EG&G Idaho, Inc.

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Author(s): T. R. Yackle

Date of Document: September 1979

Responsible NRC Individual and NRC Office or Division: R. VanHouten

This document was prepared primarily for preliminary or internal use. It has not received full review and approval. Since there may be substantive changes, this document should not be considered final.

EG&G Idaho, Inc.
Idaho Falls, Idaho 83401

for H. P. Pearson, Supervisor
Information Processing

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Under contract No. EY-76-C-07-1570
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A6041

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EGG-TFBP-5013
September 1979

LOSS-OF-COOLANT ACCIDENT TEST SERIES TC-1 EXPERIMENT OPERATING SPECIFICATION

T. R. Yackle

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory

This is an informal report intended for use as a preliminary or working document

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LOSS-OF-COOLANT ACCIDENT TEST SERIES
TC-1
EXPERIMENT OPERATING SPECIFICATION

September 1979

T. R. YACKLE

Thermal Fuels Behavior Program
EG&G Idaho, Inc.

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1216 091

CONVERSION FACTORS FOR SI AND U.S. CUSTOMARY UNITS

To Convert From	To	Multiply by
K	^oF	1.8 K - 459.67
$kg/s\text{-}m^2$	$lb/ft^2\text{-}hr$	737.4
kg/s	lb/s	2.2046
kW/m	kW/ft	0.3048
m	ft	3.2808
MPa	psi	145.05
W/m^2	$Btu/ft^2\text{-}hr$	0.3169
m^3/s	ft^3/s	35.315
ℓ/s	gal/min	15.85

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1. INTRODUCTION

The Loss of Coolant Accident (LOCA) Program[1] is part of the Department of Energy Fuel Behavior Program[2] sponsored by the Nuclear Regulatory Commission, and is directed towards providing a detailed understanding of the response of nuclear fuel rods to off-normal accident conditions. This is one of several programs being conducted by the Thermal Fuels Behavior Program of EG&G Idaho, Inc., in the Power Burst Facility (PBF) that will provide data for development and assessment of fuel behavior computer models used to predict the response of light water reactor (LWR) fuel under hypothesized accident conditions.

The purpose of this document is to specify the experiment operating procedure for the test series TC-1. The effects of externally mounted cladding thermocouples on the fuel rod thermal behavior during LOCA blowdown and reflood cycles will be investigated in the test. Potential thermocouple effects include: (a) delayed DNB, (b) momentary cladding rewets following DNB, (c) premature cladding rewet during a blowdown two-phase slug period, and (d) early cladding rewet during reflood. The two-phase slug period will be controlled by momentarily opening the hot leg valve. The slug will consist of lower plenum liquid that is sent through the flow shrouds and will be designed to quench the fuel rods at a rate that is similar to the slug experienced early in the LOFT L2-2 and L2-3 tests.

To investigate the effects of cladding thermocouples, the TC-1 test will consist of four LOFT-type fuel rods that were fabricated at Battelle and tested in the LOCA test train hardware. Each fuel rod will be instrumented with three internal fuel thermocouples located near the midplane of the fuel stack. The leads of some of these internal thermocouples will be installed in slots on the outside of the fuel pellets and the thermocouple tip will be resistance welded to the inside cladding surface. The remainder of the thermocouples will be placed approximately one mm into the fuel pellet within pellet holes. Two of the fuel rods will be instrumented with four external cladding thermocouples and will include LOFT-type thermocouple extensions to near the bottom of the rod. In this manner, a comparison will be made between the thermocouple response of rods with and without external thermocouples.

The test program will consist of two to four blowdowns that are similar to the LLR tests. Goal cladding temperatures for each blowdown will be between 900-1000 K with a two-phase slug sent through each flow shroud during blowdown. The initial test rod power will be about 39 KW/m and the PBF servo-controlled transient rods will be used to maintain a low power level throughout blowdown. Following blowdown, the reactor power will be maintained at about 2 MW for about 2 minutes as cladding temperatures increase to about 900-1000 K and reflood is initiated. There will be a maximum of four blowdowns depending upon available funds and schedule. Thermocouple effects will be investigated in the first test during blowdown and reflood with a nominal "LOFT-type" slug during blowdown and a nominal LOFT reflood rate. The test will be repeated up to three times to statistically verify the conclusions if meaningful thermocouple effects are identified during the first blowdown. If expected conditions are not established or thermocouple effects are not identified after the first blowdown (primarily during the two-phase slug), it will be recommended that the test conditions be modified rather than repeating a potentially meaningless test. Results will be compared with out-of-pile tests and should provide insight for future tests.

The test will be performed in five separate phases; loop heatup, preconditioning operation, blowdown, reflood, and quench. The tests will be sequenced as follows. The primary coolant loop conditions will be increased to the desired pressure and temperature. The test rods will be power cycled in the preconditioning phase and then operated at steady state for approximately 1-1/2 hours to build up the desired fission product inventory. The blowdown will follow, with a rapid depressurization of the PBF test train and LOCA system. The blowdown will use the same valve sequencing and initial reactor power as in LLR-5 except for the slug period when the hot leg is briefly opened and the cold leg closed. The depressurization, coolant density, and FOM will be the same as LLR-5. The test will be terminated with reflood and quench followed by long-term cooling provided by the quench system.

The fuel train, test assembly, LOCA modifications, and instrumentation associated with each component are described in Section 2. The procedures of the experiment conduct for Test TC-1 are described in Section 3. The data aquisition and reduction requirements are listed in Section 4. The posttest operations support are presented in Section 5. The status check lists for instrumentation and flow balance sheets are provided in Appendix A.

2. EXPERIMENT DESIGN

Test TC-1 will be conducted with four separately shrouded PWR type fuel rods. The fuel rods, individual flow shrouds, and fuel rod instrumentation are supported by the test train. The Test TC-1 experiment design is the same as the PBF/LLR test design presented by the Experiment Operating Specification (EOS)[3] except for minor differences in fuel rod specifications and instrumentation. The design of fuel rods, test train, LOCA modification system, and the instrumentation associated with each component is summarized in this section as presented in the LLR EOS. Further information is available in the Experiment Specification Document[4] and the Experiment Configuration Specification[5] (test train).

2.1 Fuel Rods and Shroud

The TC-1 fuel rods were fabricated by Battelle.[(6)] The geometry of the active length of the fuel rods is identical with the LOFT fuel. LOFT cladding was utilized to fabricate the fuel rods. The plenum pressure corresponds to the backfill pressure utilized for the LOFT L2 test series fuel rods (.1034 MPa, 15 psia). The fuel rod design characteristics are listed in Table I.

Differences in the TC-1 fuel rod assembly compared with LLR[(4)] are: Battelle uses longer end caps, shorter bottom insulator, shorter fuel column length, no annular fuel and approximately the upper half of the fuel column has three equally spaced slots at 120^0 that are approximately 0.66 mm deep and 0.66 m wide to accomodate internal thermocouples. The Battelle design uses shorter cladding, an internal zircaloy transfer piece that permits the internal thermocouple leads to transfer from near the cladding surface into the plenum spring annulus. The stainless steel upper rod adapter is longer. The overall result of these fuel rod differences relative to an LLR is:

TABLE I

TEST TC-1 FUEL ROD NOMINAL DIMENSIONS

Cladding material - Zircaloy-4

Cladding outside diameter - 10.72 mm

Cladding inside diameter - 9.48 mm

Cladding wall thickness - 0.62 mm

Diametral gap - 0.186 mm

Pellet diameter - 9.294 ± 0.013 mm

Pellet length - 15.24 ± 0.25 mm

Pellet dish volume - 1% of the pellet volume

Fuel enrichment - 9.9%

Fuel length - 868.7 mm

Top insulating pellet length - 5.08 ± 0.127 mm

Bottom insulating pellet length - 3.175 ± 0.127 mm

---

(1) the rod internal void volume with slotted fuel pellets is greater than in an LLR, and

(2) the elevation of the top of the fuel active column is lower by 45.72 mm than in an LLR.

Each fuel rod will be encased within a fluted flow shroud as shown in Figure 1. The flow shrouds are Zircaloy-4 with an initial outside diameter of 25.4 mm, a wall thickness of 1.24 mm, and a flow area the same as LOC-11.

2.2 Test Train

The TC-1 test train positions and supports the four test fuel rods as shown in Figures 1 and 2. Major test train components are the fuel rod support plates, IPT flow shroud, two particle screens and the catch basket, several filler pieces, and the reflood line.

The fuel rod support plates position each rod within the active core region. The upper support plate is fixed near the top of the rods allowing the rod to expand axially downward with the lower end of each rod positioned by the lower support plate.

The IPT flow shroud directs the coolant from the IPT inlet down to the lower plenum and into the individual fuel rod flow shrouds. The IPT shroud is fabricated in three sections, two stainless steel and one zircaloy. The zircaloy section is positioned in the central core region.

The coolant passing the fuel rods is channeled through particle screens located in the lower and upper plenums. The screens are sized with equivalent openings as in the screens in the blowdown measurement spools. A catch basket is located below the lower plenum particle screen to catch molten fuel in the event of severe rod failure and to protect the IPT.

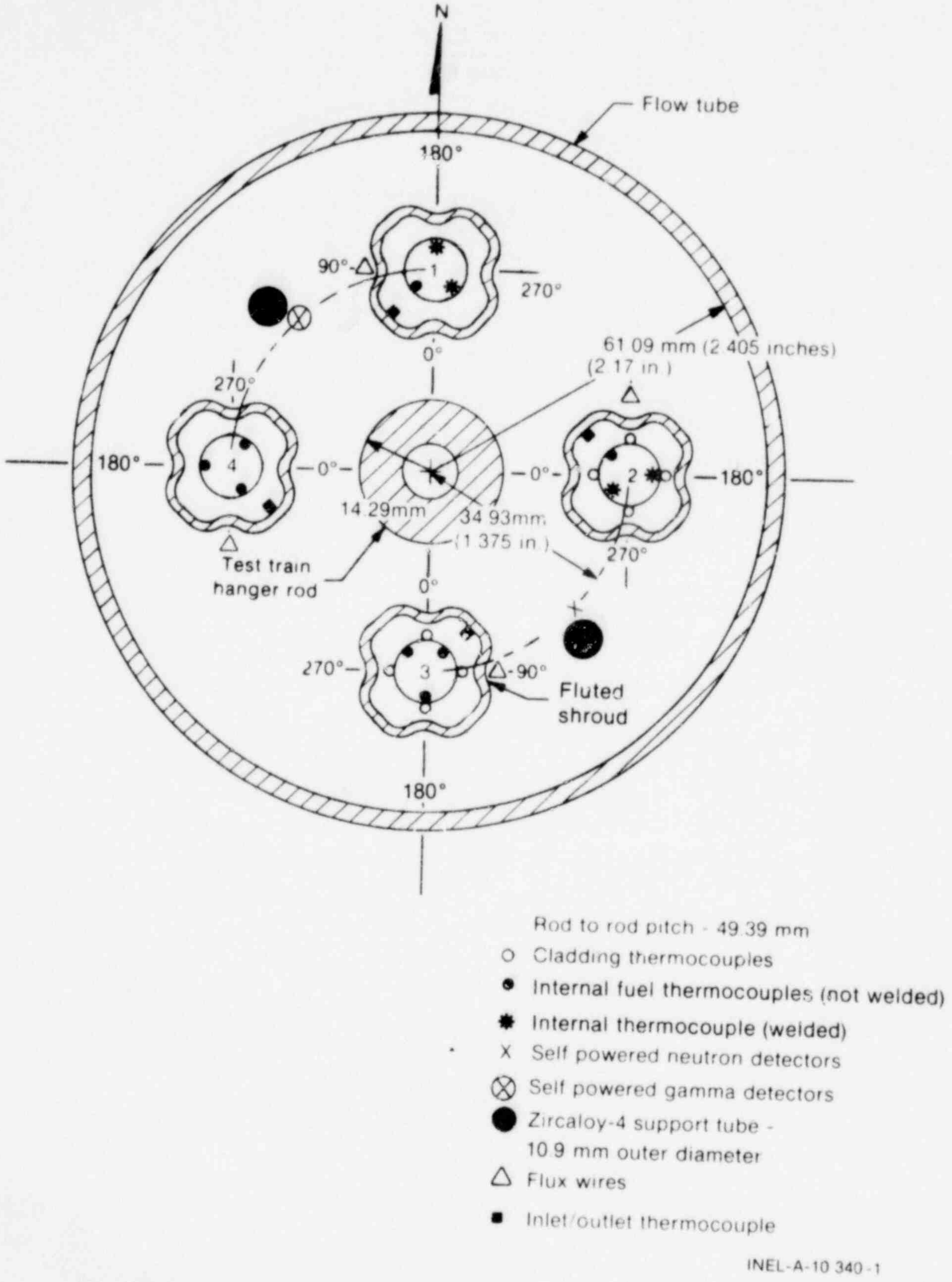

Fig. 1 Test TC-1 fuel train orientation.

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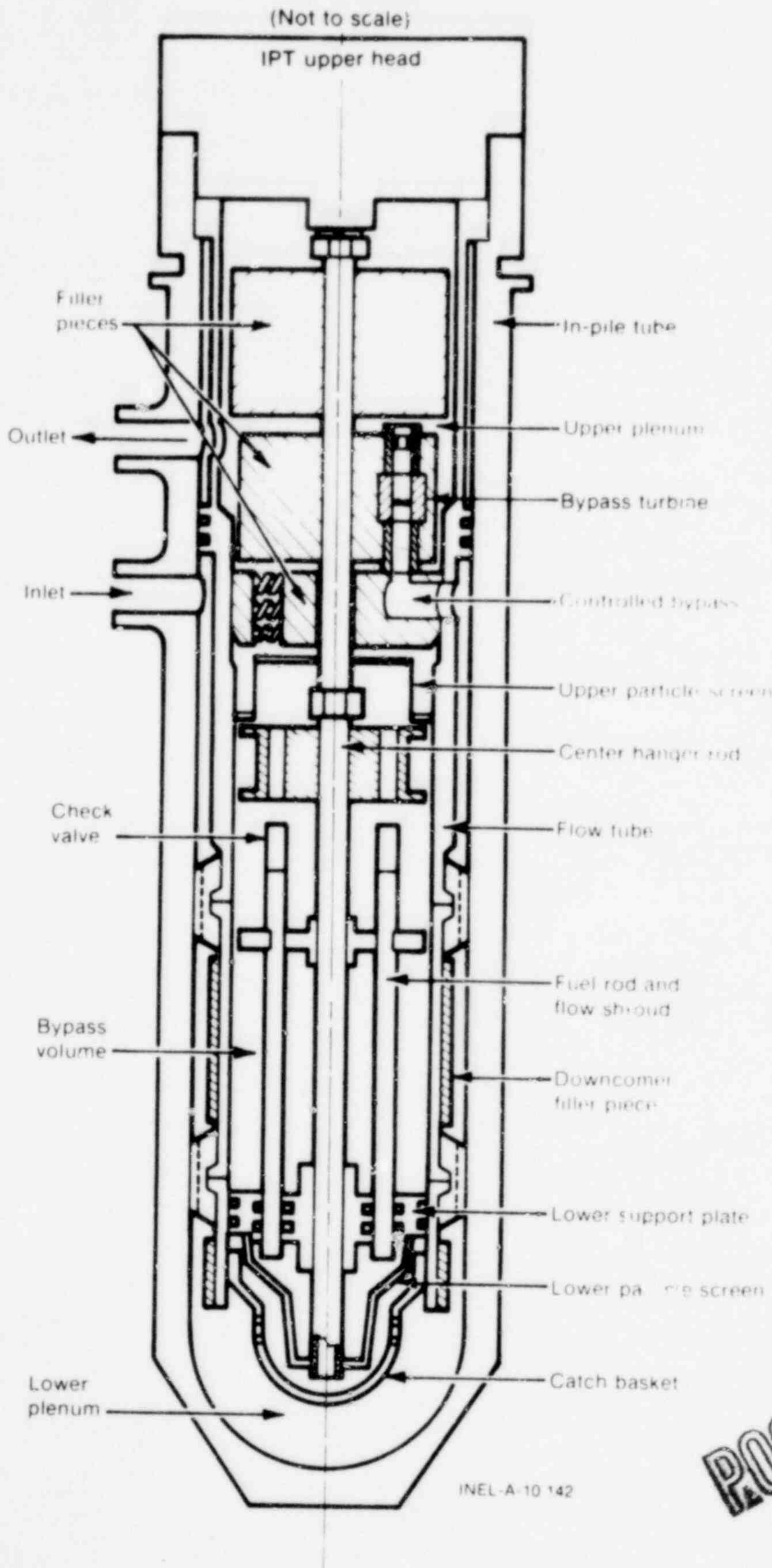

Fig. 2 Test TC-1 test train illustration.

Filler pieces are located in the IPT exit volume, the upper plenum and the downcomer region to reduce the large volumes of water in the test train. Each filler piece is sized for the maximum reduction in water volume consistent with providing sufficient coolant flow.

The controlled bypass flow path is fabricated as part of the upper plenum filler piece and is located between the IPT inlet and the upper plenum. The bypass provides a low resistance flow path between the upper plenum and the IPT inlet during blowdown and can be orificed to control the relative flow resistance between the bypass flow path and the flow shrouds.

The capability of providing reflood water to the lower plenum is available through the zircaloy hanger rod tube. Test TC-1 will use the reflood system to quench the rods with a controlled reflood rate.

2.3 LOCA Blowdown System

The PBF-LOCA blowdown loop is illustrated in Figure 3. The blowdown system provides the means to isolate the IPT from the primary coolant loop during blowdown and directs the coolant into the blowdown tank. The blowdown is initiated with quick opening and closing valves located in the hot-leg and cold-leg blowdown lines. Four Henry nozzles (the same as used in LLR[4]), two in the cold-leg and two in the hot-leg, provide the break plane for the desired break flow rate and depressurization rate. The Henry nozzle throat areas and locations for Test TC-1 are tabulated in Table II. Both cold-leg blowdown valves will be initially opened in Test TC-1 after the IPT is isolated from the primary coolant loop, and the system will depressurize through the cold-leg Henry nozzles into the blowdown tank.

A small line with a controllable valve connects the hot and cold blowdown piping legs. This line provides a small flow rate to keep the hot and cold-legs at the system temperature and pressure prior to

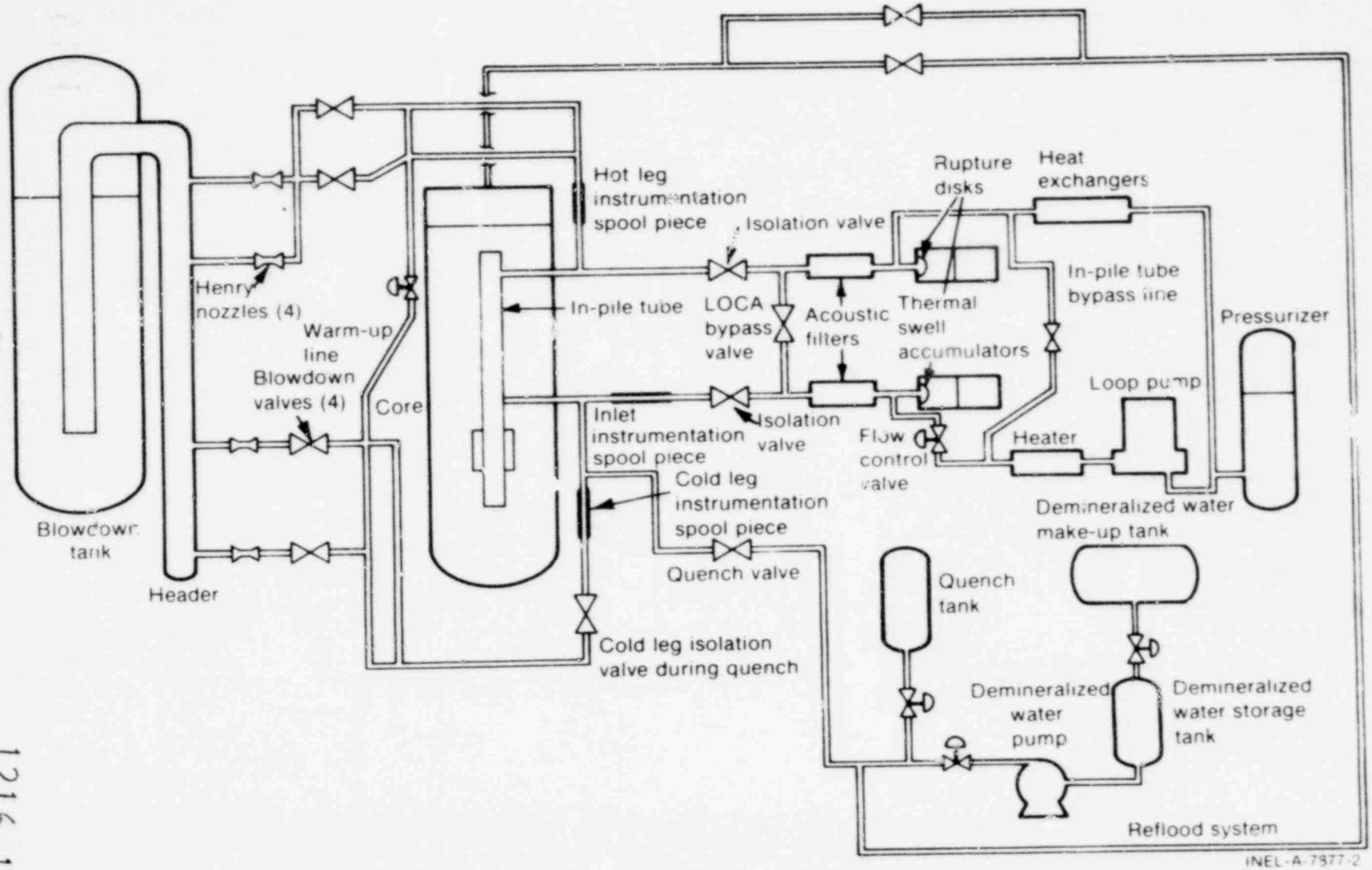

Fig. 3 PBF-LOCA blowdown system illustration.

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TABLE II

TEST TC-1 HENRY NOZZLE THROAT DIAMETERS AND LOCATIONS

Nozzle Designation	Location	Throat Diameter (mm)
FE-11-1-1	Hot leg	14.22
FE-11-1-2	Hot leg	13.56
FE-LR-C-1	Cold leg	12.47
FE-LR-C-2	Cold leg	23.90

blowdown. The valve and line also provide additional mechanisms for controlling the coolant mass flow through the fuel assembly.

The blowdown header and tank collect and contain the coolant ejected from the IPT and piping during blowdown, quench, and post blowdown cooling and also confine any fission products carried from the fuel rods by the coolant.

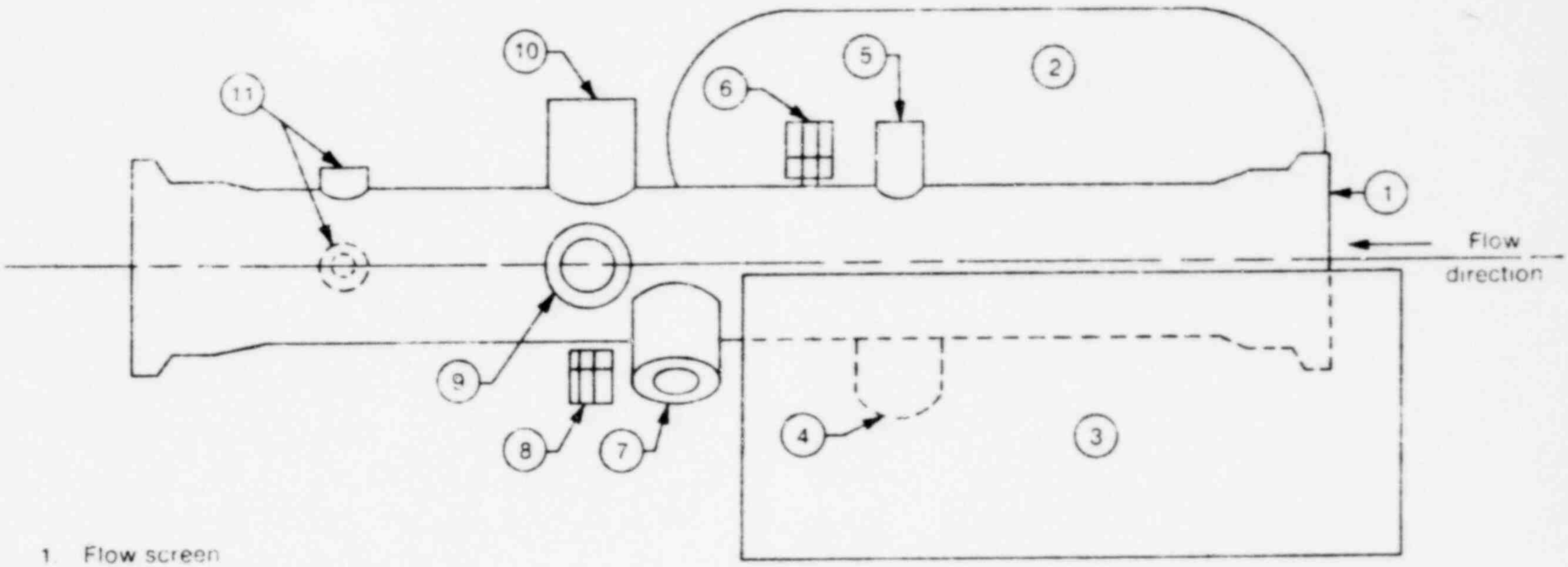
Posttest quench cooling is accomplished by opening the quench valve (and closing the cold leg blowdown valves) and opening the hot-leg to permit coolant from the quench tank to enter the IPT. The quench tank is pressurized by a nitrogen gas system and heated to about 366 K. If needed, longer term cooling is accomplished by reconnecting the IPT to the existing loop (opening the isolation valves and closing the bypass and blowdown valves) and permitting the primary coolant loop to recirculate through the IPT.

The LOCA system contains an initial condition measurement spool and a blowdown measurement spool in each blowdown leg. This instrumentation is described in Subsection 2.4.

The sequencing of the blowdown valve during the transient is controlled by a time-sequential programmer in the Programming and Monitoring System (P&MS). Signals for cladding temperature and elapsed time are input to the P&MS.

2.4 Instrumentation

A brief description of the Test TC-1 instrumentation is provided in this section. The instrumentation of the Test TC-1 fuel train is designed to measure the fuel surface and cladding surface temperature, axial length changes and coolant pressure, temperature, density, and flow rate. The location of the fuel rod instrumentation is shown in Figure 1. An illustration of a blowdown measurement spool piece is shown in Figure 2.



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1. Flow screen
2. Source cask of gamma densitometer
3. Detector cask of gamma densitometer
4. Pressure - water cooled standoff (saturated blowdown)
5. Resistance temperature detector (initial temperature)
6. Thermocouple (blowdown temperature)
7. Pressure difference (inter spool)
8. Pressure difference (across flow screen, fission product sample tap)
9. Pressure - flush mounted (subcooled blowdown)
10. Drag disk
11. Turbine flow meter and pickup coils

Fig. 4 PBF-LOCA blowdo ı measurement spool illustration

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The planned instrumentation for the measurement of parameters for each fuel rod consists of the following:

(1) Four cladding surface themocouples on Rod 01 and 03 and three fuel surface thermocouples on each rod (see Figure 1).

(2) One EG&G Idaho, Inc., axial length change transducer located at the lower end of each rod. The device is not temperature compensated or thermally shielded, so it will detect rather than quantify length changes during the transient blowdown quench and cooling phases of the test.

(3) Seven self-powered neutron detectors (SPND) used to correlate reactor power to calibrated fuel rod power and to determine the axial power profile at different power levels.

(4) An aluminum-cobalt alloy flux wire located on each fuel rod flow shroud. The devices yield the time averaged neutron flux near the rod.

(5) Three self-powered gamma detectors (SPGD) located at the core midplane and $\pm$ 228.6 mm to determine the gamma flux.

Planned instrumentation for measurement of coolant parameters in the IPT includes:

(1) A Flow Technology, Inc., bi-directional turbine meter located at the top and bottom of each fuel rod shroud. Two pickup coils of EG&G Idaho, Inc., design and manufacture are associated with each turbine to determine flow direction.

(2) A differential thermocouple to measure the temperature increase across each fuel rod flow channel during steady state operation for power calibration purposes.

(3) Two thermocouples for each fuel rod coolant channel to measure the fuel rod coolant inlet and outlet temperatures.

(4) Three thermocouples located in the IPT upper plenum above the fuel rod flow shroud outlet. These instruments aid in determining temperature gradients in the upper plenum region. The thermocouples are structurally attached to the hanger rod.

(5) One thermocouple located in the nearly stagnant bypass volume at the midplane of the active fuel length.

(6) Two thermocouples located in the lower plenum, 0.06 and 0.28 m below the lower support plate, are used to determine the coolant conditions in the lower plenum. The lower thermocouple junction is also below the pressure transducer located in the lower plenum.

(7) One EG&G Idaho, Inc., pressure tranducer (strainpost-type) to measure any large IPT overpressure transients. The transducer is located 0.19 m below the lower support plate.

(8) Two EG&G Idaho, Inc., pressure tranducers (strainpost-type) located 0.04 m above the top of the fuel rod flow shrouds and 0.19 m below the lower support plate to measure the pressure changes during the blowdown transient.

(9) One Kaman pressure transducer (eddy current type) located 0.04 m above the rod shroud outlet to measure the preblowdown and saturated coolant blowdown pressure.

(10) Two liquid level detectors inside the lower particle screen and one detector inside the lower end of two of the flow shrouds.

(11) One bidirectional flow turbine located in the downcomer-to-upper plenum bypass region.

Planned instrumentation for the measurement spools includes:

(1) A Rosemount resistance temperature detector to measure the preblowdown temperature of the coolant in each spool.

(2) An exposed Rosemount ribbon thermocouple (Type K) to measure the coolant temperature in each spool during the transient.

(3) A flush mounted pressure transducer from Precise Sensors, Inc., (bounded strain gauge) to measure the preblowdown and subcooled decompression in each spool.

(4) A water cooled, stand-off mounted, pressure transducer from Precise Sensors, Inc., (bounded strain gauge) to measure the preblowdown and saturated decompression in each spool.

(5) A full flow turbine meter with graphite bearings from Flow Technology, Inc., to measure preblowdown coolant velocity to the IPT in the initial condition spool and during the transient in the hot- and cold-leg spools.

(6) A Ramapo drag disk in the hot- and cold-leg spools to measure the coolant momentum flux during the transient.

(7) An EG&G Idaho, Inc., three-beam gamma densitometer on both the hot- and cold-leg spools to measure coolant density.

(8) A pressure differential transducer connecting the hot- and cold-leg spools. This device will measure the preblowdown pressure difference across the test train and the spool-to-spool difference during the transient.

(9) An Endevco accelerometer attached to each blowdown spool to measure the loadings on the gamma densitometer.

Plant instrumentation measurements that will be used in the analysis of the test results are listed in Table III.

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TABLE III

TEST TC-1 PLANT INSTRUMENTATION

Description	Designation[a]
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1101PT
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1102PT
Position of Cold Leg Blowdown Valve	VALVbPOSbbLRC103PT
Position of Cold Leg Blowdown Valve	VALVbPOSbbLRC204PT
Position of Isolation Valve	VALVbPOSbbLM1105PT
Position of Isolation Valve	VALVbPOSbbLM1106PT
Position of Bypass Valve	VALVbPOSbbLM1107PT
Position of Quench Valve	VALVbPOSbbLM1108PT
Position of Warm Up Line Valve	VALVbPOSbbLM1116PT
Position of Cold Leg Shutoff Valve	VALVbPOSbbLM1118PT
Outlet Coolant Pressure Transducer	OUTbPRESbbPT-30bPT
Outlet Coolant Flow Transducer	OUTbFLOWbbFT-29bPT
Outlet Coolant Temperature	OUTbTEMPbbTT-29bPT
Quench Tank Coolant Level	QNCHbLEVbbLT-10bPT
Quench Tank Coolant Temperature	QNCHbTMPbbTIC17bPT
Quench Coolant Flow Rate	QNCHbFLObbFT-14bPT
Blowdown Tank Pressure	BLOWbPRSbbPT-12bPT
Blowdown Tank Liquid Level	BLOWbLEVbbLIT17bPT
Loop Pressure	SYSbPRESbbPRS10bPT
IPT Differential Pressure	IPTbDELPbbDPR-10PT
Loop Flow Rate	LOOPbFLObbFRC-10PT
FPDS Gross Gamma Rate Detector 1	FPDSGAMAbbNUMb01FP
FPDS Gross Gamma Rate Detector 2	FPDSGAMAbbNUMb02FP
FPDS Gross Gamma Rate Detector 3	FPDSGAMAbbNUMb03FP
FPDS Gross Neutron Rate	FPDSNEUTbbNEUTRNFP
Reactor Power NMS-3 30 MW	REACTPOWbbNMS-03PT
Reactor Power NMS-4 30 MW	REACTPOWbbNMS-04PT
Reactor Power PPS-1 30 MW	REACTPOWbbPPS-01PT
Reactor Power PPS-2 30 MW	REACTPOWbbPPS-02PT
Transient Rod 1 Position	TRANSRODbbNUMb01PT
Transient Rod 2 Position	TRANSRODbbNUMb02PT
Transient Rod 3 Position	TRANSRODbbNUMb03PT
Transient Rod 4 Position	TRANSRODbbNUMb04PT

a. b denotes a blank

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3. EXPERIMENT OPERATING PROCEDURE

Details of the experiment procedure of Test TC-1 are discussed in the following sections. Each experiment operating phase and the instrument status requirements are considered individually. The four blowdown/reflood tests of TC-1 (A, B, C, and D) consist of the following phases:

(1) Instrument status check

(2) Heatup

(3) Instrument drift checks

(4) Power calibration

(5) Preconditioning (TC-1A only)

(6) Decay heat build-up

(7) Blowdown and reflood

(8) Quench and cooldown.

Nuclear operation will start with the power calibration phase and terminate in the blowdown phase of the transient. Nuclear operation will last approximately six hours for TC-1A and approximately 1-1/2 hours for TC-1B, C and D at a reactor power less than or equal to 18 MW. The specific operating sequence for TC-1A and TC-1B, C, and D is shown in Tables IV and V, respectively.

A representative sample of the liquid in the loop should be taken prior to test operation and immediately after the test for chemical analysis. A representative liquid sample shall be taken from the blowdown tank after test completion for chemical analysis. Disposition of these samples will be determined at a later time.

TABLE IV

OPERATING SEQUENCE FOR TEST TC-1A

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW or noted) (NMS-3)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
30	0	0	Ambient	0	0.69	Instrument status check, verify DARS.
30	0	0	366	0.4,0.6,0.8, 0.8,0.6,0.4	0.69	Flow balance check with warmup line closed.
360	0	0	366 to 600	0.4	15.51	Heatup, DARS status checks.
15	0	0	600	0.4,0.6,0.8,	15.51	Flow turbine calibration with warmup line closed.
30	0	100 (kW)	600	0.6	15.51	Instrument status and drift check zero power offsets taken, transient rods inserted four inches.
5	0 to 10	100 kW to 3.7	600	0.6	15.51	Power calibration, ramp 1.
10	10	3.7	600	0.6	15.51	Calculation of rod powers
5	10 to 20	3.7 to 7.4	600	0.6	15.51	Power calibration, ramp 2.
10	20	7.4	600	0.6	15.51	Calculation of rod powers.
5	20 to 30	7.4 to 11	600	0.6	15.51	Power calibration, ramp 3.
10	30	11	600	0.6	15.51	Calculation of rod powers.
5	30 to 39.4	11 to 14.5	600	0.6	15.51	Power calibration, ramp 4.
10	39.4	14.5	600	0.6	15.51	Calculation of rod powers.
20	39.4 to 0	14.5 to 0.1	600	0.6	15.51	Ramp down power, 1st cycle of preconditioning finished.

TABLE IV (continued)

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW or noted) (NMS-3)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
10	0	0.1	600	0.6	15.51	Prepare for second cycle.
10	0 to 20	0.1 to 7.4	600	0.6	15.51	Power calibration, ramp 5, and 2nd cycle of preconditioning.
5	20	7.4	600	0.6	15.51	Calculation of rod powers.
5	20 to 30	7.4 to 11	600	0.6	15.51	Power calibration, ramp 6.
5	30	11	600	0.6	15.51	Calculation of rod powers.
5	30 to 39.4	11 to 14.5	600	0.6	15.51	Power calibration, ramp 7.
5	39.4	14.5	600	0.6	15.51	Calculation of rod powers.
20	39.4 to 0	14.5 to 0.1	600	0.6	15.51	Ramp power decrease, 2nd cycle of preconditioning.
10	0	0.1	600	0.6	15.51	Prepare for third cycle.
10	0 to 20	0.1 to 7.4	600	0.6	15.51	Power calibration, ramp 8, and 3rd cycle of preconditioning.
5	20	7.4	600	0.6	15.51	Calculation of rod powers.
5	20 to 30	7.4 to 11	600	0.6	15.51	Power calibration, ramp 9.
5	30	11	600	0.6	15.51	Calculation of rod powers.
5	30 to 39.4	11 to 14.5	600	0.6	15.51	Power calibration, ramp 10.
5	39.4	14.5	600	0.6	15.51	Calculation of rod powers.
20	39.4 to 0	14.5 to 0	600	0.6	15.51	Prepare for 4th cycle (decay heat buildup).
30	0	0	600	0.6	15.51	Remove cladding scrams.

TABLE IV (continued)

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW or noted) (NMS-3)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
20	0 to 39.4	0 to 14.5	600	0.6	15.51	Ramp power increase, 4th cycle.
90	39.4	14.5	600	0.6	15.51	Decay heat buildup, instrument status checks, initial conditions checked.
240 (s)	39.4 to 0	14.5 to 0	-	-	-	Transient sequence commences with reactor power controlled by transient rod servo controller.
240	0	0	370	1.0	0.1	Cooldown phase.

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TABLE V

OPERATING SEQUENCE FOR TESTS TC-1 B, C, and D

Time Duration (Min or noted)	Anticipated Reactor Peak Rod Power (kW/m)	Power (MW or noted) (NMS-3)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
30	0	0	Ambient	0	0.69	Instrument status check, verify DARS
30	0	0	366	0.4	0.69	Measurement status check.
360	0	0	366 to 600	0.4	15.51	Heatup, DARS status checks.
30	0	0.1	600	0.6	15.51	Instrument status and drift check, transient rods inserted four inches.
10	0 to 20	0.1 to 7.4	600	0.6	15.51	
5	20	7.4	600	0.6	15.51	Power calibration.
5	20 to 30	7.4 to 11	600	0.6	15.51	
5		11	600	0.6	15.51	Power calibration.
5	30 to 39.4	11 to 14.5	600	0.6	15.51	
90	39.4	14.5	600	0.6	15.51	Decay heat buildup, instrument status check.
240 (s)	39.4 to 0	14.5 to 0	-	-	-	Transient sequence, blowdown.
240	0	0	370	1.0	0.1	Cooldown phase.

Prior to each blowdown/reflood phase of TC-1 a REDCOR checkout of the blowdown transient sequence described in Section 3.7 will be conducted. This test may be performed before the test train is installed. The objectives are to:

(1) Provide a checkout of the servo control system

(2) Determine the proper REDCOR timing sequence to ensure that blowdown events are initiated as specified.

The timing of each event (valve opening and closing, simulated reactor power and power demand function, and transient rod position) should be recorded to ensure that the sequence is properly set. This test may be deleted if the Thermal Fuels Behavior Program (TFBP) LOCA Project Engineer or Management is satisfied that the blowdown transient can be programmed as specified.

3.1 Instrument Status Check

To monitor the experiment and to meet test objectives, it is necessary that certain instrumentation be operable throughout the experiment or during specific phases of the experiment. The loss of a critical instrument will require test procedures to be suspended. Therefore, after data acquisition and reduction system DARS checkout is completed, measurement status checks are to be made during heatup and after achieving critical reactor conditions, unless requested otherwise by the Experiment Specification and Analysis (ES&A) representative of Fuel Research Division. Checklists, which are to be incorporated in the experiment operating procedure and detailed operating procedure, will be completed during the status checks (Appendix A). Certification that each instrument is within range must be made by the LWRD Representative or his alternate. If the readings are not within range, or at any time during the test there is an apparent malfunction in an instrument or data channel, remedial actions must be completed or the ES&A representative's approval must be obtained before continuing test operation. If it is determined that an instrument has failed or that repairs can be made only by removing the test train, test procedure will be suspended pending a decision by the LOCA Project Engineer, TFBP Management, and appropriate Directorate management.

Prior to any data acquisition, the PBF/DARS output will be verified by inputing 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 by the supervisor of the Instrument and Data Section or his alternate prior to loop heatup.

The PBF/DARS readiness for test will be verified by performing the following:

(1) Run the seven Teledyne System Tests and the PDP-11/05 processor diagnostics and verify the successful completion of each.

(2) Introduce a five step voltage signal (0%, 25%, 50%, 75%, and 100%) of the full-scale measurement range into all active inputs via the calibration bus of the data system low-level amplifiers.

(3) Record the calibration voltages on each of the data acquisition systems.

(4) Reduce the calibration data from the DARS for all active channels. Produce data tapes and verification plots for review by the Data Integrity Review Committee (DIRC).

During the cold hydrostatic test an instrument status check at pressures of 10%, 20%, 30%, . . ., 100%, 90%, 80%, . . ., 10% of the 15.51 MPa system pressure will be performed as follows:

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(1) Allow the system to come to equ ibrium.

(2) Obtain a DARS printout of measurement data and statisitics while simultaneously recording the Heise gauge pressure at each pressure step.

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 and reverified. In addition, any channels being doubly recorded on the surveillance system channel electronics cannot be changed after verification. A posttest integrated data systems calibration will be performed after reactor building reentry is permitted.

3.2 Heatup Phase

When the loop coolant temperature has reached about 500 K the reactor may be brought to criticality, if deemed necessary, and then to about 3 MW until the coolant inlet temperature reaches the desired level of 600 K.

During heatup an instrument status check shall be performed at 5 equispaced temperatures by obtaining a DARS printout of measurement data and statistics while simultaneously recording Heise gauge pressure at each step. The DIRC will review the following during this testing period:

(1) Instrument status

(2) DARS status

(3) Data system changes

(4) Flow verification and drift check data.

During TC-1A, the loop and test train flow meters will be intercalibrated at a constant inlet temperature and pressure by increasing the test rod flow rates from 0.4ℓ/s to 0.8ℓ/s with the warmup line closed. During this flow calibration, instruments will be checked for undesirable temperature and flow sensitivities.

3.3 Instrument Drift Recording and Status Check

Data channels will be recorded for at least 30 minutes to establish instrument drift rates. This recording should be completed after heatup at stable system conditions of 600 ±1 K inlet temperature, 15.51 ±0.14 MPa IPT pressure, and 0.6 ±0.015 l/s flow through each shroud.

3.4 Power Calibration Phase

After the reactor is critical at about 100 kW to 2 MW and just prior to begining the power calibration cycle the transient rods should be inserted four inches into the core. The reactor critical measurements check should then be completed.

Power calibration will be performed during the three preconditioning cycles of TC-1A and during the decay heat buildup phase of TC-1B, C, and D. It will provide data to intercalibrate the test rod powers determined by thermal-hydraulic measurements with reactor power and data from the self-powered neutron detectors mounted on the test train. After the intercalibration, the reactor can be operated with reference to the calibrated SPNDs to provide the desired fuel rod power.

The calibration phase of the experiment will be initiated by establishing the coolant pressure, temperature, and flow rate at the predetermined values listed in Table IV and Table V. To perform the calibration, the reactor power will be increased to a known level, the system allowed to reach equilibrium ($\sim$5 minutes), and the test rod power and neutron detector outputs recorded. This procedure will be repeated at a number of power levels up to a maximum reactor power of approximately 14.5 MW and maximum rod power of 39.4 kW/m. The maximum power ramp rate for the calibration phase of the test is 2 kW/m per minute.

During power calibration an instrument status check shall be performed by obtaining a DARS printout of measurement data and statistics while simultaneously recording the Heise gauge pressure at each step in the power calibration. DIRC review of the following will be accomplished during the power calibration and preconditioning phase of testing.

(1) Instrument status

(2) Power calibration data

(3) Drift check data

(4) Data system configuration and calibration status

The figure-of-merit, relating fuel rod peak power to driver core power, has been calculated to be 2.72 kW/m/MW for the PBF/LLR[3] test rods and this value should correspond to the TC-1 rods. This value will be compared with the figure-of-merit determined during the test. In the event of a large discrepancy between calculated and measured figure-of-merit, as determined by the LOCA Project Engineer, test procedure will be suspended pending resolution of the discrepancy by the LOCA Project Engineer and TFBP Management.

3.5 Preconditioning Phase (TC-1A Only)

The four fuel rods will be preconditioned during TC-1A by cycling the power to promote fuel pellet cracking and restructuring and to allow the initiation of pellet-cladding mechanical interaction to stabilize. A ramp rate of 2 kW/m per minute will be used with constant peak power levels of 39.4 kW/m for 10 to 30 minutes and zero to 100 kW reactor power for 10 minutes between the cycles.

3.6 Decay Heat Buildup Phase

After completion of the preconditioning phase the reactor power should be increased, at a corresponding fuel rod power ramp rate of 2 kW/m per minute, to approximat y 14.5 MW, or whatever is necessary (maximum of 18 MW) to provide a fuel rod peak power of 39.4 kW/m, and held at that power for approximately 90 minutes. This length of time is necessary to build up approximately 78% of the maximum possible decay heat in the rods. If the reactor is shut down during the decay heat buildup, this phase will have to be repeated.

Approximately 15 minutes before blowdown, the reactor power will be switched to transient rod servo-control (transient rods inserted 4 inches into the bottom of the core region).

3.7 Blowdown and Reflood Phase

The specific steps of the blowdown phase are provided in Table VI. Immediately prior to blowdown, readings should be taken from the quench and blowdown tank transducers as specified in Appendix A. After establishing the required initial conditions of Tables IV and V, and approximately 20 seconds before blowdown, the warmup line will be shut by the reactor operator and the test rod flows verified to be 0.6 l/s. The TFBP Project Engineer will then verify proper setting of all initial conditions before the transient is initiated.

The blowdown sequence will then be initiated. The reactor power will be controlled with the transient rods (TR) during the blowdown, as detailed in Table VI and Figure 5. The TR servo-controller will be in the steady state mode of operation during the entire test. During

TABLE VI

PROGRAMMING AND MONITORING SYSTEM CONTROLLED EVENT SEQUENCE

Time Event is Initiated (s)	Loop Bypass Valve[a]	Isolation Valve[b]	Hot Leg Blowdown Valves[c]		Cold Leg Blowdown Valves[d]		Quench Water Valve[e]	Warmup Line Valve[f]	Cold Leg Shutoff Valve[g]	Comments
			(1) (14.22 mm)	(2) (13.56 mm)	(3) (12.47 mm)	(4) (23.90 mm)				
--	X[h]	0	X	X	X	X	X	0	0	Cladding scram set points turned off.
-20.0	X	0	X	X	X	X	X	X	0	Operator closes warmup line and verifies test rod coolant flow to 0.6 l/s per shroud. Action is verified by TFBP Project Engineer before initiation of the transient.
-5.0	X	0	X	X	X	X	X	X	0	REDCOR initiates function generator routine.
0.00	0	X	X	X	X	X	X	X	0	Isolate loop and open bypass valve.
0.10	0	X	X	X	0	0	X	X	0	Open cold leg valves.
1.50	0	X	X	X	0	0	X	X	0	Maintain 100% of reactor power.
1.50	0	X	X	X	0	0	X	X	0	Linearly reduce reactor power to 13.8% in 0.1 s.

TABLE VI (continued)

PROGRAMMING AND MONITORING SYSTEM CONTROLLED EVENT SEQUENCE

Time Event is Initiated (s)	Loop Bypass Valve[a]	Isolation Valve[b]	Hot Leg Blowdown Valves[c]		Cold Leg Blowdown Valves[d]		Quench Water Valve[e]	Warmup Line Valve[f]	Cold Leg Shutoff Valve[g]	Comments
			(1) (14.22 mm)	(2) (13.56 mm)	(3) (12.47 mm)	(4) (23.90 mm)				
1.60	0	X	X	X	0	0	X	X	0	Maintain reactor power at 13.8%
4.00	0	X	X	X	0	X	X	X	0	Close large cold leg.
7.00	0	X	X	0	X	X	X	X	0	Open hot leg, close cold leg.
9.00	0	X	X	X	0	X	X	X	0	Open cold leg, close hot leg.
22.00	0	X	X	X	0	0	X	X	0	Open large cold leg.
115.00	0	X	X	X	0	0	X	X	0	Scram reactor.
115.00	0	X	X	X	0	0	X	X	0	Reflood cycle.
240	0	X	0	0	X	X	0	X	X	Quench

(a) VALVbPOSbbLM1107PT
(b) VALVbPOSbbLM1105PT and VALVbPOSbbLM1106PT
(c) VALVbPOSbbLM1101PT and VALVbPOSbbLM1102PT
(d) VALVbPOSbbLMLRC1PT and VALVBPOSbbLMLRC2PT
(e) VALVbPOSbbLM1108PT
(f) VALVbPOSbbLM1116PT
(g) VALVbPOSbbLM1118PT
(h) X indicates closed, 0 indicates open.

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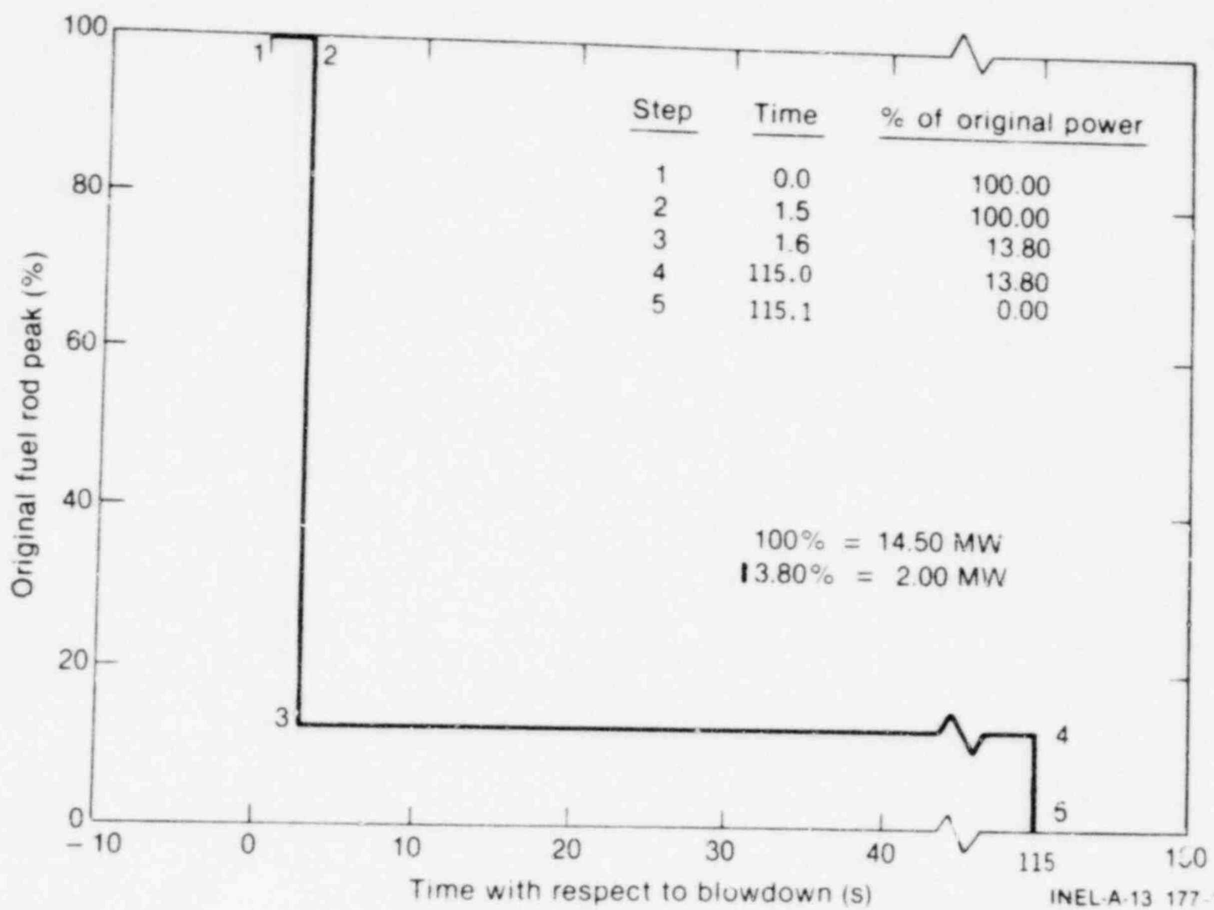

Fig. 5 Reactor power variation with time during the transient.

blowdown the power demands will be controlled by the function generator which is interfaced with the TR servo-control system. The function generator will be started at the appropriate time by REDCOR.

Manual control of the reactor power during blowdown may be required during the TC-1 tests. Between 7 and 15 s a two-phase slug of liquid should momentarily quench some or all of the rods. After this quench, the reactor power will be maintained at 2.0 MW and the cladding temperature should heat up to a goal temperature of approximately 900-1000 K before 115 s. To insure this goal is established, the reactor operator can manually control the driver core power (within 0.5 to 5 MW) after 20 s and until 115 s. As a guideline, the cladding temperature of CLADTC1b1b53+0bb01 should be monitored on the reactor console strip charts along with the NMS-3 core power. The LOCA project engineer will monitor other cladding thermocouples at the DARS to assist in reaching the 900-1000 K goal temperature.

Proper designation of the REDCOR-timed sequence is extremely important to ensure that the timed events occur as specified. The PBF Operations Branch will determine offsets to be applied for each step so as to ensure the correct timed sequence.

After 115 s into blowdown when the lower plenum pressure is at approximately 0.45 MPa, the reflood portion of the test will begin as listed in Table VII. The controlled reflood is performed by injecting the coolant from the quench tank through the reflood system directly into the IPT upper head, down the center hanger rod into the plenum volume beneath the lower particle screen. System operation involves: (1) filling the lower plenum to the bottom of the active fuel as soon as possible, within 5 seconds at a rate of 1.58 ℓ/s and maintaining this level prior to reflood of the fuel, and (2) providing the constant cold reflood rate to the flow shrouds at a rate of 0.50 l/s. The reflood coolant temperature will be approximately 311 K (100°F) when entering the IPT through the upper head penetration.

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TABLE VII

REFLOOD RATES FOR TEST TC-1

	Initiation Time (s)	Termination Time (s)
Initial reflood high flow rate (1.58 /s)	115	120
Final reflood low flow rate (0.50 /s)	120	240

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The ultimate success of the TC-1 test series depends upon the timing of the two-phase slug (7 to 9 s) during blowdown. The objective of the hot leg valve sequence during this time period is to force a slug of two-phase liquid from the lower plenum through the flow shrouds. This slug is to be timed to simulate the two-phase slug that occurred during the LOFT L2-3[7] test. If the desired results are not achieved during TC-1A, alternate methods of timing the hot and cold leg valves are recommended in Table VIII. The exact sequence for TC-1B, C, and D will be determined within approximately 6 hours of the previous blowdown.

3.8 Quench and Cooldown Phase

After 240 seconds, posttest quench cooling water heated to about 366 K will commence with a mass flow rate of 4 l/s for 60 seconds.

After the quench phase, cooling water will be pumped from the storage tank provided by the deminerlization pump and the quench tank will be pressurized at 1.03 MPa for 60 s of quench flow. Beyond this time, the cooling water flow rate will be reduced to 0.4 l/s. The flow rate can be adjusted to keep the cladding surface temperature below 600 K.

3.9 Shutdown and Abnormal Test Termination Requirements

The test will be shutdown if a failure of all the system pressure measurements occurs. The test may also be terminated by the responsible LWR Fuel Research Division ES&A representative if there is no more useful data to be gained by continuing operation.

The electronics to initiate an automatic reactor scram in the event of unexpected cladding film boiling will be used for Test TC-1A. The system will be installed for the power calibration, preconditioning, and decay heat buildup phases, and must be removed

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TABLE VIII

PRELIMINARY BLOWDOWN VALVE SEQUENCES FOR TC-1B, C, AND D

Time of Event	Hot Leg Valve 1 (14.22 mm)	Hot Leg Valve 2 (13.56 mm)	Cold Leg Valve 3 (12.47 mm)	Cold Leg Valve 4 (23.90 mm)	Comments
			METHOD 1[a]		
0.1	X	X	0	0	Initiate blowdown.
3.75	X	X	0	X	Close large cold leg.
7.00	X	0	X	X	Open hot leg, close cold leg.
12.00	X	X	0	X	Close hot leg, open cold leg.
22.00	X	X	0	0	Open large cold leg.
240.00	0	0	X	X	Quench.
			METHOD 2[b]		
0.1	X	X	0	0	Initiate blowdown.
3.75	X	X	0	X	Close large cold leg.
7.00	X	0	0	X	Open hot leg, leave cold leg open.
12.00	X	X	0	X	Close hot leg.
22.00	X	X	0	0	Open large cold leg.
240.00	0	0	X	X	Quench

a. Method 1 will extend the 2-phase slug period during blowdown if results of TC-1A are not satisfactory.

b. Method 2 will reduce the 2-phase slug rate during blowdown if results of TC-1A indicate the quench is to rapid.

before the blowdown transient is initiated. The circuit should scram the reactor if cladding thermocouples CLADTC1b1b53+0bb01 and CLADTC1b2b53+0bb02 measure 700 K. A 2-second delay in scram should be included to account for signal noise.

In case of unexpected cladding temperatures in excess of 1200 K at any time during the transient, the quench or reflood system will be activated based on an average temperature computed automatically from thermocouple measurements on each test rod.

4. DATA ACQUISITION AND REDUCTION REQUIREMENTS

Instrumentation displays in the PBF/DARS will identify the fuel rod, flow shroud, test train, spoolpiece, and plant instruments according to the identifiers in Tables IX through XII. Prior to each nuclear operation, it will be verified that data are being recorded and are retrievable.

4.1 Data Acquisition Requirements

The data channels should be set to record the data based on the requirements of Tables IX through XII. All of the narrow-band DARS channels should be available for display on the Vector General. The surveillance system is an acceptable backup system. The PBF/DARS will record data during the cold hydrostataic pressure check, the flow calibration, the heatup phases, during all nuclear operation, and will be left on until the loop has been depressurized after the blowdown. The surveillance system (SS) need not record data during heatup and 30 minutes after test termination unless requested by the ES&A representative.

The data channels required to be displayed on the strip charts during power calibration and fuel conditioning and the blowdown phase are provided in Figure 6. The ES&A designation and explanation of the instrumentation are presented in Tables IX through XII. The display and recording requirements are subject to change at the discretion of the TFBP representative in case of instrument failure or unusual test behavior.

To satisfy the TC-1 program objectives, only a small number of instruments on Tables IX through XII are required. These instruments are: (1) the cladding and fuel thermocouples, (2) the inlet/outlet and differential thermocouples, (3) the LVDTs, (4) the cold leg pressure, (5) the shroud turbine meters, and (6) the initial condition spool piece temperature. The remainder of the instruments listed in

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TABLE IX

TEST TC-1 FUEL TRAIN INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location[a]	Rod Number	Instrument Identifier[b]	Recording Ranges	Minimum Frequency Recording Required (Hz)[c]
Fuel Rod						
Cladding surface temperature[d]	Type K thermocouple	0.053 m - 0°	2	CLADTC1b2b53+0bb02	300 to 1500 K	10
		- 90°	2	CLADTC1b2b53+90b02		
		- 180°	2	CLADTC1b2b53+18002		
		- 270°	2	CLADTC1b2b53+27002		
		0.053 m - 0°	3	CLADTC1b3b53+0bb03		
		- 90°	3	CLADTC1b3b53+90b03		
		- 180°	3	CLADTC1b3b53+18003		
		- 270°	3	CLADTC1b3b53+27003		
Internal fuel temperature[d]	Type K thermocouple	0.053 m - 60°	1	FUELTC1b1b53+60b01	300 to 1500 K	10
		- 180°	1	FUELTC1b1W53+18001		
		- 300°	1	FUELTC1b1W53+30001		
		0.053 m - 60°	2	FUELTC1b2b53+60b02		
		- 180°	2	FUELTC1b2W53+18002		
		- 300°	2	FUELTC1b2W53+30002		
		0.053 m - 60°	3	FUELTC1b3b53+60b03		
		- 180°	3	FUELTC1b3b53+18003		
		- 300°	3	FUELTC1b3b53+30003		
		0.053 m - 60°	4	FUELTC1b4b53+60b04		
		- 180°	4	FUELTC1b4b53+18004		
		- 300°	4	FUELTC1b4b53+30004		
Cladding axial strain[d]	LVDT	End of fuel rod	1	CLADbDSPbbT.1bbb01	-12 to 12 mm	100
			2	CLADbDSPbbTC1bbb02		
			3	CLADbDSPbbTC1bbb03		
			4	CLADbDSPbbTC1bbb04		

a. All elevations are measured from axial midplane of the fuel stack. The positive direction is with the coolant flow. Radial orientations are defined by Figure 1.

b. b denotes blank.

c. Minimum recording frequency is calculated from required instrument response time. Final designation of the instrument response time will be determined by the Instrument and Data section.

d. Required instruments for data qualification.

TABLE IX (continued)

Measurement	Instrument Type	Location[a]	Rod Number	Instrument Identifier[b]	Recording Ranges	Minimum Frequency Recording Required (Hz)[c]
Flow Shroud						
Shroud coolant flow[d]	Bidirectional turbine flowmeter	Lower shroud extension	1	FLOWRATEbbINLETb01	-2.5 to 1.5 ℓ/s	100
			2	FLOWRATEbbINLETb02		
			3	FLOWRATEbbINLETb03		
			4	FLOWRATEbbINLETb04		
		Upper shroud extension	1	FLOWRATEbbOUTLET01		
			2	FLOWRATEbbOUTLET02		
			3	FLOWRATEbbOUTLET03		
			4	FLOWRATEbbOUTLET04		
Shroud liquid level	Liquid level detectors	Lower shroud extension	1	SHRDbLEVbbINLETb01	OFF=0, ON=1	10
			2	SHRDbLEVbbINLETb02		
			3	SHRDbLEVbbINLETb03		
			4	SHRDbLEVbbINLETb04		
Inlet coolant temperature[d]	Type K thermocouple	-0.439 m - 135°	1	INLTbTMPbbTC1bbb01	339 to 820 K	10
		-0.439 m - 135°	2	INLTbTMPbbTC1bbb02		
		-0.439 m - 135°	3	INLTbTMPbbTC1bbb03		
		-0.439 m - 135°	4	INLTbTMPbbTC1bbb04		
Outlet coolant temperature[d]	Type K thermocouple	+0.439 m - 135°	1	OUTbTEMPbbTC1bbb01	339 to 820 K	10
		+0.439 m - 135°	2	OUTbTEMPbbTC1bbb02		
		+0.439 m - 135°	3	OUTbTEMPbbTC1bbb03		
		+0.439 m - 135°	4	OUTbTEMPbbTC1bbb04		
Coolant differential temperature[d]	Type K thermocouple pair	±0.439 m - 135°	1	DELbTEMPbb45bbbb01	0 to 15 K	10
		±0.349 m - 135°	2	DELbTEMPbb45bbbb02		
		±0.439 m - 135°	3	DELbTEMPbb45bbbb03		
		±0.439 m - 135°	4	DELbTEMPbb45bbbb04		

a. All elevations are measured from axial midplane of the fuel stack. Radial orientations are defined by Figure 1.
b. b denotes blank.
c. Minimum frequency is calculated from required instrumentation response time. Final designation of the instrument response time will be determined by the Instrument and Data Section.
d. Required instruments for data qualification.

TABLE X

TEST TC-1 TEST TRAIN INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location[a]	Instrument Identifier[d]	Recording Ranges	Minimum Recording Frequency Required (Hz)
Test Train					
IPT liquid level	Liquid level detector	Lower particle screen	IPTbLEVLbbNO.1bLTT	OFF=0, ON=1	10
			IPTbLEVLbbNO.2bLTT	OFF=0, ON=1	10
Bypass temperature	Type K thermocouple	Hanger rod, lower particle screen	BYPbTEMPbbNO.LTTLC	300 to 800 K	10
		Hanger rod, fuel midplane	BYPbTEMPbbNO.2bbTT		
		Hanger rod, shroud outlet plus 50 mm	BYPbTEMPbbNO.3bUTT		
		Hanger rod, IPT outlet	BYPbTEMPbbNO.5bUTT		
		Hanger rod between shroud & IPT outlet	BYPbTEMPbbNO.4bUTT		
Lower plenum temperature	Type K TC	Lower support plate	PLATbTMPbbbbbbLTT	300 to 800 K	10
Neutron flux No. 1[b]	SPND	-0.343 m	NEUTbFLXbb-34.3bTT	0 to 160 nA	10
No. 2		-0.229 m	NEUTbFLXbb-22.9bTT		
No. 3		-0.114 m	NEUTbFLXbb-11.4bTT		
No. 4		0.0	NEUTbFLXbbbb0.0bTT		
No. 5		+0.142 m	NEUTbFLXbb+14.2bTT		
No. 6		+0.229 m	NEUTbFLXbb+22.9bTT		
No. 7		+0.343 m	NEUTbFLXbb+34.3bTT		
System pressure	EG&G, Idaho, Inc., 69 MPa PXD	Center tie rod, below shroud inlets	SYSbPRESbb69EGbLTT	0 to 69 MPa	100
System coolant pressure	EG&G, Idaho, Inc., 17 MPa PXD	Center tie rod, below shroud inlets	SYSbPRESbb17EGbLTT	0 to 18 MPa	100
System coolant pressure	EG&G, Idaho, Inc., 17 MPa PXD	Hanger rod, above shroud outlets	SYSbPRESbb17EGbUTT	0 to 18 MPa	100
System coolant pressure	Kaman 17 MPa PXD	Hanger rod, above shroud outlets	SYSbPRESbb17KAbUTT	0 to 18 MPa	100
Gamma flux No. 1[c]	SPGD	-0.229 m	GAMAbFLXbb-22.9bTT	0 to 100 nA	10
Gamma flux No. 2	SPGD	0.0	GAMAbFLXbbb00.0bTT	0 to 100 nA	10
Gamma flux No. 3	SPGD	+0.229 m	GAMAbFLXbb+22.9bTT	0 to 100 nA	10
Controlled bypass turbine	Bidirectional turbine flowmeter	Upper plenum filler piece	FLOWRATEbbCONTBYTT	-40 to 12 /s	100

a. All elevations are measured from axial midplane of the fuel stack.
b. Include a channel for gamma compensation and measure the "sign" or direction of the current.
c. Include a channel for gamma compensation.
d. b denotes blank.

TABLE XI

TEST TC-1 HOT LEG, COLD LEG, AND INITIAL CONDITIONS SPOOL PIECES INSTRUMENT IDENTIFICATION DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Instrument Identifier[a]	Recording Ranges	Minimum Recording Frequency Required (Hz)[b]
Coolant volumetric flow rate	Bidirection turbine flowmeter	ICSVFLOWbbFE05SPIC CLSVFLOWbbFE06SPCL HLSVFLOWbbFE09SPHL	0 to 20 ℓ/s 0 to 100 ℓ/s 0 to 50 ℓ/s	100
Momentum flux	Drag disk	CLMOMFLXbbFE07SPHL ICMOMFLXbbFE10SPIC HLMOMFLXbbFE08SPCL	0 to 40000 $kg/m\text{-}s^2$ 0 to 2000 $kg/m\text{-}s^2$ 0 to 20000 $kg/m\text{-}s^2$	100
Steady-state coolant temperature	RTD	ICSSTEMPbbTE20SPIC[d] CLSSTEMPbbTE22SPCL HLSSTEMPbbTE23SPCL	280 to 650 K	10
Transient coolant temperature	Type K thermocouple	ICTCTEMPbbTE21SPIC CLTCTEMPbbTE24SPCL HLTCTEMPbbTE25SPHL	280 to 650 K	10
Subcooled coolant pressure (flush mounted)	Pressure transducer	ICPRESSFbbPE08SPIC[d] CLPRESSFbbPE10SPCL HLPRESSFbbPE12SPHL	0 to 21 MPa	100
Saturated coolant pressure	Pressure transducer, water cooled	ICPRESSWbbPE09SPIC[d] CLPRESSWbbPE11SPCL HLPRESSWbbPE13SPHL	0 to 21 MPa	100
Coolant pressure differential (hot to cold leg)	Pressure transducer	DELPCLHLbbDPE-OSHL	0 to 1 MPa	100
Coolant density	Gamma densitometer	CLDENSUPbbDENS1UCL CLDENSCEbbDENS1CCL CLDENSLObbDENS1LCL HLDENSUPbbDENS2UHL HLDENSCEbbDENS2CHL HLDENSLObbDENS2LHL	0 to 800 kg/m^3	100
Spool piece accelerometer[c]	Three axes accelerometer	CLbACCELbbAE-1-1CL CLbACCELbbAE-1-2CL CLbACCELbbAE-1-3CL HLbACCELbbAE-2-1HL HLbACCELbbAE-2-2HL HLbACCELbbAE-2-3HL		
Sample pipe temperature[c]	Type K thermocouple	FPbTEMPbbbPIPE01FP FPbTEMPbbbPIPE02FP FPbTEMPbbbPIPE03FP FPbTEMPbbbPIPE04FP FPbTEMPbbbPIPE05FP FPbTEMPbbbPIPE06FP FPbTEMPbbbPIPE07FP FPbTEMPbbbPIPE08FP FPbTEMPbbbPIPE09FP	0 to 800 K	10

a. b denotes blank

b. Minimum frequency is calculated from required instrumentation response time. Final designation of the instrument response time will be completed by the Instrument and Data Section.

c. Not required.

d. Required instruments for data qualification.

TABLE XII

TEST TC-1 PLANT INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location	Instrument Identifier	Recording Ranges	Minimum Recording Frequency Required (Hz)
Valve position	Limit switches	Cold-leg	VALVbPOSbbLMLRC1PT	Open, closed	1000
		Cold-leg	VALVbPOSbbLMLRC2PT		
		Hot-leg	VALVbPOSbbLM1101PT		
		Hot-leg	VALVbPOSbbLM1102PT		
		Bypass	VALVbPOSbbLM1107PT		
		Isolation	VALVbPOSbbLM1105PT		
		Isolation	VALVbPOSbbLM1106PT		
		Quench	VALVbPOSbbLM1108PT		
		Warmup line	VALVbPOSbbLM1109PT		
		Cold leg shutoff	VALVbPOSbbLM1110PT		
Outlet coolant flow	Transducer	Outlet	OUTbFLOWbbFT-29bPT	0 to 20 /s	10
Quench tank coolant level	Level detector	Quench tank	QNCHbLEVbbLT-10bPT	0 to 100%	10
Quench tank coolant thermocouple	Thermocouple	Quench tank	QNCHbTMPbbTIC27bPT	0 to 500 K	10
Quench tank flow	Turbine meter	Quench tank	QNCHbFLObbFT-L4bPT	0 to 5 /s	10
Blowdown tank liquid level	Level detector	Blowdown tank	BLOWbLEVbbLIT17bPT	0 to 100%	10
Blowdown tank PXD	Pressure transducer	Blowdown tank	BLOWbPRSbbPT-12bPT	0 to 1 MPa	10
Transient rod position 1	LVDT	TR drive 1	TRANSRODbbNUMb01PT	0 to 2 m	100
Transient rod position 2	LVDT	TR drive 2	TRANSRODbbNUMb02PT	0 to 2 m	100
Transient rod position 3	LVDT	TR drive 3	TRANSRODbbNUMb03PT	0 to 2 m	100
Transient rod position 4	LVDT	TR drive 4	TRANSRODbbNUMb04PT	0 to 2 m	100
Gross gamma rate	No.1 NaI gamma detector	FPDS	FPDSGAMAbbNUMb01FP	10 to 10^6 counts/s	10
Gross gamma rate	No.2 NaI gamma detector	FPDS	FPDSGAMAbbNUMb02FP		
Gross gamma rate	No.3 NaI gamma detector	FPDS	FPDSGAMAbbNUMb03FP		
Gross neutron ra[illegible]	BF_3 neutron detector	FPDS	FPbNEUTbbbNEUTRNFP		
Core power (30 M[illegible]	NMS-3 Ionization chamber	Reactor vessel wall	REACbPOWbbNMS-03PT	0 to 30 MW	10
Core power (30 MW)	NMS-4 Ionization chamber	Reactor vessel wall	REACbPOWbbNMS-04PT	0 to 30 MW	10
Core power (30 MW)	PPS-1 Ionization chamber	Reactor vessel wall	REACbPOWbbPPS-01PT	0 to 30 MW	10
Core power (30 MW)	PPS-2 Ionization chamber	Reactor vessel wall	REACbPOWbbPPS-02PT	0 to 30 MW	10
System pressure	Heise pressure quage	Plant	SYSbPRESbbHEISEbPT	0 to 17 MPa	10
IPT pressure drop	ΔP PXD	Plant	IPTbDELPbbDPR-10PT	0 to 0.69 MPa	10
Loop flow	Venturi flowmeter	Plant	LOOPbFLObbFRC-10PT	0 to 0.07 m^3/s	10
Low flow reflood turbine	Turbine meter	Reflood system	REFLOODbLOWbFLObbb	0 to 0.5 /s	10
High flow reflood turbine	Turbine meter	Reflood system	REFLOODbHIGHbFLObb	0 to 2 /s	10

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	FUELTC1b2W53+18002 Fuel Temperature FUELTC1b2W53+30002	CLADbDSPbbTC1bbb03 CLAD DSP CLADbDSPbbTC1bbb04
CLADTC1b2b53+0bb02 Cladding Temperature CLADTC1b2b53+90b02	FUELTC1b3b53+60b03 Fuel Temperature FUELTC1b3b53+18003	FLOWRATEbbINLETb01 Shroud Turbine Meter FLOWRATEbbINLETb02
CLADTC1b3b53+0bb03 Cladding Temperature CLADTC1b3b53+90b03	FUELTC1b3b53+30003 Fuel Temperature FUELTC1b4b53+60b04	FLOWRATEbbINLET03 Shroud Turbine Meter FLOWRATEbbINLET04
FUELTC1b1b53+60b01 Fuel Temperature FUELTC1b1W53+18001	FUELTC1b4b53+18004 Fuel Temperature FUELTC1b4b53+30004	ICSSTEMPbbTE20SPIC Spool Temperature CLTCTEMPbbTE24SPCL
FUELTC1b1W53+30001 Fuel Temperature FUELTC1b2b53+60b02	CLADbDSPbbTC1bbb01 CLAD DSP CLADbDSPbbTC1bbb02	CLSVFLOWbbFE06SPCL Spool Turbine Meter ICSVFLOWbbFE05SPIC

Fig. 6 Strip chart setup for Test TC-1.

Tables IX through XII are requested to be included in the DARS, but are not to be qualified. Additionally, the test schedule or budget should not be changed to repair any "non-essential" instruments that fail in the process of the test.

4.2. Test Results Letter Report

Test data plots for the Test Results Letter Report are to be prepared within 72 hours of the completion of the test. Due to the short time allocated for preparation of this document, it is mandatory that this requirement be met.

A complete list of the plots that are required for the Test Results Letter Report will be provided by the TFBP TC-1 Project Engineer within two weeks of the test.

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5. REFERENCES

1. J. M. Broughton and P. E. MacDonald, Light Water Reactor Fuel Behavior Program Description: PBF-LOCA Experiment Requirements, ANC (January 1975).

2. 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).

3. D. J. Varacalle, "PBF/LOFT Lead Rod Test Program Experiment Operating Specification", TFBP-TR-302, Rev. 1, January 1979.

4. D. J. Varacalle, "PBF/LOFT Lead Rod Test Program Experiment Specification Document", TFBP-TR-282, June 1978.

5. W. P. Polkinghorn, S. B. Letson, "PBF/LOFT Lead Rod Test Experiment Configuration Specification", ES 50364, June 1978.

6. F. E. Panesko, "Product Specification TC1 Fuel Rods", TTPS 1025, Rev. 1, Aug. 28, 1979.

7. D. L. Reeder, "Quick Look Report on LOFT Nuclear Experiment L2-3", QLR-L2-3, May 1979.

APPENDIX A

STATUS CHECK LISTS FOR INSTRUMENTATION

TABLE-AI (Power Calibration)

MEASUREMENT STATUS CHECK DURING POWER CALIBRATION

REACTOR POWER	0	KW
COOLANT TEMPERATURE	600	K (Average of test train inlet TC's)
COOLANT PRESSURE	15.51	MPa (Heise)
SHROUD FLOW RATE	0.6	l/s (Average of test train inlet flowmeters)

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
CLADTC1b2b53+0bb02		K	Temperature ± 4 K	
CLADTC1b2b53+90b02		K	Temperature ± 4 K	
CLADTC1b2b53+18002		K	Temperature ± 4 K	
CLADTC1b2b53+27002		K	Temperature ± 4 K	
CLADTC1b3b53+0bb03		K	Temperature ± 4 K	
CLADTC1b3b53+90b03		K	Temperature ± 4 K	
CLADTC1b3b53+18003		K	Temperature ± 4 K	
CLADTC1b3b53+27003		K	Temperature ± 4 K	
FUELTC1b1b53+60b01		K	Temperature ± 4 K	
FUELTC1b1W53+18001		K	Temperature ± 4 K	
FUELTC1B1W53+30001		K	Temperature ± 4 K	
FUELTC1b2b53+60b02		K	Temperature ± 4 K	
FUELTC1b2W53+18002		K	Temperature ± 4 K	
FUELTC1b2W53+30002		K	Temperature ± 4 K	
FUELTC1b3b53+60b03		K	Temperature ± 4 K	
FUELTC1b3b53+18003		K	Temperature ± 4 K	
FUELTC1b3b53+30003		K	Temperature ± 4 K	
CLADbDSPbbTC1bbb01		mm	1.0 ± 0.5 mm	
CLADbDSPbbTC1bbb02		mm	1.0 ± 0.5 mm	
CLADbDSPbbTC1bbb03		mm	1.0 ± 0.5 mm	
CLADbDSPbbTC1bbb04		mm	1.0 ± 0.5 mm	
INLTbTMPbbTC1bbb01		K	Temperature ± 4 K	
INLTbTMPbbTC1bbb02		K	Temperature ± 4 K	
INLTbTMPbbTC11bb03		K	Temperature ± 4 K	
INLTbTMPbbTC1bbb04		K	Temperature ± 4 K	
OUTbTEMPbbTC1bbb01		K	Temperature ± 4 K	

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OUTbTEMPbbTC1bbb02		K	Temperature ± 4 K	
OUTbTEMPbbTC1bbb03		K	Temperature ± 4 K	
OUTbTEMPbbTC1bbb04		K	Temperature ± 4 K	
DELbTEMPbb135bbb01		K	± 0.05 K	
DELbTEMPbb135bbb02		K	± 0.05 K	
DELbTEMPbb135bbb03		K	± 0.05 K	
DELbTEMPbb135bbb04		K	± 0.05 K	
FLOWRATEbbINLETb01		l/s	Flow ± 0.001 l/s	
FLOWRATEbbINLETb02		l/s	Flow ± 0.001 l/s	
FLOWRATEbbINLETb03		l/s	Flow ± 0.001 l/s	
FLOWRATEbbINLETb04		l/s	Flow ± 0.001 l/s	
FLOWRATEbbOUTLET01		l/s	Flow ± 0.001 l/s	
FLOWRATEbbOUTLET02		l/s	Flow ± 0.001 l/s	
FLOWRATEbbOUTLET03		l/s	Flow ± 0.001 l/s	
FLOWRATEbbOUTLET04		l/s	Flow ± 0.001 l/s	
NEUTbFLXbb-34.3bTT	N/A		N/A	N/A
NEUTbFLXbb-22.9bTT	N/A		N/A	N/A
NEUTbFLXbb-11.4bTT	N/A		N/A	N/A
NEUTbFLXbbbb0.0bTT	N/A		N/A	N/A
NEUTbFLXbb+14.2bTT	N/A		N/A	N/A
NEUTbFLXbb+22.9bTT	N/A		N/A	N/A
NEUTbFLXbb+34.3bTT	N/A		N/A	N/A
BYPbTEMPbbNO.1bLTT		K	Temperature ± 4 K	
BYPbTEMPbbNO.2bbTT		K	Temperature ± 4 K	
BYPbTEMPbbNO.3bUTT		K	Temperature ± 4 K	
BYPbTEMPbbNO.4bUTT		K	Temperature ± 4 K	
BYPbTEMPbbNO.5bUTT		K	Temperature ± 4 K	
PLATbTMPbbbbbbLTT		K	Temperature ± 4 K	
SYSbPRESbb69EGbLTT		MPa	Heise ± 3.5 MPa	
SYSbPRESbb17EGbLTT		MPa	Heise ± 0.7 MPa	
SYSbPRESbb17EGbUTT		MPa	Heise ± 0.7 MPa	
SYSbPRESbb17KAbUTT		MPa	Heise ± 0.7 MPa	
GAMAbFLXbb-22.9bTT	N/A		N/A	N/A
GAMAbFLXbbb00.0bTT	N/A		N/A	N/A
GAMAbFLXbb+22.9bTT	N/A		N/A	N/A

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
FLOWRATEbbCONTBYTT	____	l/s	16 ± 1.0 l/s	____
SHRDbLEVbbINLETb01	N/A		N/A	N/A
SHRDbLEVbbINLETb02	N/A		N/A	N/A
SHRDbLEVbbINLETb03	N/A		N/A	N/A
IPTbLEVLbbNO.1bLTT	N/A		N/A	N/A
IPTbLEVLbbNO.2bLTT	N/A		N/A	N/A
ICSVFLOWbbFE05SPIC	____	l/s	Flow(c) ± 0.02 l/s	____
CLSVFLOWbbFE06SPCL	____	l/s	(c) ± 0.02 l/s	____
HLSVFLOWbbFE09SPHL	____	l/s	(c) ± 0.02 l/s	____
CLMOMFLXbbFE07SPCL	N/A		N/A	N/A
HLMOMFLXbbFE08SPHL	N/A		N/A	N/A
ICSSTEMPbbTE20SPIC	____	K	Temperature ± 4 K	____
CLSSTEMPbbTE22SPCL	____	K	Temperature ± 4 K	____
HLSSTEMPbbTE23SPHL	____	K	Temperature ± 4 K	____
ICTCTEMPbbTE21SPIC	____	K	Temperature ± 4 K	____
CLTCTEMPbbTE24SPCL	____	K	Temperature ± 4 K	____
HLTCTEMPbbTE25SPHL	____	K	Temperature ± 4 K	____
ICPRESSFbbPE08SPIC	____	MPa	Heise ± 0.2 MPa	____
CLPRESSFbbPE10SPCL	____	MPa	Heise ± 0.2 MPa	____
HLPRESSFbbPE12SPHL	____	MPa	Heise ± 0.2 MPa	____
ICPRESSWbbPE09SPIC	____	MPa	Heise ± 0.2 MPa	____
CLPRESSWbbPE11SPCL	____	MPa	Heise ± 0.2 MPa	____
HLPRESSWbbPE13SPHL	____	MPa	Heise ± 0.2 MPa	____
DELPCLHLbbDPE-05HL	N/A	MPa	N/A	N/A
CLDENSUPbbDENS1UCL	N/A		N/A	N/A
CLDENSCEbbDENS1CCL	N/A		N/A	N/A
CLDENSLObbDENS1LCL	N/A		N/A	N/A
HLDENSUPbbDENS2UHL	N/A		N/A	N/A
HLDENSCEbbDENS2CHL	N/A		N/A	N/A
HLDENSLObbDENS2LHL	N/A		N/A	N/A
CLbACCELbbAE-1-1CL	N/A		N/A	N/A

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PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
CLbACCELbbAE-1-2CL	N/A	N/A	N/A
CLbACCELbbAE-1-3CL	N/A	N/A	N/A
HLbACCELbbAE-2-1HL	N/A	N/A	N/A
HLbACCELbbAE-2-2HL	N/A	N/A	N/A
HLbACCELbbAE-2-3HL	N/A	N/A	N/A
HENRYPXDbbFE11-1PT	______ MPa	Heise ± 0.2 MPa	
HENRYPXDbbFE11-2PT	______ MPa	Heise ± 0.2 MPa	
HENRYPXDbbFE11-3PT	______ MPa	Heise ± 0.2 MPa	
HENRYPXDbbFE11-4PT	______ MPa	Heise ± 0.2 MPa	
FPbTEMPbbbPIPE01FP	N/A	N/A	N/A
FPbTEMPbbbPIPE02FP	N/A	N/A	N/A
FPbTEMPbbbPIPE03FP	N/A	N/A	N/A
FPbTEMPbbbPIPE04FP	N/A	N/A	N/A
FPbTEMPbbbPIPE05FP	N/A	N/A	N/A
FPbTEMPbbbPIPE06FP	N/A	N/A	N/A
FPbTEMPbbbPIPE07FP	N/A	N/A	N/A
FPbTEMPbbbPIPE08FP	N/A	N/A	N/A
FPbTEMPbbbPIPE09FP	N/A	N/A	N/A
CLbDNTMPbbDENTC1CL	N/A	N/A	N/A
CLbDNTMPbbDENTC2CL	N/A	N/A	N/A
CLbDNTMPbbDENTC3CL	N/A	N/A	N/A
HLbDNTMPbbDENTC1HL	N/A	N/A	N/A
HLbDNTMPbbDENTC2HL	N/A	N/A	N/A
HLbDNTMPbbDENTC3HL	N/A	N/A	N/A
VALVbPOSbbLM1101PT	N/A	N/A	N/A
VALVbPOSbbLM1102PT	N/A	N/A	N/A
VALVbPOSbbLMLRC1PT	N/A	N/A	N/A
VALVbPOSbbLMLRC2PT	N/A	N/A	N/A
VALVbPOSbbLM1105PT	N/A	N/A	N/A
VALVbPOSbbLM1106PT	N/A	N/A	N/A
VALVbPOSbbLM1107PT	N/A	N/A	N/A

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
VALVbPOSbbLM1108PT	N/A		N/A	N/A
VALVbPOSbbLM1109PT	N/A		N/A	N/A
VALVbPOSbbLM1110PT	N/A		N/A	N/A
OUTbPRESbbPT-30bPT		MPa	Heise ± 0.7 MPa	
OUTbFLOWbbPT-29bPT		l/s	Flow[(c)] ± 0.3 l/s	
OUTbTEMPbbTT-29bPT		K	Temperature ± 4 K	
QNCHbLEVbbLT-10bPT	N/A		N/A	N/A
QNCHbTMPbbTIC27bPT	N/A		N/A	N/A
QNCHbFLObbFT-14bPT	N/A		N/A	N/A
BLOWbPRSbbPT-12bPT	N/A		N/A	N/A
BLOWbLEVbbLIT17bPT	N/A		N/A	N/A
SYSbPRESbbPRS10bPT	N/A		N/A	N/A
IPTbDELPbbDPR-10PT	N/A		N/A	N/A
LOOPbACTbbFBM-01PT	N/A		N/A	N/A
LOOPbFLObbFRC-10PT	N/A		N/A	N/A
FPbGAMMAbbNO.1bbFP	N/A		N/A	N/A
FPbGAMMAbbNO.2bbFP	N/A		N/A	N/A
FPbGAMMAbbNO.3bbFP	N/A		N/A	N/A
FPbNEUTbbbbbbbbbFP	N/A		N/A	N/A
REACbPOWbbNMS-03PT	N/A		N/A	N/A
REACbPOWbbNMS-04PT	N/A		N/A	N/A
REACbPOWbbPPS-01PT	N/A		N/A	N/A
REACbPOWbbPPS-02PT	N/A		N/A	N/A

a. This certification must be signed by the LWRD Repr[illegible]entative or his alternate. For all cases where the instruments are not within range the TFBP Project Engineer's approval must be obtained to continue the test procedures.

b. One per shroud required as minimum operable instrumentation.

c. Flow determined during flow split.

TABLE-AII

MEASUREMENT STATUS CHECK AT 80 - 100 KW

REACTOR POWER	80 - 100	KW
COOLANT TEMPERATURE	590 K	Average of test train inlet TC's
COOLANT PRESSURE	15.51 MPa	
SHROUD FLOW RATE	1.0 l/s	

PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
NEUTbFLXbb-34.3bTT	________nA	± 0.8 nA	________
NEUTbFLXbb-22.7bTT	________nA	± 0.8 nA	________
NEUTbFLXbb-11.4bTT	________nA	± 0.8 nA	________
NEUTbFLXbbbb0.0bTT	________nA	± 0.8 nA	________
NEUTbFLXbb+14.2bTT	________nA	± 0.8 nA	________
NEUTbFLXbb+22.9bTT	________nA	± 0.8 nA	________
NEUTbFLXbb+34.3bTT	________nA	± 0.8 nA	________
GAMMAbFLXbb-22.9bTT	________nA	± 0.8 nA	________
GAMMAbFLXbbb00.0bTT	________nA	± 0.8 nA	________
GAMMAbFLXbb+22.9bTT	________nA	± 0.8 nA	________

a. This certification must be signed by the LWRD Representative or his alternate. For all required instruments that are not within range the TFBP Project Engineer's approval must be obtained to continue the test procedure. Instrumentation listed which is not required shall be marked NA and initialed by the LWRD Representative.

TABLE A-II

FLOW BALANCE WORK SHEET

Conditions:
Coolant Temp. ____
Coolant Press. ____

	Shroud Flows	Bypass Flow	IC Flow	%Leakage
(1)	________	________	______	______
(2)	________			
(3)	________			
(4)	________			
Ave.	________			

	Shroud Flows	Bypass Flow	IC Flow	%Leakage
(1)	________	________	______	______
(2)	________			
(3)	________			
(4)	________			
Ave.	________			

	Shroud Flows	Bypass Flow	IC Flow	%Leakage
(1)	________	________	______	______
(2)	________			
(3)	________			
(4)	________			
Ave.	________			

TABLE A-III

POSTTEST CHECK LIST AND DARS SETUP
DOCUMENTATION CHECKLIST

Integrated Data System Calibration Procedure Checklist	______
Data Recording Verification Procedure Checklist	______
Measurement Status - Ambient	______
- 340 K (During Heatup)	______
- 600 K (After Heatup Prior to Nuclear Operation)	______
- Reactor Critical (100 KW)	______
Posttest Checklist and DARS Setup Documentation Checklist	______
Quench Tank and Blowdown Tank Readings	______
Flow Balance Readings	______
DARS Channel Setup Log Sheet	______
SS Channel Setup Log Sheet	______
DARS Narrow Band and Wide Band Tape Log Sheets	______
DARS Parameter/Sensor Directory	______
DARS Inactive Parameter Directory	______
REDCOR Printout	______
SS Strip Charts	______