig. 1 Schematic cross section of Test RIA 1-4 assembly showing relative positions of fuel rods and coolant flow shroud.

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referred to as a test assembly. The test assembly consists of a hanger rod which connects the test bundle to the IPT closure head. A fine mesh fragment screen is located between the test rods and the PBF IPT outlet to prevent fuel and cladding fragments from being dispersed throughout the IPT in the event of fuel rod failure.

2.3 Instrumentation

The instrumentation for Test RIA 1-4 is designed to provide information for use in the calorimetric calculation of the rod bundle power during steady state operation. The cladding thermocouples will also provide an indication of time in film boiling and the coolant pressure transducers will provide information on possible coolant pressure pulse generated during the power burst.

2.3.1 Fuel Rod Instrumentation. The measurement requirements for the fuel rod instrumentation are summarized in Table III and include instrument description, range, response time, and signal conditioning.

Fuel Rods 804-1, 804-5 and 804-6 will each be instrumented with two cladding surface thermocouples. The other six fuel rods will be uninstrumented. The cladding surface thermocouples are titanium sheathed, Type S thermocouples with spaded junctions. The thermocouples are resistance welded to the cladding outer surface. The axial elevation is measured from the bottom of the fuel stack and the circumferential orientations of the thermocouples are as shown in Table III, and Figure 2.

2.3.2 Test Assembly Instrumentation. The test assembly instrumentation consists of the following:

(1) Two EG&G Idaho, Inc., 69 MPa pressure transducers for measuring large pressure pulses. One transducer is located near the flow shroud outlet and the other is located near the shroud inlet.

TABLE II

TEST RIA 1-4 FUEL ROD INSTRUMENTATION

Measurement	Instrument	Instruments per Rod	Instrument Location[a]	Rod to be Instrumented	Operating Range	Estimated Response Time(s)	Comments
Cladding Surface Temperature	Thermocouple	2	590±2mm @ 315±5° 790±2mm @ 135±5°	804-1	300 to 2150 K	0.10	Resistance welded Type S with spaded junction and titanium sheath.
Cladding Surface Temperature	Thermocouple	2	590±2mm @ 315±5° 790±2mm @ 135±5°	804-5	300 to 2150 K	0.10	
Cladding Surface Temperature	Thermocouple	2	590±2mm @ 135±5° 790±2mm @ 315±5°	804-6	300 to 2150 K	0.10	

a. All elevations are measured from the bottom of the fuel stack.

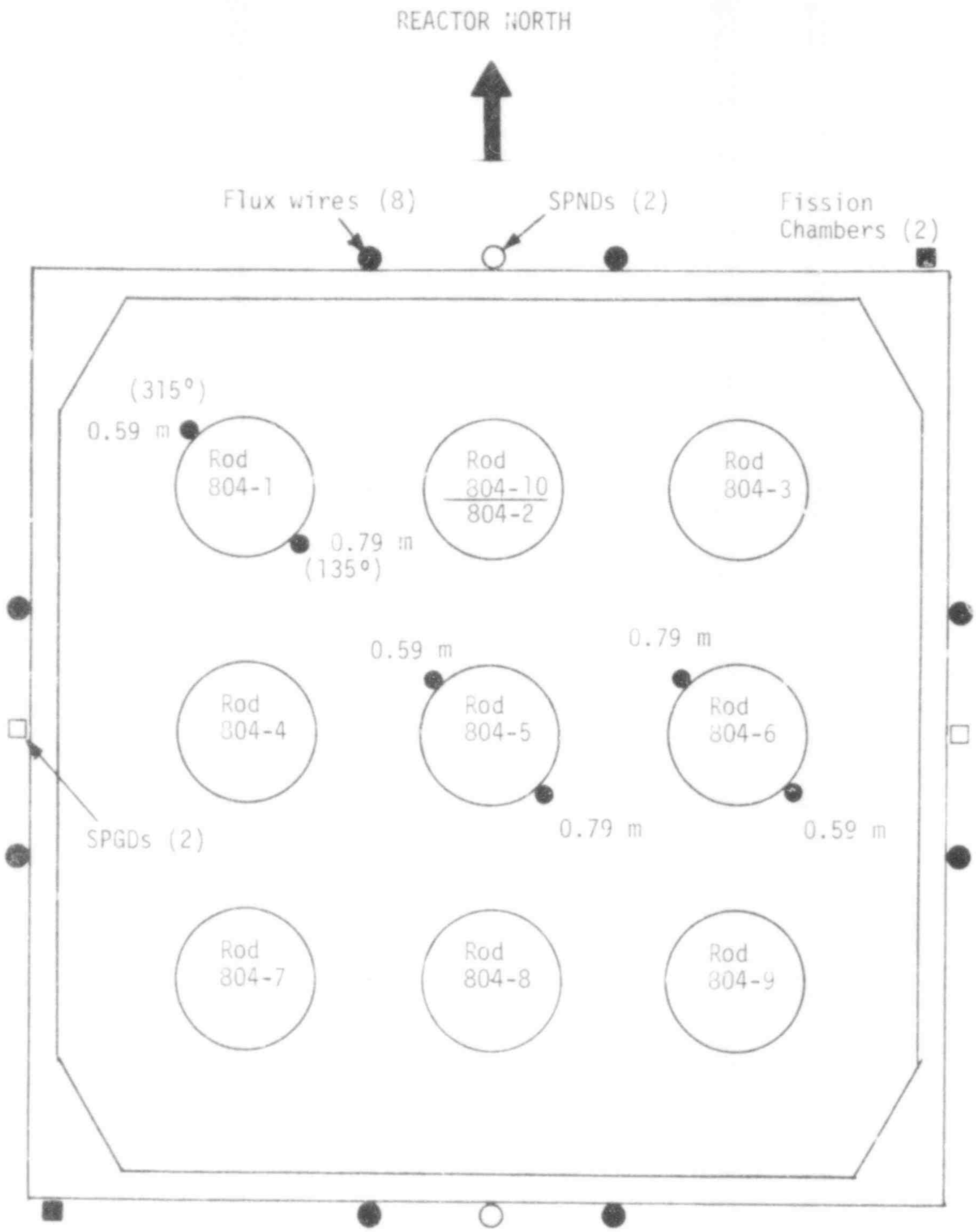

Fig 2. Schematic cross section through the Test RIA 1-4 nine-rod cluster showing the locations of cladding surface thermocouples, the flux wires, SPNDs, SPGDs and fission chambers. (Elevations are relative to the bottom of the fuel stack.)

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(2) Two EG&G Idaho, Inc., 17.2 MPa pressure transducers, one located near the shroud outlet for the measurement of normal system pressure and the other transducer is connected by tubing to the flow shroud wall at 452 mm above the bottom of the fuel stack.

(3) Two Flow Technology bi-directional flow turbine meters located in tandem at the flow shroud inlet.

(4) Four EG&G Idaho, Inc., Type K thermocouples located at the flow shroud inlet to measure the coolant inlet temperature.

(5) Two EG&G Idaho, Inc., Type K thermocouples located at the flow shroud outlet to measure the coolant outlet temperature.

(6) Two EG&G Idaho, Inc., Type K thermocouples attached to the outer wall of the flow shroud at 0 and 180 degree orientations to measure shroud temperature.

(7) Eight removable (0.51% cobalt-99.49% aluminum) flux wires positioned vertically (two per side) on each of the four outer surfaces of the coolant flow shroud to measure the time averaged neutron flux during the power calibration and conditioning phase.

(8) Eight removable (100% cobalt) flux wires positioned vertically (two per side) on each of the four outer surfaces of the coolant flow shroud to measure the time averaged neutron flux during the power burst.

(9) Two Reuter-Stokes cobalt self-powered neutron detectors (SPNDs), one each located at, 0 and 180 degrees on the outer surface of the coolant flow shroud, to measure the relative neutron flux for use in correlating reactor power to the calibrated fuel rod power.

(10) Eight pairs of EG&G Idaho, Inc., Type T differential thermocouples positioned at the inlet and outlet of the coolant flow shroud to measure the temperature rise across the shroud.

(11) Two Reuter-Stokes platinum self-powered gamma detectors (SPGDs), one each located at 90 and 270 degrees on the outer surface of the coolant flow shroud, to measure the relative gamma flux.

(12) Two evacuated U-235 fission chambers located on opposite corners of the coolant flow shroud to measure relative neutron flux.

Table IV summarizes the test assembly instrumentation including information as to description, range, response time, and signal conditioning. The schematic in Figure 3 is a representation of the Test RIA 1-4 test train. The relative positions of the test assembly instrumentation are also shown in this figure.

2.3.3 Plant Instrumentation. Plant instrument data to be recorded on the data aquisition systems along with the test assembly and fuel rod data are as follows:

(1) NMS-3 ion chamber

(2) PPS-1, PPS-2, PPS-3, PPS-4 ion chambers

(3) TR-1, TR-2 ion chambers

(4) EV-1, EV-2 ion chambers

(5) In-pile tube system pressure

(6) In-pile tube " P"

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TABLE IV

TEST TRAIN INSTRUMENTATION FOR TEST RIA 1-4

Measurement	Instrument	Number	Instrument Location [a]	Operating Range	Estimated Response Time (s)	Comments
Support Structure						
Coolant Pressure	Pressure Transducers	2	Near Test Bundle Flow Inlet and Outlet	0 to 69 MPa	1×10^{-4}	To measure large pressure pulses.
Coolant Pressure	Pressure Transducer	1	Support Structure	0 to 17.2 MPa	---	To measure normal system pressure.
Coolant Pressure	Pressure Transducer	1	Support Structure	0 to 17.2 MPa	1×10^{-4}	Connected by tubing to flow shroud wall at 452 mm elevation.
Coolant Flowrate	Turbine Flowmeter	2	Flow Channel Inlet	0.568 to 5.68 l/s	0.01	
Coolant Inlet Temperature	Thermocouple	4	Rod Bundle Flow Inlet	300 to 600 K	N/A	---
Coolant Outlet Temperature	Thermocouple	2	Rod Bundle Flow Outlet	300 to 600 K	N/A	---
Flow Shroud Temperature	Thermocouple	2	375 ± 1 mm	300 to 1600 K	0.10	Attached to outer wall of flow shroud at 0 and 180 degrees.
Neutron Flux	Flux Wires	8(100% Cobalt) 8(0.51% Cobalt)	Vertically Along Flow Channel	1×10^{18} nvt	---	0.51% cobalt wires for steady state operation; replaced with 100% cobalt wires for power burst.

TABLE IV (continued)

Measurement	Instrument	Number	Instrument Location [a]	Operating Range	Estimated Response Time (s)	Comments
Relative Neutron Flux	Cobalt SPND	2	2 SPND on outer surface of flow shroud on opposite sides at 0 and 180 degrees. Active length centered at 452±1 mm.	1.6×10^{17} n/cm^2·s	0.002	Gamma and neutron sensitivity of each SPND must be measured. 101.6 mm active length.
Coolant Differential Temperature	Thermocouple Pairs	8 Pairs	At Inlet and Outlet of Rod Bundle	0 to 20 K	N/A	Type T thermocouples.
Relative Gamma Flux	Platinum SPGD	2	2 SPGD on outer surface of flow shroud on opposite sides at 90 and 270 degrees. Active length centered at 452±1 mm.	1×10^{12} R/hr	0.002	
Relative Neutron Flux	U-235 Fission Chambers	2	Attached to the outer surface of flow shroud on opposite corners. Active length centered at 762 ± 1 mm.			

a. All elevations are measured from the bottom elevation of fuel stacks.

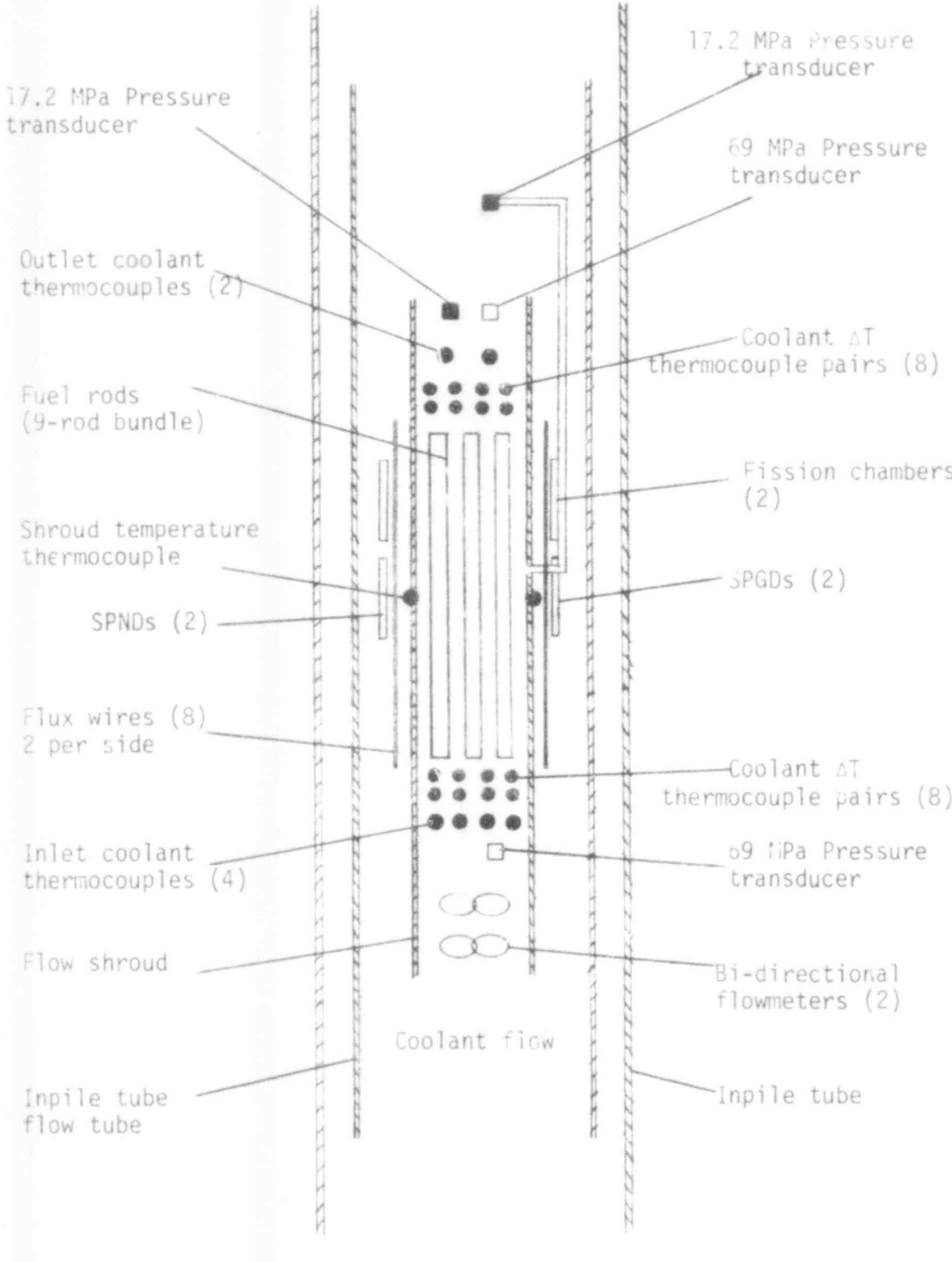

Fig. 3 Schematic representation of the Test RIA 1-4 test train assembly showing relative locations of the test assembly instrumentation.

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(7) Loop flow rate

(8) Loop fission product detection system

(9) Core fuel rod linear variable differential transformers (LVDTs) (3)

(10) Reactor vessel strain gauges (6)

(11) Loop pressure transducers (6)

(12) Ashcroft loop pressure gauge

(13) Core pressure transducers (3)

In addition, (0.51% cobalt-99.49% aluminum) flux wires will be installed in both the reflector and fuel regions of the core for the power calibration and preconditioning. 100% cobalt flux wires will be installed before the power burst. The digital readout for the Ashcroft loop pressure gauge should be available for monitoring from the PBF control room.

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3. EXPERIMENT OPERATING PROCEDURE

Details of the Test RIA 1-4 experiment procedures are described for each of the experiment operating phases along with the requirements for the instrumentation status checks and heatup procedures in the following sections.

Test RIA 1-4 is to be conducted in three primary test phases: (a) the fuel rod power calibration and conditioning phase, (b) the trial power bursts, and (c) the power burst transient. Interspaced between these phases will be several instrument status checks, loop heat-up, and loop cooldown steps. The nuclear portion of the operation will begin with the power calibration phase, which will also serve as a conditioning phase. This will be followed by a shutdown to remove and replace the test train flux wires, and an exchange of fuel rods. During this time when the test train is removed from the IPT, several trial power bursts will be performed to assess the proper period for the actual power burst. The test train will be reinserted in the IPT and the power burst will be performed, thus terminating the Test RIA 1-4 test sequence. The specific operating sequence for the test is presented in Table V and is shown graphically in Figure 4.

3.1 Instrument Status Checks and Minimum Operable Instrumentation

To monitor the experiment status and to meet test objectives requires that certain fuel rod and test assembly instrumentation be operable throughout the experiment or during specific phases of the experiment. The loss of a critical instrument or a critical combination of instruments needed for a current or subsequent test phase will require the test procedures to be suspended until the RIA project leader's approval has been obtained to continue the test. Since instrument status will be monitored on the PBF/Data Acquisition and Reduction System (PBF/DARS) display, the source of instrument output difficulties can range from instrument malfunction or failure, signal conditioning, transmission or DARS calibration problems. If the experiment is interrupted by an apparent instrumentation

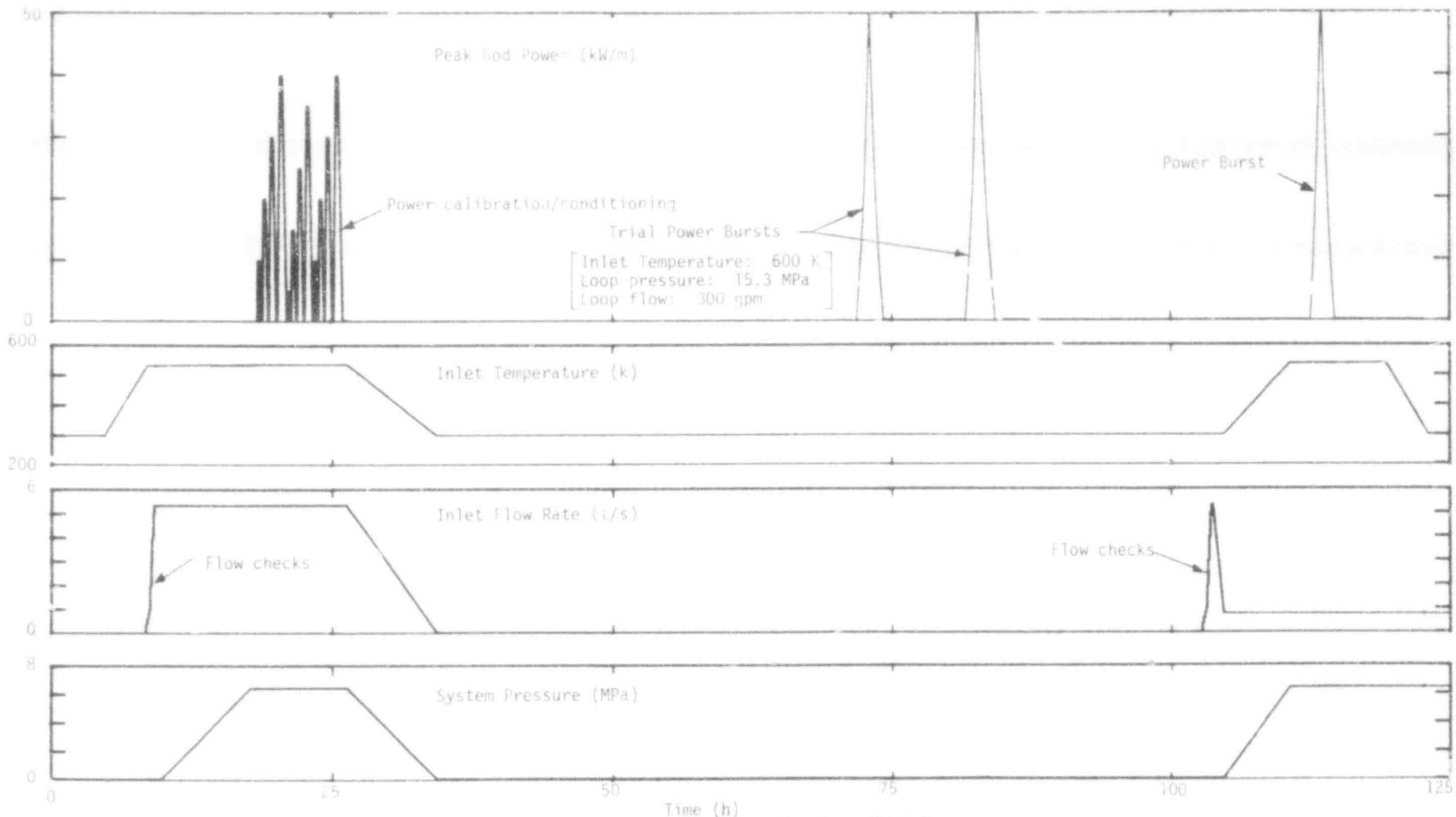

Fig. 4 Operating sequence for Test RIA 1-4

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TABLE V

OPERATING SEQUENCE FOR TEST RIA 1-4

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Across Shroud (K)	Comments
30	0	0	0	Ambient	0	Ambient	0	Instrument status check, verify DARS calibration
[illegible] hr	0	0	0	Ambient	0	as Req'd	0	Cold Hydrostatic check of loop
30	0	0	0	Ambient	2.0	Ambient	0	Instrument status check prior to heatup, DIRC review required
8 hr	0	0	0	Ambient to 538	2.0	Ambient to 6.45	0	Heatup and pressurization phase with periodic instrument status checks at 350, 400, 450, and 500 K
30	0	0	0	538	5.36	6.45	0	Instrument status check and verify DARS calibration[c], zero power offsets taken, drift check, DIRC review required
45	0	0	0	538	0.4, 0.6, 0.8, 1.0, 2.0, 3.0, 4.0, 5.0, 5.36	6.45	0	Flow check (shroud versus IPT bypass)
5	0 to 0.1	0.6	0 to 70 kW	538	5.36	6.45	0.2	Start Conditioning Phase I
5	0.1 to 10	0.6 to 61	70 kW to 6.9	538	5.36	6.45	--	Power calibration Step I (power increase)
10	10	61	6.9	538	5.36	6.45	2.6	Calculate rod powers

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TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Across Shroud (K)	Comments
5	10 to 0.1	61 to 0.6	6.9 to 70 kW	538	5.36	6.45	--	Power calibration Step 1 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
10	0.1 to 20	0.6 to 122	70 kW to 13.8	538	5.36	6.45	--	Power calibration Step 2 (power increase)
10	20	122	13.8	538	5.36	6.45	5.2	Calculate rod powers
10	20 to 0.1	122 to 0.6	13.8 to 70 kW	538	5.36	6.45	--	Power calibration Step 2 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
15	0.1 to 30	0.6 to 183	70 kW to 21	538	5.36	6.45	--	Power calibration Step 3 (power increase)
10	30	183	21	538	5.36	6.45	7.8	Calculate rod powers
15	30 to 0.1	183 to 0.6	21 to 70 kW	538	5.36	6.45	--	Power calibration Step 3 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
20	0.1 to 40	0.6 to 258	70 kW to 27.8	538	5.36	6.45	--	Power calibration Step 4 (power increase)
10	40	258	27.8	538	5.36	6.45	10.3	Calculate rod powers
20	40 to 0.1	258 to 0.6	27.8 to 70 kW	538	5.36	6.45	--	Power calibration Step 4 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	End Conditioning Phase I Check zeros and offsets

TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Across Shroud (K)	Comments
2.5	0.1 to 5	0.6 to 30	70 kW to 3.5	538	5.36	6.45	--	Start Conditioning Phase II Power calibration Step 5 (power increase)
10	5	30	3.5	538	5.36	6.45	1.3	Calculate rod powers
2.5	5 to 0.1	30 to 0.6	3.5 to 70 kW	538	5.36	6.45	--	Power calibration Step 5 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
7.5	0.1 to 15	0.6 to 91	70 kW to 10.4	538	5.36	6.45	--	Power calibration Step 6 (power increase)
10	15	91	10.4	538	5.36	6.45	3.9	Calculate rod powers
7.5	15 to 0.1	91 to 0.6	10.4 to 70 kW	538	5.36	6.45	--	Power calibration Step 6 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
12.5	0.1 to 25	0.6 to 152	70 kW to 17.4	538	5.36	6.45	--	Power calibration Step 7 (power increase)
10	25	152	17.4	538	5.36	6.45	6.5	Calculate rod powers
12.5	25 to 0.1	152 to 0.6	17.4 to 70 kW	538	5.36	6.45	--	Power calibration Step 7 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
17.5	0.1 to 35	0.6 to 213	70 kW to 24.2	538	5.36	6.45	--	Power calibration Step 8 (power increase)

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TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Across Shroud (K)	Comments
10	35	213	24.3	538	5.36	6.45	9.1	Calculate rod powers
17.5	35 to 0.1	213 to 0.6	24.3 to 70 kW	538	5.36	6.45	--	Power calibration Step 8 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	End Conditioning Phase II Check zeros and offsets
5	0.1 to 10	0.6 to 61	70 kW to 6.9	538	5.36	6.45	--	Start Conditioning Phase III Power calibration Step 9 (power increase)
10	10	61	6.9	538	5.36	6.45	2.6	Calculate rod powers
5	10 to 0.1	61 to 0.6	6.9 to 70 kW	538	5.36	6.45	--	Power calibration Step 9 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
10	0.1 to 20	0.6 to 122	70 kW to 13.8	538	5.36	6.45	--	Power calibration Step 10 (power increase)
10	20	122	13.8	538	5.36	6.45	5.2	Calculate rod powers
10	20 to 0.1	122 to 0.6	13.8 to 70 kW	538	5.36	6.45	--	Power calibration Step 10 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
15	0.1 to 30	0.6 to 183	70 kW to 21	538	5.36	6.45	--	Power calibration Step 11 (power increase)
10	30	183	21	538	5.36	6.45	7.8	Calculate rod powers

TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Peak Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Acros: Shroud (K)	Comments
15	30 to 0.1	183 to 0.6	21 to 70 kW	538	5.36	6.45	--	Power calibration Step 11 (power decrease)
5	0.1	0.6	70 kW	538	5.36	6.45	0.2	Check zeros and offsets
20	0.1 to 40	0.6 to 258	70 kW to 27.8	538	5.36	6.45	--	Power calibration Step 12 (power increase)
10	40	258	27.8	538	5.36	6.45	10.3	Calculate rod powers
20	40 to 0.1	258 to 0.6	27.8 to 70 kW	538	5.36	6.45	--	Power calibration Step 12 (power decrease)
15	0.1	0.6	70 kW	538	5.36	6.45	0.2	End Conditioning Phase III Check zeros and offsets
5	0.1 to 0	0.6 to 0	70 kW to 0	538	5.36	6.45	--	Shut reactor down instrument status check and verify DARS calibration[c]
8 hr	0	0	0	538 to Ambient	5.36 to 0	6.45 to Ambient	--	Loop cool down and depressurization
32 hr	0	0	0	Ambient	0	Ambient	--	Remove test train, replace shroud flux wires, replace core flux wires, replace fuel rod 804-10 with rod 804-2, prepare reactor for trial power bursts with test train out of the IPT
8 hr	--	--	0	Ambient	--	as Req'd	--	Cold Hydrostatic check of loop
8 hr	--	--	0	Ambient to 600	--	15.2	--	Heatup and pressurization phase (300 gpm loop flow)

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TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Presure (MPa)	Expected ΔT Across Shroud (K)	Comments
8 hr	--	--	--	600	0	15.2	--	Conduct trial power burst I (2.3 ms period; 50,000 MW peak power)
2 hr	0	--	0	600	0	15.2	--	Remove core flux wires and send them to counting lab
8 hr	--	--	--	600	0	15.2	--	Conduct trial power burst II (2.7 ms period; 37,000 MW peak power)
8 hr	--	--	0	600 to Ambient	--	15.2 to Ambient	--	Loop cooldown and depressurization
2 hr	0	--	0	Ambient	0	Ambient	--	Remove core flux wires and send them to counting lab
8 hr	0	0	0	Ambient	0	Ambient		Install test train in IPT
30	0	0	0	Ambient	0	Ambient		Instrument status check and verify DARS calibration[c]
8 hr	0	0	0	Ambient	0	as Req'd		Cold Hydrostatic check of loop
8 hr	0	0	0	Ambient to 538	0.766	Ambient to 6.45		Heatup and pressurization phase with periodic instrument status checks at 350, 400, 450, and 500 K
30	0	0	0	538	0.766	6.45		Instrument status, and DARS calibration[c] zero power offsets taken, drift check, DIRC review required
30	0	0	0	538	0.4, 0.6, 0.8, 1.0	Ambient 6.45		Flow check (shroud versus IPT bypass)

TABLE V (continued)

Time[a] Duration (Min or as Noted)	Peak Rod Power (kW/m)	Total Bundle Power (kW)	Anticipated[b] Reactor Power (MW or as Noted)	Inlet Temperature (K)	Shroud Flow (l/s)	System Pressure (MPa)	Expected ΔT Across Shroud (K)	Comments
4 hr	--		--	538	0.766	6.[illegible]		Perform Power Burst
4 hr	0		0	538	0.766	6.45		Maintain constant system conditions to aquire fission product data.
8 hr	0		0	538 to Ambient	0.766	6.45 to Ambient		Begin system cool down and loop depressurization and posttest DARS calibration

a. Time for power calibration steps assumes a ramp rate of 2 kW/m/min.

b. Reactor power estimated using 1.44 kW/m per MW.

c. DARS calibration of all operable instrumentation listed in Table VI.

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malfunction, it will be necessary for cognizant data system and instrumentation personnel to determine the source of the malfunction indicated and the remedial action necessary for test procedures to continue. If it is determined that an instrument has failed or that repairs can be made only by removing the test train from the reactor, test procedures will remain suspended. This experiment status will be maintained pending a decision by the RIA Project Leader and TFBP Management, as to the course of action to be followed.

Instrumentation for Test RIA 1-4 have been defined in terms of minimum operable instrumentation in Table VI for various times during the test sequence. Instrument status checks are planned before and during the test to ensure conformity to the requirements in Table VI. Instrument status checks will occur at the TRA assembly area and again in the reactor building prior to loading the test train in the in-pile tube (IPT). Each fuel rod and test assembly transducer will be checked according to the Instrument Checkout Procedures documented in the Assembly Procedures (TP-RIA-1401 and TP-RIA-1402). Any quality discrepancy reports issued as a result of TP-RIA-1401 and TP-RIA-1402 must be signed off by the RIA Project Leader or his alternate. DIRC review must be completed prior to heatup, prior to performing the power calibration, and prior to performing the final power burst.

Status checks are to be made prior to the power calibration phase, and prior to the power burst. Table VII lists the operating conditions and the acceptance criteria for each instrument of the test. The acceptable operation criteria appear in the table as ranges of measured values in SI units. The ranges stipulated are based on the listed operating conditions and expected accuracies of the instruments used. Appendix A contains check lists, consistent with Table VII, that are to be incorporated in the Experiment Operating Procedures. The supervisor of the Instrumentation and Data section and the RIA Project Leader or their designated alternates will certify that each instrument for the experiment is within the acceptable operating limits as specified on the check lists contained in Appendix A. For any situation in which the instruments are not

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TABLE VI

MINIMUM REQUIRED OPERABLE INSTRUMENTATION
DURING VARIOUS PHASES OF TEST RIA 1-4

INSTRUMENTATION	Number of Instruments	PRE-INSTALLATION[a] OF TEST TRAIN IN IPT	DURING[a] HEAT-UP	PRE-[a] POWER CALIBRATION PHASE	PRE-[a] POWER BURST PHASE
Cladding Thermocouples	(6)	6 of 6 Req'd	5 of 6 Req'd	4 of 6 Req'd	4 of 6 Req'd
Flow Shroud Thermocouples	(2)	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
69 MPa Coolant Pressure Transducers	(2)	2 of 2 Req'd	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
17 MPa Coolant Pressure Transducers	(2)	2 of 2 Req'd	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
Shroud Coolant Flowmeters	(2)	2 of 2 Req'd	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
Coolant Inlet Thermocouples	(2)	2 of 2 Req'd	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
Coolant Outlet Thermocouples	(2)	2 of 2 Req'd	1 of 2 Req'd	Not Req'd	Not Req'd
Coolant Differential Thermocouples	(8)	8 of 8 Req'd	8 of 8 Req'd	6 of 8 Req'd	Not Req'd
SPNDs	(2)	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
SPGDs	(2)	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
Core Transient Ion Chambers Capable of Monitoring Expected Peak Power	(4)	Not Req'd	3 of either EV-1, EV-2, TR-1 and TR-2, or Equivalent Req'd	3 of either EV-1, EV-2 TR-1 and TR-2, or Equivalent Req'd	3 of either EV-1, EV-2, TR-1, and TR-2, or equivalent Req'd
U-235 Fission Chambers	(2)	2 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd	1 of 2 Req'd
Ashcroft Loop Pressure Gauge	(1)	---	Req'd	Req'd	Req'd

a. Any descrepancies must be approved by RIA Project Leader.

[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (MPa)	[illegible]	[illegible]	6.45 + 0.14
[illegible]	[illegible]	[illegible]	0.268 + 0.05

INSTRUMENT	ACCEPTABLE RANGE		
Fuel Rod Instrument			
Fuel Rod 804-1 Cladding T/Cs (2)	430 to 470 K	522 to 544 K	522 to 554 K
Fuel Rod 804-5 Cladding T/Cs (2)	430 to 470 K	522 to 554 K	522 to 554 K
Fuel Rod 804-6 Cladding T/Cs (2)	430 to 470 K	522 to 554 K	522 to 554 K
Test Train Instrumentation			
Flow Shroud Thermocouples (2)	430 to 470 K	522 to 554 K	522 to 544 K
Flow Shroud Turbine Flowmeters(2)	1.8 to 2.2 l/s	5.1 to 5.6 l/s	0.7 to 0.8 l/s
Coolant Inlet T/Cs (4)	440 to 460 K	528 to 548 K	528 to 548 K
Coolant Outlet T/Cs (2)	440 to 460 K	528 to 548 K	528 to 548 K
Coolant ΔT T/C Pairs (8)	-1.0 to +1.0 K	-1.0 to 1.0 K	Not Required
17.2 MPa Shroud Pressure Transducers (1)	± 2.0 MPa of Ashcroft Guage	± 2.0 MPa of Ashcroft Gauge	± 2.0 MPa of Ashcroft
17.2 MPa Pressure Transducer (1)	± 2.0 MPa of Ashcroft Guage	± 2.0 MPa of Aschroft Gauge	± 2.0 MPa of Ashcroft Gauge
69 MPa Pressure Transducer (2)	±3.5 MPa of Ashcroft Guage	±3.5 MPa of Ashcroft Gauge	±3.5 MPa of Ashcroft Gauge
Neutron Detector (2)	IR > 10^6	IR > 10^6	IR > 10^6
Gamma Detector (2)	IR > 10^6	IR > 10^6	IR > 10^6

a. As determined by average reading of the inlet thermocouples on test train.

b. As determined by Ashcroft loop pressure guage.

functioning within the specified limits, the approval of the RIA Project Leader or his alternate must be obtained in order to continue the test procedures. Any deviation from the acceptance criteria will be cause for further instrument checkout and corrective action taken where possible. Criteria deviations must be cross-checked against the minimum operable instrumentation list presented in Table VI and appropriate actions taken where necessary. The last status check will be performed just before the power burst.

Prior to any data acquisition, the PBF/DARS output will be verified by inputting voltages to the low level amplifiers or in accordance with a checklist to be supplied by the Instrument and Data Systems Section. This checklist will be incorporated in the Experiment Operating Procedures and will be signed off by the supervisor of the Instrumentation and Data section and RIA Project Leader or their designated alternates prior to loop heatup. All data channels must be calibrated prior to recording test data. The data acquisition equipment for the Fission Product Detection System (FPDS) is to be checked for proper operation prior to nuclear operation, and any malfunction reported to the RIA Project and FPDS Project Leaders.

In the event of a DARS channel failure, permission must be obtained from the Supervisor of the Instrumentation and Data Section or his alternate before the failed channel can be changed. If any channels are changed subsequent to the DARS cerification, then the changed channels must be reverified. An integrated data systems calibration of the minimum required instruments listed in Table VI will be performed just prior to and just after each nuclear operation. In the event that the DARS becomes inoperative during nuclear operation, the reactor power will be quickly reduced to 70 kW or less.

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3.2 Heat Up Phase Prior to Power Calibration and Conditioning

The initial part of the testing will consist of a complete instrument status check and verification of the Data Aquisition and Reduction System (DARS) to insure it is operating correctly. This checkout will be followed by a hydrostatic pressure check of the IPT. The maximum shroud flow will not exceed 2 l/s during heatup. Following the hydrostatic check and loop heatup, a coolant flow check will be performed as specified in Table V. The coolant flow check data is to be recorded on the flow balance checklists presented in Appendix A. The purpose of this is to verify coolant flow rates and obtain flow bypass ratios for use in calculating coolant flow rate in the event of a flow turbine meter malfunction. Another instrument status check and DARS data listing is to be obtained after the flow balance has been completed prior to heatup of the loop. During the heatup phase, DARS data printouts are to be obtained at approximately 50 K increments based on average test train inlet temperature and an instrument status check list is to be completed at approximately 450 K and again at the desired test temperature, 538 K. Instrument offsets will be determined and the DARS directory will be changed to compensate for the zero power offsets.

PBF/DARS on-line display will be monitored by ES&A personnel throughout heatup to evaluate the experiment instrumentation. DARS data printouts are to be taken approximately every hour through the entire test sequence and after each planned or unplanned change in the system conditions.

3.3 Prenuclear Instrument Drift Recording

Data channels shall be recorded for at least 30 minutes to establish any instrument drift rates. This recording should be done after heat-up and prior to nuclear operation at stable system conditions of: 538 $\pm$ 1.0 K inlet temperature, 6.45 $\pm$ 0.14 MPa IPT pressure, and 5.36 $\pm$ 0.2 l/s flow through the flow shroud.

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3.4 Fuel Rod Power Calibration and Conditioning

The objectives of the power calibration and conditioning phases of the test are to intercalibrate the thermal-hydraulically determined fuel rod bundle power with reactor power and the self-powered neutron detectors (SPNDs) mounted on the test assembly and to achieve an inventory of short lived fission products in the irradiated MAPI fuel rods. The on-line power calibration will be accomplished by measuring the coolant pressure, coolant inlet temperature, coolant temperature rise, and coolant flow through the flow shroud. The power calibration/conditioning cycles are shown in Figure 4.

Calibration of the DARS channels for the minimum required instruments listed in Table VI is required prior to the performance of the power calibration/preconditioning test phase and also at the conclusion of the power calibration/conditioning test phase. Data are to be recorded on both the narrow band and wide band channels for the power calibration/conditioning test phase. The required coolant conditions during these phases are: 538 $\pm$ 1.0 K inlet temperature, 6.45 $\pm$ 0.14 MPa IPT pressure, and 5.36 $\pm$ 0.2 l/s flow through the flow shroud. To perform the calibration, the reactor power will be increased to a predetermined level, the system allowed to reach equilibrium (5 to 10 minutes) and the fuel rod bundle power and neutron detector outputs measured and a DARS data printout obtained. After each power step the fuel rod bundle power is reduced to nearly zero (0.1 kW/m), a DARS data printout obtained, and the instrumentation offsets checked. This procedure will be repeated for a number of power level steps up to a maximum reactor power of approximately 27.8 MW. The maximum power increase ramp rate for the calibration phase of the test [illegible] kW/m per minute. The maximum power reduction ramp rate is not limited. The PBF reactor control rod position is to be recorded by the reactor console operators for each power level during the power calibration/conditioning test phase. The operating sequence for Test RIA 1-4 is presented in Table V.

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The figure-of-merit, relating total bundle power to driver core power, has been calculated to be 9.6 kW/MW. This value will be compared with the figure-of-merit determined during the test.

A temporary Channel 3 reactor shutdown circuit is required to shutdown the reactor if the cladding surface thermocouples (CLAD TMP 59-315 01 and CLAD TMP 59-135 06) on Rods 804-1 or 804-6 indicate a temperature in excess of 700 K. The shutdown circuit will include a time delay of 2 s to eliminate shutdown from noise spikes. This circuit will be removed or made inoperable prior to running the power burst.

After completion of the fuel rod power calibration and conditioning phases, the loop will be cooled down, the test train removed from the IPT, and the 0.51% cobalt-99.49% aluminum flux wires mounted on the flow shroud will be removed and replaced with 100% cobalt flux wires. The 0.51% cobalt-99.49% aluminum flux wire installed in the core will be replaced with a 100% cobalt flux wire. The irradiated core flux wires should be sent to the Radiation Measurement Laboratory for counting. Fuel Rod 804-10 will be replaced with fuel Rod 804-2 in the test train. A DARS calibration is to be conducted along with an instrument status check.

3.5 Trial Power Bursts

The PBF reactor is to be prepared for the performance of several trial power bursts to verify the reactor period required to achieve the desired energy deposition in the test rod bundle during the actual power burst. Reactor primary coolant conditions will be nominally 15000 gpm flow, 295 $\pm$3 K inlet temperature, and atmospheric pressure.

The trial power bursts will be performed as described in Section 3.7 with the test train out of the IPT. IPT loop required operating conditions will be: 600 $\pm$5 K inlet temperature, 15.3 $\pm$0.2 MPa IPT pressure, and 18.9 $\pm$0.2 l/s total loop flow. After each trial burst, the 100% cobalt core flux wires are to be replaced

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and the irradiated flux wires sent to the Radiation Measurement Laboratory as soon as possible for counting. Two trial bursts are tentatively planned, one at a reactor period of 2.3 ms and the other at a reactor period of 2.7 ms. The exact reactor periods will be determined on the basis of the power calibration core flux wire and on-line results. Data from the two trial power bursts and the power calibration data will be analyzed to determine if another trial burst is needed before inserting the test train. This determination will be made by the RIA Project Leader or his alternate.

At the completion of the trial burst testing the loop will be cooled down and depressurized and test train will be reinserted in the IPT. An instrumentation status check and DARS calibration will be performed at this time.

3.6 Loop Heatup Prior to Power Burst Testing

A cold hydrostatic check of the test loop will be conducted prior to heatup. The loop heatup will be interspaced with instrument status checks as shown in Table V. The maximum coolant shroud flow should not exceed 2 l/s. DARS data printouts are also to be obtained at approximately 50 K increments based on average test train inlet temperature. An instrument status check list is to be completed at approximately 450 K and again at the desired test temperature, 538 K. When the desired test conditions (538 $\pm$1.0 K coolant inlet temperature, 0.766 $\pm$0.4 l/s coolant shroud flow rate and 6.45 $\pm$0.14 MPa coolant pressure) are achieved, a coolant flow balance check measurement, and the zero power instrument offsets obtained and instrument drift characteristics will be recorded.

The DARS is to be recording data during the hydrostatic pressure check, during heatup, and during the flow calibration.

3.7 Power Burst Testing

The reactor period for the power burst will be chosen on the basis of the trial power bursts and power calibration results. Reactor physics calculations and PBF Lead Rod data presently indicate that a power burst with a 2.5 ms period will be required to obtain a corner rod energy of 280 cal/g UO_2. The two cladding thermocouple (Channel 3) reactor shutdown circuits will be made inoperable prior to running the power burst. Reactor primary coolant conditions will be nominally 15000 gpm flow, 295 $\pm$3 K inlet temperature, and atmospheric pressure.

The following sequence of operations leading to the initiation of a power burst is designed to minimize the steady state energy before the transient. It is essential that the steady state contribution of the flux wire activation be a small percentage of the power burst activation.

(1) The control rods will be withdrawn an amount required to establish a reactor power burst period of approximately 10 s. The reactor power will be allowed to increase until the "chamber operable light" indicates that the chambers are functioning properly. Immediately upon reaching this level, the control rods will be inserted an amount required to make the reactor subcritical, causing the power to rapidly decrease. Allow no more than 50% power overshoot above the chamber operable set point, in the event a chamber is not functioning properly.

(2) The reactor will be made critical at about 100 W for determination of the low power critical position of the control rods.

(3) The transient rods will then be drawn into the core to a position representative of the reactivity insertion required for the reactor transient.

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(4) The control rods will then be withdrawn to make the reactor critical at about 100 W. The reactivity inserted by the withdrawal of the control rods and the worth of the transient rods will be compared to ensure that the increment of control rod withdrawal determined for the power burst is not grossly in error.

(5) Steps 1 through 4 will be repeated if necessary to achieve the calculated control rod position required for the power burst.

(6) The transient rods will then be fully inserted in the core, with the control rod position adjusted to the required increment of withdrawal as determined in steps (4) and (5) above for the desired reactivity insertion.

(7) The power burst will be initiated manually. The control rod shutdown time or power trip level will be the same as that used previously in the PBF Lead Rod Test Series for approximately the same reactor period.

Data will be recorded on both the wideband and the narrowband DARS channels during the power burst test phase. Provision is also to be made to record the time of scram initiation and the control rod seat time referenced to IRIG time. The loop conditions during the power burst (flow rate, temperature and pressure) are to be maintained approximately constant for four hours after the power burst to allow acquisition of FPDS data on both the narrowband DARS and PDP-15 recording systems. The loop flow rate should not be manually increased during this time period to minimize the possibility of altering posttest conditions of the test assembly.

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4. DATA ACQUISITION AND REDUCTION REQUIREMENTS

Instrumentation displays in the PBF Data Acquisition and Reduction System (PBF/DARS) will identify the fuel rod, test assembly, and plant instruments according to the identifiers in Table VIII. Prior to each nuclear operation, it shall be verified that data are being recorded and that data are retrievable.

4.1 Data Acquisition Requirements

The data channels should be set to record the data based on the requirements of Table VIII. Instruments requiring high frequency recording will be set up to record on the DARS wideband channels. Those channels on the wideband recorders should also be recorded on narrowbands. All of the narrowband DARS channels should be available for display on the Vector General. All instruments which are designated as minimum operable instrumentation for the pre-power burst phase of Test RIA 1-4 (Table VI) will be recorded on at least two independent systems of equivalent frequency response to insure against the loss of data. The PBF/DARS narrowband channels will record data during the cold hydrostatic pressure check, the flow calibration, the heatup phases during all nuclear operation, and until the loop has been depressurized after the power burst. Both the wideband and the narrowband DARS recorders are to be turned on during the power calibration/conditioning phase. The wideband DARS is to be turned on for 30 minutes; starting 2 minutes before and ending 28 minutes after the power burst. Figure 5 indicates the data channels which will be required to be displayed on the strip charts during power calibration and fuel conditioning, and the power burst. The display and recording requirements are subject to change at the discretion of the RIA Project Leader or his alternate in the event of instrument failure or unusual test behavior. The core neutron chamber ranges shown in Table VIII are preliminary and should be set according to the expected peak power of the test. The upper range should be set to cover the peak power.

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TABLE VIII

TEST RIA 1-4 INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument	Location [a]	Rod Number	Identifier	Recording Ranges	Frequency Response Required
Fuel Rod						
Cladding Surface Temperature	TC	0.59 m - 315°	804-1	CLAD TMP 59-315 01	300 to 2100 K	High
Cladding Surface Temperature	TC	0.79 m - 135°	804-1	CLAD TMP 79-135 01	300 to 2100 K	High
Cladding Surface Temperature	TC	0.59 m - 315°	804-5	CLAD TMP 59-315 05	300 to 2100 K	High
Cladding Surface Temperature	TC	0.79 m - 135°	804-5	CLAD TMP 79-135 05	300 to 2100 K	High
Cladding Surface Temperature	TC	0.59 m - 135°	804-6	CLAD TMP 59-135 06	300 to 2100 K	High
Cladding Surface Temperature	TC	0.79 m - 315°	804-6	CLAD TMP 79-315 06	300 to 2100 K	High
Test Train						
Shroud Coolant Flow	Bi-directional Flow Turbine	Lower Shroud Extension	-	FLOWRATE INLET 01TT	0 to 6.0 l/s	Normal
Shroud Coolant Flow	Bi-directional Flow Turbine	Lower Shroud Extension	-	FLOWRATE INLET 02TT	0 to 6.0 l/s	Normal
Flow Turbine Frequency	AC Output From Flow Turbine	Lower Shroud Extension	-	AC Flowrate 01 TT	As Required	High
Flow Turbine Frequency	AC Output From	Lower Shroud Extension	-	AC Flowrate 02 TT	As Required	High
	Flow Turbine		-	SYS PRES 69EG UTT	0 to 70 MPa	Normal
Coolant Pressure	EG&G 69 MPa Px	Upper Test Train	-	SYS PRES 69EG LTT	0 to 70 MPa	Normal
Coolant Pressure	EG&G 69 MPa PXD	Lower Test Train	-	SYS PRES 17KA UTT	0 to 25 MPa	High
Coolant Pressure	EG&G 17 MPa PXD	Upper Test Assembly	-	SHRD PRES 17KA 01TT	0 to 25 MPa	High
Shroud Pressure	EG&G 17 MPa PXD	Upper Test Assembly	-	INLT TMP 01 TT	300 to 600 K (ss)[b] ; 1000 K (tr)[c]	Normal
Coolant Inlet Temperature	TC	Lower Shroud Extension	-	INLT TMP 02 TT	300 to 600 K (ss) ; 1000 K (tr)	Normal
Coolant Inlet Temperature	TC	Lower Shroud Extension	-	INLT TMP 03 TT	300 to 600 K (ss) ; 1000 K (tr)	Normal
Coolant Inlet Temperature	TC	Lower Shroud Extension	-	INLT TMP 04 TT	300 to 600 K (ss) ; 1000 K (tr)	Normal
Coolant Inlet Temperature	TC	Lower Shroud Extension	-	OUT TEMP 01 TT	300 to 600 K (ss) ; 1000 K (tr)	Normal
Coolant Outlet Temperature	TC	Upper Shroud Extension	-	OUT TEMP 02 TT	300 to 600 K (ss) ; 1000 K (tr)	Normal
Coolant Outlet Temperature	TC	Upper Shroud Extension	-	DEL TEMP 01 TT	0 to 20 K	Normal

TABLE VIII (Continued)

TEST RIA 1-4 INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument	Location [a]	Rod Number	Identifier	Recording Ranges	Frequency Response Required
Fuel Rod						
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 02 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 03 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 04 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 05 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 06 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 07 TT	0 to 20 K	Normal
Coolant Temperature Rise	ΔT Pair	Top and Bottom of Shroud	-	DEL TEMP 08 TT	0 to 20 K	Normal
Flow Shroud Temperature	TC	Outer Surface of Flow Shroud (0°)	-	SHRDTEMP -0 01 TT	300-600 K (ss); 2100 K (tr)	Normal
Flow Shroud Temperature	TC	Outer Surface of Flow Shroud (180°)	-	SHRDTEMP-180 02 TT	300-600 K (ss); 2100 K (tr)	Normal
Neutron Flux No. 1	SPND	Outer Surface of Flow Shroud (0°)	-	NEUT FLX -0 01 TT	10^{-10} to 10^{-3} amps	High
Neutron Flux No. 2	SPND	Outer Surface of Flow Shroud (180°)	-	NEUT FLX-180 02 TT	10^{-10} to 10^{-3} amps	High
Gamma Flux No.1	SPGD	Outer Surface of Flow Shroud (90°)	-	GAMMA FLX-90 01 TT	10^{-10} to 10^{-3} amps	High
Gamma Flux No. 2	SPGD	Outer Surface of Flow Shroud (270°)	-	GAMMA FLX-270 02TT	10^{-10} to 10^{-3} amps	High
Neutron Flux No. 3	Fission Chamber	Outer Surface of Flow Shroud (45°)	-	FISS CHBR 01 TT		High
Neutron Flux No. 4	Fission Chamber	Outer Surface of Flow Shroud (225°)	-	FISS CHBR 02 TT		High
Gross Gamma Rate	No. 1 Gamma Detector	FPDS	-	FP GAMMA NO.1 FP	10 to 10^6 counts/s	Normal
Gross Gamma Rate	No. 2 Gamma Detector	FPDS	-	FP GAMMA NO.2 FP	10 to 10^6 counts/s	Normal
Gross Gamma Rate	No. 3 Gamma Detector	FPDS	-	FP GAMMA NO.3 FP	10 to 10^6 counts/s	Normal
Gross Neutron Rate	Neutron Detector	FPDS	-	FP NEUT FP	10 to 10^6 counts/s	Normal
FPDS Flow Rate	No. 1 Flowmeter	FPDS	-	FP FLOW NO.1 FP	0 to 64 cm^3/s	Normal
FPDS Flow Rate	No. 2 Flowmeter	FPDS	-	FP FLOW NO.2 FP	0 to 64 cm^3/s	Normal
Pipe Temperature	Thermocouple	FPDS	-	FP TEMP PIPE FP	300 to 600 K (ss); 1000 K (tr)	Normal
Cubical Temperature	Thermocouple	FPDS	-	FP TEMP CUBICLFP	300 to 600 K (ss); 1000 K (tr)	Normal

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TABLE VIII (Continued)

TEST RIA 1-4 INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument	Location	Rod Number	Identifier	Recording Ranges	Frequency Response Required
FPDS [d]						
Plant [e]						
NMS-3 (30 MW)	Ion Chamber	Plant	-	REAC POW 30NMS3PT	0 to 40 MW	Normal
PPS-1 (50 MW)	Ion Chamber	Plant	-	REAC POW 50PPS1PT	0 to 50 MW	High
PPS-2 (50 MW)	Ion Chamber	Plant	-	REAC POW 50PPS2PT	0 to 50 MW	High
PPS-2 (5000 MW)	Ion Chamber	Plant	-	REAC POW 5KPPS2PT	0 to 5000 MW	High
PPS-3 (16 MW)	Ion Chamber	Plant	-	REAC POW 16PPS3PT	0 to 16 MW	High
PPS-3 (16000 MW)	Ion Chamber	Plant	-	REAC POW 16KPS3PT	0 to 16000 MW	High
PPS-4 (16 MW)	Ion Chamber	Plant	-	REAC POW 16PPS4PT	0 to 16 MW	High
PPS-4 (16000 MW)	Ion Chamber	Plant	-	REAC POW 16KPS4PT	0 to 16000 MW	High
TR-1 (50 MW)	Ion Chamber	Plant	-	REAC POW 50TR1PT	0 to 50 MW (ss); 100 MW (tr)	High
TR-1 (50000 MW)	Ion Chamber	Plant	-	REAC POW 100KTR1PT	0 to 100,000 MW (tr)	High
TR-2 (50 MW)	Ion Chamber	Plant	-	REAC POW 50TR2PT	0 to 50 MW (ss); 100 MW (tr)	High
TR-2 (50000 MW)	Ion Chamber	Plant	-	REAC POW 100KTR2PT	0 to 100,000 MW (tr)	High
EV-1 (50 MW)	Evacuation Chamber	Plant	-	REAC POW 50EV1PT	0 to 50 MW (ss); 100 MW (tr)	High
EV-1 (50000 MW)	Evacuation Chamber	Plant	-	REAC POW 100KEV1PT	0 to 100,000 MW (tr)	High
EV-2 (50 MW)	Evacuation Chamber	Plant	-	REAC POW 50EV2PT	0 to 50 MW (ss); 100 MW (tr)	High
EV-2 (50000 MW)	Evacuation Chamber	Plant	-	REAC POW 100KEV2PT	0 to 100,000 MW (tr)	High
System Pressure	PXD	Plant	-	SYS PRES PT	0 to 17 MPa	Normal
IPT Pressure	ΔP PXD	Plant	-	IPT DELP PT	0 to 0.69 MPa	Normal
Loop Flow	Venturi	Plant	-	LOOP FLO PT	0 to 0.063 m^3/s	Normal
Vessel Strain	Strain Gauge	Plant	-	VESTRAIN NO.1 PT	0 to 500 in/in	Normal
Vessel Strain	Strain Gauge	Plant	-	VESTRAIN NO.2 PT	0 to 500 in/in	Normal
Core Rod Axial Growth	Core LVDT No. 1	Plant	-	CLAD DSP CORE1 PT	$\pm$ 12.7 mm	High
Core Rod Axial Growth	Core LVDT No. 2	Plant	-	CLAD DSP CORE2 PT	$\pm$ 12.7 mm	High
Core Rod Axial Growth	Core LVDT No. 3	Plant	-	CLAD DSP CORE3 PT	$\pm$ 12.7 mm	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-20 PT	0 to 34 MPa	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-23 PT	0 to 34 MPa	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-24 PT	0 to 34 MPa	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-25 PT	0 to 34 MPa	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-34 PT	0 to 34 MPa	High
Loop Coolant Pressure	0 to 34 MPa PXD	Plant	-	LOOPPRES 5-35 PT	0 to 34 MPa	High
Core Pressure	0 to 34 MPa PXD	Plant	-	COREPRES W PT	0 to 34 MPa	High
Core Pressure	0 to 34 MPa PXD	Plant	-	COREPRES NE PT	0 to 34 MPa	High
Core Pressure	0 to 34 MPa PXD	Plant	-	COREPRES SE PT	0 to 34 MPa	High

a. All elevations are relative to the bottom elevation of the fuel stack.
b. Steady state (ss).
c. Transient (tr).
d. Fission Product Detection System (FPDS)
e. The indicated ranges of the core neutron chambers are preliminary and may be changed at the discretion of the TF&D representative if necessary.

	FLOW RATE INLET 01 TT FLOW RATE INLET 02 TT	INLET TMP 01 TT INLET TMP 02 TT
CLAD TMP 59-315 01 CLAD TMP 79-135 01	CLAD TMP 59-315 05 CLAD TMP 79-135 05	CLAD TMP 59-135 06 CLAD TMP 79-315 06
DEL TEMP 01 TT DEL TEMP 02 TT	FP GAMMA NO. 1 FP FP GAMMA NO. 2 FP	FP GAMMA NO. 3 FP FP NEUT FP
SYS PRES 69EG UTT SYS PRES 69EG LTT	SYS PRES 17KA UTT SHRD PRES 17KA 01 TT	REAC POW 40NMS-3 PT SYS PRES PT
NEUT FLX -0 01 TT NEUT FLX -180 02 TT	GAMMA FLX -90 01 TT GAMMA FLX -270 02 TT	FISS CHBR 01 TT FISS CHBR 02 TT

Fig. 5 Strip chart set-up for Test RIA 1-4 power calibration, conditioning, and power burst phases.

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Within 24 hours after termination of the test, the RIA Project Leader should be given copies of the check lists contained in Appendix A, the strip charts, copies of the reactor console log book pages pertaining to Test RIA 1-4, and other documentation necessary to establish specific data requirements and to prepare the Quick Look Report. A complete list of the required information is given in Table IX.

4.2 Data Reduction Requirements

Data reduction and plotting requirements are separated into three segments. The first segment concerns data reduction and plot requirements needed for the test conduct. The second segment concerns data reduction and presentation requirements for the RIA 1-4 Quick Look Report and the third segment concerns the Test Results Report. Additional plotting requirements will be stipulated for the test analysis, based on test performance and postt t code analyses.

4.2.1 Test Conduct. In order to determine the power burst required to achieve the fuel rod target energy for RIA 1-4, it will be necessary to process some of the power calibration data prior to conducting the actual power burst.

The following data requirements are needed:

(1) Integration of the nine-rod assembly calorimetrically-measured power during all nuclear operation to determine total assembly energy during steady state nuclear operation.

(2) Second order regression fit of assembly power as a function of each of the following: TR-1, TR-2, EV-1, EV-2, SPND-1, SPND-2, SPGD-1, and SPGD-2 during power calibration portion of the test.

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TABLE IX

POSTTEST DOCUMENTATION REQUIREMENTS

Measurement Status
- Ambient
- 538 K (after heatup prior to power calibration)
- Reactor critical (100 kW)
- Ambient
- 538 K (prior to each power burst)
DARS Channel Setup Log Sheet
Backup data system Channel Setup Log Sheet
DARS Log Sheets
DARS Parameter/Sensor Directory
Strip Charts
Copy of Reactor Console Log

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(3) The DARS is to have the capability of making on-line plots of parameter versus parameter to aid in the evaluation of instrument and fuel rod performance.

4.2.2 Quick Look Report. Test data plots and pretest data calculation comparison plots for the Quick Look Report are to be prepared within 3 working days after the completion of the test; it is mandatory that this requirement be met. The Quick Look Report will contain only plots of data from the final power burst of the test. A complete list of the plots required for the Quick Look Report will be provided by the RIA Project Engineer within two weeks of the test. The plots generated will go directly into the Quick Look Report without redrawing or handling by graphics personnel. The plots size should conform to 8-1/2 x 11-inch paper with conventional margins. All plotted data are to be in standard SI units. That portion of the SPORT[a] computer program required to compute reactor energy and reactivity as a function of time from the power history will be programmed into the PBF/DARS computer and the data from the trial power bursts and the actual power burst will be processed through the program. Digital printout of all the data from the reactor neutron detecting chambers (EV-1, EV-2, TR-1 and TR-2), SPGDs, and SPNDs during the trial power bursts and the actual power burst will be required.

4.2.3 Test Results Report. Data plot requirements for the Test Results Report are expected to evolve during the analysis of the test data. These requirements will be transmitted to the data system group.

The data associated with the fuel rod and test assembly instrumentation presented in Table X shall be thoroughly reviewed and categorized as qualified, restrained, trend, or failed data. The time period and priority for which this data is to be qualified is also presented in Table X.

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a. B. J. Powe , R. N. Hagen and S. O. Johnson, SPORT-A System for Processing Reactor Transient Dat on the IBM-7040 Computer, IDO-17078 (July 1965).

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TABLE X

DATA QUALIFICATION REQUIREMENTS

Measurement	Instrument (s)	Test Phases for Data Qualification	Priority[a]
Cladding Surface Temperature	CLAD TMP 59-315 01	Power Calibration/Conditioning, Power Burst[b]	2,1
	CLAD TMP 79-135 01	Power Calibration/Conditioning, Power Burst[b]	2,1
	CLAD TMP 59-315 05	Power Calibration/Conditioning, Power Burst[b]	2,1
	CLAD TMP 79-135 05	Power Calibration/Conditioning, Power Burst[b]	2,1
	CLAD TMP 59-135 06	Power Calibration/Conditioning, Power Burst[b]	2,1
	CLAD TMP 79-135 06	Power Calibration/Conditioning, Power Burst[b]	2,1
Shroud Flow	FLOWRATE INLET 01TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	FLOWRATE INLET 02TT	Power Calibration/Conditioning, Power Burst[b]	1,1
Coolant Pressure	SYS PRES 69 EG UTT	Power Burst[b]	1
	SYS PRES 69 EG LTT	Power Burst[b]	1
	SYS PRES 17 KA UTT	Power Calibration/Conditioning, Power Burst[b]	1,1
	SHRD PRES 17 KA 01TT	Power Burst[b]	1
Coolant Inlet Temperature	INLT TMP 01 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	INLT TMP 02 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	INLT TMP 03 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	INLT TMP 04 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
Coolant Outlet Temperature	OUT TMP 01 TT	Power Burst[b]	1
	OUT TMP 02 TT	Power Burst[b]	1
Coolant Temperature Rise	DEL TEMP 01 through 08	Power Calibration/Conditioning,	1
Flow Shroud Temperature	SHRD TEMP -0 01 TT	Power Burst[b]	1
	SHRD TEMP -180 02TT	Power Burst[b]	1

TABLE X (continued)

Measurement	Instrument (s)	Test Phases for Data Qualification	Priority[a]
Neutron Flux	NEUT FLX -0 01 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	NEUT FLX -180 02 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	FISS CHBR 01 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	FISS CHBR 02 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
Gamma Flux	GAMMA FLX -90 01 TT	Power Calibration/Conditioning, Power Burst[b]	1,1
	GAMMA FLX -270 02TT	Power Calibration/Conditioning, Power Burst[b]	1,1
Fission Product Detection	FP GAMMA No. 1 FP	Power Burst[c]	1
	FP GAMMA No. 2 FP	Power Burst[c]	1
	FP GAMMA No. 3 FP	Power Burst[c]	1
	FP NEUT	Power Burst[c]	
Reactor Power	REAC POW 30 NMS3PT	All Nuclear Operation	2
	REAC POW 50 TR1 PT	All Nuclear Operation	1
	REAC POW 50 TR2 PT	All Nuclear Operation	1
	REAC POW 50 EV1 PT	All Nuclear Operation	1
	REAC POW 50 EV2 PT	All Nuclear Operation	1
	REAC POW 100 KTR1PT	All Power Bursts[d]	1
	REAC POW 100 KTR2PT	All Power Bursts[d]	1
	REAC POW 100 KEV1PT	All Power Bursts[d]	1
	REAC POW 100 KEV2PT	All Power Bursts[d]	1
System Pressure	SYS PRES PT	All Phases	1

a. Priority ranking is: 1-highest, 2-next highest.

b. If possible, data should be qualified for 10 minutes after time of peak power.

c. If possible, data should be qualified until loop is depressurized after power burst.

d. If possible, data should be qualified for 1 minute after time of peak power for trial and final power bursts.

5. OPERATIONS SUPPORT

Before the test and following each cooldown, two loop water samples will be taken for chemical and fission product analysis. Coolant samples must be taken before the remote loop cleanup equipment is valved into the system. One sample should be analyzed for nitrogen, oxygen, and hydrogen and the other sample sent to the TRA counting laboratory for fission product and uranium analysis. Additional elemental analysis of the loop coolant samples may be required if requested by the Fission Product Detection System (FPDS) Project Leader or RIA Project Leader. Copies of the Analysis are to be sent to the RIA Project Leader and the FPDS Project Leader.

Core flux wires should be removed and shipped immediately to the Radiation Measurements Laboratory after the power calibration/-conditioning phase is completed, and after each trial power burst. Core flux wire scan results from the power calibration/conditioning phase and trial power bursts are required before performing the actual power burst.

Table XI lists the fission product inventory and the total activity (R/hr) at 30.5 cm distance, in air, from the fuel rods at various times after nuclear operations. The calculations presented are based on expected power operation. Deviations between the planned and actual power histories may require recalculation of the activity levels and fission product inventories. The hot cell has a current acceptance limit of 10^{-2} curies of I^{131} per fuel rod. According to Table XI, intact fuel rods can be shipped to the hot cell within 106 days after the final shutdown of Test RIA 1-4. Fuel rods that fail during testing may be shipped to the hot cell within one week after the test is completed.

It is anticipated that all fuel rods will fail, the fuel rod cladding will be heavily oxidized and in an embrittled conditon. Therefore, posttest handling, shipment, and storage should be performed as carefully as possible to minimize further fuel rod

TABLE XI

RESULTS OF RADIOLOGICAL HAZARDS ANALYSIS FOR TEST RIA 1-4

	Decay (day)[a]								
Parameter	1	7	28	56	63	70	77	84	91
Ci of I-131	7.609+1[b]	4.996+1	8.238+0	7.397-1	4.048-1	2.215-1	1.212-1	6.635-2	3.635-2
Ci of I-132	2.556+2	7.115+1	8.035-1	2.065-3	neg.	—	—	—	—
Ci of I-133	6.903+2	5.961+0	3.572-7	neg	—	—	—	—	—
Ci of I-134	2.86-4	neg	—	—	—	—	—	—	—
Ci of I-135	3.064+2	neg	—	—	—	—	—	—	—
R/hr@ 30.5 cm from Rod	1.770+3	2.319+2	7.956+1	5.565+1	5.335+1	5.149+1	5.030+1	4.924+1	4.839+1

a. Based on an average rod.

b. 7.609+1 = 7.609×10^1.

damage. All fuel rod instrument leads are to be tagged with the connector number and instrument identifier during the disassembly procedure. This identification will allow verification of instrument positions during hot cell disassembly.

Closure plugs should be installed on the upper and lower ends of the flow shroud to prevent further loss of material from failed fuel rods during handling and shipment to the hot cell.

6. POSTIRRADIATION EXAMINATION REQUIREMENTS

The postirradiation examination (PIE) requirements for Test RIA 1-4 will vary depending on fuel rod failure and the degree of fragmentation that occurs. It is assumed that all nine rods will fail. The tentative outline for the PIE consists of the following:

(1) A gamma scan and neutron fluence (nvt) determination of the eight 0.51% cobalt flux wires attached to the flow shroud during the steady state part of the test and the eight cobalt flux wires on the shroud for the power burst. Each wire will be tagged to identify wire number, location, test phase, and top end of wire.

(2) A gamma scan and nvt determination of the four flux wires inserted in the PBF core. Each wire will be cut to 1.22 m length and tagged to identify wire number, location, irradiation time, and top end of wire.

(3) The visual, dimensional, and photographic examination of the flow shroud. All loose fragments of failed fuel rods should be weighed and screened.

(4) Neutron radiography of flow shroud and fuel rods. A special fixture will be required to hold the assembly.

(5) Epoxy entire flow shroud with fuel rods in place.

(6) Sectioning of the nine-rod assembly to obtain 20 burnup samples and 25 metallurgical mounts.

(7) The preparation of two samples for scanning electron microscope (SEM) examination.

(8) Two samples for microprobe analysis and four cladding gas samples.

7. REFERENCES

1. United States Nuclear Regulatory Commission, Reactor Safety Research Program, Description of Current and Planned Reactor Safety Research Sponsored by the Nuclear Regulatory Commission's Division of Reactor Safety Research, NUREG-75/058 (June 1975).

2. L. B. Thompson, D. L. Hagrman, P. E. MacDonald, Light-Water Reactor Fuel Behavior Program Description: RIA Fuel Behavior Experiment Requirements, RE-S-76-187 (October 1976).

3. Z. R. Martinson, R. S. Semken, RIA 1-4 Experiment Specification Document, TFBP-TR-278 Revision 1 (January 1978).

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APPENDIX A

STATUS CHECKLISTS FOR INSTRUMENTATION

INSTRUMENT STATUS CHECKS

The checklists provided in this appendix are to be incorporated in the RIA 1-4 Experiment Operating Procedure.

Checklist No. 1

TRA Assembly Area

This checklist is found in "Instrument Check Procedure," TP-RIA-1401.

Checklist No. 2

Pre-In-Pile Tube Loading

This checklist is found in "Instrument Checkout Procedure," TP-RIA-1402.

INSTRUMENT STATUS PRIOR TO POWER CALIBRATION

Check List No. 3

Reactor Power	- 0.0 MW	Minimum required operable instrumentation available for RIA 1-4 EOS
Plant IPT Coolant Temperature	538 K	
Ashcroft Pressure Gauge	6.45 MPa	____________ Instrument Data Section representative
Shroud Flow Rate	5.36 l/s	____________ TFBD representative in charge

Instrument Identifier	PBF/DARS Reading	Required Range	Certification Instrument is within Range [a]
CLAD TMP 59-315 01	________K	518 to 558 K	________
CLAD TMP 79-135 01	________K	518 to 558 K	________
CLAD TMP 59-315 05	________K	518 to 558 K	________
CLAD TMP 79-135 05	________K	518 to 558 K	________
CLAD TMP 59-135 06	________K	518 to 558 K	________
CLAD TMP 79-315 06	________K	518 to 558 K	________
SHRD TEMP -0 01 TT	________K	518 to 558 K	________
SHRD TEMP -180 02TT	________K	518 to 558 K	________
SYS PRES 69EG UTT	________MPa	±3.5 MPa of Ashcroft	________
SYS PRES 69EG LTT	________MPa	±3.5 MPa of Ashcroft	________
SYS PRES 17EG UTT	________MPa	±2 MPa of Ashcroft	________
SHRD PRES 17EG 01TT	________MPa	±2 MPa of Ascroft	________
FLOWRATE INLET 01TT	________ l/s	5.36 ± 0.2 l/s	________
FLOWRATE INLET 02TT	________ l/s	5.36 ± 0.2 l/s	________
INLT TMP 01 TT	________K	528 to 548 K	________
INLT TMP 02 TT	________K	528 to 548 K	________
INLT TMP 03 TT	________K	528 to 548 K	________
INLT TMP 04 TT	________K	528 to 548 K	________
OUT TEMP 01 TT	________K	528 to 548 K	________
OUT TEMP 02 TT	________K	528 to 548 K	________

DEL TEMP	01 TT	______ K	± 1.0 K	______
DEL TEMP	02 TT	______ K	± 1.0 K	______
DEL TEMP	03 TT	______ K	± 1.0 K	______
DEL TEMP	04 TT	______ K	± 1.0 K	______
DEL TEMP	05 TT	______ K	± 1.0 K	______
DEL TEMP	06 TT	______ K	± 1.0 K	______
DEL TEMP	07 TT	______ K	± 1.0 K	______
DEL TEMP	08 TT	______ K	± 1.0 K	______
FP TEMP PIPE	FP	______ K	460 to 458 K	______
NEUT FLX -0	01 TT	______		______
NEUT FLX -180	02TT	______		______
GAMMA FLX -90	01 TT	______		______
GAMMA FLX -270	02TT	______		______
FISS CHBR	01 TT	______		______
FISS CHBR	02 TT	______		______

a. This certification must be signed by the Supervisor or his alternate of the Instrumentation and Data Section. For instruments not within the acceptable operating limits, the Supervisor of the Test Train Fabrication Section or his alternate must certify that the instrument is not functioning. For all cases where the instruments are not within the acceptable operating limits, the RIA Projects Leader or his alternat approval must be obtained to continue the test procedures.

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INSTRUMENT STATUS AFTER POWER CALIBRATION

Check List No. 4

Reactor Power	- 0.0 MW	Minimum required operable instrumentation available for RIA 1-4 EOS
Plant IPT Coolant Temperature	538 K	
Ashcroft Pressure Gauge	6.45 MPa	________ Instrument Data Section representative
Shroud Flow Rate	5.36 l/s	________ TFBD representative in charge

Instrument Identifier	PBF/DARS Reading	Required Range	Certification Instrument is within Range [a]
CLAD TMP 59-315 01	________ K	518 to 558 K	________
CLAD TMP 79-135 01	________ K	518 to 558 K	________
CLAD TMP 59-315 05	________ K	518 to 558 K	________
CLAD TMP 79-135 05	________ K	518 to 558 K	________
CLAD TMP 59-135 06	________ K	518 to 558 K	________
CLAD TMP 79-315 06	________ K	518 to 558 K	________
SHRD TEMP 0 01 TT	________ K	518 to 558 K	________
SHRD TEMP 0 02TT	________ K	518 to 558 K	________
SYS PRES 69EG UTT	________ MPa	±3.5 MPa of Ashcroft	________
SYS PRES 69EG LTT	________ MPa	±3.5 MPa of Ashcroft	________
SYS PRES 17EG UTT	________ MPa	±2 MPa of Ashcroft	________
SHRD PRES 17EG 01TT	________ MPa	±2 MPa of Ashcroft	________
FLOWRATE INLET 01TT	________ l/s	5.36 ± 0.2 l/s	________
FLOWRATE INLET 02TT	________ l/s	5.36 ± 0.2 l/s	________
INLT TMP 01 TT	________ K	528 to 548 K	________
INLT TMP 02 TT	________ K	528 to 548 K	________
INLT TMP 03 TT	________ K	528 to 548 K	________
INLT TMP 04 TT	________ K	528 to 548 K	________
OUT TEMP 01 TT	________ K	528 to 548 K	________
OUT TEMP 02 TT	________ K	528 to 548 K	________

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DEL TEMP	01 TT	________ K	± 1.0 K	________
DEL TEMP	02 TT	________ K	± 1.0 K	________
DEL TEMP	03 TT	________ K	± 1.0 K	________
DEL TEMP	04 TT	________ K	± 1.0 K	________
DEL TEMP	05 TT	________ K	± 1.0 K	________
DEL TEMP	06 TT	________ K	± 1.0 K	________
DEL TEMP	07 TT	________ K	± 1.0 K	________
DEL TEMP	08 TT	________ K	± 1.0 K	________
FP TEMP PIPE	FP	________ K	460 to 548 K	________
NEUT FLX -0	01 TT	________		________
NEUT FLX -180	02TT	________		________
GAMMA FLX -90	01 TT	________		________
GAMMA FLX -270	02TT	________		________
FISS CHBR	01 TT	________		________
FISS CHBR	02 TT	________		________

a. This certification must be signed by the Supervisor or his alternate of the Instrumentation and Data Section. For instruments not within the acceptable operating limits, the Supervisor of the Test Train Fabrication Section or his alternate must certify that the instrument is not functioning. For all cases where the instruments are not within the acceptable operating limits, the RIA Projects Leader or his alternates approval must be obtained to continue the test procedures.

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INSTRUMENT STATUS AFTER TEST TRAIN INSERTION
FOLLOWING TRIAL POWER BURSTS

Check List No. 5

Reactor Power	- 0.0 MW	Minimum required operable instrumentation available for RIA 1-4 EOS
Plant IPT Coolant Temperature	Ambient	
Ashcroft Pressure Gauge	Ambient	____________ Instrument Data Section representative
Shroud Flow Rate	0.0 l/s	____________ TFBD representative in charge

Instrument Identifier	PBF/DARS Reading	Required Range	Certification Instrument is within Range [a]
CLAD TMP 59-315 01	________ K	Ambient	________
CLAD TMP 79-135 01	________ K	Ambient	________
CLAD TMP 59-315 05	________ K	Ambient	________
CLAD TMP 79-135 05	________ K	Ambient	________
CLAD TMP 59-135 06	________ K	Ambient	________
CLAD TMP 79-315 06	________ K	Ambient	________
SHRD TEMP -0 01 TT	________ K	Ambient	________
SHRD TEMP -180 02TT	________ K	Ambient	________
SYS PRES 69EG UTT	________ MPa	±3.5 MPa of Ashcroft	________
SYS PRES 69EG LTT	________ MPa	±3.5 MPa of Ashcroft	________
SYS PRES 17EG UTT	________ MPa	±2 MPa of Ashcroft	________
SHRD PRES 17EG 01TT	________ MPa	±2 MPa of Ashcroft	________
FLOWRATE INLET 01TT	________ l/s	0.0	________
FLOWRATE INLET 02TT	________ l/s	0.0	________
INLT TMP 01 TT	________ K	Ambient	________
INLT TMP 02 TT	________ K	Ambient	________
INLT TMP 03 TT	________ K	Ambient	________
INLT TMP 04 TT	________ K	Ambient	________
OUT TEMP 01 TT	________ K	Ambient	________
OUT TEMP 02 TT	________ K	Ambient	________

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DEL TEMP	01 TT	________ K		________
DEL TEMP	02 TT	________ K		________
DEL TEMP	03 TT	________ K		________
DEL TEMP	04 TT	________ K		________
DEL TEMP	05 TT	________ K		________
DEL TEMP	06 TT	________ K		________
DEL TEMP	07 TT	________ K		________
DEL TEMP	08 TT	________ K		________
FP TEMP PIPE	FP	________ K	Ambient ± 20 K	________
NEUT FLX -0	01 TT	________		________
NEUT FLX -180	02TT	________		________
GAMMA FLX -90	01 TT	________		________
GAMMA FLX -270	02TT	________		________
FISS CHBR	01 TT	________		________
FISS CHBR	02 TT	________		________

a. This certification must be signed by the Supervisor or his alternate of the Instrumentation and Data Section. For instruments not within the acceptable operating limits, the Supervisor of the Test Train Fabrication Section or his alternate must certify that the instrument is not functioning. For all cases where the instruments are not within the acceptable operating limits, the RIA Projects Leader or his alternates approval must be obtained to continue the test procedures.

INSTRUMENT STATUS DURING HEATUP PRIOR POWER BURST

Check List No. 6

Reactor Power	- 0.0 MW	Minimum required operable instrumentation available for RIA 1-4 EOS
Plant IPT Coolant Temperature	450 K	____________Instrument Data Section representative
Ashcroft Pressure Gauge	6.45 MPa	
Shroud Flow Rate	0.766 l/s	____________TFBD representative in charge

Instrument Identifier	PBF/DARS Reading	Required Range	Certification Instrument is within Range [a]
CLAD TMP 59-315 01	________K	430 to 470 K	________
CLAD TMP 79-135 01	________K	430 to 470 K	________
CLAD TMP 59-315 05	________K	430 to 470 K	________
CLAD TMP 79-135 05	________K	430 to 470 K	________
CLAD TMP 59-135 06	________K	430 to 470 K	________
CLAD TMP 79-315 06	________K	430 to 470 K	________
SHRD TEMP -0 01 TT	________K	430 to 470 K	________
SHRD TEMP -180 02TT	________K	430 to 470 K	________
SYS PRES 69EG UTT	________MPa	±3.5 MPa of Ashcroft	________
SYS PRES 69EG LTT	________MPa	±3.5 MPa of Ashcroft	________
SYS PRES 17EG UTT	________MPa	±2 MPa of Ashcroft	________
SHRD PRES 17EG 01TT	________MPa	±2 MPa of Ashcroft	________
FLOWRATE INLET 01TT	________ l/s	0.766 ± 0.04 l/s	________
FLOWRATE INLET 02TT	________ l/s	0.766 ± 0.04 l/s	________
INLT TMP 01 TT	________K	440 to 460 K	________
INLT TMP 02 TT	________K	440 to 460 K	________
INLT TMP 03 TT	________K	440 to 460 K	________
INLT TMP 04 TT	________K	440 to 460 K	________
OUT TEMP 01 TT	________K	440 to 460 K	________
OUT TEMP 02 TT	________K	440 to 460 K	________

DEL TEMP	01 TT	______ K		______
DEL TEMP	02 TT	______ K		______
DEL TEMP	03 TT	______ K		______
DEL TEMP	04 TT	______ K		______
DEL TEMP	05 TT	______ K		______
DEL TEMP	06 TT	______ K		______
DEL TEMP	07 TT	______ K		______
DEL TEMP	08 TT	______ K		______
FP TEMP PIPE	FP	______ K	366 to 460 K	______
NEUT FLX -0	01 TT	______		______
NEUT FLX -180	02TT	______		______
GAMMA FLX -90	01 TT	______		______
GAMMA FLX -270	02TT	______		______
FISS CHBR	01 TT	______		______
FISS CHBR	02 TT	______		______

a. This certification must be signed by the Supervisor or his alternate of the Instrumentation and Data Section. For instruments not within the acceptable operating limits, the Supervisor of the Test Train Fabrication Section or his alternate must certify that the instrument is not functioning. For all cases where the instruments are not within the acceptable operating limits, the RIA Projects Leader or his alternates approval must be obtained to continue the test procedures.

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INSTRUMENT STATUS PRIOR TO POWER BURST

Check List No. 7

Reactor Power	- 0.0 MW	Minimum required operable instrumentation available for RIA 1-4 EOS
Plant IPT Coolant Temperature	5.38 K	
Ashcroft Pressure Gauge	6.45 MPa	____________ Instrument Data Section representative
Shroud Flow Rate	0.766 1/s	____________ TFBD representative in charge

Instrument Identifier	PBF/DARS Reading	Required Range	Certification Instrument is within Range [a]
CLAD TMP 59-315 01	____________ K	518 to 558 K	____________
CLAD TMP 79-135 01	____________ K	518 to 558 K	____________
CLAD TMP 59-315 05	____________ K	518 to 558 K	____________
CLAD TMP 79-135 05	____________ K	518 to 558 K	____________
CLAD TMP 59-135 06	____________ K	518 to 558 K	____________
CLAD TMP 79-315 06	____________ K	518 to 558 K	____________
SHRD TEMP -0 01 TT	____________ K	518 to 558 K	____________
SHRD TEMP -180 02TT	____________ K	518 to 558 K	____________
SYS PRES 69EG UTT	____________ MPa	±3.5 MPa of Ashcroft	____________
SYS PRES 69EG LTT	____________ MPa	±3.5 MPa of Ashcroft	____________
SYS PRES 17EG UTT	____________ MPa	±2 MPa of Ashcroft	____________
SHRD PRES 17EG 01TT	____________ MPa	±2 MPa of Ashcroft	____________
FLOWRATE INLET 01TT	____________ 1/s	0.766 ± 0.04 1/s	____________
FLOWRATE INLET 02TT	____________ 1/s	0.766 ± 0.04 1/s	____________
INLT TMP 01 TT	____________ K	528 to 548 K	____________
INLT TMP 02 TT	____________ K	528 to 548 K	____________
INLT TMP 03 TT	____________ K	528 to 548 K	____________
INLT TMP 04 TT	____________ K	528 to 548 K	____________
OUT TEMP 01 TT	____________ K	528 to 548 K	____________
OUT TEMP 02 TT	____________ K	528 to 548 K	____________

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DEL TEMP	01 TT	____________ K		____________
DEL TEMP	02 TT	____________ K		____________
DEL TEMP	03 TT	____________ K		____________
DEL TEMP	04 TT	____________ K		____________
DEL TEMP	05 TT	____________ K		____________
DEL TEMP	06 TT	____________ K		____________
DEL TEMP	07 TT	____________ K		____________
DEL TEMP	08 TT	____________ K		____________
FP TEMP PIPE	FP	____________ K	460 to 548 K	____________
NEUT FLX -0	01 TT	____________		____________
NEUT FLX -180	02TT	____________		____________
GAMMA FLX -90	01 TT	____________		____________
GAMMA FLX -270	02TT	____________		____________
FISS CHBR	01 TT	____________		____________
FISS CHBR	02 TT	____________		____________

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a. This certification must be signed by the Supervisor or his alternate of the Instrumentation and Data Section. For instruments not within the acceptable operating limits, the Supervisor of the Test Train Fabrication Section or his alternate must certify that the instrument is not functioning. For all cases where the instruments are not within the acceptable operating limits, the RIA Projects Leader or his alternates approval must be obtained to continue the test procedures.

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PREPOWER CALIBRATION FLOW BALANCE CHECKLIST

CHECKLIST NO 8

Coolant Temperature 538 K
Coolant Pressure 6.45 MPa

Nominal Shroud Flow (l/s)	Bypass Valve Setting [a] Valve 29[c]	Bypass Valve Setting [a] Valve 30[d]	Flowrate Inlet 01 TT (l/s)	Flowrate Inlet 02 TT (l/s)	Average Shroud Flow (l/s)	Total Loop Flowrate (l/s)	Bypass[b] Flow Ratio
0.4							
0.6							
0.8							
1.0							
2.0							
3.0							
4.0							
5.0							
5.36							

a. Defined as number of full tur ; of valve from fully open position.

b. Defined as $\frac{\text{Total Loop Flow Rate - Average Shroud Flow}}{\text{Total Loop Flow Rate}}$.

c. Valve 29 is Valve GT-BB-10-29.

d. Valve 30 is Valve GT-BB-10-30.

PREPOWER BURST FLOW BALANCE CHECKLIST

CHECKLIST NO. 9

Coolant Temperature 538 K
Coolant Pressure 6.45 MPa

Nominal Shroud Flow (l/s)	Bypass Valve Setting [a]		Flowrate Inlet 01 TT (l/s)	Flowrate Inlet 02 TT (l/s)	Average Shroud Flow (l/s)	Total Loop Flowrate (l/s)	Bypass Flow Ratio [b]
	Valve 29[c]	Valve 30[d]					
0.4	____	____	____	____	____	____	____
0.6	____	____	____	____	____	____	____
0.8	____	____	____	____	____	____	____
1.0	____	____	____	____	____	____	____

a. Defined as number of full turns of valve from fully open position.

b. Defined as $\frac{\text{Total Loop Flow Rate - Average Shroud Flow}}{\text{Total Loop Flow Rate}}$.

c. Valve 29 is Valve GT-BB-10-29.

d. Valve 30 is Valve GT-BB-10-30.