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Author(s):

T. R. Yackle, M.E. Waterman

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M. L. Picklesimer

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

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INTERIM REPORT

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LOSS-OF-COOLANT ACCIDENT TEST SERIES
TEST LOC-6
EXPERIMENT OPERATING SPECIFICATION

T. R. YACKLE
M. E. Waterman

Thermal Fuels Behavior Program
EG&G Idaho, Inc.

Approved: R.K. McCardell
R. K. McCardell, Manager
PBF Experiment Specification and Analysis Branch

P. E. MacDonald
P. E. MacDonald, Manager
LWR Fuel Research Division

J. P. Kester, Manager
TFPB Technical Support Division

A M Jensen for 7/18/80
C. O. Doucette, Manager
PBF Facility Division

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1. INTRODUCTION

The objective of the Power Burst Facility (PBF) Loss of Coolant Accident (LOCA) Test LOC-6 is to determine the magnitude and axial extent of cladding ballooning at high α-phase temperatures during a large break LOCA. The cladding ballooning data of the test will be used to assess the out-of-pile multi-rod data currently used for licensing LWR's. In particular, program results will be used to evaluate the influence of irradiation on cladding deformation.

The LOCA tests simulate accident conditions in a pressurized water reactor (PWR) core resulting from 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 and consequently, the fuel rod cladding will increase temperature and may balloon and rupture.

The experiment operating procedure for Test LOC-6 is specified in this document. The test will be performed using four separately shrouded fuel rods of PWR 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 of Test LOC-6 will result in peak cladding temperatures stabilizing in the high α-phase. Cladding ballooning with moderate 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 six separate phases; isothermal blowdown(s), loop heatup, preconditioning operation, blowdown, reflood, and quench. After the isothermal blowdowns, 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.

The fuel train, test assembly, LOCA modifications, and instrumentation associated with each component are described in Section 2, the procedures of the experiment conduct for Test LOC-6 are provided in Section 3, and the data aquisition, reduction and qualification requirements are listed in Section 4. Status check lists of instrumentation, and flow balance sheets are provided in Appendix A.

2. EXPERIMENT DESIGN

Test LOC-6 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-6 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 and improved check valve and flow shroud designs. The design of fuel rods, test train, LOCA modification system, and the instrumentation associated with each component are presented in this section. 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 in the Saxton[6] reactor and two unirradiated rods of Saxton design. The two irradiated rods (841 and 911) are designated 606-10 and 606-12, and the two unirradiated rods (936 and 937) are designated 606-9 and 606-11. The as-fabricated nominal design characteristics of these fuel rods are given in Table 1. Rods 606-9 and 606-10 are prepressurized to 2.41 MPa, typical of PWR rod beginning-of-life pressures, and Rods 606-11 and 606-12 are prepressurized to 4.83 MPa, typical of PWR rod end-of-life pressures. The unirradiated rods are contained in stainless steel flow shrouds, whereas the irradiated rods are contained in zircaloy flow shrouds. This was done to reduce the power in the unirradiated rods to that of the irradiated rods. The flow shrouds are similar to the fluted shrouds used in Test LOC-11.[7] The characteristics of the individual flow shrouds are shown in Table 2. A plane view of the fuel rod orientation and instrumentation within the in-pile tube (IPT) is shown in Figure 1.

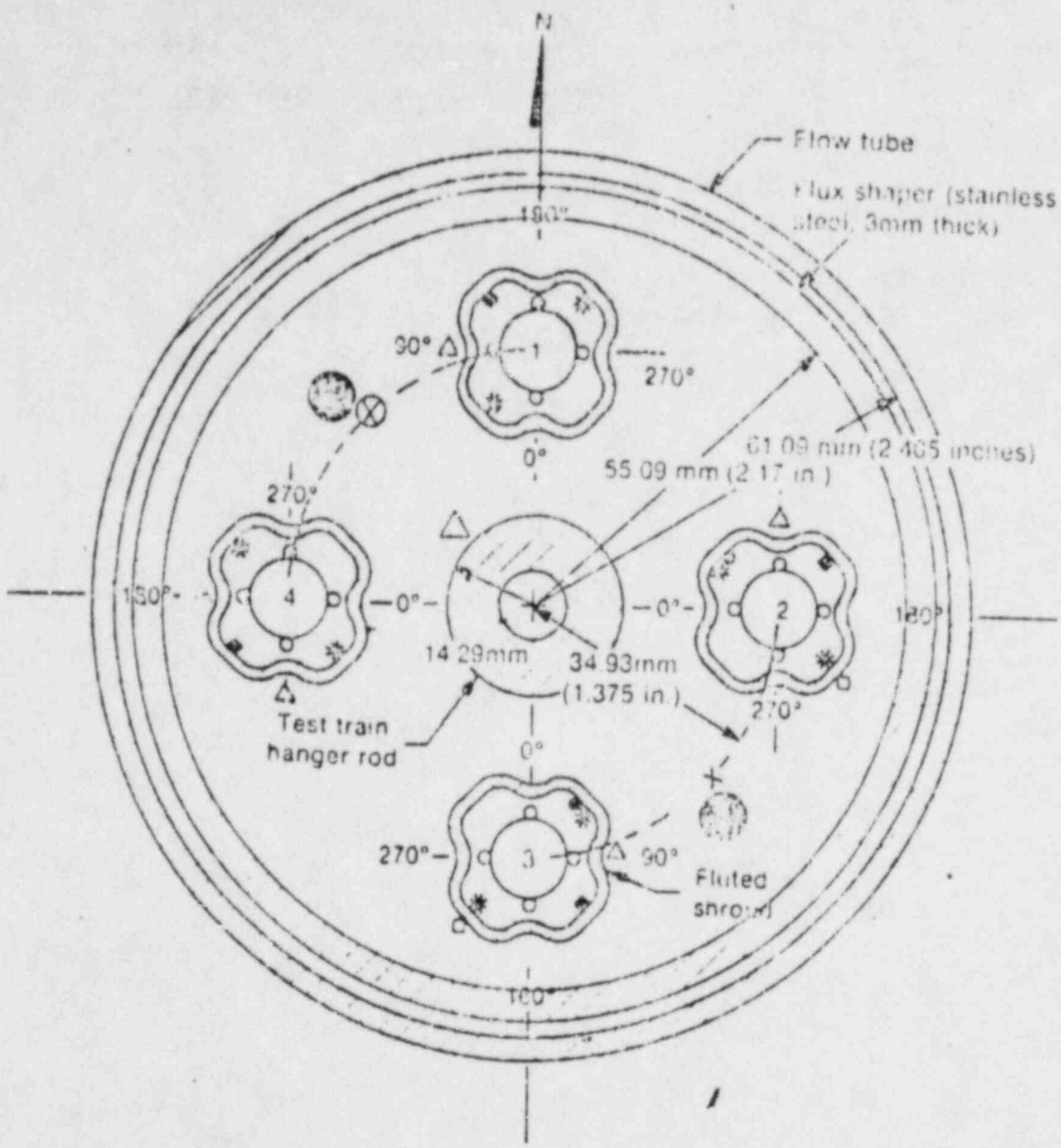
TABLE 1. TEST LOC-6 FUEL ROD NOMINAL DESIGN CHARACTERISTICS

Test LOC-6 Rod Designation	606-9	606-10	606-11	606-12
Saxton Rod Designation	936	841	937	911
Fuel pellet material	UO_2	UO_2	UO_2	UO_2
Pellet diameter (mm)	8.534	8.534	8.534	8.534
Pellet length (mm)	15.24	15.24	15.24	15.24
Pellet dish depth (mm)	0.34	0.34[a]	0.34	0.34[a]
Pellet dish spherical radius (mm)	16.08	16.08[a]	16.08	16.08[a]
Pellet center hole diameter (mm)	1.88	- -	1.88	- -
Center hole location above bottom of fuel pellet stack (mm)	533.4	--	533.4	--
Fuel stack length (mm)	889	886	889	886
Fuel burnup (MWd/t)	0	17010	0	11900
Fuel enrichment (preirradiation)	12.5	12.5	12.5	12.5
Fuel density (% TD)	94.5	92.0	94.5	92.0
Cladding material	Zr-4	Zr-4	Zr-4	Zr-4
Cladding outside diameter (mm)	9.93	9.93	9.93	9.93
Cladding inside diameter (mm)	8.75	8.75[a]	8.75	8.75[a]
Cladding wall thickness (mm)	0.59	0.59	0.59	0.59
Pellet-cladding diametral gap (mm)	0.216	0.216	0.216	0.216
Insulating pellet material	Al_2O_3	Al_2O_3	Al_2O_3	Al_2O_3
Top insulating pellet length (mm)	15.24	18.32	15.24	17.99
Bottom insulating pellet length (mm)	6.35	6.35	6.35	6.35
Fill gas composition	He	He	He	He
Fill gas pressure (MP)	2.41	2.41	4.83	4.83

a. Assuming no loss of pellet dish dimensions due to fuel restructuring.

TABLE 2. TEST LOC-6 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



Rod Locations	Rod No.	Internal pressure
1	606-09	2.41MPa
2	606-10	2.41MPa
3	606-11	4.83MPa
4	606-12	4.83MPa

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

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Figure 1. Test LOC-6 fuel train orientation.

2.2 Test Train

The LOC-6 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 stainless steel flux shaper is located within the central section to flatten the axial power profile within $\pm$ 5% over a 31 cm section.

All of the coolant passing the fuel rods is channeled through particle screens located in the lower and upper plenums. 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.

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

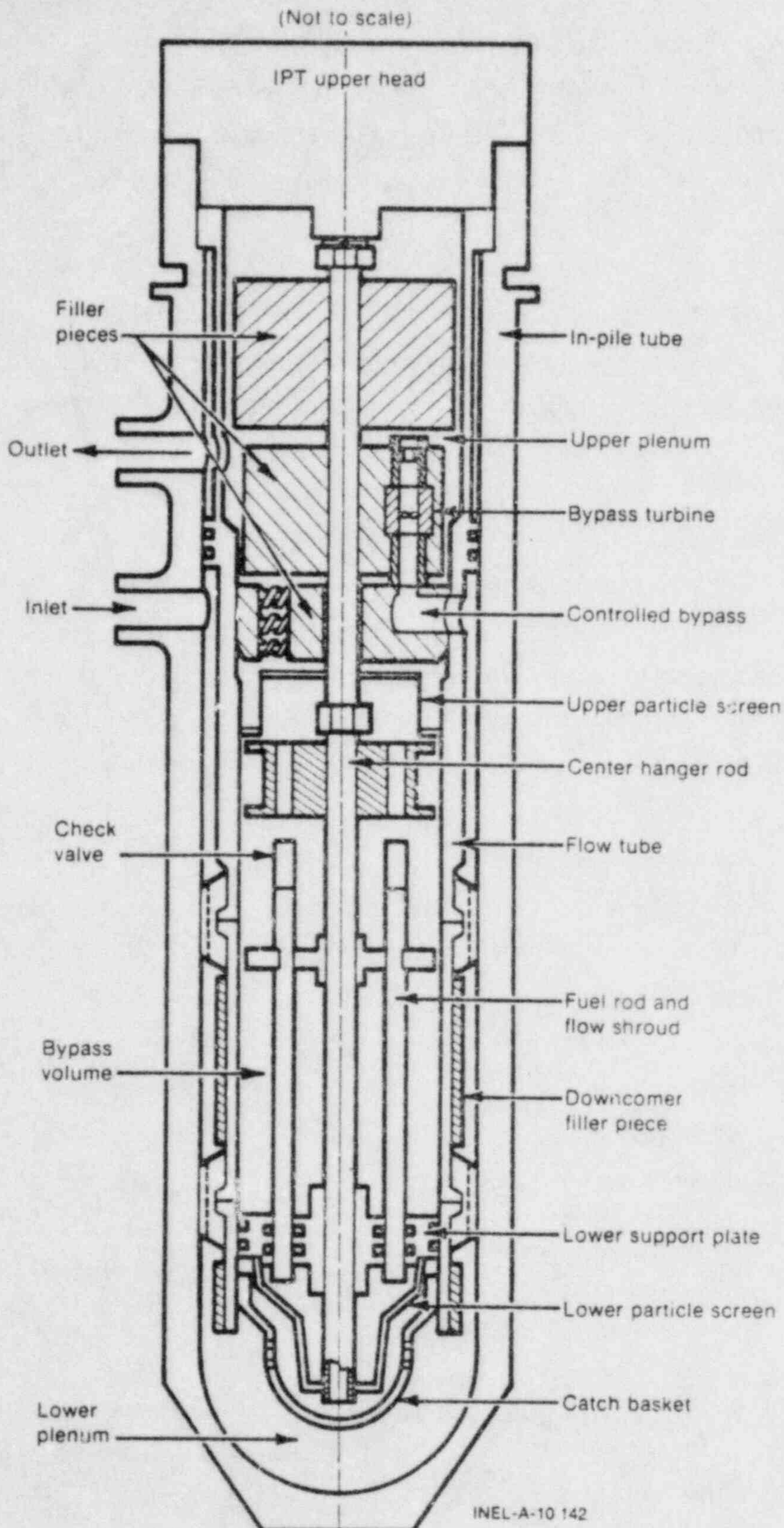


Figure 2. Test LOC-6 test train.

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-6 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-6 are tabulated in Table 3. Both cold-leg blowdown valves will be opened in Test LOC-6, after the IPT is isolated from the primary coolant loop, and the system will depressurize through the Henry nozzles into the blowdown tank.

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

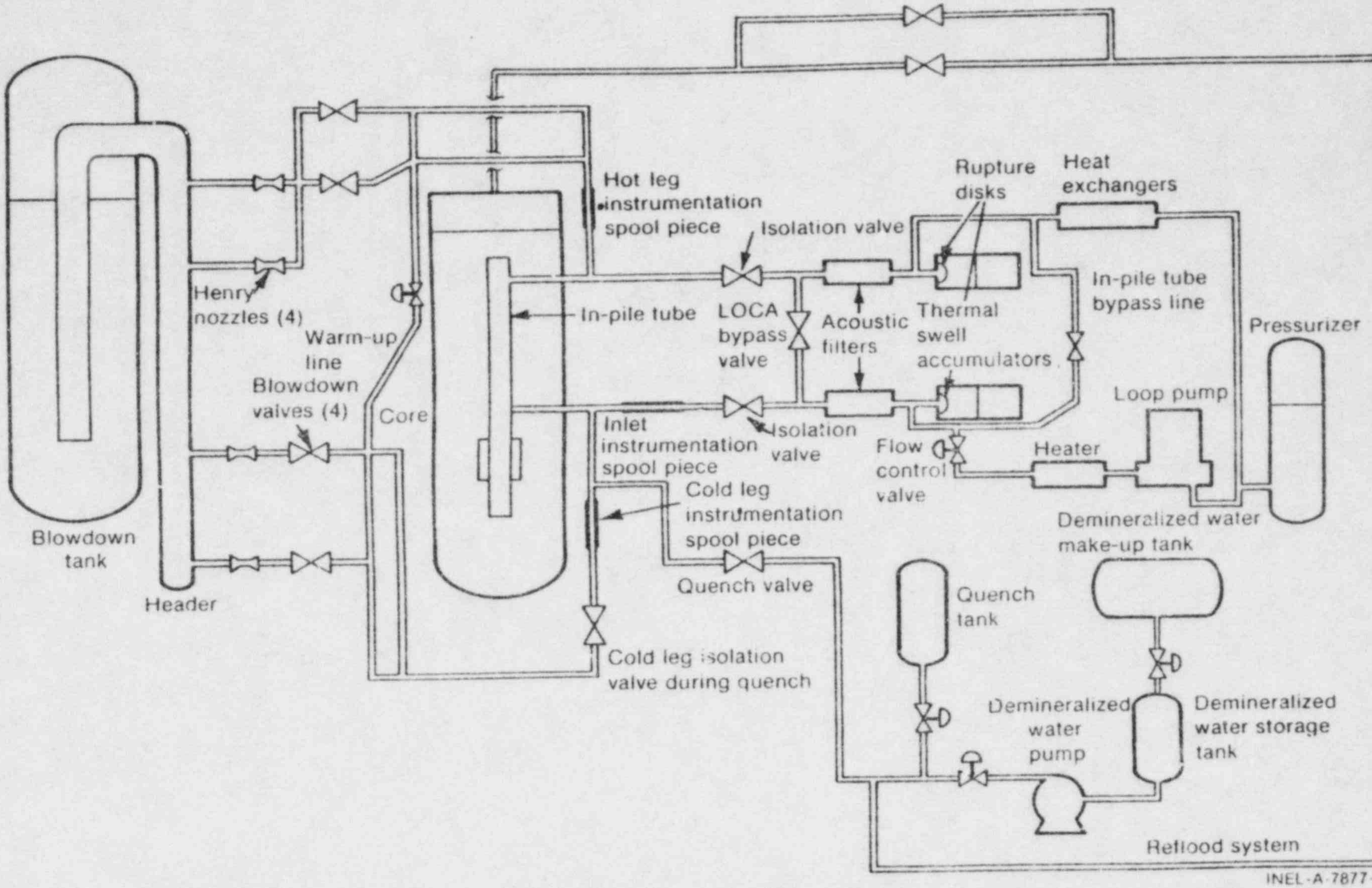


Fig. 3 PBF-LOCA blowdown system

TABLE 3. TEST LOC-6 HENRY NOZZLE THROAT DIAMETERS AND LOCATIONS

Nozzle Association With Blowdown Valve	Location	Throat Diameter (mm)
GB-LM-11-1-1	Hot leg	14.22
GB-LM-11-1-2	Hot leg	13.56
GB-LM-11-1-3	Cold leg	14.22
GB-LM-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.

2.4 Instrumentation

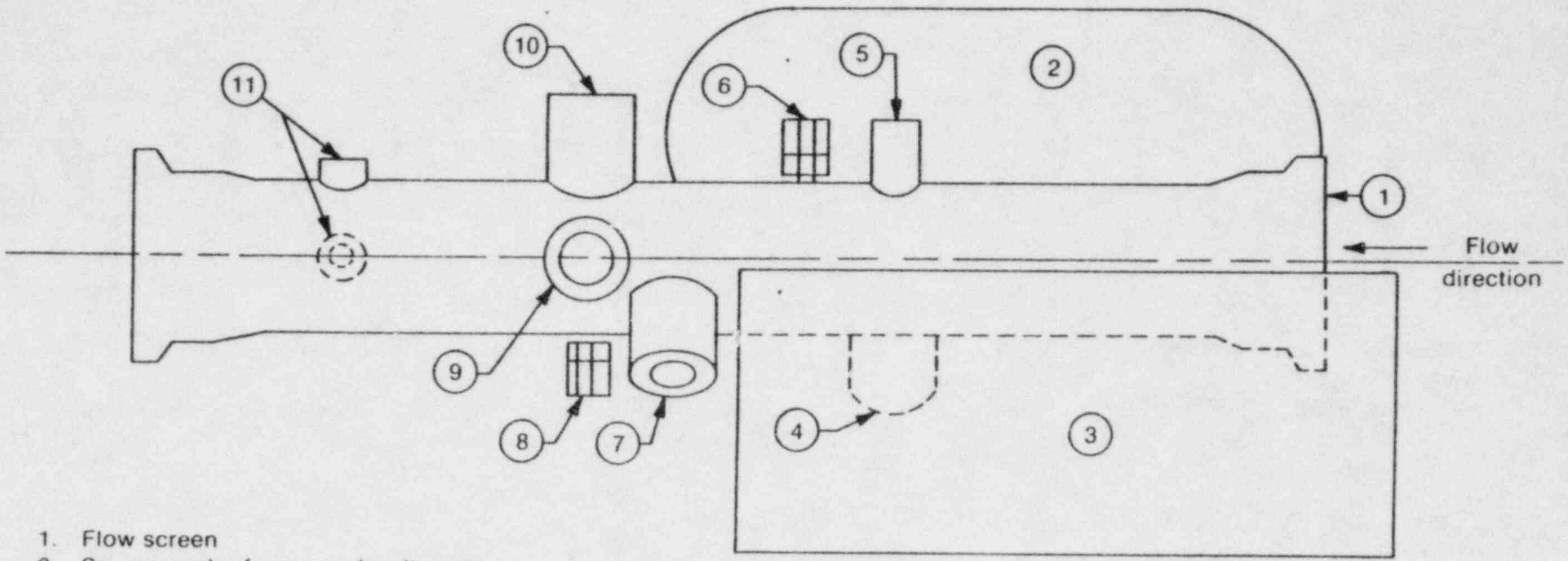
A brief description of the Test LOC-6 instrumentation is provided in this section. The instrumentation of the Test LOC-6 fuel train is designed to measure the fuel rod surface and centerline temperature, plenum pressure and temperature, axial length change, and coolant pressure, temperature, density, 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 variable impedance-type pressure transducer is used to measure each fuel rod plenum pressure. The pressure transducer is contained in a stainless steel cylinder. The cylinder has a silver sleeve on the inner surface to reduce the effects of radial temperature gradients, and is sealed on both ends to reduce axial temperature gradients.

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. Additional data on the thermocouples is listed in Table 4.

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 606-9 and 606-11.



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

TABLE 4. TEST LOC-6 THERMOCOUPLE DATA

Thermocouple	Type	Insulation	Material	Sheath OD (mm) (mm)	Wall Thickness	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.

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 each 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.

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 606-10 and 606-11 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 606-10 and 606-12 to measure the flow shroud 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.

10. Two EG&G Idaho, Inc., pressure tranducers (strain-post-type) located 0.04 m above the top of the fuel rod shrouds 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. 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.

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 5.

TABLE 5. TEST LOC-6 PLANT INSTRUMENTATION

Description	Designation[a]
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1101PT
Position of Hot Leg Blowdown Valve	VALVbPOSbbLM1102PT
Position of Cold Leg Blowdown Valve	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 Flow Transducer	OUTbFLOWbbFT-29bPT
Quench Tank Coolant Level	QNCHbLEVbbLT-10bPT
Quench Coolant Flow Rate	QNCHbFLObbFT-14bPT
Blowdown Tank Pressure	BLOWbPRSbbPT-12bPT
Loop Pressure	SYSbPRESbbPRS10bPT
System Pressure	SYSbPRESbbHEISEbPT
IPT Differential Pressure	IPTbDELPbbDPR-10PT
Loop Flow Rate	LOOPbFLObbFRC-10PT
FPDS Gross Gamma Rate Detector 1	FPDSGAMAbbNUMb01FP
FPDS Gross Gamma Rate Detector 2	FPDSGAMAbbNUMb02FP
FPDS Gross Gamma Rate Detector 3	FPDSGAMAbbNUMb03FP
FPDS Gross Neutron Rate	FPDSNEUTbbNEUTRNFP
Reactor Power NMS-3 30 MW	REACTPOWbbNMS-03PT
Reactor Power NMS-4 30 MW	REACTPOWbbNMS-04PT
Reactor Power PPS-1 30 MW	REACTPOWbbPPS-01PT
Reactor Power PPS-2 30 MW	REACTPOWbbPPS-02PT
Transient Rod 1 Position	TRANSRODbbNUMb01PT
Transient Rod 2 Position	TRANSRODbbNUMb02PT
Transient Rod 3 Position	TRANSRODbbNUMb03PT
Transient Rod 4 Position	TRANSRODbbNUMb04PT

a. b denotes blank.

3. EXPERIMENT OPERATING PROCEDURE

Details of the experiment procedure of Test LOC-6 are discussed in the following sections. Each experiment operating phase and the instrument status requirements are considered individually below.

Two weeks prior to nuclear operation a series of isothermal blowdown tests will be performed to evaluate checkvalve operation, blowdown valve sequencing, and magnitude of flow shroud leakages. The goal of these tests will be to conduct two TC-3-type blowdowns and one LOC-6 type blowdown to determine the performance of the check valves, flow shrouds, and valve sequencing.

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 at a reactor power less than or equal to 26 MW. The specific operating sequence for the test is shown in Table 6 and Figure 5.

Prior to Test LOC-6 a REDCOR checkout of the blowdown transient sequence 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.

TABLE 6. OPERATING SEQUENCE FOR TEST LOC-6

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 warmup line closed.
30	0	0	366	0.4	0.69	Measurement status check at 366 K inlet temperature.
360	0	0	366 to 590	0.4	13.8	Heatup, DARS status checks.
15	0	0	590	0.4	13.8	Rod pressure transducer check.
15	0	0	590	0.4,0.6,0.8,1.0	15.51	Test train flow turbine calibration 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.
10	0 to 13	0.1 to 6.5	590	1.0	15.51	
60	13	6.5	590	1.0	15.51	Power calibration, ramp 1, and instrumentation check
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.
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.

TABLE 6. (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
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 0.1	590	1.0	15.51	
10	0	0.1	590	1.0	15.51	Prepare for 4th cycle (decay heat buildup).
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	-	-	-	Cooldown phase.

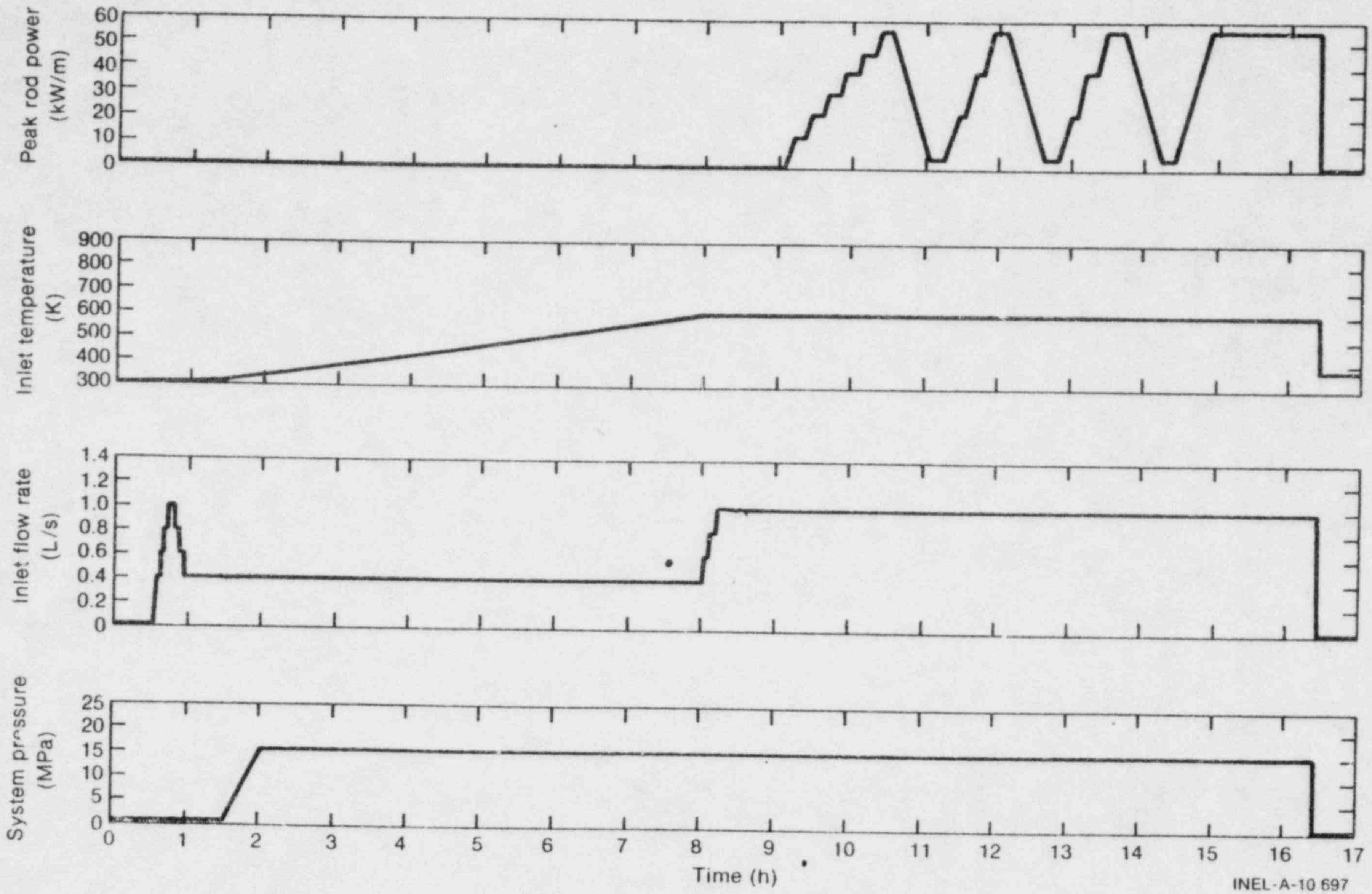


Fig. 5 Operating sequence for LOC-6

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 the data acquisition and reduction system (DARS) checkout is completed, measurement status checks are to be made (a) before each isothermal blowdown, (b) prior to heatup at ambient conditions, (c) after achieving critical reactor conditions (d) prior to the LOC-6 blowdown, unless requested otherwise by the Experiment Specification and Analysis (ES&A) representative of Fuel Research Division, or his alternate. If 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 to 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 procedures will be suspended pending a decision by the LOCA Project Engineer, TFBP Management, or appropriate Directorate management.

Prior to any data acquisition, the PBF/DARS output will be verified by applying voltages to the low level amplifiers or in accordance with a DOP. This DOP 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.

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

1. Allow the system to come to equilibrium.

2. Obtain a DARS printout of measurement data and statistics 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. A posttest integrated data systems calibration will be performed after reactor building reentry is permitted.

3.2 Isothermal Blowdowns

A series of isothermal (nonnuclear) blowdowns will be performed prior to the nuclear phase of Test LOC-6 to evaluate the performance of the flow shroud checkvalves during a rapid system depressurization, and to determine the ability of the flow shrouds to resist leakages. The isothermal tests will be performed prior to the nuclear phase of Test LOC-6, but will not be allowed to delay the LOC-6 nuclear test schedule without the approval of the responsible ES&A engineer.

The coolant conditions for the isothermal tests will be 580 K and 15.51 MPa, at the IPT inlet. The flowrate for the isothermal blowdowns will be 0.8 ℓ/s for the TC-3 type blowdowns and 1.0 ℓ/s for the TC-6 type blowdown. The first series of blowdowns will be TC-3 type, and the last will be LOC-6 type.

The valve sequencing during the TC-3 type isothermal tests will be the same as shown in Table 7, in preparation of the TC-3 test series. The valve sequencing during the LOC-6 type isothermal test will be the same as the LOC-6 blowdown sequence, as shown in Table 8. Data will be recorded by the DARS and the parameters of importance during this phase are (a) inlet and outlet flowrates of each rod, (b) controlled bypass flowrate, (c) cladding LVDT response, (d) system pressures, (e) pressure differential between hot leg and cold leg, and (f) rod internal pressures.

TABLE 7. PROGRAMMING AND MONITORING SYSTEM CONTROLLED EVENT SEQUENCE FOR TC-3 TYPE ISOTHERMALS

Time Event is Initiated (s)	Loop Bypass Valve[a]	Isolation Valve[b]	Hot Leg Blowdown Valves[c]		Cold Leg Blowdown Valves[d]		Quench Water Valve[e]	Warmup Line Valve[f]	Cold Leg Shutoff Valve[g]	Comments
			(1) (14.22 mm)	(2) (13.56 mm)	(3) (12.70 mm)	(4) (23.90 mm)				
--	X[(h)]	0	X	X	X	X	X	0	0	
-20.0	X	0	X	X	X	X	X	X	0	Operator closes warmup line and verifies test rod coolant flow to 0.8 l/s per shroud. Action is verified by TFBP Project Engineer before initiation of the transient.
-5.0	X	0	X	X	X	X	X	X	0	REDCOR initiates function generator routine.
0.00	0	X	X	X	X	X	X	X	0	Shut down loop coolant pump, isolate loop and open bypass valve.
0.10	0	X	X	X	0	0	X	X	0	Open cold leg valves.

TABLE 7. (Continued)

Time Event is Initiated (s)	Loop Bypass Valve[a]	Isolation Valves[b]	Hot Leg Blowdown Valves[c]		Cold Leg Blowdown Valves[d]		Quench Water Valve[e]	Warmup Line Valve[f]	Cold Leg Shutoff Valve[g]	Comments
			(1) (14.22 mm)	(2) (13.56 mm)	(3) (12.70 mm)	(4) (23.90 mm)				
4.00	0	X	X	X	0	X	X	X	0	Close large cold leg.
5.20	0	X	X	X	X	X	X	X	0	Close small cold leg
5.50	0	(i)	X	X	X	X	X	X	0	Two phase slug phase
5.56	0	(j)	X	X	X	X	X	X	0	Open isolation valves
5.62	0	X	X	0	X	X	X	X	0	Close islolation valves/open hot leg.
11.00	0	X	X	X	0	X	X	X	0	Open cold leg, close hot leg.
22.00	0	X	X	X	0	0	X	X	0	Open large cold leg.
100.00	0	X	X	X	0	0	X	X	0	Reflood cycle.
240	0	X	0	0	X	X	0	X	X	Quench

a. VALVbPOSbbLM1107PT

b. VALVbPOSbbLM1105PT and VALVbPOSbbLM1106PT

c. VALVbPOSbbLM1101PT and VALVbPOSbbLM1102PT

d. VALVbPOSbbLM1103PT and VALVBPOSbbLM11104

e. VALVbPOSbbLM1108PT

f. VALVbPOSbbLM1116PT

g. VALVbPOSbbLM1118PT

h. X indicates closed, 0 indicates open.

i. Opening of the isolation valves is initiated.

j. Closing of the isolation valves is initiated.

TABLE 8. PROGRAMMING AND MONITORING SYSTEM CONTROLLED EVENT SEQUENCE FOR TEST LOC-6

Time event is initiated[a] (s)	Loop Bypass Valve[b]	Isolation Valve[c]	Hot Leg Blowdown Valves[d]	Cold Leg Blowdown Valves[e]	Quench Water Valve[f]	Warmup Line Valve[g]	Cold Leg Shutoff Valve[h]	Comments
-	X[h]	0	X	X	X	0	0	
-20.00	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.
- 4.00	X	0	X	X	X	X	0	REDCOR initiates function generator routine.
- 1.50[j]	X	0	X	X	X	X	0	Linearly reduce reactor power to 30.7% in 0.5 s.
- 1.00[j]	X	0	X	X	X	X	0	Linearly reduce reactor power to 23.3% in 0.5 s.
- 0.50[j]	X	0	X	X	X	X	0	Linearly reduce reactor power to 17.8% in 1.0 s.
0.00	0	X	X	X	X	X	0	Isolate loop and open bypass valve,
0.10	0	X	X	0	X	X	0	Open cold leg valves
0.50[j]	0	X	X	0	X	X	0	Linearly reduce reactor power to 13.2% in 1.5 s.
2.00[j]	0	X	X	0		X	0	Linearly reduce reactor power to 10.1% in 3.0 s.
5.00[j]	0	X	X	0	X	X	0	Linearly reduce reactor power to 7.6% in 4.0 s.
9.0[j]	0	X	X	0	X	X	0	Maintain reactor power at 7.6% for 90.9 s.
99.9[j]	0	X	X	0	X	X	0	Scram reactor.
100.0	0	X	X	0	X	X	0	Initiate reflood.
240.0	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. VALVbPOSbbLM1103PT and VALVbPOSbbLM1104PT
f. VALVbPOSbbLM1108PT
g. VALVbPOSbbLM1116PT
h. VALVbPOSbbLM1118PT
i. X indicates closed, 0 indicates open.
j. Events not included in isothermal tests.

The determination of checkvalve failure will be made by observing the inlet and outlet flow rate response during the isothermal blowdown. If the responsible ES&A project engineer determines that a checkvalve has failed to operate, further tests will be suspended until corrective actions are determined.

The determination of excessive flow shroud leakages will be made by comparison of preblowdown and postblowdown flow rates through each flow shroud and the response of the inlet and outlet flowmeters during the blowdown. If excessive flow shroud leakages are determined to have occurred, the responsible ES&A project engineer may postpone further tests to determine the nature of the leakages and their impact upon the successful accomplishment of the LOC-6 test objectives.

3.3 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 to determine the extent of flow shroud leakages. With the warmup line closed, the flow as indicated by a test train turbine should be increased from 0.4 ℓ/s to as high as possible, but not to exceed 1.0 ℓ/s, and then reduced to 0.4 ℓ/s. Readings should 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. The information will be used to determine the extent of flow shroud leakages for comparison with test train design specifications. In the event of fuel rod flow shroud leakages in excess of 14% of the total test train flow, test procedures 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 6 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.

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.

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

3.4 Instrument Drift Recording and Status Check

Data channels will be recorded for at least 30 minutes to establish instrument drift rates. This recording should be completed after heatup at stable system conditions of 590 K inlet temperature, 15.51 MPa IPT pressure, and 1.0 ℓ/s flow through each shroud. Table A-3 in Appendix A will be used to indicate the status of the test instrumentation. Malfunctioning instrumentation will be indicated as such in the remarks column by the TFBP Project or his representative, and the checklist will then be included in the EOP.

3.5 Power Calibration Phase

After the reactor is critical at about 100 kW 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.

The calibration phase of the experiment will be initiated by establishing the coolant pressure, temperature, and flow rate at the predetermined values of Table 6. To perform the calibration, the reactor power will be increased to a known level, the system allowed to reach equilibrium (∿ 2 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.

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 and Test LOC-5 determined the figure-of-merit to be 2.1. 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 may be suspended pending resolution of the discrepancy by the LOCA Project Engineer and TFBP Management.

3.6 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.

3.7 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.

Approximately 15 minutes before blowdown, the reactor power will be switched to transient rod servo-control.

3.8 Blowdown and Reflood Phase

The specific steps of the blowdown phase are provided in Table 8. After establishing the required initial conditions of Table 6, and approximately 20 seconds before blowdown, the warmup line will be shut by the reactor operator and the test rod flows reset to 1.0 ℓ/s. The TFBP Project Engineer will then verify proper setting of all initial conditions before the transient is initiated.

The blowdown sequence will then be initiated. The reactor power will be controlled with the transient rods (TR) during the blowdown, as detailed in Table 8 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. Operator control of the reactor power may be required to achieve expected cladding temperatures during blowdown.

After 20 s of blowdown, the operator will monitor the cladding thermocouple CLAD606bbb19+0bb11. If cladding temperatures are less than 900 K, the reactor power will be increased to a maximum of 5 MW to achieve goal cladding temperatures between 900 and 975 K. If cladding temperatures are less than 800 K the reactor will be scrammed and the test may be repeated. Automatic scram will occur at about 100 s. The ES&A Project Engineer will coordinate with the operator in the control of the reactor during the test.

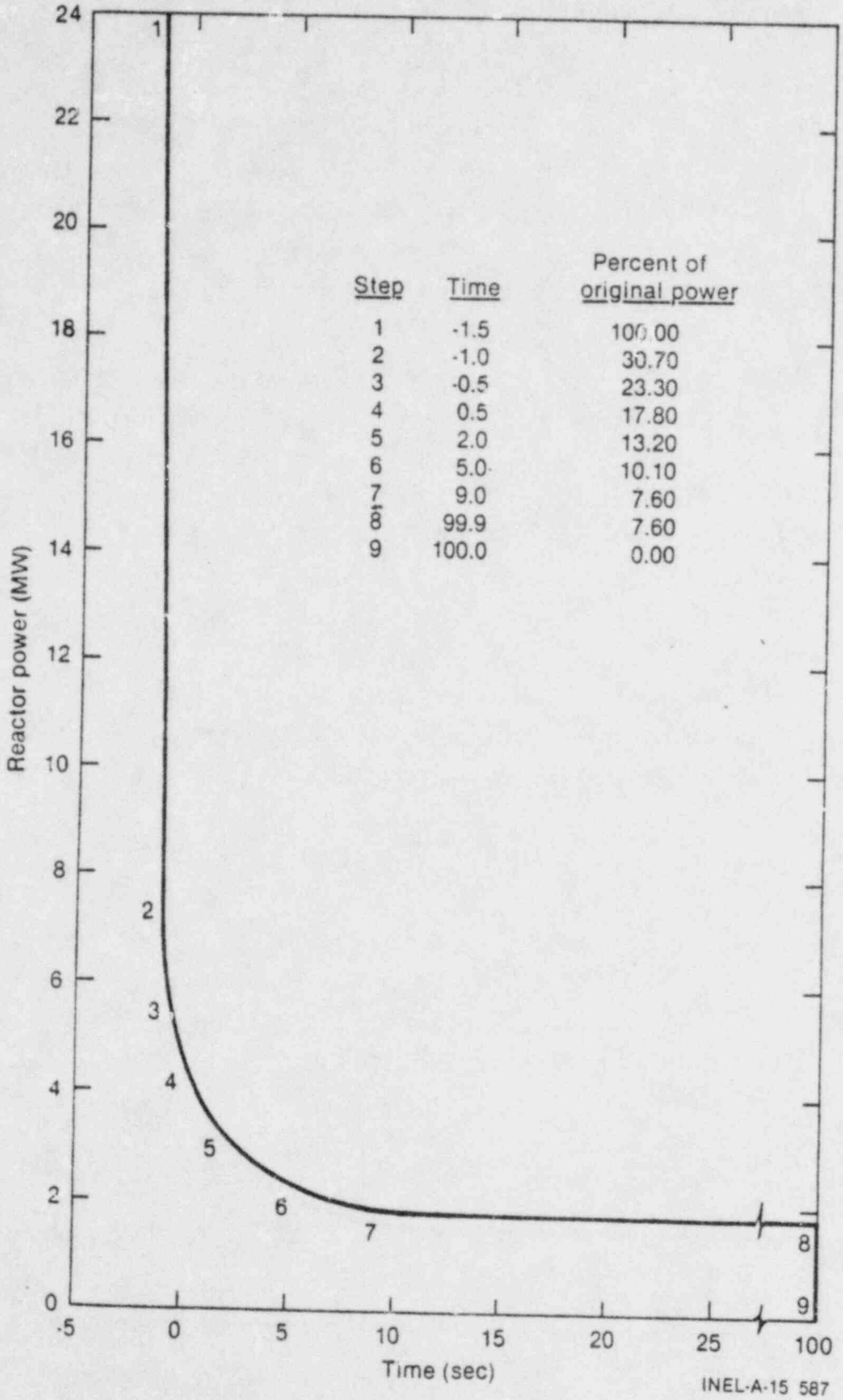


Figure 6. Reactor power variation with time during the transient.

One hundred seconds (100 s) after blowdown initiation, when the lower plenum pressure is at approximately 0.45 MPa, the reflood portion of the test will begin as shown in Table 8. The controlled reflood is performed by injecting the coolant from the quench tank through the reflood system directly into the IPT upper head, down the center hanger rod into the plenum volume beneath the lower particle screen. System operation involves: (1) filling the lower plenum to the bottom of the active fuel as soon as possible, within 5 seconds at a rate of 1.58 ℓ/s, and maintaining this level prior to reflood of the fuel, and (2) providing the constant cold reflood rate to the flow shrouds at a rate of 0.95 ℓ/s. The reflood coolant temperature will be approximately 311 K ($100^{\circ}F$) when entering the IPT through the upper head penetration.

3.9 Quench and Cooldown Phase

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

After the [illegible]ase, cooling water will be pumped from the storage tank pr[illegible]ued 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 0.4 ℓ/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.

3.10 Shutdown and Abnormal Test Termination Requirements

The test will be shut down 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.

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 1500 K at any time during the transient (based on an average temperature computed automatically from thermocouple measurements on each test rod), the quench system will be activated.

4. DATA ACQUISITION, REDUCTION AND QUALIFICATION 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 9 through 12. Prior to each nuclear operation, it will be verified that the 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 9 through 12. All of the narrow-band DARS channels should be available for display on the Vector General. The surveillance system strip charts are required to display some instruments and voltage inputs may be taken from the DARS. The PBF/DARS will record data during the cold hydrostatic 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 or until the ES&A representative requests otherwise.

The Quick Look Report data, as indicated in Table 9 through 12, should be recorded on narrow band, and backed up on wide band at 1000 Hz recording frequency. As an additional backup to the data being recorded on the DARS, the on-line trend data, and 20-minute files should be dumped to magnetic tape. The 8-hour trend data should be dumped every 8 hours starting with heatup through blowdown and until test termination. The 20-minute files should be dumped after blowdown such that the 20-minutes will span blowdown.

The data channels that are required to be displayed on the strip charts during the power calibration, fuel preconditioning, and blowdown phases are indicated in Figure 7. The ES&A designation and explanation of the instrumentation are presented in Tables 9 through 12. 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.

TABLE 9. TEST LOC-6 FUEL TRAIN INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location[a]	Rod Number[b]	Instrument Identifier[c]	Recording Ranges	Minimum Frequency Recording Required (Hz)[d]	Report Requirements
Fuel Rod							
Fuel centerline temperature	W5%Re/W26%Re thermocouple	0.130 m	1	TFCL606bbb13bbTC09	300 to 2500 K	10	f,g
		0.130 m	3	TFCL606b1b13bbTC11		10	f,g
Cladding surface temperature	Type K thermocouple	0.186 m - 0°	1	CLAD606bbb19+0bb09	300 to 1200 K	10	f,g
		0.186 m - 180°	1	CLAD606bbb19+18009			f,g
		0.236 m - 90°	1	CLAD606bbb24+90b09			f,g
		0.236 m - 270°	1	CLAD606bbb24+27009			f,g
		0.186 m - 0°	2	CLAD606bbb19+0bb10			f,g
		0.186 m - 180°	2	CLAD606bbb19+18010			f,g
		0.236 m - 90°	2	CLAD606bbb24+90b10			f,g
		0.236 m - 270°	2	CLAD606bbb24+27010			f,g
		0.186 m - 0°	3	CLAD606bbb19+0bb11			f,g
		0.186 m - 180°	3	CLAD606bbb19+18011			f,g
		0.236 m - 90°	3	CLAD606bbb24+90b11			f,g
		0.236 m - 270°	3	CLAD606bbb24+27011			f,g
		0.186 m - 0°	4	CLAD606bbb19+0bb12			f,g
		0.186 m - 180°	4	CLAD606bbb19+18012			f,g
		0.236 m - 90°	4	CLAD606bbb24+90b12			f,g
		0.236 m - 270°	4	CLAD606bbb24+27012			f,g
Plenum temperature	Type K thermocouple	Fuel rod plenum	1	PLNMbTMPbb606bbb09	300 to 1100 K	10	f,g
			2	PLNMbTMPbb606bbb10			f,g
			3	PLNMbTMPbb606bbb11			f,g
			4	PLNMbTMPbb606bbb12			f,g
Plenum pressure	Kaman 17-MPa pressure transducer	Fuel rod plenum	1	RODbPRESbb606bbb09	0 to 18 MPa	10	f,g
			2	RODbPRESbb606bbb10			f,g
			3	RODbPRESbb606bbb11			f,g
			4	RODbPRESbb606bbb12			f,g
Cladding axial strain	LVDT	Bottom of rod	1	CLADbDSPbb606bbb09	-12 to 12 mm	100	f,g
			2	CLADbDSPbb606bbb10			f,g
			3	CLADbDSPbb606bbb11			f,g
			4	CLADbDSPbb606bbb12			f,g
FLOW SHROUD							
Fuel rod power profile[e]	Flux wire 99.5% Al and 0.5% Co	One on the outside	1	FLUX606bbb180bbb09			g
		of each flow shroud	2	FLUX606bbb180bbb10			g
		(180°) and the hanger	3	FLUX606bbb180bbb11			g
		rod (236°)	4	FLUX606bbb180bbb12			g
				FLUXHRODbb236bbbHR			g

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

b. Rod numbers are defined in Figure 1.

c. b denotes blank.

d. 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.

e. Not recorded.

f. Quick Look Report, backup on WB at 1000 Hz recording frequency.

g. Test Results Reports.

TABLE 9. (continued)

Measurement	Instrument Type	Location[a]	Rod Number[b]	Instrument Identifier[c]	Recording Ranges	Minimum Frequency Recording Required (Hz)[d]	Report Requirements
Flow Shroud							
Shroud coolant flow	Bidirectional turbine flowmeter	Lower shroud extension	1	FLOWRATEbbINLETb09	-2.5 to 1.5 /s	100	e,f
			2	FLOWRATEbbINLETb10			e,f
			3	FLOWRATEbbINLETb11			e,f
			4	FLOWRATEbbINLETb12			e,f
		Upper shroud extension	1	FLOWRATEbbOUTLET09			e,f
			2	FLOWRATEbbOUTLET10			e,f
			3	FLOWRATEbbOUTLET11			e,f
			4	FLOWRATEbbOUTLET12			e,f
Outer shroud wall temperature	Type K thermocouple	-0.120 m - 225°	2	SHRDbTMPbb-120bb10	300 to 1200 K	10	e,f
		0.m - 225°	2	SHRDbTMPbbb000bb10			e,f
		+0.120 m - 225°	2	SHRDbTMPbb+120bb10			e,f
		-0.120 m - 225°	3	SHRDbTMPbb-120bb11			e,f
		0.m - 225°	3	SHRDbTMPbbb000bb11			e,f
		+0.120 m - 225°	3	SHRDbTMPbb+120bb11			e,f
Bulk coolant temperature	Type K thermocouple	-0.120 m - 135°	2	BULKbTMPbb-120bb10	339 to 820 K	10	e,f
		0. m - 135°	2	BULKbTMPbbb000bb10			e,f
		+0.120 m - 135°	2	BULKbTMPbb+120bb10			e,f
		-0.120 m - 135°	3	BULKbTMPbb-120bb11			e,f
		0.m - 135°	3	BULKbTMPbbb000bb11			e,f
		+0.120 m - 135°	3	BULKbTMPbb+120bb11			e,f
Inlet coolant temperature	Type K thermocouple	-0.439 m - 135°	1	INLTbTMPbb60609b09	339 to 820 K	10	e,f
		-0.439 m - 135°	2	INLTbTMPbb60610b10			e,f
		-0.439 m - 135°	3	INLTbTMPbb60611b11			e,f
		-0.439 m - 135°	4	INLTbTMPbb60612b12			e,f
Outlet coolant temperature	Type K thermocouple	+0.439 m - 135°	1	OUTbTEMPbb60609b09	339 to 820 K	10	e,f
		+0.439 m - 135°	2	OUTbTEMPbb60610b10			e,f
		+0.439 m - 135°	3	OUTbTEMPbb60611b11			e,f
		+0.439 m - 135°	4	OUTbTEMPbb60612b12			e,f
Coolant differential temperature	Type K thermocouple pair	±0.439 m - 45°	1	DELbTEMPbb45bbbb09	0 to 15 K	10	e,f
		±0.439.m - 225°	1	DELbTEMPbb225bbb09			e,f
		±0.349 m - 45°	2	DELbTEMPbb45bbbb10			e,f
		±0.439 m - 225°	2	DELbTEMPbb225bbb10			e,f
		±0.439 m - 45°	3	DELbTEMPbb45bbbb11			e,f
		±0.439 m - 225°	3	DELbTEMPbb225bbb11			e,f
		±0.439 m - 45°	4	DELbTEMPbb45bbbb12			e,f
		±0.439 m - 225°	4	DELbTEMPbb225bbb12			e,f

a. All elevations are measured from axial midplane of the fuel stack. Radial orientations are defined by Figure 1.

b. Rod numbers are defined in Figure 1.

c. b denotes blank.

d. 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.

e. Quick Look Report, backup on WB at 1000 Hz recording frequency.

f. Test Results Report.

TABLE 10. TEST LOC-6 TEST TRAIN INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location[a]	Instrument Identifier	Recording Ranges	Minimum Recording Frequency Required (Hz)	Report Requirements
Test Train						
Bypass temperature	Type K thermocouple	Hanger rod, lower particle screen	BYPbTEMPbbNO.LTTLC	300 to 800 K	10	e
		Hanger rod, fuel midplane	BYPbTEMPbbNO.2bbT"			e
		Hanger rod, shroud outlet plus 50 mm	BYPbTEMPbbNO.3bUT1			e
		Hanger rod, IPT outlet	BYPbTEMPbbNO.5bUTT			e
		Hanger rod between shroud & IPT outlet	BYPbTEMPbbNO.4bUTT			e
Lower plenum temperature	Type K TC	Lower support plate	PLATbTMPbbbbbbbLTT	300 to 800 K	10	e
Neutron flux No. 1[b]	SPND	-0.343 m	NEUTbFLXbb-34.3bTT	0 to 160 nA	10	e
No. 2		-0.229 m	NEUTbFLXbb-22.9bTT			e
No. 3		-0.114 m	NEUTbFLXbb-11.4bTT			e
No. 4		0.0	NEUTbFLXbbbb0.0bTT			e
No. 5		+0.142 m	NEUTbFLXbb+14.2bTT			e
No. 6		+0.229 m	NEUTbFLXbb+22.9bTT			e
No. 7		+0.343 m	NEUTbFLXbb+34.3bTT			e
System pressure	EG&G Idaho, Inc., 69 MPa PXD	Center tie rod, below shroud inlets	SYSbPRESbb69EGbLTT	0 to 69 MPa	100	d,e
System coolant pressure	EG&G Idaho, Inc., 17 MPa PXD	Center tie rod, below shroud inlets	SYSbPRESbb17EGbLTT	0 to 18 MPa	100	d,e
System coolant pressure	EG&G Idaho, Inc., 17 MPa PXD	Hanger rod, above shroud outlets	SYSbPRESbb17EGbUTT	0 to 18 MPa	100	d,e
System coolant pressure	Kaman 17 MPa PXD	Hanger rod, above shroud outlets	SYSbPRESbb17KAbUTT	0 to 18 MPa	100	d,e
Gamma flux No. 1[c]	SPGD	-0.229 m	GAMAbFLXbb-22.9bTT	0 to 100 nA	10	e
Gamma flux No. 2	SPGD	0.0	GAMAbFLXbbb00.0bTT	0 to 100 nA	10	e
Gamma flux No. 3	SPGD	+0.229 m	GAMAbFLXbb+22.9bTT	0 to 100 nA	10	e
Controlled bypass turbine	Bidirectional turbine flowmeter	Upper plenum filler piece	FLOWRATEbbCONTBYTT	-40 to 12 ℓ/s	100	d,e

a. All elevations are measured from axial midplane of the fuel stack.
b. Include a channel for gamma compensation and measure the "sign" or direction of the current.
c. Include a channel for gamma compensation.
d. Quick Look Report, backup on WB at 1000 Hz recording frequency.
e. Test Results Report.

TABLE 11. TEST LOC-6 HOT LEG, COLD LEG, AND INITIAL CONDITIONS SPOOL PIECES INSTRUMENT IDENTIFICATION DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

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

a. b denotes blank

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

c. Not required.

d. Quick Look Report, backup on WB at 1000 Hz recording frequency.

e. Test Results Report.

TABLE 12. TEST LOC-6 PLANT INSTRUMENT IDENTIFICATION, DATA CHANNEL RECORDING, AND DISPLAY REQUIREMENTS

Measurement	Instrument Type	Location	Instrument Identifier	Recording Ranges	Minimum Recording Frequency Required (Hz)	Report Requirements
Valve position	Limit switches	Cold-leg	VALVbPOSbbLM1103PT	Open, closed	1000	b
		Cold-leg	VALVbPOSbbLM1104PT			b
		Hot-leg	VALVbPOSbbLM1101PT			b
		Hot-leg	VALVbPOSbbLM1102PT			b
		Bypass	VALVbPOSbbLM1107PT			b
		Isolation	VALVbPOSbbLM1105PT			b
		Isolation	VALVbPOSbbLM1106PT			b
		Quench	VALVbPOSbbLM1108PT			b
		Warmup line	VALVbPOSbbLM1109PT			b
		Cold leg shutoff	VALVbPOSbbLM1110PT			b
Outlet coolant flow	Transducer	Outlet	OUTbFLOWbbFT-29bPT	0 to 20 ℓ/s	10	a,b
Quench tank coolant level	Level detector	Quench tank	QNCHbLEVbbLT-10bPT	0 to 100%	10	b
Quench tank flow	Turbine meter	Quench tank	QNCHbFLObbFT-L4bPT	0 to 5 ℓ/s	10	b
Blowdown tank PXD	Pressure transducer	Blowdown tank	BLOWbPRSbbPT-12bPT	0 to 1 MPa	10	b
Transient rod position 1	LVDT	TR drive 1	TRANSRODbbNUMb01PT	0 to 2 m	100	b
Transient rod position 2	LVDT	TR drive 2	TRANSRODbbNUMb02PT	0 to 2 m	100	b
Transient rod position 3	LVDT	TR drive 3	TRANSRODbbNUMb03PT	0 to 2 m	100	b
Transient rod position 4	LVDT	TR drive 4	TRANSRODbbNUMb04PT	0 to 2 m	100	b
Gross gamma rate	No.1 NaI gamma detector	FPDS	FPDSGAMAbbNUMb01FP	10 to 10^6 counts/s	10	b
Gross gamma rate	No.2 NaI gamma detector	FPDS	FPDSGAMAbbNUMb02FP			b
Gross gamma rate	No.3 NaI gamma detector	FPDS	FPDSGAMAbbNUMb03FP			b
Gross neutron rate	BF_3 neutron detector	FPDS	FPbNEUTbbbNEUTRNFP			b
Core power (30 MW)	NMS-3 Ionization chamber	Reactor vessel wall	REACbPOWbbNMS-03PT	0 to 30 MW	10	a,b
Core power (30 MW)	NMS-4 Ionization chamber	Reactor vessel wall	REACbPOWbbNMS-04PT	0 to 30 MW	10	a,b
Core power (30 MW)	PPS-1 Ionization chamber	Reactor vessel wall	REACbPOWbbPPS-01PT	0 to 30 MW	10	a,b
Core power (30 MW)	PPS-2 Ionization chamber	Reactor vessel wall	REACbPOWbbPPS-02PT	0 to 30 MW	10	a,b
System pressure	Heise pressure guage	Plant	SYSbPRESbbHEISEbPT	0 to 17 MPa	10	a,b
IPT pressure drop	ΔP PXD	Plant	IPTbDELPbbDPR-10PT	0 to 0.69 MPa	10	a,b
Loop flow	Venturi flowmeter	Plant	LOOPbFLObbFRC-10PT	0 to 0.07 m^3/s	10	a,b
Low flow reflood turbine	Turbine meter	Reflood system	REFLOODbbbLOWFLObb	0 to 1 ℓ/s	10	a,b
High flow reflood turbine	Turbine meter	Reflood system	REFLOODbbbHIGHFLOb	0 to 2 ℓ/s	10	a,b

a. Quick Look Report, backup on WB at 1000 Hz recording frequency.
b. Test Results Report.

See Tables 9 - 12 for designation and detailed explanation of instrumentation.	FLOWRATEbbINLET09 Shroud Coolant Flow FLOWRATEbbINLET10	CLADbDSPbb60609b09 Cladding Axial Strain CLADbDSPbb60610b10
RODPRESSbb606bb09 Rod Pressure RODPRESSbb606bb10	FLOWRATEbbINLET11 Shroud Coolant Flow FLOWRATEbbINLET12	CLADbDSPbb60611b11 Cladding Axial Strain CLADbDSPbb60612b12
RODPRESSbb606bb11 Rod Pressure RODPRESSbb606bb12	FLOWRATEbbOUTLET09 Shroud Coolant Flow FLOWRATEbbOUTLET10	TFCL60609b13bbTC09 Centerline Temp. TFCL60611b13bbTC11
CLAD60609b19+0bb09 Cladding Temperature CLAD60610b19+0bb10	FLOWRATEbbOUTLET11 Shroud Coolant Flow FLOWRATEbbOUTLET12	CLSVFLOWbbFE06SPCL Spool Turbine Meter ICSVFLOWbbFE05SPIC
CLAD60611b19+0bb11 Cladding Temperature CLAD60612b19+0bb12	INLTbTMPbb606bbb09 Coolant Inlet Temp. Reactor Power REACbPOWbbNMS-03PT	CLPRESSbbPE10SPCL Spool Pressure ICPRESSbbPE08SPIC

Figure 7. Strip chart setup for Test LOC-6.

4.2 Data Reduction and Qualification Requirements

After the posttest voltage insertion calibration has been completed and evaluated, the DIRC chairman will authorize disassembly of the experiment.

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[8], (b) a tape directory in EDF format that 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 that 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

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

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

4. Cooldown - 10 seconds.

Data qualification will be performed for those instruments listed in Table 13, for the indicated test phases. The instrument qualification requirements are listed in the order of perference, and should be strictly followed unless otherwise requested by the ES&A Representative.

TABLE 13. TEST LOC-6 INSTRUMENT QUALIFICATION

Instrumentation		Heatup	Power Calibration and Preconditioning	Test and 15 minutes of Cooldown
1.	Cladding TC's (all)	-	-	X
2.	Plenum pressure transducer	X	X	X
3.	LVDT's	X	X	X
4.	Centerline TC's	-	X	X
5.	Shroud flow meters	-	X	X
6.	Differential TC's	-	X	-
7.	Inlet coolant TC's	-	X	X
8.	Bulk coolant TC's	-	-	X
9.	Coolant RTD (initial condition)	X	X	X
10.	Coolant RTD (cold/hot leg)	-	-	X
11.	Flush pressure transducer (spools)	-	-	X
12.	Standoff pressure transducer (spools)	-	-	X
13.	Spool piece flowmeters	-	X (initial condition only)	X (all)
14.	Drag discs	-	-	X
15.	γ-densitometers	-	-	X
16.	Spool TC's	-	X (initial conditions only)	X (all)

TABLE 13. (continued)

Instrumentation		Heatup	Power Calibration and Preconditioning	Test and 15 minutes of Cooldown
17.	SPND's	-	X	X
18.	SPGD's	-	X	X
19.	Core power (all chambers)	-	X	X
20.	Lower plenum pressure (EGG 17 MPa)	-	X	X
21.	Upper plenum pressure (EGG 17 MPa)	-	X	X
22.	Outlet shroud TC's	-	X	X
23.	Outer shroud wall TC's	-	-	X
24.	Plenum TC's	-	X	X
25.	Bypass hanger TC's	-	-	X
26.	Controlled bypass turbine	-	X	X
27.	Low flow reflood	-	-	X
28.	High flow reflood	-	-	X
29.	Hot-to-cold leg ΔP	-	-	X

Data reduction and plotting requirements are separated into two segments in the following subsections. The first segment concerns data reduction and plotting requirements needed for the preparation of the Test LOC-6 Quick Look Report. The second concerns the Test Results (Topical) Report. Additional plotting requirements will be stipulated for the test analysis, based on test performance and posttest 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 as soon as possible after completion of the test. 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 provided by the TFBP LOCA Project Engineer within two weeks of the test.

4.2.2 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.

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. S. B. Letson, LOC-6 Test Experiment Configuration Specification, ES-50447B, June 1980

6. G. W. Gibson, et al., Characteristics of UO_2-Zircaloy Fuel Rod Materials from the Saxton Reactor for Use in Power Burst Facility, ANCR-NUREG-1321, September 1976.

7. J. R. Larson, PBF-LOCA Test Series Test LOC-11 Experiment Operating Specification, TFBP-TR-209, October 1977.

8. R. W. Obnes, Reference Manual: MAC-RAN III-Time Series Data Analysis System, Agababian Associates, 1973.

APPENDIX A

STATUS CHECK LISTS OF INSTRUMENTATION

TABLE A-1. (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	l/s

PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	REMARKS
RODbPRESbb606bbb09	______ MPa	2.4 $\pm$ 0.1 MPa	______
RODbPRESbb606bbb10	______ MPa	2.4 $\pm$ 0.1 MPa	______
RODbPRESbb606bbb11	______ MPa	4.8 $\pm$ 0.1 MPa	______
RODbPRESbb606bbb12	______ MPa	4.8 $\pm$ 0.1 MPa	______

TABLE A-2. MEASUREMENT STATUS CHECK AT 80 - 100 KW

REACTOR POWER	________	
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	REMARKS
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	________
GAMAbFLXbb-22.9bTT	________nA	± 0.8 nA	________
GAMAbFLXbbb00.0bTT	________nA	± 0.8 nA	________
GAMAbFLXbb+22.9bTT	________nA	± 0.8 nA	________

TABLE A-3. MEASUREMENT STATUS CHECK
PRIOR TO ISOTHERMALS AND LOC-6 BLOWDOWN

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

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	REMARKS
CLAD60609b19+0bb09	________	K	Temperature ± 4 K	______
CLAD60609b19+18009	________	K	Temperature ± 4 K	______
CLAD60609b24+90b09	________	K	Temperature ± 4 K	______
CLAD60609b24+27009	________	K	Temperature ± 4 K	______
CLAD60610b19+0bb10	________	K	Temperature ± 4 K	______
CLAD60610b19+18010	________	K	Temperature ± 4 K	______
CLAD60610b24+90b10	________	K	Temperature ± 4 K	______
CLAD60610b24+27010	________	K	Temperature ± 4 K	______
CLAD60611b19+0bb11	________	K	Temperature ± 4 K	______
CLAD60611b19+18011	________	K	Temperature ± 4 K	______
CLAD60611b24+90b11	________	K	Temperature ± 4 K	______
CLAD60611b24+27011	________	K	Temperature ± 4 K	______
CLAD60612b19+0bb12	________	K	Temperature ± 4 K	______
CLAD60612b19+18012	________	K	Temperature ± 4 K	______
CLAD60612b24+90b12	________	K	Temperature ± 4 K	______
CLAD60612b24+27012	________	K	Temperature ± 4 K	______
TFCL60609b13bbTC09	________	K	Temperature ± 4 K	______
TFCL60611b13bbTC11	________	K	Temperature ± 4 K	______
CLADbDSPbb606bbb09	________	mm	1.0 ± 0.5 mm	______
CLADbDSPbb606bbb10	________	mm	1.0 ± 0.5 mm	______
CLADbDSPbb606bbb11	________	mm	1.0 ± 0.5 mm	______
CLADbDSPbb606bbb12	________	mm	1.0 ± 0.5 mm	______
RODbPRESbb606bbb09	________	MPa	5.0 ± 0.1 MPa	______
RODbPRESbb606bbb10	________	MPa	5.0 ± 0.1 MPa	______

TABLE A-3 (continued)

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	REMARKS
RODbPRESbb606bbb11	________	MPa	10.0 ± 0.7 MPa	________
RODbPRESbb606bbb12	________	MPa	10.0 ± 0.7 MPa	________
PLNMbTMPbb606bbb09	________	K	Temperature ± 4 K	________
PLNMbTMPbb606bbb10	________	K	Temperature ± 4 K	________
PLNMbTMPbb606bbb11	________	K	Temperature ± 4 K	________
PLNMbTMPbb606bbb12	________	K	Temperature ± 4 K	________
INLTbTMPbb606bbb09	________	K	Temperature ± 4 K	________
INLTbTMPbb606bbb10	________	K	Temperature ± 4 K	________
INLTbTMPbb606bbb11	________	K	Temperature ± 4 K	________
INLTbTMPbb606bbb12	________	K	Temperature ± 4 K	________
OUTbTEMPbb606bbb09	________	K	Temperature ± 4 K	________
OUTbTEMPbb606bbb10	________	K	Temperature ± 4 K	________
OUTbTEMPbb606bbb11	________	K	Temperature ± 4 K	________
OUTbTEMPbb606bbb12	________	K	Temperature ± 4 K	________
DELbTEMPbb45bbbb09	________	K	± 0.05 K	________
DELbTEMPbb225bbb09	________	K	± 0.05 K	________
DELbTEMPbb45bbbb10	________	K	± 0.05 K	________
DELbTEMPbb225bbb10	________	K	± 0.05 K	________
DELbTEMPbb45bbbb11	________	K	± 0.05 K	________
DELbTEMPbb225bbb11	________	K	± 0.05 K	________
DELbTEMPbb45bbbb12	________	K	± 0.05 K	________
DELbTEMPbb225bbb12	________	K	± 0.05 K	________
BULKbTMPbb-120bb11[a]	________	K	Temperature ± 4 K	________
BULKbTMPbbb000bb11	________	K	Temperature ± 4 K	________
BULKbTMPbb+120bb11	________	K	Temperature ± 4 K	________
BULKbTMPbb-120bb12	________	K	Temperature ± 4 K	________
BULKbTMPbbb000bb12	________	K	Temperature ± 4 K	________
BULKbTMPbb+120bb12	________	K	Temperature ± 4 K	________
SHRDbTMPbb-120bb10[a]	________	K	Temperature ± 4 K	________
SHRDbTMPbbb000bb10	________	K	Temperature ± 4 K	________
SHRDbTMPbb+120bb10	________	K	Temperature ± 4 K	________

a. One per shroud required as minimum operable instrumentation.

TABLE A-3 (continued)

PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	REMARKS
SHRDbTMPbb-120bb11	____ K	Temperature ± 4 K	____
SHRDbTMPbbb000bb11	____ K	Temperature ± 4 K	____
SHRDbTMPbb+120bb11	____ K	Temperature ± 4 K	____
FLOWRATEbbINLETb09	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbINLETb10	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbINLETb11	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbINLETb12	____ s	Flow ± 0.001 l/s	____
FLOWRATEbbOUTLET09	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbOUTLET10	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbOUTLET11	____ l/s	Flow ± 0.001 l/s	____
FLOWRATEbbOUTLET12	____ l/s	Flow ± 0.001 l/s	____
NEUTbFLXbb-34.3bTT	N/A	N/A	____
NEUTbFLXbb-22.9bTT	N/A	N/A	____
NEUTbFLXbb-11.4bTT	N/A	N/A	____
NEUTbFLXbbbb0.0bTT	N/A	N/A	____
NEUTbFLXbb+14.2bTT	N/A	N/A	____
NEUTbFLXbb+22.9bTT	N/A	N/A	____
NEUTbFLXbb+34.3bTT	N/A	N/A	____
BYPbTEMPbbNO.1bLTT	____ K	Temperature ± 4 K	____
BYPbTEMPbbNO.2bbTT	____ K	Temperature ± 4 K	____
BYPbTEMPbbNO.3bUTT	____ K	Temperature ± 4 K	____
BYPbTEMPbbNO.4bUTT	____ K	Temperature ± 4 K	____
BYPbTEMPbbNO.5bUTT	____ K	Temperature ± 4 K	____
PLATbTMPbbbbbbbLTT	____ K	Temperature ± 4 K	____
SYSbPRESbb69EGbLTT	____ MPa	Heise ± 3.5 MPa	____
SYSbPRESbb17EGbLTT	____ MPa	Heise ± 0.7 MPa	____
SYSbPRESbb17EGbUTT	____ MPa	Heise ± 0.7 MPa	____
SYSbPRESbb17KAbUTT	____ MPa	Heise ± 0.7 MPa	____
GAMAbFLXbb-22.9bTT	N/A	N/A	____
GAMAbFLXbbb00.0bTT	N/A	N/A	____
GAMAbFLXbb+22.9bTT	N/A	N/A	____

TABLE A-3 (continued)

PARAMETER ID	PBF/DARS READING		REQUIRED RANGE	REMARKS
FLOWRATEbbCONTBYTT		l/s	16 $\pm$ 1.0 l/s	
SHRDbLEVbbINLETb09	N/A		N/A	
SHRDbLEVbbINLETb10	N/A		N/A	
SHRDbLEVbbINLETb11	N/A		N/A	
SHRDbLEVbbINLETb12	N/A		N/A	
IPTbLEVLbbNO.1bLTT	N/A		N/A	
IPTbLEVLbbNO.2bLTT	N/A		N/A	
ICSVFLOWbbFE05SPIC		l/s	Flow[a] $\pm$ 0.02 l/s	
CLSVFLOWbbFE06SPCL		l/s	(c) $\pm$ 0.02 l/s	
HLSVFLOWbbFE09SPHL		l/s	(c) $\pm$ 0.02 l/s	
CLMOMFLXbbFE07SPCL	N/A		N/A	
HLMOMFLXbbFE08SPHL	N/A		N/A	
ICSSTEMPbbTE20SPIC		K	Temperature $\pm$ 4 K	
CLSSTEMPbbTE22SPCL		K	Temperature $\pm$ 4 K	
HLSSTEMPbbTE23SPHL		K	Temperature $\pm$ 4 K	
ICTCTEMPbbTE21SPIC		K	Temperature $\pm$ 4 K	
CLTCTEMPbbTE24SPCL		K	Temperature $\pm$ 4 K	
HLTCTEMPbbTE25SPHL		K	Temperature $\pm$ 4 K	
ICPRESSFbbPE08SPIC		MPa	Heise $\pm$ 0.2 MPa	
CLPRESSFbbPE10SPCL		MPa	Heise $\pm$ 0.2 MPa	
HLPRESSFbbPE12SPHL		MPa	Heise $\pm$ 0.2 MPa	
ICPRESSWbbPE09SPIC		MPa	Heise $\pm$ 0.2 MPa	
CLPRESSWbbPE11SPCL		MPa	Heise $\pm$ 0.2 MPa	
HLPRESSWbbPE13SPHL		MPa	Heise $\pm$ 0.2 MPa	
DELPCLHLbbDPE-05HL	N/A	MPa	N/A	
CLDENSUPbbDENS1UCL	N/A		N/A	
CLDENSCEbbDENS1CCL	N/A		N/A	
CLDENSLObbDENS1LCL	N/A		N/A	
HLDENSUPbbDENS2UHL	N/A		N/A	
HLDENSCEbbDENS2CHL	N/A		N/A	
HLDENSLObbDENS2LHL	N/A		N/A	
CLbACCELbbAE-1-1CL	N/A		N/A	

a. Flow determined during flow split.

TABLE A-3 (continued)

PARAMETER ID	PBF/DARS READING	REQUIRED RANGE	REMARKS
CLbACCELbbAE-1-2CL	N/A	N/A	
CLbACCELbbAE-1-3CL	N/A	N/A	
HLbACCELbbAE-2-1HL	N/A	N/A	
HLbACCELbbAE-2-2HL	N/A	N/A	
HLbACCELbbAE-2-3HL	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	
FPbTEMPbbbPIPE02FP	N/A	N/A	
FPbTEMPbbbPIPE03FP	N/A	N/A	
FPbTEMPbbbPIPE04FP	N/A	N/A	
FPbTEMPbbbPIPE05FP	N/A	N/A	
FPbTEMPbbbPIPE06FP	N/A	N/A	
FPbTEMPbbbPIPE07FP	N/A	N/A	
FPbTEMPbbbPIPE08FP	N/A	N/A	
FPbTEMPbbbPIPE09FP	N/A	N/A	
CLbDNTMPbbDENTC1CL	N/A	N/A	
CLbDNTMPbbDENTC2CL	N/A	N/A	
CLbDNTMPbbDENTC3CL	N/A	N/A	
HLbDNTMPbbDENTC1HL	N/A	N/A	
HLbDNTMPbbDENTC2HL	N/A	N/A	
HLbDNTMPbbDENTC3HL	N/A	N/A	
VALVbPOSbbLM1101PT	N/A	N/A	
VALVbPOSbbLM1102PT	N/A	N/A	
VALVbPOSbbLMLRC1PT	N/A	N/A	
VALVbPOSbbLMLRC2PT	N/A	N/A	
VALVbPOSbbLM1105PT	N/A	N/A	
VALVbPOSbbLM1106PT	N/A	N/A	
VALVbPOSbbLM1107PT	N/A	N/A	

TABLE A-3 (continued)

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

a. Flow determined during flow split.

TABLE A-4. FLOW BALANCE WORK SHEET

Conditions:

Coolant Temp. _____

Coolant Press. _____

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

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

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