NRC Research and Technical Assistance Report

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January 1981

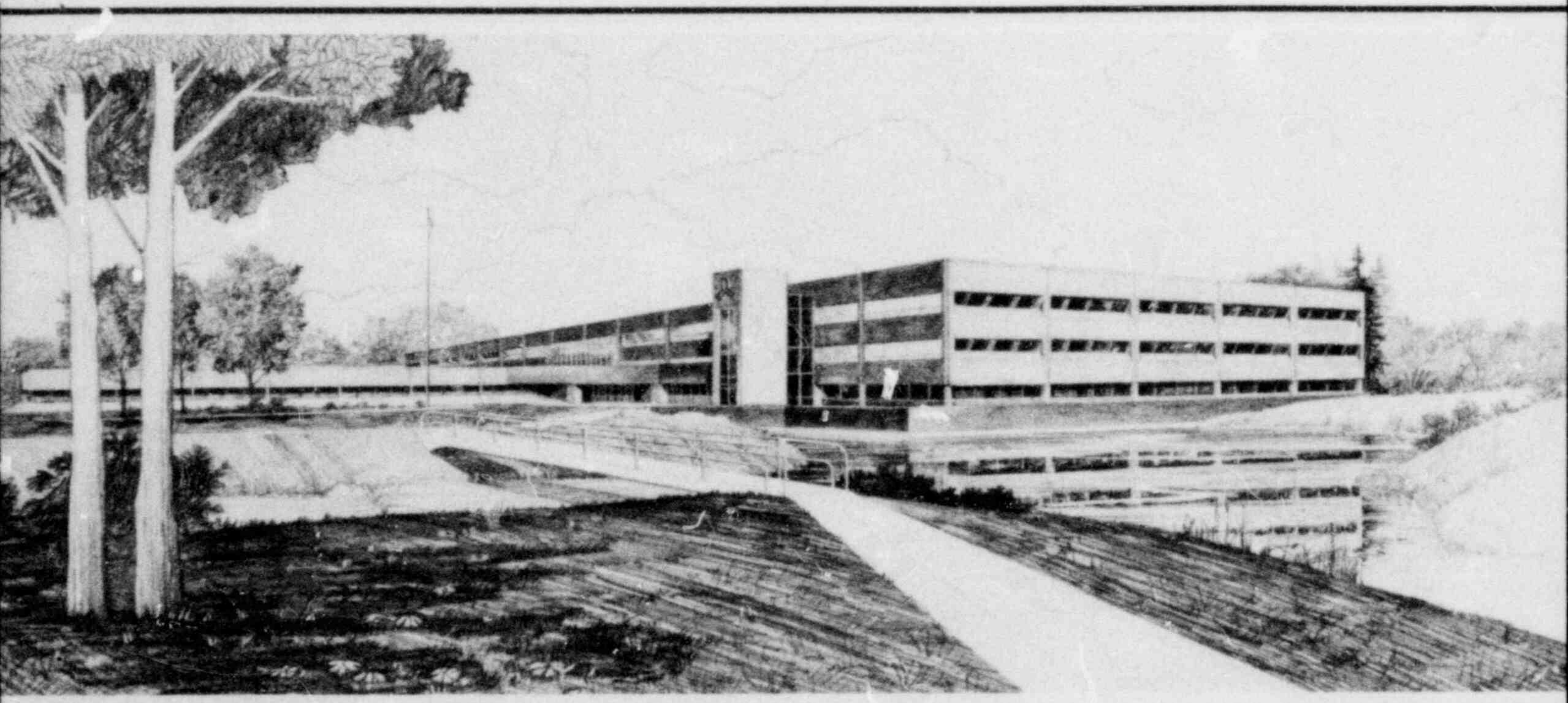
OPERATIONAL TRANSIENT TEST SERIES

OPTRAN 1-2

EXPERIMENT SPECIFICATION DOCUMENT

D. T. Sparks

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



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1. INTRODUCTION

The PBF Operational Transient (OPTRAN) test series is being conducted in the Power Burst Facility (PBF) to define the behavior of light water reactor fuel rods during transient reactor conditions. The key safety issues the OPTRAN test series will address are:

1. Should a nuclear power plant be derated following a severe operational transient?

2. Should regulations be imposed to limit pellet-cladding interaction in irradiated fuel rods?

3. Should nuclear power plants be modified to reduce the probability of a severe transient without scram?

During OPTRAN 1-2, the second test in the OPTRAN test series, two shrouded preirradiated GE BWR/6 segmented fuel rods will be tested. Two unirradiated BWR type heater fuel rods will be used to preheat the coolant for the two test rods. The specific objective of the test is to scope the fuel rod behavior during severe anticipated transients under boiling transition conditions. The experiment will consist of multiple transients to define the onset of boiling transition and subsequent fuel rod damage.

This document defines the hardware and instrumentation requirements for Test OPTRAN 1-2. It contains specifications for the fuel rods and flow shrouds, the test train assembly, and the test instrumentation. Test train environment information is also provided to aid in the design of the test hardware. The specifications presented are best estimates of the requirements needed to satisfy the test objectives. Where specifications or instrument requirements cannot be met, personnel in charge of the hardware design and personnel in charge of experiment specifications and analysis will evaluate alternate approaches. Meeting test objectives will be the prime consideration.

Additional information on operational transients, taken from the OPTRAN Experiment Requirements Document,[1] is provided in Section 2 to aid in understanding the requirements set forth in this document. Specifications for the test fuel rods, shrouds and test train support structure are described in Section 3. Section 4 discusses the instrumentation required to meet the test objectives. In Section 5, the preliminary reactor operation requirements are provided, and finally, the posttest procedures are described in Section 6.

2. SUMMARY OF OPERATIONAL TRANSIENTS

Operational transients with scram are defined as: incidents of moderate frequency, any one of which may occur during a calendar year for a particular plant and result in no fuel rod failures; and infrequent incidents, any one of which may occur during the lifetime of the plant and result in some fuel rod failure. An operational transient without scram is an operational transient during which it is arbitrarily assumed that the reactor contol system fails to insert the control rods and terminate the transient. This type of transient has not occurred to date.

Operational transients with and without scram in boiling water reactors (BWR) are characterized by a loss of primary heat removal, collapse of the voids in the core, and reactivity initiated power increases up to 775% of the rated power for a short period, or power ramps to 120% of rated power. Anticipated transients with and without scram in pressurized water reactors (PWR) are characterized by power ramps to 150% of rated power, overpressure, film boiling for less than 20 seconds, simultaneous coastdown of reactor power and primary coolant flow, and other mild disturbances. Analysis has indicated that these transients are not as severe as BWR events in terms of fuel rod behavior.

The fuel rods are subjected to dryout operation in BWRs only during the most severe transients. In PWRs the fuel rods are subjected to film boiling operation only during a locked rotor transient. Since the time in dryout or film boiling is only a few seconds and the peak cladding temperatures calculated by reactor vendors are below 1100 K, cladding collapse, rather than oxidation, is the most probable cladding damage mechanism. During the power ramps in which film boiling is not produced, stress corrosion cracking (SCC) assisted pellet-cladding interaction (PCI) is the most probable damage mechanism.

To investigate these damage mechanisms, the OPTRAN Test Series was proposed for the Power Burst Facility (PBF). Seven tests, Tests OPTRAN 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, and 1-7 are planned. Two of the first four tests will simulate operational transients in a BWR and are directed toward evaluating the cladding collapse and PCI damage mechanisms in irradiated fuel rods. The instrumentation required for these tests is not significantly different from the instrumentation already used for fuel rod behavior tests in the PBF. Strain gages will be added to evaluate PCI. A few of the rods will have internal instrumentation, but most will not so that the internal chemistry of the previously irradiated rods will be preserved. The postirradiation examinations will concentrate on evaluating the PCI damage mechanism.

Conduct of these proposed OPTRAN tests will complement the inpile experiment program currently being conducted in the PBF and, in part, provide experimental data which will aid in establishing fuel rod damage criteria appropriate for plant operational transients. The value of the proposed tests is enhanced by the use of previously irradiated fuel rods.

3. EXPERIMENT HARDWARE DESIGN

Specifications for the fuel rods, flow shrouds, and test train support structure for Test OPTRAN 1-2 are presented in this section. The basic test configuration consists of four shrouded fuel rods, paired so that the shroud outlets of two unirradiated rods are attached by tubing to the shroud inlets of two preirradiated rods. The rods are installed symmetrically about the PBF IPT centerline in a support structure. Test train instrumentation will be attached to the support structure.

The test train/fuel train assembly must be capable of withstanding an environment of 561 K (550°F) water at 7.24 MPa (1050 psi) with two phase flow for a minimum of 200 hours. Subcooled flowrates through the shrouds will be as much as 820 cm^3/s (13.9 gpm). Welding and brazing shall be performed in accordance with the applicable sections of the assembly and quality assurance specifications. Helium leak detection tests will be performed on the fuel rods prior to assembly in the test train. Zirconium and zirconium alloy materials used in this test assembly shall be in accordance with ASTM B-351, ASTM B-352, or ASTM B-353.

3.1 Test Fuel Rods and Flow Shrouds Design

The test will be comprised of two preirradiated BWR/6 segmented test fuel rods provided by the General Electric Co. In addition to the two test rods, two unirradiated fuel rods will be used to heat the coolant for the test rods. These unirradiated fuel rods will be assembled with available fuel and cladding. A schematic of the G. E. rods is provided in Figure 1. The designations for the rods will be 902-1, 902-2, 902-3, and 902-4. Designations and burnups for the four fuel rods are given in Table 1. The nominal design characteristics for the OPTRAN 1-2 fuel rods are given in Table 2. Table 3 presents the pretest characterization requirements. Except where noted, all the pretest characterization will be performed by the PBF PIE Section.

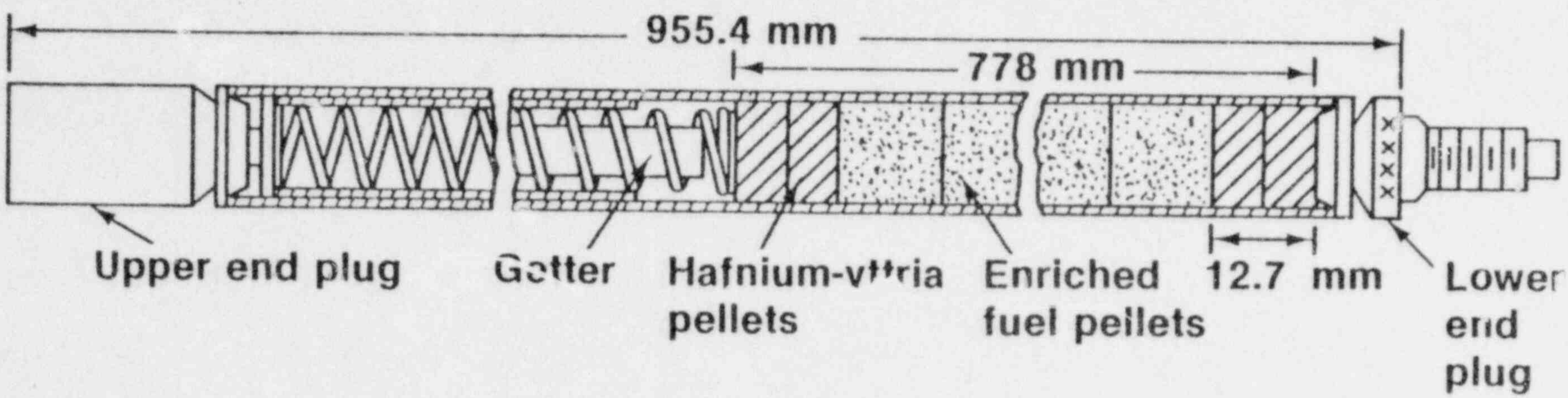

Fig. 1 Schematic representation of GE BWR/6 segmented fuel rod.

TABLE 1. TEST OPTRAN 1-2 FUEL ROD DESIGNATIONS AND BURNUPS

Original Rod Designation	Original Core Axial Location	Rod type	PBF OPTRAN Designation	Burnup (GWd/t)
N. A.	N. A.	Reference	902-1	0
0D07-4	Top	Reference	902-2	10
N. A.	N. A.	Reference	902-3	0
0A06-4	Top	Reference	902-4	10

TABLE 2. TEST OPTRAN 1-2 FUEL ROD DESIGN CHARACTERISTICS

CHARACTERISTICS[a]	GE BWR/6 RODS	HEATER RODS
Fuel		
Material	UO_2	UO_2
Enriched pellet stack length (mm)	752.6[b]	752.6
Pellet outside diameter (mm)	10.57 (0.416 in.)	10.57 (0.416 in.)
Pellet length (mm)	10.66 (0.420 in.)	10.66 (0.420 in.)
End configuration	chamfer	chamfer
Density (%TD)[c]	95 to 96	92 to 97
Initial enrichment (wt%)	2.87	10
Cladding		
Material	Zr-2	Zr-2
Tube outside diameter (mm)	12.52 (0.493 in.)	12.52 (0.493 in.)
Tube inside diameter (mm)	10.80 (0.425 in.)	10.80 (0.425 in.)
Cladding thickness (mm)	0.86 (0.034 in.)	0.86 (0.034 in.)
Fuel Rod		
Overall length (mm)	955.4[d] (37.6 in.)	As required
Gas plenum length (mm)	139.7 (5.5 in.)	As required
Flux depressor pellets	92.3% HfO_2-7.7% Y_2O_3	none
Diametral gas gap (mm)	0.305 (0.012 in.)	0.305 (0.012 in.)
Fill gas composition	As received	Helium
Fill gas pressure	As received	2.58 MPa
Getter assembly outside diameter (mm)	10.56 (0.416 in.)	none
Getter assembly length (mm)	50.8 (2.0 in.)	none

TABLE 2. (continued)

CHARACTERISTICS[a]	GE BWR/6 RODS	HEATER RODS
Shrouds		
Material	Zr-4	Zr-4
Tube outside diameter (mm)	22.225 (0.875 in.)	22.225 (0.875 in.)
Tube inside diameter (mm)	19.05 (0.75 in.)	19.05 (0.75 in.)
Connecting line outside diameter (mm)	17.462 (0.6875 in.)	
Connecting line inside diameter (mm)	14.287 (0.5625 in.)	

a. Data are preirradiation values.

b. Pellet stack also contains 12.7 mm (0.50 in.) of hafnium-ytrium oxide pellets at each end of fuel column. Total length 778 mm (30.03 in.).

c. Theoretical density (TD) of UO_2 is 10.97 g/cm^3.

d. Lower end plug has threaded extension for joining segmented pieces together. Length of extension piece is not known.

TABLE 3. TEST OPTRAN 1-2 FUEL ROD PRETEST CHARACTERIZATION

Measurement	Measurements Made on These Fuel Rods	Measurement Accuracy	Comments
Cladding outside diameter and fuel rod straightness	902-2, 902-4	Dia. ± .005 mm Str. ± 1.0 mm	PEC Scan at 10° intervals.
Gross gamma scan	902-2, 902-4		Gamma scan each rod at 0°.
Fuel rod overall length	All Rods	± 1 mm	Endcap-to-endcap. Should be measured after any end plug modifications.[a]
Neutron radiograph	902-2, 902-4		Neutrograph.
Fuel stack length	902-2, 902-4	± 1 mm	Obtain from neutron radiograph.
Leak check	All Rods		Each rod must pass leak check. Should be checked before any modifications.[a]
Photographs	902-2, 902-4		Photographs at 0° and 180° orientation. Photographs should be taken after thermocouples have been attached.
Fuel rod weight	All Rods	± 1.0 g	Weigh after end plug modifications have been completed.

a. These measurements will be made by the TFBP Technical Support Division.

In addition to the pretest characterization, a visual inspection should be made prior to assembly to make sure that the test rod cladding tubes are free from any severe scratches or defects. Scratches and/or defects shall be evaluated prior to use.

Angular orientation scribe marks will be made on both the upper and lower end caps of each fuel rod at zero degrees with an identifying index mark at zero degrees. In addition, the OPTRAN 1-2 rod designations given in Table 1 will be permanently marked on both ends of each rod for identification.

Secure positioning of the top end of each fuel rod is required. The rods must be fixed at the top to eliminate lateral, longitudinal, or rotational movement. The bottom end of the rods must be free to expand axially. The preirradiated rods will not be opened or penetrated in any manner during end plug modification or instrument attachment.

Each test fuel rod will be surrounded by a coolant flow shroud. The four shrouds will be fabricated of zircaloy-4 and will have a circular cross section with an inner diameter of 19.05 ± 0.1 mm (0.750 ± 0.004 in.) and a wall thickness of no more than 1.8 mm (0.07 in.). As-built diameter of each flow shroud should be obtained at 0° and 90°, at each end. Each flow shroud should have three centering screws at two axial elevations (± 254 mm from axial midplane of fuel). A spring mechanism on one centering screw at each elevation, combined with the two additional centering screws, will simulate the presence of a commercial BWR grid spacer.

The outlets of the flow shrouds for Rods 902-1 and 902-3 will be connected to the shroud inlets of Rods 902-2 and 902-4 with a tubing section of approximately the same cross-sectional flow area as the flow shroud annulus. The tubing should be designed with consideration given to minimizing flow resistance and leakage. A remotely operated orifice will be installed in the shroud outlets for Rods 902-1 and 902-3 to provide a bypass for the coolant exiting the heater rods. The orifice size will be adjusted during operation to provide the required flow split between heater rod and test rod. The adjustable orifice should have an opening time (10 to 90%) of about 5 seconds and flow capability from zero to 380 cm^3/s (6 gpm) in both subcooled and saturated (up to 15% quality) coolant. If a variable orifice cannot be designed and installed, a fixed orifice with provisions to size in the PBF canal will be installed. The leakage from the shroud inlets of the upstream rods to the outlets of the downstream rods should be minimized (with no orifice). Leakage path should be identified and leakage quantified for a pressure differential of 0.15 MPa. Figure 2 is a simplified schematic of the connection between the shrouds of the rod pairs. Figure 3 is a cross-sectional view showing the location of the fuel rods and flow shrouds in the test assembly.

3.2 Test Train Support Structure Design

The Battelle, Pacific Northwest Laboratory (PNL) 4X test assembly will be used for Test OPTRAN 1-2. Figure 4 is a pictorial view of the hardware.

The hardware will position symmetrically the four fuel rods in the PBF reactor in-pile tube. Each rod should be fixed rigidly at the top after installation in the test assembly, with the rod free to expand axially downward against the fuel rod axial growth measurement transducer (LVDT). The test fuel rods will be positioned such that the axial midplane of each active fuel stack is at the same elevation as the axial midplane of the PBF core fuel rods (±4 mm) and such that each rod is centered in each flow shroud.

The bottom flow restrictor orifice plates will be sized and the support structure modified to provide the minimum flow bypass obtainable with the Battelle hardware. The bypass to shroud flow ratio (combined) will be less than 6:1.

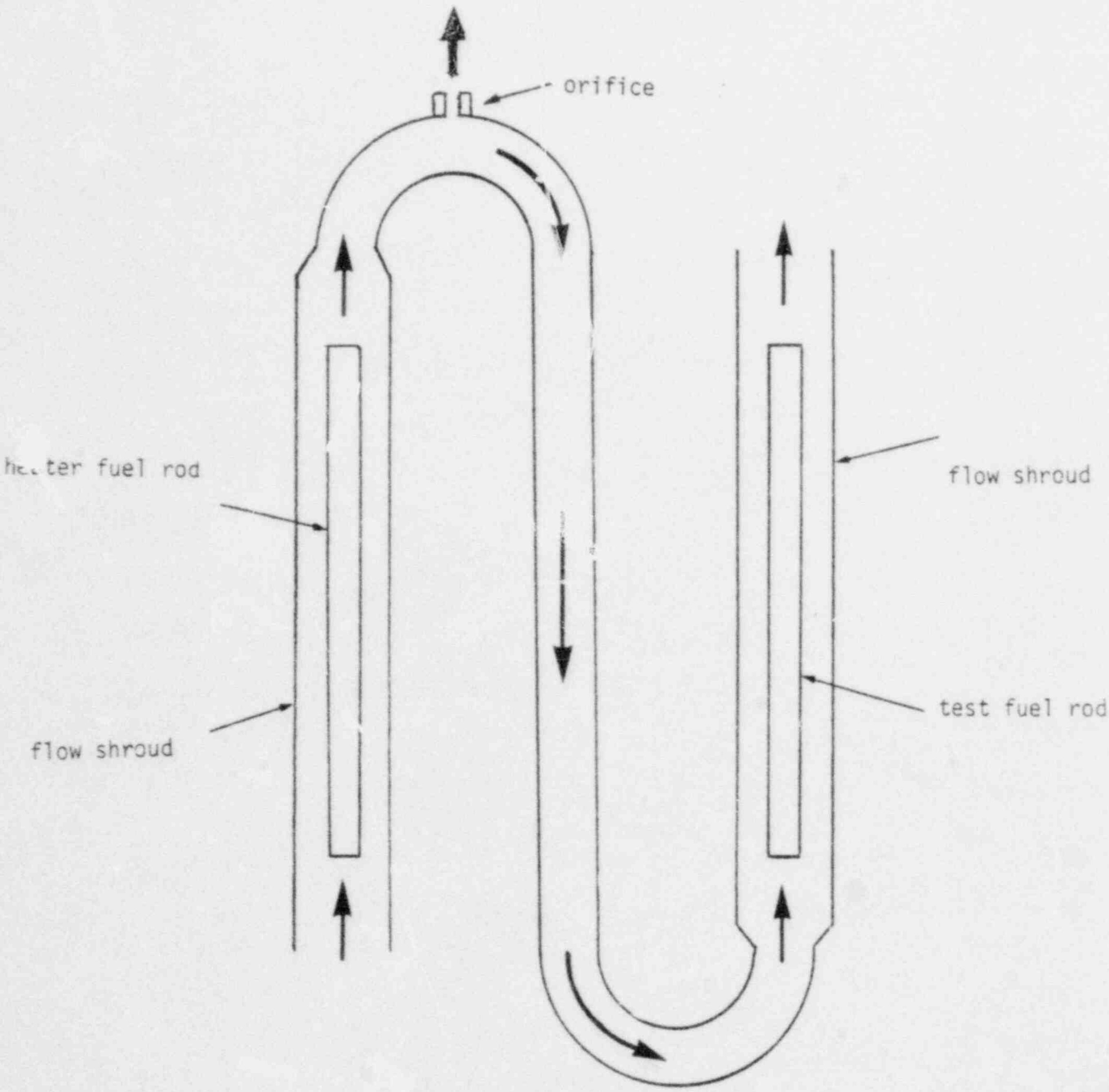

Fig. 2 Schematic of shroud pair showing flow path.

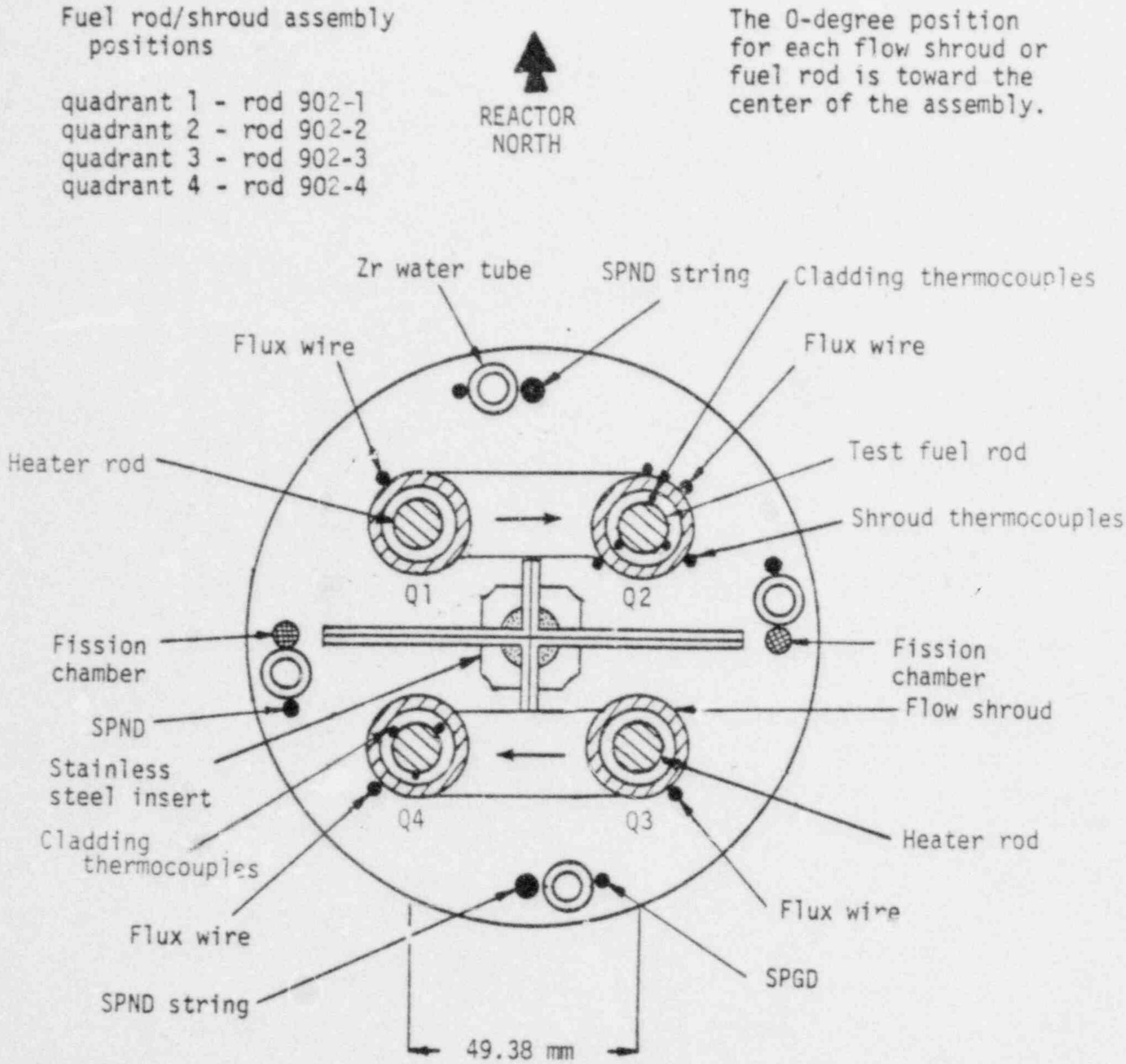

Fig. 3 Cross-sectional view of test assembly showing relationship between fuel rods, shrouds, and rod and shroud instrumentation.

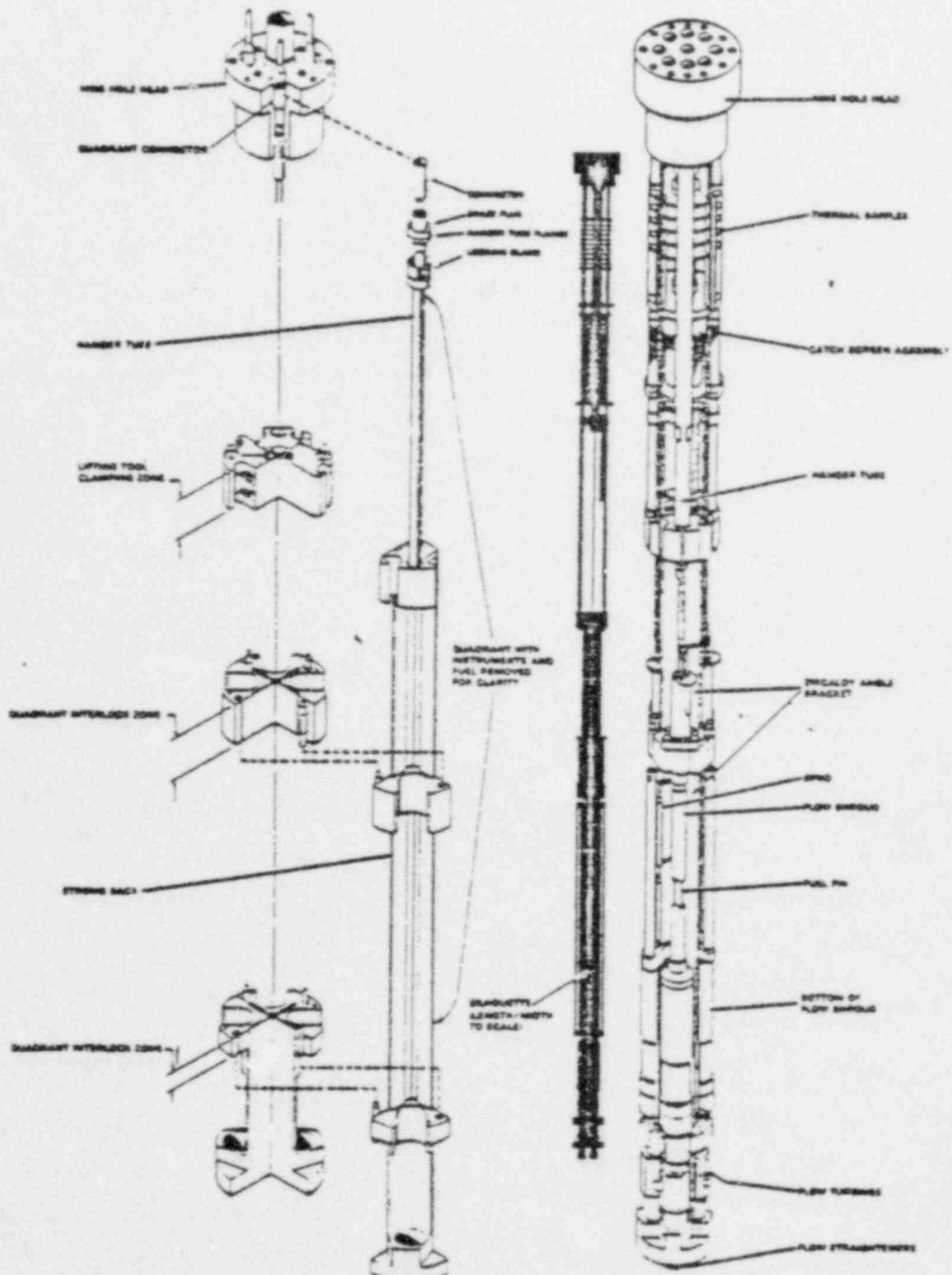

Fig. 4 The Battelle, PNL four quadrant test train assembly.

4. INSTRUMENT REQUIREMENTS

The instrumentation for this test is designed for calorimetric measurement of the rod power during steady state operation and to aid in determining fuel rod characteristics and failure mechanisms during an operational transient. Figure 3 (Section 2) illustrates the radial instrument placement for the test rods and flow shrouds. Table 4 contains a list of the instrumentation requirements for the test rods and flow shrouds, and Table 5 contains a list of the instrumentation required for the test train assembly. Instrument calibrations should be performed on the differential thermocouples (or representative ΔTs) and LVDTs over a range of temperature conditions from ambient to 561 K (550°F). The cladding thermocouples should be calibrated over a range of temperature conditions from ambient to 1000 K (1340°F).

4.1 Test Fuel Rods and Flow Shrouds Instrumentation

The two irradiated rods (Rods 902-2 and 902-4) will be instrumented each with three cladding thermocouples (6 thermocouples). The cladding thermocouples will be 0.70 mm (0.028 in.) diameter, zircaloy sheathed tungsten-rhenium per EG&G Drawing 411989-1. The thermocouple tips will be resistance welded to the fuel rod cladding. Preformed zirconium clips will be attached by resistance welding beginning approximately one inch from the tip of the thermocouple and spaced at about 125 mm (5 inch) intervals along the TC and up the fuel rod for support. One thermocouple on each of Rods 902-2 and 902-4 will be located at the 0° orientation (towards the test train axial centerline) and 70 $\pm$ 2.5 mm (2.76 $\pm$ 0.1 in.) above the axial midplane of the test rod fuel. A second thermocouple on each rod will be located at 120° and plus 170 $\pm$ 2.5 mm (6.69 $\pm$ 0.1 in.), and the third will be at 240° and plus 270 $\pm$ 2.5 mm (10.[illegible] $\pm$ 0.1 in.).

To evaluate radiation effects in the test train, three additional thermocouples will be located on the outer flow shroud wall in quadrant 2 isolated from the temperature of the shroud wall. These should be identical to the cladding thermocouples. One thermocouple will be located

TABLE 4. INSTRUMENT REQUIREMENTS FOR TEST OPTRAN 1-2 FUEL ROD AND SHROUD INSTRUMENTATION

Instrument	Measurement Location[a]	Fuel Rod or Shroud Number[b]	Instrument Range	Desired Accuracy	Comments
Cladding Thermocouples (6)	70 ± 2.5 mm - 0° 170 ± 2.5 mm - 120° 270 ± 2.5 mm - 240°	902-2 902-4	300 to 1300 K	as received	Resistance welded. Premium grade tungsten-rhenium per EG&G Drawing 411989-1. A minimum thermocouple size is required to limit perturbation of the dryout condition
Shroud flux wires(4)	180°	902-1, 902-2, 902-3, 902-4	as received	as received	0.51% cobalt, 99.49% aluminum. Each should be permanently tagged for identification.
Shroud thermocouples(3)	70 ± 2.5 mm - 0° 170 ± 2.5 mm - 120° 270 ± 2.5 mm - 240°	902-2	300 to 1300 K	as received	Same thermocouple size and type as used for cladding thermocouples

a. All elevations are relative to the axial midplane of the PBF core, all orientations relative to the center of the assembly.

b. Shroud number is the same as its corresponding rod number.

TABLE 5. INSTRUMENT REQUIREMENTS FOR TEST OPTRAN 1-2 TEST TRAIN ASSEMBLY

Measurement	Instrument	Instrument Location	Instrument Range	Instrument Accuracy	Comments
Coolant pressure	Pressure transducer (2)	One transducer attached by tubing to the midplane elevation of 902-2 and 902-4 flow shrouds.	0 to 17.2 MPa	±0.5 MPa	To measure system pressure during steady state and transient operation. Should be calibrated at ambient. Transducers will be out of head.
Coolant pressure	Pressure transducer (1)	One transducer located near the outlet of flow shroud 902-2.	0 to 17.2 MPa	±0.5 MPa	To measure normal system pressure. Should be calibrated from ambient to 600 K.
Coolant pressure	External pressure transducer (1)	Outside IPT head, near the shroud outlet of 902-4.	0 to TBD MPa[a]	±1% of full scale range	To measure normal system pressure. Transducer should be calibrated at ambient. Transducer will be out of head.
Coolant flow	Turbine flowmeter (4)	Inlet of flow shrouds.[b]	63 to 820 cm^3/s	±1% of full scale range	Should be calibrated to 820 cm^3/s.
Outlet coolant flow[c]	Turbine flowmeter (2)	In outlet of flow shrouds 902-2 and 902-4	63 to 820 cm^3/s	±1% of full scale range	Should be calibrated to 820 cm^3/s.
Coolant inlet temperature	Thermocouple (2)	In flow shrouds at inlet of Rods 902-2 and 902-4	300 to 600 K	as recieved	Premium grade Type K thermocouples.

TABLE 5. (continued)

Measurement	Instrument	Instrument Location	Instrument Range	Instrument Accuracy	Comments
Coolant inlet temperature	Thermocouple (2)	Inlet of flow shrouds 902-1 and 902-3.	300 to 600 K	as received	Premium grade Type K thermocouples.
Coolant outlet temperature	Thermocouple (2)	Outlet of flow shrouds 902-2 and 902-4.	300 to 600 K	as received	Premium grade Type K thermocouples.
Coolant outlet temperature	Thermocouple (2)	In flow shrouds at outlet of Rods 902-1 and 902-3.	300 to 600 K	as recieved	Premium grade Type K thermocouples.
Coolant inlet temperature	RTD (1)	Inlet region of test train.	300 to 600 K	as recieved	Premium grade RTD.
Coolant differential temperature	Thermocouple pairs (4)	One at inlet and outlet of each rod.	0 to 30 K	as received	Premium grade Type T thermocouples. Inlet leg should be calibrated up to 600 K.
Relative neutron flux	Cobalt SPNDs (762 mm) (2)	One detector located on the water tubes in quadrants 2 and 4. (0-mm elevation).	0 to 2.5×10^{14} $n/cm^2 \cdot s$	as received	Premium grade. Gamma and neutron sensitivity of each SPND must be measured.

TABLE 5. (continued)

Measurement	Instrument	Instrument Location	Instrument Range	Instrument Accuracy	Comments
Relative neutron flux (continued)	Cobalt SPNDs (100 mm) (10)	Two strings of five detectors each located on the water tubes in quadrants 1 and 3. (0, ±150, and ±300 mm)	0 to 2.5×10^{14} $n/cm^2 \cdot s$	as received	Premium grade. Gamma and neutron sensitivity of each SPND must be measured.
Relative neutron flux	U-235 fission chambers (2)	One fission chamber and one gamma compensating chamber located on the water tubes in quadrants 2 and 4. (0-mm elevation)	0 to 2.5×10^{14} $n/cm^2 \cdot s$	as received	Same type of chambers as OPTRAN 1-1. Gamma and neutron sensitivity of each chamber must be measured.
Relative gamma flux	Platinum SPGD (100 mm) (2)	One detector located on the water tubes in quadrants 1 and 3. (0-mm elevation)	0 to 6.0×10^{8} R/hr	as received	Premium grade. Gamma and neutron sensitivity of each SPGD must be measured. Active length will be 102 mm.
Cladding axial elongation	LVDT (4)	Bottom end of each rod	± 12.7 mm	±0.2 mm	Should be calibrated up to 600 K

a. Measurement range of transducer will be determined from a transient analysis of connecting measurement tubing used as a pulse attenuator.

b. If the line connecting the outlet of the heater rods to the test rod inlet cannot be routed to utilize normal test train flowmeters, a flowmeter in each connecting line will be substituted for inlet flowmeters on Rods 902-2 and 902-4.

c. A two-phase momentum flux measurement in the outlets of Rods 902-2 and -4 is highly desirable and should be considered for development.

at 0° on the flow shroud and at the +70 ± 2.5 mm elevation. A second thermocouple will be at 120° on the shroud and at the +170 ± 2.5 mm elevation, and the third thermocouple will be at 240° and +270 ± 2.5 mm.

The lower end caps of the OPTRAN 1-2 test rods should mesh with the plungers of the test train cladding linear variable differential transducers (LVDTs).

Four (0.51% cobalt - 99.49% aluminum) flux wires each enclosed in a small diameter zircaloy tube, will be attached to the outer wall of the flow shroud at 180° in each quadrant. Each flux wire will be identified with a marking or a permanent tag specifying shroud attachment. The as-built axial and lateral position of each flux wire holder will be measured. The flux wires will extend over the active fuel length of the rods; the bottom of the flux wires aligned with the bottom of the active fuel stack. Provision should be made for measurement (±2.5 mm) of the axial position of the flux wires.

4.2 Test Train Assembly Instrumentation

Four LVDTS will be fitted to the test train assembly to mesh with the lower endcaps of the rods.

Zircaloy-4 water-filled tubes (10.7 mm outer diameter) will fix strings of five cobalt self-powered neutron detectors (SPNDs) on the hardware in each of Quadrants 1 and 3. The active length of the cobalt emitters for these SPNDs is 102 ± 2 mm (4 in.), and they will be positioned at the axial midplane of the active fuel length, at ± 150 mm (5.9 in.), and at ± 300 mm (11.8 in.) from the axial midplane of the fuel (±2.5 mm). A platinum SPGD with an active length of 102 ± 2 mm will also be fixed to water tubes in each of quadrants 1 and 3. Water-filled tubes will also be used to fix one full length cobalt SPND in each of Quadrants 2 and 4. The active length of the cobalt emitters for these SPNDs will be 762 ± 2 mm (30 in.), and they will be axially centered. In addition, evacuated U-235 fission chambers with gamma compensating chambers will be fixed on the waterfilled tubes in Quadrants 2 and 4. The center of the sensitive length of each fission detector will be positioned at the PBF core axial midplane.

The Type T differential thermocouple pairs used to measure the coolant temperature rise through each flow shroud should be positioned to minimize measurement errors. The positioning and attachment of the coolant thermocouples and pressure transducers should also be designed to minimize measurement errors.

All the flowmeters will be calibrated prior to installation. Straightening upstream of the 902-1 and 902-3 flowmeters will be required. Due to volume constraints within the IPT flow tube, routing of the line connecting the heater rod outlets to the test rod inlets to utilize the normal test train inlet flowmeter configuration may not be feasible. In this event, a flowmeter in each connecting line will be required. Leak checks of the completed assembly will be performed to locate and quantify leakage in the test configuration.

The pressure transducers measuring coolant pressure at the midplane of Rods 902-2 and 902-4 will have water filled sense lines to out of head pressure sensors.

5. REACTOR OPERATION

Detailed reactor operation specifications will be provided in the Test OPTRAN 1-2 Experiment Operation Specification (EOS) document. The sequence will begin with about 24 hours of steady state power operation to condition the test fuel rods. During the steady state period, sufficient calorimetric data will be obtained to determine the figure of merit (F.O.M. = ratio of test rod power to driver core power) and an accurate basis for introducing the OPTRAN 1-2 rod power transients. Each transient will be initiated with steady state (inlet) coolant conditions of 550 K, 7.24 MPa, and 350 to 650 cm^3/s.

6. POSTTEST PROCEDURES

Closure plugs should be installed on the upper and lower ends of each flow shroud after removal from the test assembly to prevent loss of material during handling and shipment to the hot cell. Posttest handling, shipment and storage should be performed carefully to minimize the possibility of additional fuel rod damage. Fuel rods that have not obviously failed will be leak tested at the hot cell.

REFERENCES

1. D. W. Croucher, M. K. Charyulu, Experiment Requirements for the Study of Anticipated Transients With and Without Scram, TFBP-TR-308, January 1979.