INTERIM REPORT

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Author(s): **T. R. Yackle**

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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.

Kay Rose
for H. P. Pearson, Supervisor
Information Processing
EG&G Idaho

Prepared for
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

NRC Fin #A6041

INTERIM REPORT

NRC Research and Technical Assistance Report

998 217

TFBP-TR-309
Rev. 1
for U.S. Nuclear Regulatory Commission

LOSS-OF-COOLANT ACCIDENT TEST SERIES TEST LOC 5 EXPERIMENT OPERATING SPECIFICATION

T.R. YACKLE

August 197[illegible]

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT DE-AC07-76IDO1570

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FORM EG&G-1844
(Rev. 5-77)

DOCUMENT REVISION REQUEST

(1) OPER. NO. ______

PAGE 1 OF 1

(2) REQUESTER	(3) DRR DATE	(4) DRR NO.
T. R. Yackle	9/4/79	TFBP-211

(5) DOCUMENT NO. (IF APPLICABLE)	DOCUMENT TITLE	DOCUMENT ISSUE DATE
TFBP-TR-309, Rev. 1	LOSS OF COOLANT ACCIDENT TEST SERIES TEST LOC-5 EOS	Aug 1979

(6) CHECK APPLICABLE BLANK
PERMANENT CHANGE X TEMPORARY CHANGE ______ BULLETIN ______

(7) MANAGER APPROVAL ______ DATE ______

(8) PRINT OR TYPE PROPOSED CHANGE — NUMBER EACH CHANGE SEQUENTIALLY IN 1ST COLUMN AND RECORD PAGE AND STEP OR PARAGRAPH NUMBER FOR EACH CHANGE.

(9) FOR WRITER'S USE

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1	34	13	Change "X" in Cold Leg Blowdown Valve column to "O"
2	34	Note (2)	Change valve description to VALVbPOSbbLM1103PT and VALVbPOSbbLM1104PT
3	37	1	Change 0.086 l/s to 0.190 l/s

USE CONTINUATION SHEET AS REQUIRED

NEXT ANTICIPATED NEED FOR DOCUMENT WITH THIS REVISION INCORPORATED: DATE/EVENT ______

(10) JUSTIFICATION: (REASON FOR CHANGE — NUMBER TO CORRESPOND TO ITEM NO. ABOVE):

1) The cold leg should remain open throughout blowdown until quench

2) Incorrect valve identity

3) Low flow reflood rate incorrectly specified in the text

(11) OTHER DOCUMENTATION AFFECTED:

DOC. NO.	DRR NO.	DATE COMPLETED

(12) ORIGINATING DRR NO: ______

(13) REVIEW

NAME/SIGNATURE	ORG.	DATE	NAME/SIGNATURE	ORG.	DATE	NAME/SIGNATURE	(14) REVIEW CODE	ORG.	DATE
T R Yackle	2810	9/04	[signature]	2600	9-4-79			QUALITY DIV.	
R W Garner	2810	9/04/79	R. K. McCardell	2810	9-4-79			SAFETY DIV.	
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(15) COMMENTS:

(16) ADDITIONAL DRRS IN THIS DOCUMENT REVISION

(17) DOCUMENT CONTROLLER

(18) RELEASE DATE:

(19) DRR COMPLETED DATE:

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FORM EG&G-1844
(Rev. 5-77)

DOCUMENT REVISION REQUEST

PAGE 1 OF ____

② REQUESTER	③ DRR DATE	④ DRR NO.
M. E. Waterman	August 22, 1979	TFBP-209

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TFBP-TR-309, Rev. 1	LOSS-OF-COOLANT ACCIDENT TEST SERIES TEST LOC-5 EXPERIMENT OPERATING SPECIFICATION	August, 1979

⑥ CHECK APPLICABLE BLANK
PERMANENT CHANGE XX TEMPORARY CHANGE ____ BULLETIN ____

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1	37	5	Change "CLAD808b2b19+0bb0Z" to "CLAD839b2b19+0bb0Z"
2	47		Change "RODbPRESSbb808bbb0Z" to "RODbPRESSbb839bbb0Z"
3			With the exception of TABLE X, all references to Rods 934, 839, 935, and 912 should be changed to [illegible] 605-5, 605-6, 605-7, and 605-8, respectively.

USE CONTINUATION SHEET AS REQUIRED

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⑩ JUSTIFICATION: (REASON FOR CHANGE — NUMBER TO CORRESPOND TO ITEM NO. ABOVE):

1. Rod 808 replaced by Rod 839
2. Rod 808 replaced by Rod 839
3. Rod numbers replaced to establish rod identification consistency.

⑪ OTHER DOCUMENTATION AFFECTED

DOC. NO.	DRR NO.	DATE COMPLETED

⑫ ORIGINATING DRR NO. ____

⑬ REVIEW

NAME/SIGNATURE	ORG.	DATE	NAME/SIGNATURE	ORG.	DATE	NAME/SIGNATURE	⑭ REVIEW CODE	ORG.	DATE
[signature]	2810	8/22/79						QUALITY DIV	
[signature]	2810	8/23/79						SAFETY DIV	
R. K. McCardell	2810	8/24/79						PRAC	

⑮ COMMENTS

⑯ ADDITIONAL DRRS IN THIS DOCUMENT REVISION

⑰ DOCUMENT CONTROLLER	⑱ RELEASE DATE	⑲ DRR COMPLETED DATE

TFBP-TR-309
Revision 1

LOSS-OF-COOLANT ACCIDENT TEST SERIES
TEST LOC 5
EXPERIMENT OPERATING SPECIFICATION

August 1979

T. R. YACKLE

Thermal Fuels Behavior Program
EG&G Idaho, Inc.

Approved: J. M. Broughton

J. M. Broughton, Supervisor
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EG&G Idaho, Inc.

FORM EG&G-398
(Rev 12-78)

INTERIM REPORT

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Revision 1

Contract Program or Project Title: Thermal Fuels Behavior Program

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Type of Document: EOS

Author(s): T. R. Yackle

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Responsible NRC Individual and NRC Office or Division: Dr. M. L. Picklesimer, Reactor Safety Research

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

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Idaho Operations Office
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INTERIM REPORT

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TABLES

FIGURES

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CONVERSION FACTORS FOR SI AND U.S. CUSTOMARY UNITS

To Convert From	To	Multiply by
K	°F	1.8 K - 459.67
kg/s-m^2	lb/ft^2-hr	737.4
kg/s	lb/s	2.2046
kW/m	kW/ft	0.3048
m	ft	3.2083
MPa	psi	145.05
W/m^2	Btu/ft^2-hr	0.3169
m^3/s	ft^3/s	35.315
/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 LOCA tests simulate accident conditions in a pressurized water reactor (PWR) core resulting in a loss of fuel rod coolant. During a LOCA the coolant conditions are characterized by a rapid core depressurization and drastic changes in both coolant mass flow and quality. Depending on the size and location of the break in the cold- or hot-leg, system depressurization will be completed within approximately 30 seconds. Cooling of the fuel rods will degrade during the accident. The fuel rod cladding will heat up and may balloon and rupture.

The purpose of this document is to specify the experiment operating procedure for Test LOC-5. The test will be performed using four, separately shrouded fuel rods of PWR 15x15 design. Two rods have been previously irradiated and two rods will be unirradiated. One unirradiated and one irradiated rod will be backfilled with helium to a pressure typical of beginning-of-life PWR fuel rods, and the other rods will be backfilled to a pressure typical of fuel rods at the end-of-operational life.

The behavior of PWR fuel rods during the LOCA conditions for Test LOC-5 will result in peak cladding temperatures stabilizing in the β-phase. Cladding ballooning with relatively large strain to failure is expected on all four rods. Additionally, a comparison will be made between the behavior of irradiated and unirradiated fuel rods.

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 condition will be increased up 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 test will be terminated with reflood and quench followed by long-term cooling provided by the quench system.

Section 2 of this document describes the fuel train, test assembly, LOCA modifications, and instrumentation associated with each component. Section 3 presents the procedures of the experiment conduct for Test LOC-5. Section 4 lists the data aquisition and reduction requirements. The posttest operations support and the post irradiation examination requirements are presented in Sections 5 and 6. Appendix A provides the status check lists for instrumentation and flow balance sheets.

2. EXPERIMENT DESIGN

Test LOC-5 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 LOC-5 experiment design is the same as the Test LOC-3 design presented by the Experiment Operating Specification (EOS)[3] except for minor differences in fuel rod specifications. This section summarizes the design of fuel rods, test train, LOCA modification system, and the instrumentation associated with each component as presented by the Test LOC-3 EOS. Further information is available in the Experiment Specification Document[4] and the Experiment Configuration Specification[5].

2.1 Fuel Rods and Shroud

The fuel rods consist of two rods that were previously irradiated to about 16000 MWd/t in the Saxton reactor and two unirradiated rods of Saxton design. The two irradiated rods are designated 839 and 912, and the two unirradiated rods are designated 934 and 935. The fuel rod designation and burnup are given in Table I. The as-fabricated nominal design characteristics of these fuel rods are given in Table II. Rods 839 and 934 are prepressurized to 2.41 MPa, typical of the PWR rod beginning-of-life pressure and Rods 912 and 935 are prepressurized to 4.83 MPa, typical of the PWR rod end-of-life pressure. The unirradiated rods are contained in stainless steel shrouds, whereas the irradiated rods are contained in zircaloy shrouds. The flow shrouds are similar to the fluted shrouds used in Test LOC-11[6]. The characteristics of the individual flow shrouds are shown in Table III. A plane view of the fuel rod orientation and instrumentation within the in-pile tube (IPT) (Subsection 2.4.1) is shown in Figure 1.

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TABLE I

TEST LOC-5 FUEL ROD DESIGN CHARACTERISTICS

Test	Rod Type	Rod No.	Helium Pre-Pressurization (MPa)	Burnup (MWd/t)	U-235 Enrichment (%)	Fuel Theoretical Density (%)
LOC-5	Saxton	934	2.41	0	12.5	94.5 ± 0.5
	Saxton	935	4.83	0	12.5	94.5 ± 0.5
	Saxton	839	4.83	17,660	12.5	92 ± 0.5
	Saxton	912	2.41	16,050	12.5	89.5 ± 0.5

TABLE II

TEST LOC-5 FUEL ROD NOMINAL DIMENSIONS

Cladding material	zircaloy-4
Cladding outside diameter	9.93 mm
Cladding inside diameter	8.75 mm
Cladding wall thickness	0.59 mm
Diametral gap	0.216 mm (unirradiated)
Pellet diameter	8.534 $\pm$ 0.013 mm (Rods 839, 934, 935), 8.484 $\pm$ 0.013 mm (Rod 912)
Pellet length	15.24 $\pm$ 0.25 mm
Pellet dish depth	0.34 mm, spherical radius - 16.08 mm
Pellet centerhole	1.88 $\pm$ 0.05 mm (unirradiated)
Fuel length	889 mm
Top insulating pellet length	15.24 $\pm$ 0.25 mm
Bottom insulating pellet length	6.35 $\pm$ 0.25 mm (unirradiated rods)
Plenum volume	2.917 cm^3 (included plenum pressure transducer and sensor line volumes)

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TABLE III

TEST LOC-5 FUEL ROD SHROUD CHARACTERISTICS

	Irradiated Rods	Unirradiated Rods
Shroud material	Zircaloy	Stainless steel
Wall thickness (mm)	1.24	1.33
Initial outside diameter (mm)	25.4	25.4
Flow area per shroud (mm^2)	229	225

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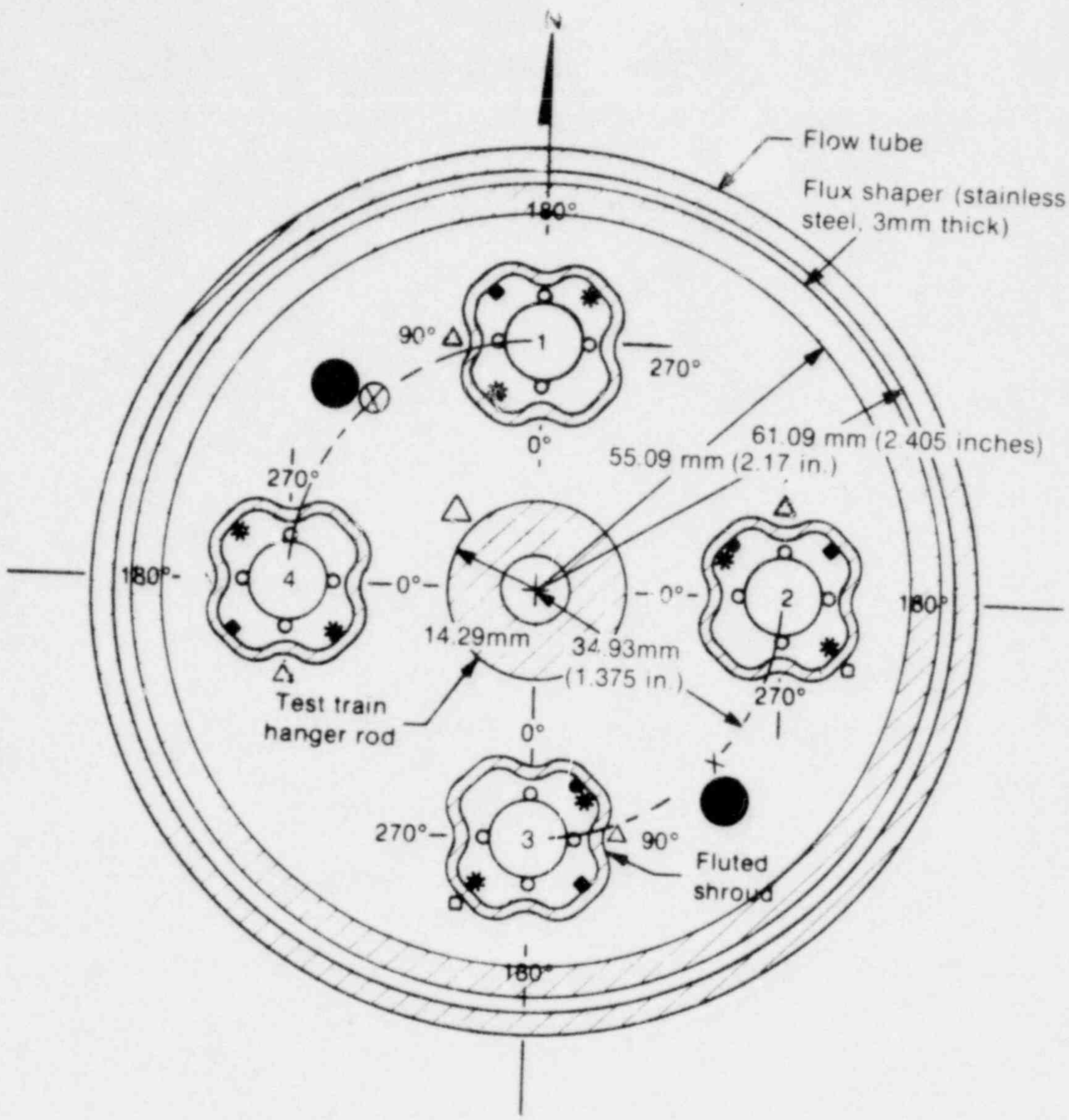

Rod locations	Rod No.	Internal pressure
1	934	(2.41 MPa)
2	839	(2.41 MPa)
3	935	(4.83 MPa)
4	912	(4.83 MPa)

Rod to rod pitch - 49.39 mm

- O Cladding thermocouples
- X Self powered neutron detectors
- ⊗ Self powered gamma detectors
- ● Zircaloy-4 support tube - 10.9 mm outer diameter
- △ Flux wires
- • Inside shroud coolant thermocouples
- □ Outside shroud surface thermocouples
- ✱ Differential thermocouple
- ■ Inlet/outlet thermocouple

INEL-A-10 340

Fig. 1 Test LOC-5 fuel train orientation

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2.2 Test Train

The LOC-5 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, the flux shaper, 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 each rod 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. A flux shaper is located within the zircaloy section to flatten the axial power profile within ± 5% over a 31 cm section in the central core region.

All of 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.

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 area.

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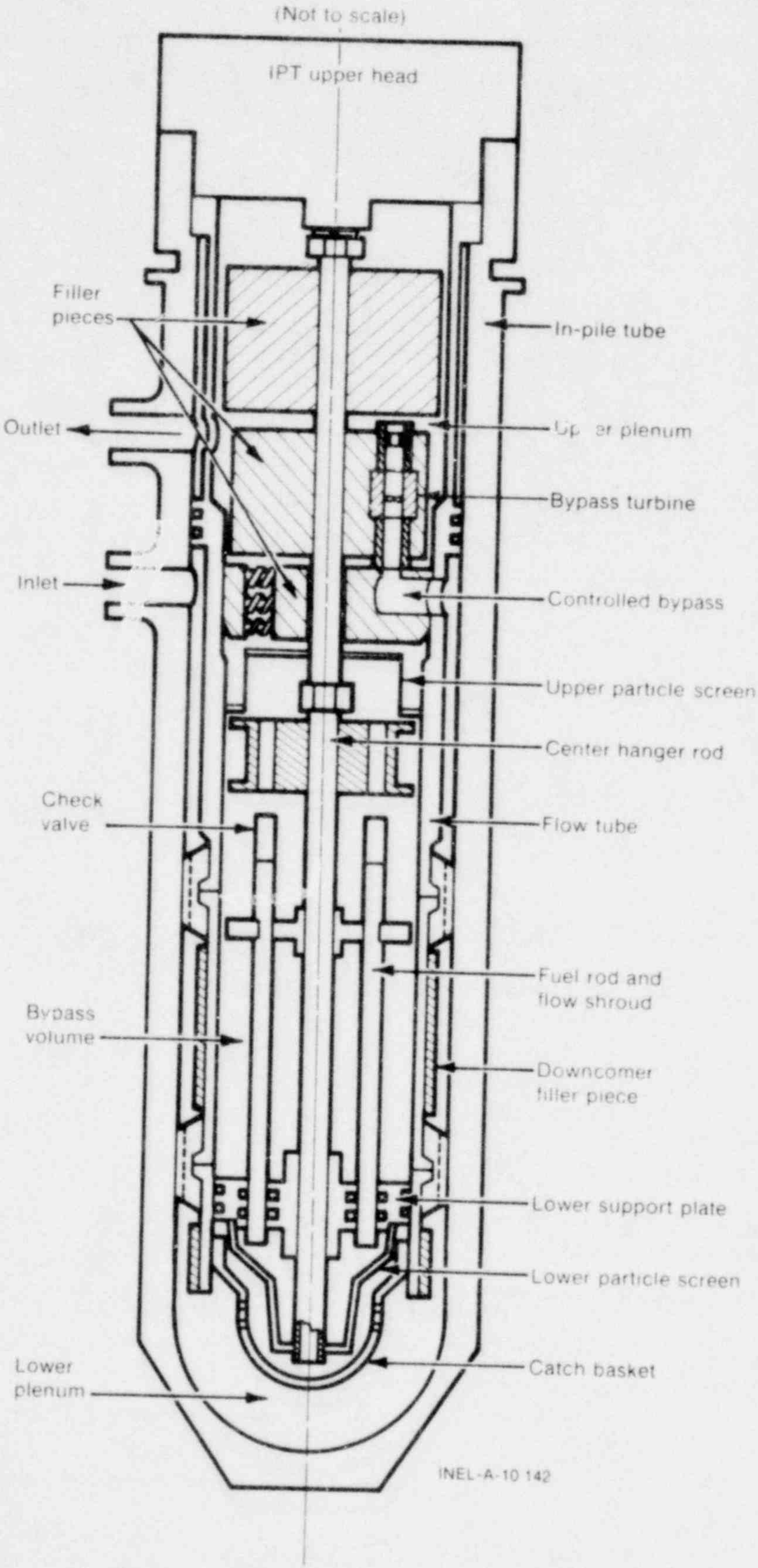

Fig. 2 Test LOC-5 test train illustration

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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 includes the capability of being 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 LOC-5 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- and cold-leg blowdown lines. Four Henry nozzles, 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 LOC-5 are tabulated in Table IV. Both cold-leg blowdown valves will be opened in Test LOC-5, after the IPT is isolated from the primary coolant loop, and the system will depressurize through the Henry nozzles and into the blowdown tank.

A small line connects the hot and cold blowdown piping legs with a controllable valve. This line provides a small flow rate to keep the hot-and cold-legs at the system temperature and pressure prior to 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. It will also confine any fission products carried from the fuel rods by the coolant.

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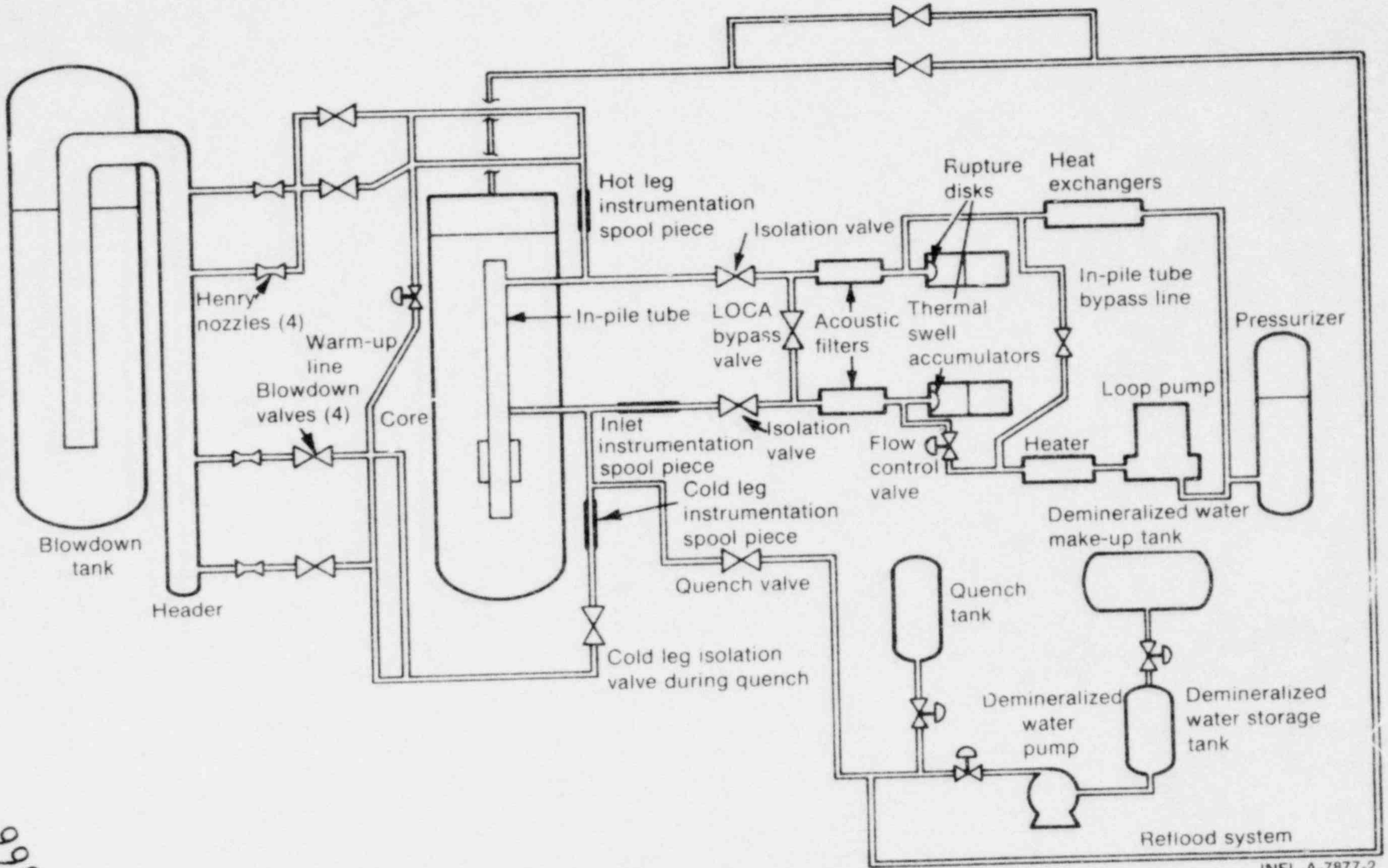

Fig. 3 PBF-LOCA blowdown system illustration

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TABLE IV

TEST LOC-5 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-11-1-3	Cold leg	14.22
FE-11-1-4	Cold leg	13.56

Posttest quench cooling is accomplished by opening the quench valve (and closing the cold leg blowdown valves) 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 blowdown measurement spool in each blowdown leg. This instrumentation is described in the 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 LOC-5 instrumentation is provided in this section. The instrumentation of the Test LOC-5 fuel train is designed to measure the fuel rod surface and centerline temperature, plenum pressure and temperature, axial length change, 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 4.

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

(1) One Kaman strain gauge-type pressure transducer, fitted with a slip-fitting sleeve to protect the device from thermal transients is used to measure each fuel rod plenum pressure. The sleeve consists of a stainless steel annular jacket containing a silver cylinder on the inner surface and separated from the outer surface by a helium filled gap.

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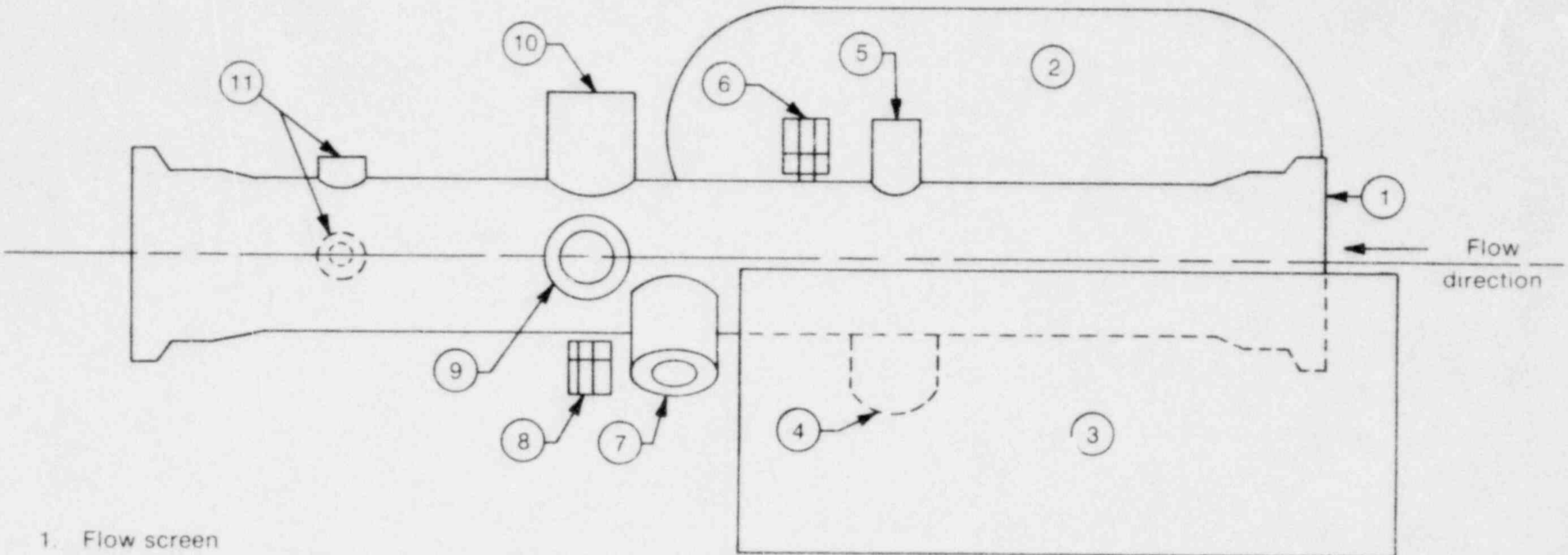

1. Flow screen
2. Source cask of gamma densitometer
3. Detector cask of gamma densitometer
4. Pressure - water cooled standoff (saturated blowdown)
5. Resistance temperature detector (initial temperature)
6. Thermocouple (blowdown temperature)
7. Pressure difference (inter spool)
8. Pressure difference (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 blowdown measurement spool illustration

(2) Four cladding surface thermocouples spot welded to the cladding. The orientation of the junctions above the bottom of the fuel stack are shown in Figure 1. Table V lists additional data on the thermocouples.

(3) One tungsten-rhenium centerline thermocouple located 570 mm above the bottom of the fuel stack in a 1.88-mm-diameter hole of previously unirradiated Rods 934 and 935.

(4) One plenum temperature thermocouple located in the midregion of the plenum of each rod.

(5) 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.

(6) Seven self-powered neutron detectors (SPND) used to correlate reactor power to calibrated fuel rod power and to determine the axial power profile with power level.

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

(8) Three self-powered gamma detectors (SPGD) located at the core midplane and $\pm$ 228.6 mm, and used 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.

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TABLE V

TEST LOC-5 THERMOCOUPLE DATA

Thermocouple	Type	Insulation	Material	Sheath OD (mm)	Wall Thickness (mm)	Junction type
Centerline	W5%Re/W26%Re	BeO Hard Fired	MoRe	1.575	0.254	Ungrounded
Cladding surface	K	MgO	Ti	1.17	0.229	Grounded, spade tip
Coolant channel differential	K	MgO	SST	1.575	0.254	Ungrounded
Plenum	K	MgO	SST	0.51	a	Grounded
Coolant	K	MgO	SST	1.575	0.254	Grounded
Coolant shroud	K	MgO	SST	1.02	0.203	Grounded
Shroud outer surface	K	MgO	SST/Ti	1.17	0.229	Grounded, spade tip

a. Wall is swaged at junction and thickness is not available.

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

(3) A pair of thermocouples for each fuel rod channel to measure the fuel rod flow inlet and outlet temperatures.

(4) Three flow shroud coolant thermocouples located on standoffs at the core midplane and ± 120 mm from the core midplane, on the flow shrouds of Rods 839 and 935 to measure the coolant temperature during the transient.

(5) Three thermocouples located at the core midplane and ± 120 mm from the core midplane, on the flow shroud of Rods 839 and 935 to measure the surface temperature.

(6) 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.

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

(8) 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.

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

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

(11) One Kaman pressure transducer (strain-guage-type) located 0.04 m above the rod shroud outlet to measure the preblowdown and saturated blowdown pressure.

(12) Two liquid level detectors inside the lower particle screen and one detector inside the lower end of each flow shroud.

(13) 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 inlet condition spool and during the transient in the hot- and cold-leg spools.

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(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 VI.

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TABLE VI

TEST LOC-5 PLANT INSTRUMENTATION

Description	Designation
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1101PT
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1102PT
Position of Cold Leg Blowdown Valve	VALVbPOSbbLM1103PT
Position of Cold Leg Blowdown Valve	VALVbPOSbbLM1104PT
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	QNCHbTMPbbTIC27bPT
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

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3. EXPERIMENT OPERATING PROCEDURE

Details of the experiment procedure of Test LOC-5 are discussed in the following sections. Each experiment operating phase and the instrument status requirements are considered individually below. The test consists of the following phases:

(1) Instrument status check

(2) Heatup

(3) Instrument drift checks

(4) Power calibration

(5) Preconditioning

(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 duration at a reactor power less than or equal to 26 MW. The specific operating sequence for the test is shown in Table VII and Figure 5.

A representative sample of the liquid in the blowdown tank and in the loop should be taken prior to test operation and immediately after the test for chemical analysis. The samples should be analyzed for nitrogen, oxygen, and hydrogen. Disposition of these samples will be determined at a later time.

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TABLE VII

OPERATING SEQUENCE FOR TEST LOC-5

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW or noted)	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	0.4,0.6,0.8,1.0 0.8,0.6,0.4	0.69	Flow balance check with warm line closed.
30	0	0	366	0.4,0.6,0.8,1.0 0.8,0.6,0.4	0.69	Flow balance check with warmup line open.
30	0	0	366	0.4	0.69	Measurement status check at 366 K inlet temperature.
360	0	0	366 to 590	0.4	15.51	Heatup, DARS status checks.
15	0	0	590	0.4	13.8 to 15.51	Rod pressure transducer check in steps of 0.34 MPa.
15	0	0	590	0.4,0.6,0.8,1.0	15.51	Test train flow turbine calibration with warmup line open.
15	0	0	590	1.0,0.8,0.6,0.4	15.51	Flow turbine calibration with warmup line closed.
5	0	0	590	0.4 to 1.0	15.51	Return to full flow with warmup line closed.
30	0	100 (kW)	590	1.0	15.51	Instrument status and drift check zero power offsets taken, transient rods inserted four inches.
7	0 to 13	100 kW to 6.5	590	1.0	15.51	Power calibration, ramp 1.
10	13	6.5	590	1.0	15.51	Calculation of rod powers
5	13 to 22	6.5 to 11	590	1.0	15.51	Power calibration, ramp 2.
10	22	11	590	1.0	15.51	Calculation of rod powers.
4	22 to 30	11 to 15	590	1.0	15.51	Power calibration, ramp 3.
10	30	15	590	1.0	15.51	Calculation of rod powers.
5	30 to 38	15 to 19	590	1.0	15.51	Power calibration, ramp 4.
10	38	19	590	1.0	15.51	Calculation of rod powers.
4	38 to 47	19 to 23.5	590	1.0	15.51	Power calibration, ramp 5.
10	47	23.5	590	1.0	15.51	Calculation of rod powers.
5	47 to 53.5	23.5 to 25.5	590	1.0	15.51	Power calibration, ramp 6.
30	53.5	25.5	590	1.0	15.51	Calculation of rod powers.

TABLE VII (continued)

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW-or noted)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
30	53.5 to 2.37	25.5 to 0.1	590	1.0	15.51	Ramp down power, 1st cycle of preconditioning finished.
10	0	0.1	590	1.0	15.51	Prepare for second ramp.
12	0 to 22	0.1 to 11	590	1.0	15.51	Power calibration, ramp 7, and 2nd cycle of preconditioning.
5	22	11	590	1.0	15.51	Calculation of rod powers.
9	22 to 38	11 to 19	590	1.0	15.51	Power calibration, ramp 8.
5	38	19	590	1.0	15.51	Calculation of rod powers.
9	38 to 53.5	19 to 25.5	590	1.0	15.51	Power calibration, ramp 9.
5	53.5	25.5	590	1.0	15.51	Calculation of rod powers.
10	53.5	25.5	590	1.0	15.51	Constant power.
30	53.5 to 0	25.5 to 0.1	590	1.0	15.51	Ramp power decrease, 2nd cycle of preconditioning.
10	0	0.1	590	1.0	15.51	Prepare for third ramp.
12	0 to 22	0.1 to 11	590	1.0	15.51	Power calibration, ramp 10, and 3rd cycle of preconditioning.
5	22	11	590	1.0	15.51	Calculation of rod powers.
9	22 to 38	11 to 19	590	1.0	15.51	Power calibration, ramp 11.
5	38	19	590	1.0	15.51	Calculation of rod powers.
9	38 to 53.5	19 to 25.5	590	1.0	15.51	Power calibration, ramp 12.
5	53.5	25.5	590	1.0	15.51	Calculation of rod powers.
10	53.5	25.5	590	1.0	15.51	Constant power.
10 s	53.5 to 40	25.5 to 20	590	1.0	15.51	
5	40	20	590	1.0	15.51	
10 s	40 to 30	20 to 15	590	1.0	15.51	
5	30	15	590	1.0	15.51	
10 s	30 to 20	15 to 10	590	1.0	15.51	
5	20	10	590	1.0	15.51	
10	20 to 0	10 to 0	590	1.0	15.51	
10	0	0	590	1.0	15.51	Prepare for 4th cycle (decay heat buildup). Remove cladding scrams.

TABLE VII (continued)

Time Duration (Min or noted)	Peak Rod Power (kW/m)	Anticipated Reactor Power (MW-or noted)	Inlet Temperature (K)	Flow Per Shroud (ℓ/s)	System Pressure (MPa)	Comments
30	0 to 53.5	25.5	590	1.0	15.51	Ramp power increase, 4th cycle.
90	53.5	25.5	590	1.0	15.51	Decay heat buildup, instrument status checks, initial conditions checked.
50 (s)	53.5 to 0	25.5 to 0	-	-	-	Transient sequence commences with reactor power controlled by transient rod servo controller.
240	0	0	370	1.0	0.1	Cooldown phase.

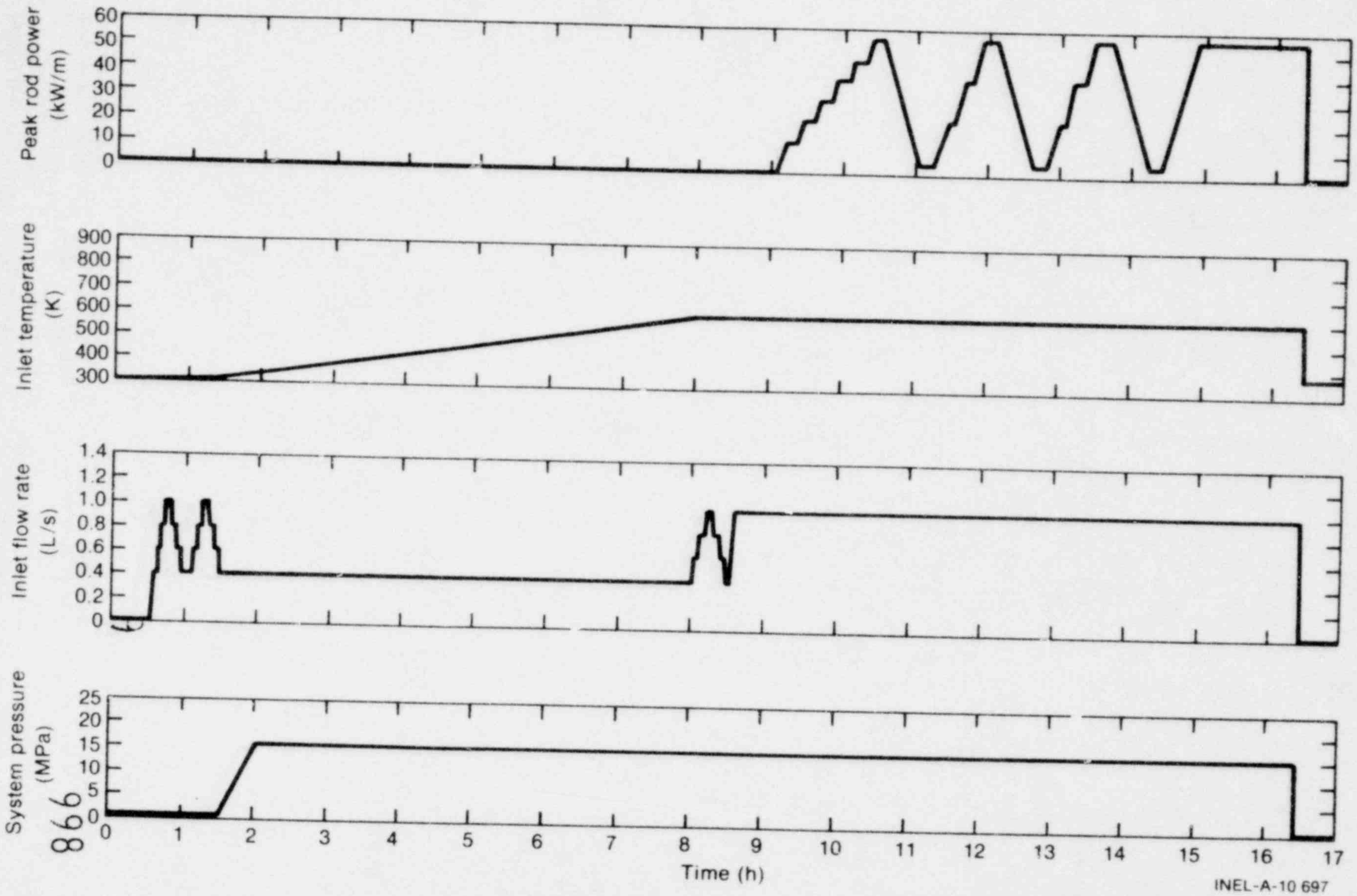

Fig. 5 Operating sequence for LOC-5

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Prior to the Test LOC-5 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 (a) prior to heatup at ambient conditions, (b) during heatup, (c) 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 in order to

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continue 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 off 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 hydrostat 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 equilibrium.

(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 channels must be 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

Immediately prior to loop heatup or during heatup at a loop temperature less than 370 K, a flow balance check will be performed. With the warmup line closed, the flow as indicated by a test train turbine should be increased from 0.4ℓ/s to as high as possible and not to exceed 1.0 ℓ/s and then reduced to 0.4ℓ/s. The warmup line should be opened and the sequence should be repeated. Readings should then be recorded as specified in the flow balance checklist, which should be incorporated in the experiment operating procedure. This checklist is given in Appendix A, Table A-IV. The information will be used to determine the bypass flow ratios for comparison with test train design specifications. In the event of unexpected bypass flow ratios, as determined by the LOCA Project Engineer, test procedure will be suspended pending resolution of discrepancies by the LOCA Project Engineer, TFBP Management and appropriate Directorate management. The flow indicated by the test train turbines should then be set to the flows stipulated in Table VII and the heatup continued.

When the loop coolant temperature has reached about 540 K the reactor may be brought to criticality, if deemed necessary, and then to about 2 MW until the coolant inlet temperature reaches the desired level of 590 K. Reactor shutdown is required before proceeding.

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.

After obtaining a coolant temperature of 590 K and pressure of 13.8 MPa, the system pressure will be increased in steps of 0.34 MPa. A DARS printout of measurement data and statistics to check and calibrate the system pressure transducers will be obtained at each step. System pressure will be re-established at 15.51 MPa for the remainder of the heatup following the pressure transducer checkout.

The loop and test train flow meters will be intercalibrated at a constant inlet temperature and pressure by increasing the te[illegible] flow rates from 0.4ℓ/s to 1.0ℓ/s with the warmup line open, and then decreasing the flow to 0.4ℓ/s with the warmup line closed. During this flow calibration, instruments will be checked for possible undesirable temperature and flow sensitivities.

3.3 Instrument Drift Recording and Status Check

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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 590 $\pm$1 K inlet temperature, 15.51 $\pm$0.14 MPa IPT pressure, and 1000 $\pm$15 cm^3/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. 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 of Table VII. 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 25.5 MW and maximum rod power of 53.5 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.

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(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 2.37 kW/m/MW. The preliminary results of Test LOC-3 determined the figure-of-merit to be 2.0. 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

The four fuel rods will be preconditioned by cycling the power to promote fuel pellet cracking and restructuring and to allow the initiation of pellet-cladding mechanical interaction to stablize. A ramp rate of 2 kW/m per minute will be used with constant peak power levels of 53.5 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 approximately 25.5 MW, or whatever is necessary (maximum of 26.5 MW) to provide a fuel rod peak power of 53.5 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.

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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 VIII. Immediately prior to blowdown, readings should be taken from the quench and blowdown tank transducers as specified in Appendix A Table A-V. After establishing the required initial conditions of the Table VII, and approximately 20 seconds before blowdown the warmup line will be shut by the reactor operator and the test rod flows reset to 1.0ℓ/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 VIII and Figure 6. The TR servo-controller will be in the steady state mode of operation during the entire test. During 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.

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 70 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 IX. 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

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TABLE VIII

PROGRAMMING AND MONITORING SYSTEM CONTROLLED EVENT SEQUENCE

Step	Estimated Time REDCOR Signal Is Initiated (s)[a]	Time Event Is Initiated (s)	Loop Bypass Valve[b]	Isolation Valve[c]	Hot Leg Blowdown Valves[d]	Cold Leg Blowdown Valves[e]	Quench Water Valve[f]	Warm-up Line Valve[g]	Cold Leg Shutoff Valve[h]	Comments
Initial	--	--	X[i]	0	X	X	X	0	0	Cladding scram set points turned off.
1	--	-20.0	X	0	X	X	X	X	0	Operator closes warmup line and verifies test rod coolant flow to 1.0 l/s per shroud. Action is verified by TFBP Project Engineer before initiation of the transient.
2	-2.0	-2.0	X	0	X	X	X	X	0	REDCOR initiates function generator routine.
3	-0.07	0.00	0	X	X	X	X	X	0	Isolate loop and open bypass valve.
4	-0.03	0.10	0	X	X	0	X	X	0	Open cold leg valves.
5	0.00	2.50	0	X	X	0	X	X	0	Maintain 100% of reactor power.
6	2.50	2.80	0	X	X	0	X	X	0	Linearly reduce reactor power to 25.50% in 0.3 s.

TABLE VIII (continued)

Step	Estimated Time REDCOR Signal Is Initiated (s)[a]	Time Event Is Initiated (s)	Loop Bypass Valve[b]	Isolation Valve[c]	Hot Leg Blowdown Valves[e]	Cold Leg Blowdown Valves	Quench Water Valve[f]	Warm-up Line Valve[g]	Cold Leg Shutoff Valve[h]	Comments
[illegible]	2.80	2.80	0	X	X	0	X	X	0	Linearly reduce reactor power to 12.75% in 2.2 s.
8	5.00	5.00	0	X	X	0	X	X	0	Linearly reduce reactor power to 7.95% in 5.0 s.
9	10.00	10.00	0	X	X	0	X	X	0	Linearly reduce reactor power to 6.80% in 2.0 s.
10	12.00	12.00	0	X	X	0	X	X	0	Linearly reduce reactor power to 6.37% in 8.0 s.
11	20.00	20.00	0	X	X	0	X	X	0	Maintain reactor power at 6.37%.
12	50.00	50.10	0	X	X	0	X	X	0	Scram reactor.
13	70.00	70.00	0	X	X	X	X	X	0	Reflood cycle.
14	240	240	0	X	0	X	0	X	X	Quench.

(a) Times are estimated for REDCOR signal. Final signal specification will be determined by the PBF Operations Branch.
(b) VALVbPOSbbLM1107PT
(c) VALVbPOSbbLM1105PT and VALVbPOSbbLM1106PT
(d) VALVbPOSbbLM1101PT and VALVbPOSbbLM1102PT
(e) VALVbPOSbbLMRC1PT and VALVBPOSbbLMRC2PT
(f) VALVbPOSbbLM1108PT
(g) VALVbPOSbbLM1116PT
(h) VALVbPOSbbLM1118PT
(i) X indicates closed, 0 indicates open.

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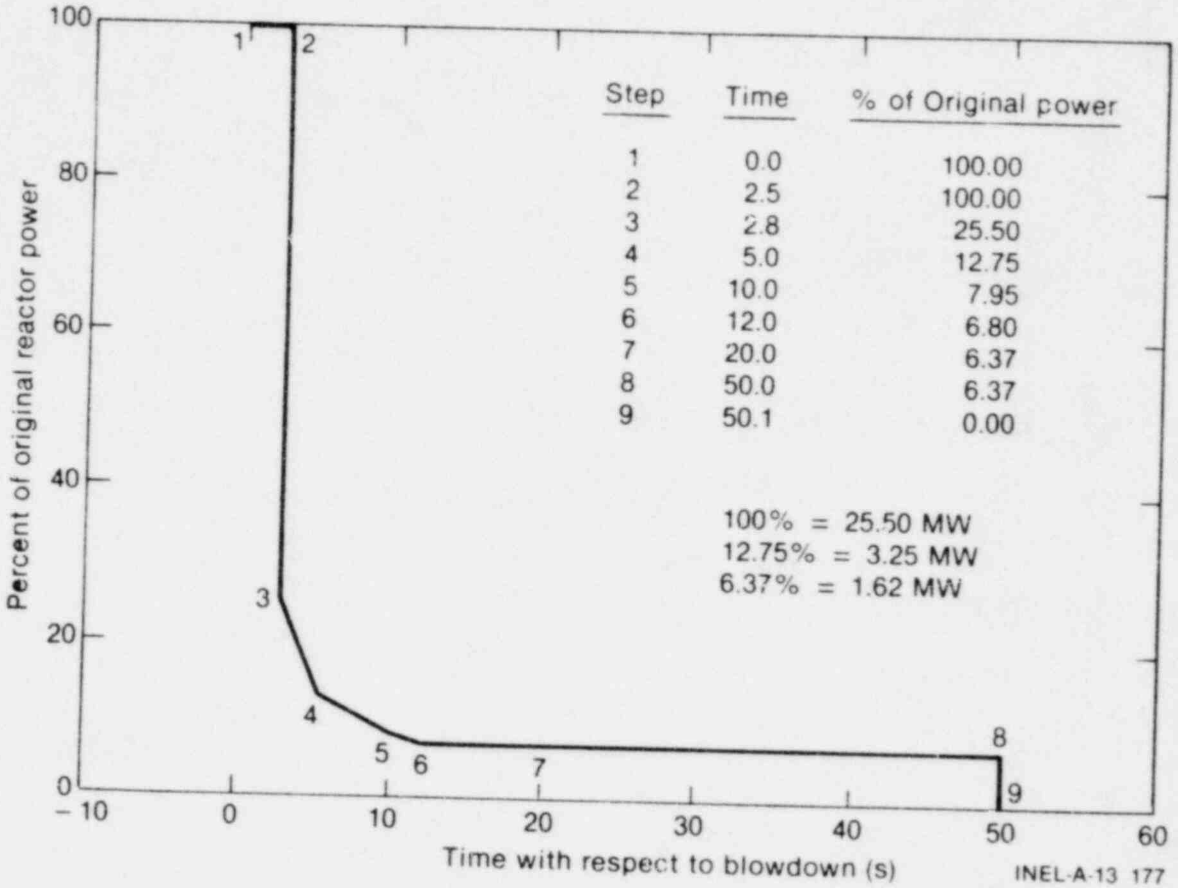

Fig. 6 Reactor power variation with time during the transient.

TABLE IX

REFLOOD RATES FOR TEST LOC-5

	Initiation Time (s)	Termination Time (s
Initial reflood high flow rate (1.58 ℓ/s)	70	75
Final reflood low flow rate (0.19 ℓ/s)	75	> 240

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 0.086 ℓ/s. The reflood coolant temperature will be approximately 311 K (100^{o}F) when entering the IPT through the upper head penetration.

3.8 Quench and Cooldown Phase

After 240 seconds, posttest quench cooling water heated to about 366 K will commence with the mass flow rate sized at 4ℓ/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 will be reduced to 0.4ℓ/s. The flow rate can be adjusted to keep the cladding surface temperature below 590 K. Longer term cooling may be provided if necessary by the existing flow loop after reconnection to the IPT.

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 LOC-5. The system will be installed for the power calibration, preconditioning, and decay heat buildup phases, and must be removed before the blowdown transient is initiated. The circuit should scram the reactor if cladding thermocouples CLAD934b1b19+0bb01 and CLAD808b2b19+0bb02 measures 700 K. A 2-second delay in scram should be included to account for signal noise.

In the event the TR servo-controller malfunctions at any time while in operation the controller must be programmed to fully insert the transient rods into the core.

In case of unexpected cladding temperatures in excess of 1700 K at any time during the transient, the quench system will be activated based on an average temperature computed automatically from thermocouple measurements on each test rod.

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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 X through XIII. Prior to each nuclear operation, it will be verified that through 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 X through XIII. 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.

Prior to heatup, the PBF/DARS should be checked as specified in the Integrated Data System Calibration Procedure (IDSCP), as supplied by the Data Systems Test Cognizant Project Engineer[b]. Following the IDSCP check, it should be verified that all recorders are recording data as specified in the Data Recording Verification Procedure[a]. After all discrepancies have been corrected and heatup initiated, the surveillance system recorders may be turned off unless otherwise requested by the ES&A representative. The DARS should

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a. Prior to nuclear operation and the blowdown, it should be verified that data are being recorded.

b. All recorders should be monitored when in recording mode in a manner determined by the Data System Branch.

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TABLE X

TEST LOC-5 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						
Fuel centerline temperature	W5%Re/W26%Re thermocouple	0.130 m	1	TFCL934b1b13bbTC01	300 to 2500 K	10
		0.130 m	3	TFCL935b3b13bbTC03		10
Cladding surface temperature	Type K thermocouple	0.186 m - 0°	1	CLAD934b1b19+0bb01	300 to 1500 K	10
		0.186 m - 180°	1	CLAD934b1b19+18001		
		0.236 m - 90°	1	CLAD934b1b24+90b01		
		0.236 m - 270°	1	CLAD934b1b24+27001		
		0.186 m - 0°	2	CLAD839b2b19+0bb02		
		0.186 m - 180°	2	CLAD839b2b19+18002		
		0.236 m - 90°	2	CLAD839b2b24+90b02		
		0.236 m - 270°	2	CLAD8392bb24+27002		
		0.186 m - 0°	3	CLAD935b3b19+0bb03		
		0.186 m - 180°	3	CLAD935b3b19+18003		
		0.236 m - 90°	3	CLAD935b3b24+90b03		
		0.236 m - 270°	3	CLAD935b3b24+27003		
		0.186 m - 0°	4	CLAD912b4b19+0bb04		
		0.186 m - 180°	4	CLAD912b4b19+18004		
		0.236 m - 90°	4	CLAD912b4b24+90b04		
		0.236 m - 270°	4	CLAD912b4b24+27004		
Plenum temperature	Type K thermocouple	Fuel rod plenum	1	PLNMbTMPbb934bbb01	300 to 1100 K	10
			2	PLNMbTMPbb839bbb02		
			3	PLNMbTMPbb935bbb03		
			4	PLNMbTMPbb912bbb04		
Plenum pressure	Kaman 17-MPa pressure transducer	Fuel rod plenum	1	RODbPRESbb934bbb01	0 to 18 MPa	10
			2	RODbPRESbb839bbb02		
			3	RODbPRESbb935bbb03		
			4	RODbPRESbb912bbb04		
Cladding axial strain	LVDT	Inlet end of rod	1	CLADbDSPbb934bbb01	-12 to 12 mm	100
			2	CLADbDSPbb839bbb02		
			3	CLADbDSPbb935bbb03		
			4	CLADbDSPbb912bbb04		
FLOW SHROUD						
Fuel rod power profile[d]	Flux wire 99.5% Al and 0.5% Co	One on the outside of each flow shroud (180°) and the hanger rod (236°)	1	FLUX934b1b180bbb01		
			2	FLUX839b2b180bbb02		
			3	FLUX935b3b180bbb03		
			4	FLUX912b4b180bbb04		
				FLUXHRODbb236bbbHR		

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 completed by the Instrument and Data section.

d. Not recorded.

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TABLE X (continued)

Measurement	Instrument Type	Location[a]	Rod Number	Instrument Identifier[b]	Recording Ranges	Minimum Frequency Recording Required (Hz)[c]
Flow Shroud						
Shroud coolant flow	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		
Outer shroud wall temperature	Type K thermocouple	-0.120 m - 225°	2	SHRDbTMPbb-120bb02	300 to 1200 K	10
		0 m - 225°	2	SHRDbTMPbbb000bb02		
		+0.120 m - 225°	2	SHRDbTMPbb+120bb02		
		-0.120 m - 225°	3	SHRDbTMPbb-120bb03		
		0 m - 225°	3	SHRDbTMPbbb000bb03		
		+0.120 m - 225°	3	SHRDbTMPbb+120bb03		
Bulk coolant temperature	Type K thermocouple	-0.120 m - 45°	2	BULKbTMPbb-120bb02	339 to 820 K	10
		0 m - 45°	2	BULKbTMPbbb000bb02		
		+0.120 m - 45°	2	BULKbTMPbb+120bb02		
		-0.120 m - 45°	3	BULKbTMPbb-120bb03		
		0 m - 45°	3	BULKbTMPbbb000bb03		
		+0.120 m - 45°	3	BULKbTMPbb+120bb03		
Inlet coolant temperature	Type K thermocouple	-0.439 m - 135°	1	INLTbTMPbb934bbb01	339 to 820 K	10
		-0.439 m - 135°	2	INLTbTMPbb839bbb02		
		-0.439 m - 135°	3	INLTbTMPbb935bbb03		
		-0.439 m - 135°	4	INLTbTMPbb912bbb04		
Outlet coolant temperature	Type K thermocouple	+0.439 m - 135°	1	OUTbTEMPbb934bbb01	339 to 820 K	10
		+0.439 m - 135°	2	OUTbTEMPbb839bbb02		
		+0.439 m - 135°	3	OUTbTEMPbb935bbb03		
		+0.439 m - 135°	4	OUTbTEMPbb912bbb04		
Coolant differential temperature	Type K thermocouple pair	+0.439 m - 45°	1	DELbTEMPbb45bbbb01	0 to 15 K	10
		$\mp$0.439 m - 225°	1	DELbTEMPbb225bbb01		
		$\mp$0.349 m - 45°	2	DELbTEMPbb45bbbb02		
		$\mp$0.439 m - 225°	2	DELbTEMPbb225bbb02		
		$\mp$0.439 m - 45°	3	DELbTEMPbb45bbbb03		
		$\mp$0.439 m - 225°	3	DELbTEMPbb225bbb03		
		$\mp$0.439 m - 45°	4	DELbTEMPbb45bbbb04		
		$\mp$0.439 m - 225°	4	DELbTEMPbb225bbb04		

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 completed by the Instrument and Data Section.

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TABLE XI

TEST LOC-5 TEST TRAIN INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location[a]	Instrument Identifier	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	PLATbTMPbbbbbbbLTT	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 ℓ/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.

TABLE XII

TEST LOC-5 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 -10 to 10 ℓ/s	100
Momentum flux	Drag disk	CLMOMFLXbbFE07SPHL ICMOMFLXbbFE10SPIC HLMOMFLXbbFE08SPCL	0 to 40000 $kg/m\text{-}s^2$ 0 to 2000 $kg/m\text{-}s_2$	100
Steady-state coolant temperature	RTD	ICSSTEMPbbTE20SPIC 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 CLPRESSFbbPE10SPCL HLPRESSFbbPE12SPHL	0 to 21 MPa	100
Saturated coolant pressure	Pressure transducer, water cooled	ICPRESSWbbPE09SPIC CLPRESSWbbPE11SPCL HLPRESSWbbPE13SPHL	0 to 21 MPa	100
Coolant pressure differential (hot to cold leg)	Pressure transducer	DELPCLHLbbDPE-05HL	0 to 1 MPa	100
Coolant density	Gamma densitimeter	CLDENSUPbbDENS1UCL CLDENSCEbbDENS1CCL CLDENSLObbDENS1LCL HLDENSUPbbDENS2UHL HLDENSCEbbDENS2CHL HLDENSLObbDENS2LHL	0 to 800 kg/m^3	100
Henry nozzle PXD	Pressure difference strain gage	HENRYPXDbbFE11-1PT HENRYPXDbbFE11-2PT HENRYPXDbbFE11-3PT HENRYPXDbbFE11-4PT	0 to 12 MPa	100
Sample pipe temperature[c]	Type K thermocouple	FPbTEMPbbbPIPE01FP FPbTEMPbbbPIPE02FP FPbTEMPbbbPIPE03FP FPbTEMPbbbPIPE04FP FPbTEMPbbbPIPE05FP FPbTEMPbbbPIPE06FP FPbTEMPbbbPIPE07FP FPbTEMPbbbPIPE08FP FPbTEMPbbbPIPE09FP	0 to 800 K	10
Densitometer temperature	Type K thermocouple	CLbDNTMPbbDENTC1CL CLbDNTMPbbDENTC2CL CLbDNTMPbbDENTC3CL HLbDNTMPbbDENTC1HL HLbDNTMPbbDENTC2HL HLbDNTMPbbDENTC3HL	280 to 650 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.

TABLE XIII

TEST LOC-5 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 pressure	Transducer	Outlet	OUTbPRESbbPT-30bPT	0 to 21 MPa	100
Outlet coolant flow	Transducer	Outlet	OUTbFLOWbbFT-29bPT	0 to 20 ℓ/s	10
Outlet coolant thermocouple	Thermocouple	Outlet	OUTbTEMPbbTT-29bPT	0 - 700 K	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 ℓ/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 rate	BF_3 neutron detector	FPDS	FPbNEUTbbbNEUTRNFP		
Core power (30 MW)	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 guage	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 0.25 ℓ/s	10
High flow reflood turbine	Turbine meter	Reflood system	REFLOODbHIGHbFLObb	0 to 2 ℓ/s	10

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continue to record data on the narrow band channels[a] through heatup and for as long as four to eight hours after test termination. The surveillance system need not record data during heatup and after test termination unless requested by the ES&A representative. The Experiment and Analysis Data System will not be utilized for Test LOC-5 purposes. The programming and monitoring system (PM&S) should record the IRIG time and identification of opening and closing the system valves listed in Table IX. No channels[b] should be disconnected or adjusted in any fashion until after the test has been terminated, unless, otherwise requested by the ES&A representative and approved by the Instrumentation and Data Section Supervisor. The DARS channel setup should then be verified by a controlled voltage insertion into the low levels or front end of the DARS using a procedure established in the standard practice for data acquisition[7] for the PBF system. After the DARS verification, no changes should be made in the electronics beyond and including the low levels and the front of the DARS, up through the on-line display or tape recorders, unless requested by the ES&A or a data system representative and approved by the Instrumentation and Data Section Supervisor. Data systems maintenance to be performed prior to and during the testing, and systems operating practices and procedures are detailed in Reference 8 for the PBF Data Acquisition System.

As an additional backup to the data being recorded on the DARS, the on-line trend and 20-minute files should be dumped to magnetic tape. The 8-hour trend data should be dumped every 8 hours starting

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a. Wide band tapes could be used if requested by the ES&A representative. During the power calibration phase, a new tape should be used.

b. Those channels recorded on the surveillance system necessary for plant operation may be changed if the TFBP representative is notified and an appropriate entry made in the TFBP experimenters console logbook.

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with heatup through blowdown and until test termination. The 20-minute files should be dumped after blowdown so that the 20-minutes will span blowdown.

Figure 7 indicates the data channels which will be required to be displayed on the strip charts during power calibration and fuel conditioning and the blowdown phase. Tables X through XIII present the ES&A designation and explanation of the instrumentation. 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.

4.2 Data Reduction Requriements

Upon termination of the test, the ES&A representative should be given copies of the checklists contained in Appendix A, Surveillance System strip charts and any 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 Appendix A, Table A-VI .

The data reduction requirements are: (a) a data set on disc (with a copy on tape), containing the reduced data channels in a MACRAN format[9], (b) a tape directory in EDF format which lists pertinent guidelines for using the tape (a MACRAN listing showing channel names and statistics is sufficient), and (c) a reduction and calibration directory in EDF format which defines how the data were reduced. The data should be in one file with the following digitizing intervals:

(1) Heatup phase up to the point where inlet temperature and flow are varied to determine instrument temperature and flow sensitivity (about four hours prior to nuclear operation) - 5 minutes

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See Tables X-XII for designation and detailed explanation of instrumentation	RODbPRESSbb934bbb01 Rod Pressure RODbPRESSbb808bbb02	FLOWRATEbbINLET03 Shroud Turbine Meter FLOWRATEbbINLET04
CLAD934b1b19+0bb01 Cladding Temperature CLAD934b1b19+18001	RODPRESSbb935bbb03 Rod Pressure RODPRESSbb912bbb04	ICSSTEMPbbTE20SPIC Spool Temperature CLTCTEMPbbTE23SPCL
CLAD935b3b19+0bb03 Cladding Temperature CLAD935b3b19+18003	DELTbTEMPbb45bbbb01 Differential Temperature DELTbTEMPbb45bbbb02	INLTbTMPbb934bbb01 Coolant Inlet Temperature Reactor Power REACbPOWbbNMS-03PT
CLADbDSPbb839bbb02 Cladding Axial Strain CLADbDSPbb912bbb04	DELTbTEMPbb45bbbb03 Differential Temperature DELTbTEMPbb45bbbb04	CLSVFLOWbbFE06SPCL Spool Turbine Meter ICSVFLOWbbFE05SPIC
TFCL934b1b13bbTC01 Centerline Temperature TFCL935b3b13bbTC03	FLOWRATEbbINLETb01 Shroud Turbine Meter FLOWRATEbbINLETb02	ICPRESSFbbPE08SPIC Spool Pressure CLPRESSWbbPE11SPCL

Fig. 7 Strip chart setup for Test LOC-5

(2) Remainder of heatup, preconditioning and decay heat buildup phases - 30 seconds

(3) Blowdown and quench phase - 0.02 seconds (test train and spool pressure transducers will be digitized at 0.001-second intervals for 0.05 seconds and stored on a second file)

(4) Cooldown - 10 seconds.

If possible, representative channels will be analyzed on the PBF/DARS for frequency content. The digitizing intervals will then be modified to accommodate the required frequencies. If necessary, a third file will be used to store selected channels at shorter digitizing intervals.

Data reduction and plotting requirements are separated into three segments in the following subsections. The first segment concerns data reduction and plot requirements needed for the preparation of the Test LOC-5 Quick Look Report. The second concerns data reduction for the Experimental Data Report; and the third, the Test Results (Topical) Report. Additional plotting requirements will be stipulated for the test analysis, based on test performance and posttest code analyses.

4.2.1 Quick Look Report

Test data plots and data pretest calculation comparison plots for the Quick Look 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. The Quick Look Report will only contain plots of data from the blowdown portion of the test.

The plots generated will go directly into the Quick Look Report without redrawing or handling by graphics personnel. The size of the plots should conform to 8-1/2 x 11-inch paper with conventional margins and two plots per page. All plotted data are to be in standard SI units.

A complete list of the plots that are required for the Quick Look Report will be provided by the TFBP LOC Project Engineer within two weeks of the test.

4.2.2 Experiment Data Report

Data plots presented in the Test LOC-5 Experiment Data Report will be used by ES&A personnel in analyzing test performance. All test train and test rod measurement transducer outputs should be plotted as functions of time during the power calibration, preconditioning, blowdown and reflood periods of the test. Due to the possibility of failure of some of the fuel temperature measurement transducers, the specific transducer outputs and test rod power levels to be plotted during the power oscillation portion of the test will be specified following the test.

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 as the need arises.

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5. GENERAL POSTIRRADIATION EXAMINATION REQUIREMENTS

If the fuel rod internal thermocouple leads do not have a fission gas seal in place, special precautions must be taken to seal the leads manually prior to cutting the instrument leads. Special care should be taken when disassembling the test train to clearly identify the axial position and orientation of each of the circumferential flux wires on the shrouds.

The usual postirradiation examination tasks (PIE) for fuel rods from previous PBF tests should apply for Test LOC-5 purposes. This involves:

(1) Test train removal, transport, and storage. This task includes:

- (a) transfer of the test assembly from the PBF canal to the MTR canal for storage prior to beginning the PIE,
- (b) transfer of the test assembly from the MTR canal to the ARA-I hot cell for the nondestructive PIE,
- (c) transfer of the test assembly from the ARA-I hot cell to the TRA hot cells for PIE completion,
- (d) transfer of the test rods, metallography samples, and remains from the TRA hot cells to the MTR canal for a six-month "holding period" storage,

(2) Detailed postirradiation examination. This task includes:

- (a) disassembly of each of the test rods from its flow shroud,
- (b) flux wire removal and counting,

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(c) visual examination of rods,

(d) neutron radiography,

(e) void volume and internal gas pressure and composition evaluations,

(f) gamma scanning,

(g) sectioning,

(h) metallography,

(i) burnup analyses,

(j) sp:cial examinations, such as scanning electron microscopy and electron microprobe analysis.

Additional information regarding PIE capabilities and requirements will be provided in a revision to this document.

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6. 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. T. R. Yackle, Loss-of-Coolant Accident Test Series, Test LOC-3 Experiment Operating Specification, TFBP-TR-306, December 1978.

4. T. R. Yackle, PBF-LOCA Tests Program Experiment Specification Document, TFBP-TR-279 (July 1978).

5. B. R. Helm, PBF LOC-3 Experiment Configuration Specification, ES-50425, (Nov. 1978).

6. J. R. Larson, PBF-LOCA Test Series Test LOC-11 Experiment Operating Specification, TFBP-TR-209, (Oct. 1977).

7. C. M. Allison, PBF Integrated Data System Test Standard Practice, (to be published).

8. E. E. Felix, Recommendations for Data Systems Maintenance and Operation, EEF-19-78, (July 1978).

9. R. W. Otnes, Reference Manual: MAC/RAN III-Time Series Data Analysis System, Agababian Associates, 1973.

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APPENDIX A

STATUS CHECK LISTS FOR INSTRUMENTATION

TABLE-AI (Prior to Heatup)

MEASUREMENT STATUS CHECK DURING HEATUP AT AMBIENT CONDITIONS

REACTOR POWER	0.0	KW
COOLANT TEMPERATURE	Ambient	K
COOLANT PRESSURE	Ambient	MPa
SHROUD FLOW RATE	0	1/s

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
RODbPRESbb934bbb01	________	MPa	2.4 ± 0.1 MPa	________
RODbPRESbb839bbb02	________	MPa	2.4 ± 0.1 MPa	________
RODbPRESbb935bbb03	________	MPa	4.8 ± 0.1 MPa	________
RODbPRE bb912bbb04	________	MPa	4.8 ± 0.1 MPa	________

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-AII (Power Calibration)

MEASUREMENT STATUS CHECK DURING POWER CALIBRATION

REACTOR POWER	0	KW
COOLANT TEMPERATURE	590	K (Average of test train inlet TC's)
COOLANT PRESSURE	15.51	MPa (Heise)
SHROUD FLOW RATE	1.0	1/s (Average of test train inlet flowmeters)

PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
CLAD934b1b19+0bb01	______ K	Temperature ± 4 K	______
CLAD934b1b19+18001	______ K	Temperature ± 4 K	______
CLAD934b1b24+90b01	______ K	Temperature ± 4 K	______
CLAD934b1b24+27001	______ K	Temperature ± 4 K	______
CLAD839b2b19+0bb02	______ K	Temperature ± 4 K	______
CLAD839b2b19+18002	______ K	Temperature ± 4 K	______
CLAD839b2b24+90b02	______ K	Temperature ± 4 K	______
CLAD839b2b24+27002	______ K	Temperature ± 4 K	______
CLAD935b3b19+0bb03	______ K	Temperature ± 4 K	______
CLAD935b3b19+18003	______ K	Temperature ± 4 K	______
CLAD935b3b24+90b03	______ K	Temperature ± 4 K	______
CLAD935b3b24+27003	______ K	Temperature ± 4 K	______
CLAD912b4b19+0bb04	______ K	Temperature ± 4 K	______
CLAD912b4b19+18004	______ K	Temperature ± 4 K	______
CLAD912b4b24+90b04	______ K	Temperature ± 4 K	______
CLAD912b4b24+27004	______ K	Temperature ± 4 K	______
TFCL934b1b13bbTC01	______ K	Temperature ± 4 K	______
TFCL935b3b13bbTC03	______ K	Temperature ± 4 K	______
CLADbDSPbb934bbb01	______ mm	1.0 ± 0.5 mm	______
CLADbDSPbb839bbb02	______ mm	1.0 ± 0.5 mm	______
CLADbDSPbb935bbb03	______ mm	1.0 ± 0.5 mm	______
CLADbDSPbb912bbb04	______ mm	1.0 ± 0.5 mm	______
RODbPRESbb934bbb01	______ MPa	5.0 ± 0.1 MPa	______
RODbPRESbb839bbb02	______ MPa	5.0 ± 0.1 MPa	______

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PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
RODbPRESbb935bbb03	________	MPa	10.0 ± 0.7 MPa	________
RODbPRESbb912bbb04	________	MPa	10.0 ± 0.7 MPa	________
PLNMbTMPbb934bbb01	________	K	Temperature ± 4 K	________
PLNMbTMPbb839bbb02	________	K	Temperature ± 4 K	________
PLNMbTMPbb935bbb03	________	K	Temperature ± 4 K	________
PLNMbTMPbb912bbb04	________	K	Temperature ± 4 K	________
INLTbTMPbb934bbb01	________	K	Temperature ± 4 K	________
INLTbTMPbb839bbb02	________	K	Temperature ± 4 K	________
INLTbTMPbb935bbb03	________	K	Temperature ± 4 K	________
INLTbTMPbb912bbb04	________	K	Temperature ± 4 K	________
OUTbTEMPbb934bbb01	________	K	Temperature ± 4 K	________
OUTbTEMPbb839bbb02	________	K	Temperature ± 4 K	________
OUTbTEMPbb935bbb03	________	K	Temperature ± 4 K	________
OUTbTEMPbb912bbb04	________	K	Temperature ± 4 K	________
DELbTEMPbb45bbbb01	________	K	± 0.05 K	________
DELbTEMPbb225bbb01	________	K	± 0.05 K	________
DELbTEMPbb45bbbb02	________	K	± 0.05 K	________
DELbTEMPbb225bbb02	________	K	± 0.05 K	________
DELbTEMPbb45bbbb03	________	K	± 0.05 K	________
DELbTEMPbb225bbb03	________	K	± 0.05 K	________
DELbTEMPbb45bbbb04	________	K	± 0.05 K	________
DELbTEMPbb225bbb04	________	K	± 0.05 K	________
BULKbTMPbb-120bb02[b]	________	K	Temperature ± 4 K	________
BULKbTMPbbb000bb02	________	K	Temperature ± 4 K	________
BULKbTMPbb+120bb02	________	K	Temperature ± 4 K	________
BULKbTMPbb-120bb03	________	K	Temperature ± 4 K	________
BULKbTMPbbb000bb03	________	K	Temperature ± 4 K	________
BULKbTMPbb+120bb03	________	K	Temperature ± 4 K	________
SHRDbTMPbb-120bb02[b]	________	K	Temperature ± 4 K	________
SHRDbTMPbbb000bb02	________	K	Temperature ± 4 K	________
SHRDbTMPbb+120bb02	________	K	Temperature ± 4 K	________

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PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	CERTIFICATION[a] THAT INSTRUMENT IS WITHIN RANGE
SHRDbTMPbb-120bb03	________ K	Temperature $\pm$ 4 K	________
SHRDbTMPbbb000bb03	________ K	Temperature $\pm$ 4 K	________
SHRDbTMPbb+120bb03	________ K	Temperature $\pm$ 4 K	________
FLOWRATEbbINLETb01	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbINLETb02	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbINLETb03	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbINLETb04	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbOUTLET01	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbOUTLET02	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbOUTLET03	________ l/s	Flow $\pm$ 0.001 l/s	________
FLOWRATEbbOUTLET04	________ l/s	Flow $\pm$ 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 $\pm$ 4 K	________
BYPbTEMPbbNO.2bbTT	________ K	Temperature $\pm$ 4 K	________
BYPbTEMPbbNO.3bUTT	________ K	Temperature $\pm$ 4 K	________
BYPbTEMPbbNO.4bUTT	________ K	Temperature $\pm$ 4 K	________
BYPbTEMPbbNO.5bUTT	________ K	Temperature $\pm$ 4 K	________
PLATbTMPbbbbbbbLTT	________ K	Temperature $\pm$ 4 K	________
SYSbPRESbb69EGbLTT	________ MPa	Heise $\pm$ 3.5 MPa	________
SYSbPRESbb17EGbLTT	________ MPa	Heise $\pm$ 0.7 MPa	________
SYSbPRESbb17EGbUTT	________ MPa	Heise $\pm$ 0.7 MPa	________
SYSbPRESbb17KAbUTT	________ MPa	Heise $\pm$ 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

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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	emperature ± 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

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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-1[illegible]bPT	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 Representative 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.

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TABLE-AIII

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 A9Y

FLOW BALANCE CHECK

Reactor Power - 0 MW
Coolant Temperature - ambient
Coolant Pressure - ambient
Shroud Flowrate - 0.4 - 1.0 l/s

DESIRED SHROUD FLOW	WARMUP LINE	LOWER TEST TRAIN FLOW (1)	AVERAGE LOWER TEST TRAIN FLOW (2)	UPPER TEST TRAIN FLOW (3)	AVERAGE UPPER TEST TRAIN FLOW (4)	AVERAGE TEST TRAIN FLOW (5)	IC SPOOL FLOW (6)	COLD LEG FLOW (7)	HOT LEG FLOW (8)	IPT CONTROLLED BY-PASS FLOW (15)	LOOP FLOW (9)	PCS LOOP BYPASS FLOW RATIO (10)	IPT VOLUME BYPASS FLOW RATIO (11)
0.4	Closed	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	$\frac{(2) + (4)}{2}$(*) = ___ l/s	___ l/s	___ l/s	___ l/s	___ l/s	___ l/s	$\frac{(9) - (6)}{(9)}$ = ___	$\frac{(6) - 4(5) - (15)}{4(5)}$ = ___
0.6	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.8	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
1.0	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.8	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.6	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.4	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
Example		Turbine-1 0.5 l/s -2 0.45 -3 0.50 -4 0.55	0.50	Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50 l/s	$\frac{0.50 + 0.50}{2}$ = 0.50 l/s	8.0 l/s	0.0 l/s	0.0 l/s	6.0 l/s	$\frac{10.0 - 8.0}{10.0}$ l/s	10.0 = 0.20	$\frac{8.0 - 4\ 1.15 - 3.0}{4\ 1.15}$ = 0.086

AVERAGE LOOP BYPASS RATIO ___ (10)

AVERAGE IPT BYPASS RATIO = ___ (11)

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TABLE AIV (Continued)

FLOW BALANCE CHECK

DESIRED SHROUD FLOW	WARMUP LINE	LOWER TEST TRAIN FLOW (1)	AVERAGE LOWER TEST TRAIN FLOW (2)	UPPER TEST TRAIN FLOW (3)	AVERAGE UPPER TEST TRAIN FLOW (4)	AVERAGE TEST TRAIN FLOW (5)	IC SPOOL FLOW (6)	COLD LEG FLOW (7)	HOT LEG FLOW (8)	IPT CONTROLLED BYPASS FLOW (15)	LOOP FLOW (9)	PCS LOOP[b] BYPASS FLOW RATIO (10)	WARMUP LINE FLOW (14)[c]
0.4	Open	Turbine[d]-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	$\frac{(2) + (4)}{2}$[a] = ___ l/s	___ l/s	___ l/s	___ l/s	___	___ l/s	$\frac{(9) - (6)}{(9)}$ = ___	(6) - (15) - 4 (5) (1 + (13)) = ___ l/s
0.6	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.8	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
1.0	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.8	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.6	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.4	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
Example		Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50	Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50 l/s	$\frac{0.50 + 0.50}{2}$ = 0.50 l/s	9.2 l/s	1.0 l/s	-1.0 l/s	6.0 l/s	12.0 l/s	$\frac{12.0 - 9.2}{12.0}$ = 0.23	9.2 - 6 - 4 0.5 (1.086) = 1.03 l/s

(a) This symbolism denotes take the results from column (2) and column (4) adding and dividing by 2 to get the average.
(b) Downstream of primary coolant pump LOOPbFLOFRC-IOPT.
(c) Downstream of primary coolant pump LOOPbFLOFRC-IOPT.
(d) Turbine-1 = ________ Turbine-2 = ________
Turbine-3 = ________ Turbine-4 = ________

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TABLE AIV (Cont'd)

FLOW BALANCE CHECK

Reactor Power - 0 MW
Coolant Temperature - 590 K
Coolant Pressure - 15.5 MPa
Shroud Flowrate - 0.4 - 1.0 l/s

DESIRED SHROUD FLOW	WARMUP LINE	LOWER TEST TRAIN FLOW (1)	AVERAGE LOWER TEST TRAIN FLOW (2)	UPPER TEST TRAIN FLOW (3)	AVERAGE UPPER TEST TRAIN FLOW (4)	AVERAGE TEST TRAIN FLOW (5)	IC SPOOL FLOW (6)	COLD LEG FLOW (7)	HOT LEG FLOW (8)	IPT CONTROLLED BY-PASS FLOW (15)	LOOP FLOW (9)	PCS LOOP BYPASS FLOW RATIO (10)	IPT VOLUME BYPASS FLOW RATIO (11)
0.4	Closed	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	$\frac{(2) + (4)}{2}$[a] = ___ l/s	___ l/s	___ l/s	___ l/s	___ l/s	___ l/s	$\frac{(9) - (6)}{(9)}$ = ___	$\frac{(6) - 4 (5) - (15)}{4 (5)}$ = ___
0.6	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.8	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
1.0	Closed	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
Example		Turbine-1 0.5 l/s -2 0.45 -3 0.50 -4 0.55	0.50	Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50 l/s	$\frac{0.50 + 0.50}{2}$ = 0.50 l/s	8.0 l/s	0.0 l/s	0.0 l/s	6.0 l/s	10.0 l/s	$\frac{10.0 - 8.0}{10.0}$ = 0.20	$\frac{8.0 - 4\ 1.15 - 3.0}{4\ 1.15}$ = 0.086

AVERAGE LOOP BYPASS RATIO (12) = ___ AVERAGE IPT BYPASS RATIO (13)

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TABLE A-V (Continued)

FLOW BALANCE CHECK

DESIRED SHROUD FLOW	WARMUP LINE	LOWER TEST TRAIN FLOW (1)	AVERAGE LOWER TEST TRAIN FLOW (2)	UPPER TEST TRAIN FLOW (3)	AVERAGE UPPER TEST TRAIN FLOW (4)	AVERAGE TEST TRAIN FLOW (5)	IC SPOOL FLOW (6)	COLD LEG FLOW (7)	HOT LEG FLOW (8)	IPT CONTROLLED BY-PASS FLOW (15)	LOOP FLOW (9)	PCS LOOP[b] BYPASS FLOW RATIO (10)	WARMUP LINE FLOW (14)[c]
1.0	Open	Turbine[d]-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	Turbine-1 ___ l/s -2 ___ -3 ___ -4 ___	___ l/s	$\frac{(2) + (4)}{2}$[a] = ___ l/s	___ l/s	___ l/s	___ l/s	___	___ l/s	$\frac{(9) - (6)}{(9)}$ = ___	(6) - (15) - 4 (5) (1 + (13)) = ___ l/s
0.8	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.6	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
0.4	Open	-1 ___ -2 ___ -3 ___ -4 ___	___	-1 ___ -2 ___ -3 ___ -4 ___	___	___	___	___	___	___	___	___	___
Example		Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50	Turbine-1 0.50 l/s -2 0.45 -3 0.50 -4 0.55	0.50 l/s	$\frac{0.50 + 0.50}{2}$ = 0.50 l/s	9.2 l/s	1.0 l/s	-1.0 l/s	6.0 l/s	12.0 l/s	$\frac{12.0 - 9.2}{12.0}$ = 0.23	9.2 - 6 - 4 0.5 (1.086) = 1.03 l/s

(a) This symbolism denotes take the results from column (2) and colum (4) adding and dividing by 2 to get the average.
(b) Downstream of primary coolant pump LOOPhFLOPC-10PT.
(c) Downstream of primary coolant pump LOOPhFLOPC-10PT.
(d) Turbine-1 = ____________ Turbine-2 = ____________
Turbine-3 = ____________ Turbine-4 = ____________

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TABLE A-V

QUENCH AND BLOWDOWN TANK READING IMMEDIATELY PRIOR TO BLOWDOWN

Measurement	Designation	Reading (Eng.)		Reading (SI)
Quench Tank Coolant Level	QNCHbLEVbbLT-10bPT	____ %		____ %
Quench Tank Coolant Temperature	QNCHbTMPbbTIC27bPT	____ F/1.8 + 255.37		____ K
Blowdown Tank Pressure	BLOWbPRSbbPT-12bPT	____ PSIA	145.05	____ MPa
Blowdown Tank Liquid Level	BLOWbbLEVbLIT17bPT	____ %		____ %

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TABLE A-VI

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 (80 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	______

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