CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

MASTER

Handwritten signature
SNPO-C

WANL-TME-1494

October, 1966

Westinghouse Astronuclear Laboratory

FLUID FLOW LABORATORY DEVELOPMENT TEST PROGRAM
(Title Unclassified)

Handwritten: TME 1494

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

50

MASTER

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1494

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1.g

TITLE: MULTIPLE CLUSTER THERMAL
TESTS

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Review	Class	Date
TR	U	4-14-82
SPECIAL REVIEW FINAL DETERMINATION		
Class: U		

Classification cancelled for changed to

by authority of

by H. F. C.

TIC, date

SEP 12 1973

OBJECTIVE: The objective of these tests is to study corrosion of the reactor peripheral and interstitial regions, particularly in the filler strip and seal areas, in order to better understand the mechanism of corrosion, the rate and extent of corrosion, the interaction of various components in regard to corrosion, and the effects of any peripheral component changes.

DESCRIPTION OF TEST: The model will be operated in a water-jacketed pressure vessel designed for containment of high pressures. The model includes components representative of the reactor and presently incorporates a core which has a diameter of 8.50 inches. A graphite electrical resistance heater element is mounted in the center of the core. The heater element is designed with a variable area cross section along its length to obtain a specific temperature distribution. The heater element transfers heat to the core by radiation, conduction and convection to a cylinder (inner core) surrounding the heater element. Mounted around the periphery of the inner core are approximately three rows of fuel elements with plugged flow channels and then filler strips. Fuel elements will be both fueled and unfueled. Around the outside of the filler strips are the seal segments and beryllium reflector, which are similar to those in the reactor.

TEST PARAMETERS:

Pressure Vessel Inlet Pressure:	250 to 850 psia
Core Inlet Pressure:	200 to 800 psia
Core Pressure Drop:	10 to 150 psid
Pressure Vessel Inlet Temperature:	Ambient (530°R)
Core Inlet Temperature:	600 to 650°R
Core Exit Gas Temperature:	4500°R
Core Material Temperature:	530 to 6000°R
Hydrogen Flow Rate:	0.02 to 0.2 lb/sec
Power Available:	250 KW

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

WANL-TME-1494

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-5. e

TITLE: SINGLE BORE BEHAVIOR

OBJECTIVE: The objectives of these tests are to determine the porous flow and corrosion characteristics of a single channel representative of a fuel element. Included in the corrosion characteristics will be matrix corrosion due to permeable flow as well as bore corrosion due to single channel flow.

DESCRIPTION OF TEST: Test specimens having a reduced outer diameter and an inner diameter of 99 mils and varying in length from 4 to 52 inches will be tested. Tests will be conducted at reactor flow rates and pressure levels either isothermal or with simulated reactor temperature profiles. The pressure differential across the specimen will be varied as required. Heat input to the specimen will be by means of radiant heat.

TEST PARAMETERS:

Fluid:	Hydrogen
Inlet Pressure:	650 to 750 psia
Temperature:	Ambient to 5000°R
Flow Rate:	.002 to .020 lbs/sec
Radial Pressure Differential:	10 to 90 psid

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-6. a

TITLE: 360° REACTOR SHIELD
TEST

OBJECTIVE: The objectives of these tests are to determine the general flow characteristics and flow distribution within the reactor/shield annulus, to define instrumentation and purge flow required during reactor tests, to select the best of the four gaseous nitrogen purge configuration schemes, and to signal any obvious problem areas involved in the use of the 360° shield annulus purge system.

DESCRIPTION OF TEST: A 1/8 scale model of the reactor, 360° shield, test car privy roof, gaseous nitrogen distribution system, and an impedance collar has been mocked up. Air will be flowed through various manifold configurations. Photographs and data will be taken of thread streamers and injected smoke. Annular pressure drop, annular temperature, and pressure drop across the impedance collar will be recorded. Reynold's similarity will be used to correlate the air flow, pressure and temperature data to the nitrogen flow requirements of the prototype.

TEST PARAMETERS:

Fluid:	Air
Inlet Pressure:	Approximately Atmospheric
Temperature	Ambient
Flow Rate:	0.2 lb/sec max.
Purge Technique	Variable

CONFIDENTIAL

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

**Astronuclear
Laboratory**

WANL-TME-1494

October, 1966

FLUID FLOW LABORATORY DEVELOPMENT TEST PROGRAM
(Title Unclassified)

by

Fluid Flow Laboratory Staff

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Concurrence:

H. S. McCreary, Manager
Advanced Reactor Design

Concurrence:

J. G. Gallagher, Manager
Thermal and Nuclear Design

Approved By:

E. A. DeZubay, Manager
Fluid Flow Laboratory

INFORMATION CATEGORY

CONFIDENTIAL R.D.

9/22/66
Authorized Classifier Date

CONFIDENTIAL

RESTRICTED DATA

Atomic Energy Act - 1954

FLUID FLOW LABORATORY DEVELOPMENT TEST PROGRAM

The test plan summarized in very brief form in this document succeeds that issued previously (Reference 1). Many of the tests listed in the previous test plan are now two years old and have become obsolete. The evolution and redirection of the NERVA Program have resulted in requirements which are no longer met by the general categorization of test designations used in the reference document. The present test plan summarized on Table I now recognizes and considers the needs of the NERVA reactor, of the NRX and XE requirement, as well as the information needs required by Reactor Analysis and Reactor Design; for their prediction reports on all engines. These requirements have been coordinated with the groups requiring the information.

The test nomenclature reverts to the philosophy originally proposed in WANL-TNR-095, which detailed the original test plan associated with the NRX development (Reference 2). The major components of the reactor are classified into four main parts: the core, the lateral support and seal system, the reflector, and the dome end. In addition to these there are two general categories: general development and miscellaneous tests. The general development category will consist of tests where basic information applicable to all types of reactors can be generated. The miscellaneous test category will provide for tests of an unexpected nature. This category can encompass problems associated with "trouble shooting" or unexpected reactor behavior requiring immediate component evaluation.

In alphabetical order each major part is divided into the sub-component and tests associated with those sub-components will be designated by numeric sequences. Additional sub-components can be added as needed to the test categorization by additional lettered groupings. For example, the twentieth test on a cluster will be designated as 1a0.0020. Similarly

CONFIDENTIAL
RESTRICTED DATA

Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1494

fuel element tests will be designated as being part of the core sub-component "b", labeled elements, and if they are tested at Waltz Mill (WANHES) will carry the designation 1.0003 for the third test or 2.0060 to designate the sixtieth test performed at the Large Site on a single element corrosion test. The prefix 1 being used to denote WANHES and the prefix 2 to denote the Large Site.

The chart labeled Table I summarizes this classification system for major parts, sub-components, and the equivalent tests as defined in the previous test plan (Reference 1). The NERVA NR-1 requirements as listed in WANL-TME-1419, the NRX-A6 Requirements, and the Reactor Analysis Information Needs are all presented on Table I. The balanced program set up to accomplish all these needs is indicated. The remaining part of this document describes the tests to be performed under each of the categories presently defined. These descriptions are brief and are intended to provide a general description of the type of test involved and not a precise definition, since the exact geometric designs of the test models are not yet available.

These test designations will go into effect October 1, 1966.

Ref. 1 - WANL-TME-1034, "NRX-A Component Test Program," dated November 1964.

Ref. 2 - WANL-TNR-095, "Component Test Program," dated May 1963.

CONFIDENTIAL
RESTRICTED DATA

Atomic Energy Act - 1954

TABLE I

Part	Sub-Component	Equivalent Test (TME-1034)	NR Requirements (TME-1419)	NRX-A6 Requirements	Reactor Design Information Needs	Reactor Analysis Information Needs	Specification Requirement
1. Core	a. Cluster	HHT-4	E2, H1, G1, G2	X	X		
	b. Element (Prefix 1 = WANHES) (Prefix 2 = Large Site)	HHT-1, 2	F1		X	X	X
	c. Thermocouple	HHT-5	H5		X		
	d. Orifice	FFL-6	F3			X	
	e. Tie Rod	FFL-21 HHT-5	E1, E2 E3, E4		X X	X X	
	f. Support Block (Single Element)	HHT-2	G1		X	X	X
2. Lateral Support and Seal	a. Filler Strip	HHT-7	C4		X	X	
	b. Seal Segment	FFL-18	C4	X	X	X	
	c. Plunger Pin Capsule	FFL-32	C1	X	X	X	
	d. Plunger Sleeve		C1				
	e. Spring Cooling		C1		X	X	
3. Reflector	a. Control Drum	FFL-8	B2	X		X	
	b. Reflector	FFL-19					
	c. Impedance Ring	FFL-20					
	d. Insulating Baffle	FFL-31	A4	X		X	
	e. Nozzle End Seal	FFL-23			X		X
	f. Flow Distribution		A3			X	

TABLE 1 (CONTINUED)

Part	Sub-Component	Equivalent Test (TME-1034)	NR Requirements (TME-1419)	NRX-A6 Requirements	Reactor Design Information Needs	Reactor Analysis Information Needs	Specification Requirement
4.	Dome						
	a. Shield		D2		X	X	
	b. Support Plate						
	c. Reflector Plenum	FFL-19				X	
	d. Instrument Ports	FFL-26			X		
	e. Seals		A1		X	X	
5.	General Development						
	a. Heat Transfer	HHT-19					
	b. Interstitial Corrosion	HHT-6				X	
	c. Permeability	FFL-26	C2			X	
	d. Thin Gap Flow	FFL-30	A2			X	
6.	Miscellaneous Tests	(Sub-components and sequences will be defined as needed.)					

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1.a

TITLE: SINGLE CLUSTER DEVELOP-
MENT TESTS

OBJECTIVE: The objectives of these tests are to determine the behavior of a fuel cluster including the fuel elements, tie rod and/or counterflow tie tube, and support block and/or blockless components; as a completely integrated assembly under reactor environmental conditions (without nuclear radiation). This is necessary in order to verify the analyses and investigate the combined thermal, physical and corrosion effects on the fuel elements and support assembly.

DESCRIPTION OF TEST: The cluster is installed in the center of a vertical furnace and heated by direct current using the elements as the resistance. Gaseous hydrogen flows through the holes of the element of the cluster and an inert atmosphere is maintained around the cluster. The hot gas is discharged into an ell shaped transition, through a heat exchanger, filtered, and finally flared and vented into the atmosphere. A pneumatic control system permits varying of the flow and pressure as required and electrical power controls permit varying temperature and rate at which power is applied to the cluster.

TEST PARAMETERS:

Cluster Exit Gas Pressure:	Up to 750 psig
Cluster Exit Gas Temperature:	Up to 5200°R
Hydrogen Mass Flow:	Up to 0.2 lb/sec
Time at Temperature:	Up to 60 Minutes by Cycling
Power Available:	2.8 MW on 20 Minutes Duty Cycle

Single Cluster Corrosion Test Assembly

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1.b

TITLE: SINGLE ELEMENT PROCESS
DEVELOPMENT AND
EVALUATION TESTS

OBJECTIVE: The objective of these tests are to evaluate process control of fuel elements, to supply reactor design information, evaluate materials, determine the fuel element life, assist in coating development, evaluate fuel elements for the fuel element pilot plant and obtain results for special tests as required by reactor testing.

DESCRIPTION OF TEST: The fuel elements are mounted in chucks in the center of a horizontal pressure vessel. Gaseous hydrogen flows through the channels of the fuel element and is heated by direct current using the element as the resistance. An inert atmosphere is maintained around the outside of the element. Time, temperature, flow, pressure and power level are varied to obtain the conditions necessary to interpret fuel element improvements.

TEST PARAMETERS: The major test parameters are element surface temperature, power input, hydrogen flow and pressure, time at power and recycles. The specific parameters will depend on the reactor design conditions for which the elements are being developed.

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1. c

TITLE: CORE THERMOCOUPLE
DEVELOPMENT AND
QUALIFICATION TEST

OBJECTIVE: These are a continuing series of tests intended to accomplish the development and qualification of core material thermocouples and core cluster exit gas thermocouples for the NERVA Reactors. These tests will determine the accuracy and life of thermocouple assemblies in a simulated reactor core environment.

DESCRIPTION OF TEST: The test facility is a high pressure furnace in which a full length fuel element containing the test model thermocouple is heated to the same operating temperature and temperature distribution as in the NERVA Reactor. The heat is supplied to the fuel element by a surrounding graphite radiant heater powered by direct electric current. The test is arranged for hydrogen gas to flow through the fuel element during the test. A helium gas blanket surrounds the uncoated exterior of the fuel element to prevent surface corrosion. For testing core exit gas thermocouples, the hot hydrogen flowing through the heated fuel element is impinged on the model thermocouple to be tested.

TEST PARAMETERS:

Fluid:	Hydrogen and Helium
Pressure:	50 to 700 psig
Temperature:	5200°R Maximum

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1.d

TITLE: ORIFICE CALIBRATION
AND TEST

OBJECTIVE: The objectives of these tests are to determine the flow characteristics of fuel element orifices under various operating conditions and to determine the effect of future design changes and perturbations on the flow characteristics. Curves of Loss Coefficient versus Reynolds Numbers will be plotted for the various orifice sizes tested for the various perturbation conditions. Design curves of loss coefficient for design Reynolds Number versus Orifice Diameter will also be obtained, and used to orifice the reactor core for the correct flow and temperature distribution.

DESCRIPTION OF TEST: Hydrogen gas enters the inlet plenum of the test fixture and passes through the simulated cluster plate, through the orifice under test and exhausts into the simulated fuel element section. The entire flow test passage can be immersed in liquid nitrogen for low temperature tests. The flow rate is measured with a sonic orifice downstream of the test section. The flow rate is varied over the flow range, and pressure, temperature, and pressure drop measurements are recorded for each flow rate. Tests will include efforts to determine the possible effects of heat addition, cross flow and cluster plate design changes, and proximity on the orifice flow characteristics.

TEST PARAMETERS:

Fluid:	Hydrogen (Constant)
Inlet Pressure:	50 to 700 psi (Constant)
Inlet Temperature:	140 to 540°R (Constant)
Mass Flow:	0 to 0.003 lb/sec (Variable)
Orifice Diameter:	0.0225 to 0.070 Inches (Variable)
Pressure Drop:	(Measured Variable)

CONFIDENTIAL
RESTRICTED DATA

Atomic Energy Act - 1954

Astronuclear
Laboratory
WANL-TME-1494

Orifice Test Fixture

CONFIDENTIAL
RESTRICTED DATA

Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1. e

TITLE: TIE ROD HARDWARE FLOW
TESTS

OBJECTIVE: The objectives of these tests are to determine the sealing effectiveness under simulated reactor operating conditions of tie rod system seals as they would be installed in the reactor and also to determine the tie rod or tie tube system flow characteristics with varying inlet parameters. This information is required to predict the exit temperature of the tie rod channels.

DESCRIPTION OF TEST: To determine the sealing effectiveness of the tie rod system seals, models will be fabricated which include the various seals which appear in the reactor. The seal leakage characteristics will be determined as a function of geometry, seal loading and surrounding reactor conditions. To determine the tie rod or tie tube system flow characteristics, models will be fabricated which include reactor geometry pertinent to the flow system. Hydrogen gas flow rate, at reactor operating conditions, will be varied over a wide range to determine local pressure drop and impedance characteristics and also conditions affecting effluent mixing. The design requirements will be determined for satisfactory mixing of the effluent gas with the other core flow as a function of the turbulence of the flow and the length or configuration of the flow path.

TEST PARAMETERS:

Fluid:	Hydrogen (Constant)
Inlet Pressure:	700 psia (Constant)
Inlet Temperature:	140 to 540°R (Constant)
Mass Flow:	0 to 0.02 lbm/sec (Variable)

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

**Astronuclear
Laboratory**
WANL-TME-1494

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-1. f

TITLE: SUPPORT BLOCK TESTS

OBJECTIVE: The objective of these tests is to corrosion test support blocks and support block lobes at the exit end of a single fuel element. Data will be obtained on coating adherence under cyclic and steady-state condition for various temperature, flow rates, and times.

DESCRIPTION OF TEST: The support blocks and support block lobes will be mounted downstream of a single fuel element and hot hydrogen will flow through the holes of the block. Various combinations of holes in the blocks may be plugged to better simulate flow conditions or obtain temperature gradients.

TEST PARAMETERS: The latest fuel element quality control specification will be used when a support block and/or lobe is tested for reactor acceptability. Specific pressure, temperature, flow, and time parameters will be used for development tests in accordance with reactor requirements.

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-2. a

TITLE: FILLER STRIP CORROSION
TESTS

OBJECTIVE: The objectives of these tests are to study corrosion in the reactor peripheral regions, particularly in the filler strip and seal areas, and also to develop means for reducing corrosion and permit more accurate predictions of corrosion as a function of temperature, pressure, hydrogen flow rate, etc. ; in the areas under consideration.

DESCRIPTION OF TEST: The filler strip corrosion test is performed in the Single Cluster Corrosion Furnace. The test components consist of simulated filler strips surrounding a graphite core in the single cluster configuration. The core is hollow in the center in order to accommodate a graphite heating rod. The filler strips are bundled together by a series of simulated seal segments. Expansion of the filler strips upon heating is provided for by a spring loaded lateral support system.

TEST PARAMETERS: Test parameters of pressure, maximum filler strip temperature, hydrogen flow rate, time, and pressure drop, will be determined by reactor design conditions.

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

**Astronuclear
Laboratory**
WANL-TME-1494

611102-1B

Hot Buffer Filler Strip Corrosion Test Model

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-2. b

TITLE: SINGLE SEAL SEGMENT
TESTS

OBJECTIVE: The objectives of these tests is to determine flow rate-pressure drop characteristics of the seal segments in the lateral support system. This includes the measurement of total design flow and the isolation of individual flows. The tests will be conducted in order to obtain required design data and to demonstrate component performance.

DESCRIPTION OF TEST: The test section consists of two flat seal segments representing one-twelfth of a full seal designed for the reactor. These segments are hand fit to the stainless steel reflector simulator by use of a set of parallels that allow each set of segments to be fit in exactly the same manner. With this sytem of control on the fit of the seal segments, it is possible to isolate flow rates through extra seal joints considering that the interface and end leakage flows do not change due to the consistency of fit. The seal system is loaded through a plunger and spring system not typical of the reactor but simulating the reactor loading. This system has the capability of varying the load over a wide range. This system will be run against a filler strip assembly containing no gaps; however a filler strip gap can be incorporated in the design with little difficulty.

TEST PARAMETERS:

Fluid:	Hydrogen (Constant)
Inlet Pressure:	500 to 700 psia (Constant)
Pressure Differential Across the Seal System	0 to 50 psig (Variable)
Temperature:	530°R (Constant)
Flow Rate:	0 to 0.2 lb/sec Hydrogen (Measured Variable)

SINGLE SEAL FIXTURE CUTAWAY

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-2. c
TITLE: PLUNGER PIN CAPSULE
SEAL TESTS

OBJECTIVE: The objective of these tests is to determine the leakage rate of the copper seals used to seal the titanium plunger pin capsule to the beryllium reflector. The seal design and the required torque must be established to minimize leakage flow.

DESCRIPTION OF TEST: A model, fabricated of beryllium containing the capsule cavity and related reactor geometry, will be tested in conjunction with a titanium plunger pin capsule and seals to determine leakage flow characteristics. Initial tests will be conducted with hydrogen at ambient temperature followed by testing at cryogenic temperatures and eventually thermal cycling.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psig
Differential Pressure:	10 to 200 psig
Temperature:	140 to 530°R
Flow:	(Measured Variable)

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

**Astronuclear
Laboratory**
WANL-TME-1494

Plunger Pin Capsule - Seal Leakage Test Assembly

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-2. d

TITLE: PLUNGER PIN CAPSULE
FLOW IMPEDANCE TESTS

OBJECTIVE: The objective of these tests is to determine the plunger pin capsule flow impedance characteristics. The tests will be conducted to obtain required design data as a function of geometry, clearance, and environmental flow conditions.

DESCRIPTION OF TEST: The test model consists of a stainless steel block into which three plunger pin capsule cavities have been machined. The axial flow hole at right angles to the cavities and intersecting all three in series is also included. Simulated plunger pin capsules are installed in the cavities. Hydrogen gas at reactor pressure level enters the inlet to the model, flows around the first capsule, the second and the third capsule; and exhausts into the atmosphere. Pressure drop across the individual capsules is measured as a function of geometry and other test parameters.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psig
Differential Pressure:	Measured Variable
Temperature:	140 to 530°R
Flow:	0 to 0.02 lb/sec

NRX-A6 PLUNGER PIN CAPSULE FLOW TEST FIXTURE

611366-3B

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1494

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-2. e

TITLE: LATERAL SUPPORT SPRING
COOLING TESTS

OBJECTIVE: The objective of these tests is to determine the adequacy of conduction cooling of the lateral support springs as a function of manufacturing variations, tolerance stack-up and eccentric positioning.

DESCRIPTION OF TEST: The model consists of a stainless steel tubing containing an electrically heated spring. The entire assembly is submerged in liquid nitrogen and tested at various pressure and power levels.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	100 to 750 psig
Temperature:	140 to 530°R
Flow:	Stagnant Hydrogen

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

CONFIDENTIAL

RESTRICTED DATA

Atomic Energy Act - 1954

Hot Spring Test Fixture

CONFIDENTIAL

RESTRICTED DATA

Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3.a

TITLE: CONTROL DRUM FLOW
TESTS

OBJECTIVE: The objective of these tests is to determine the flow impedance characteristics of the control drum system. This information is required to design data to insure proper flow distribution and cooling within the control drum.

DESCRIPTION OF TEST: The models consist of mock ups of the reactor geometry which exists within the control drum system. Included in these are the control plate, control drum bearing, control drum bearing housing, etc. The tolerances and proximity of various components within the models will be varied and the effect of these variations on the flow rate-pressure drop characteristics and flow distribution will be determined.

TEST PARAMETERS:

Fluid:	Hydrogen
Inlet Pressure:	700 psig
Temperature:	140 to 530°R
Mass Flow:	0 to 0.2 lb/sec
Pressure Drop:	Measured Variable

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3.b

TITLE: REFLECTOR IMPEDANCE
FLOW TESTS

OBJECTIVE: The objective of these tests is to determine the flow impedance characteristics of the channels and orifices within the reflector. This information is required to verify the analyses and to define the flow rate and flow distribution through the reflector system.

DESCRIPTION OF TEST: Models will be constructed containing the orifices and small clearances which exist within the reflector system. The models will be installed in a flow loop and the pressure drop as a function of geometry, tolerances, gas density, viscosity and flow rate will be determined for a range that includes reactor conditions.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	100 to 750 psig
Temperature:	140 to 530°R
Mass Flow:	0 to 0.2 lb/sec
Pressure Drop:	Measured Variable

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3. c

TITLE: IMPEDANCE RING TESTS

OBJECTIVE: The objectives of these tests is to determine the flow rate-pressure drop characteristics of the impedance ring which may exist between the beryllium reflector and the pressure vessel. This information is required to obtain experimental data for use in the analysis of the impedance ring.

DESCRIPTION OF TEST: The model contains a circumferential segment of the impedance ring which exists between the outer reflector and the pressure vessel. Included in the model is a region with dimensions and geometry necessary to mock-up the inlet and outlet to the impedance ring. Flow is introduced into the plenum at the inlet to the impedance ring. Flow passes from the plenum, through the slots in the impedance ring and into the annulus which exists between the outer reflector and the pressure vessel. From the annulus the flow exhausts into a plenum. The pressure drop across the impedance ring, and the pressure drop in the annulus is measured for various flow rates. The effects of cross flow and back side leakage will also be evaluated.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psig
Differential Pressure:	Measured Variable
Temperature:	140 to 530°R
Flow:	0 to 0.2 lb/sec

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3. d

TITLE: REFLECTOR INSULATING
BAFFLE TESTS

OBJECTIVE: The objectives of these tests is to determine the effectiveness of the thermal baffle in reducing the thermal gradients in the reflector. This information is required to determine the temperature of the hydrogen in the annulus and temperature distribution within the beryllium reflector.

DESCRIPTION OF TEST: The model contains a section of the baffle large enough to isolate an area free of end effects. Heating to simulate the beryllium reflector and cooling to simulate the reflector-pressure vessel annulus are provided. Interfacial pressure between the baffle and reflector will be controlled. The temperatures and heat flux levels of the reactor will be simulated, and the surface adjacent to the baffle will be instrumented to measure the temperatures and temperature distributions.

TEST PARAMETERS:

Fluid:	Hydrogen and Helium
Pressure:	50 to 700 psig
Temperature:	140 to 530°R
Flow:	Stagnant

THERMAL BAFFLE EFFECTIVENESS TEST FIXTURE

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3. e
TITLE: NOZZLE INTERFACE SEAL
PERFORMANCE TESTS

OBJECTIVE: The objectives of these tests is to determine the flow-pressure differential characteristics and prove the structural integrity of the nozzle interface seals. Data obtained will be used for design purposes and internal information.

DESCRIPTION OF TEST: Standard reactor fits are effectively simulated in the nozzle interface seal fixturing which consists of a circular aluminum pressure vessel and a reflector simulator. The reflector simulator is a copy of the lower portion of the inner reflector, made to reactor specifications of dimensions, surface finishes, and relief holes. The reflector simulator is cemented to the aluminum lid of the test fixture and remains an integral part of the lid for the duration of the test program. The nozzle seal is placed in the pressure vessel and is properly compressed when the reflector simulator is bottomed on the floor of the pressure vessel which simulates the nozzle flange. The test parameters listed below will be met by maintaining the total pressure upstream of the seal constant while the flow through the fixture is varied. Before and after each test, critical seal dimensions will be checked to clearly define its shape and size and show if any permanent change was incurred by the performance testing.

TEST PARAMETERS:

Inlet Pressure:	750 psig
Pressure Differential:	0 to 200 psid
Proof Test Pressure Differential:	300 psid
Temperature:	Ambient
Test Medium:	Hydrogen Gas

NOZZLE INTERFACE SEAL MODEL

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-3. f
TITLE: REFLECTOR FLOW
DISTRIBUTION TESTS

OBJECTIVE: The objective of these tests is to study the steady state and transient flow and temperature behavior of the beryllium reflector. This information is required to verify the analytical methods used to predict the temperature and flow behavior of the system.

DESCRIPTION OF TEST: Tests will be conducted on a model which will simulate a segment of a sector of the beryllium reflector. The model will contain reactor geometries and will have both external and internal heat input and will be tested under simulated reactor conditions.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psid
Temperature:	140 to 530°R
Mass Flow Rate:	0.02 to 0.2 lb/sec

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-4. a

TITLE: SHIELD FLOW TESTS

OBJECTIVE: The objective of these tests is to determine the flow rate-pressure drop characteristics of the shield modules as a function of geometry, tolerances, and other pertinent dimensions under simulated reactor operating conditions.

DESCRIPTION OF TEST: The model will be designed to contain a single shield module mounted in a simulated reactor geometry. Hydrogen will enter the inlet plenum, flow around the module and exhaust into the outlet plenum. The dimension of the hardware as well as the concentricity will be varied to determine the effect on the flow rate-pressure drop characteristics.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psig
Temperature:	140 to 530°R
Mass Flow:	0.02 to 0.2 lb/sec

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-4. b

TITLE: SUPPORT PLATE FLOW
TESTS

OBJECTIVE: The objective of these tests is to obtain the flow rate-pressure drop characteristics of the support plate and associated core axial support system. This information is required to verify the analyses and to define the flow distribution at the inlet to the core.

DESCRIPTION OF TEST: A model containing the geometry and hardware common to a segment of the core support plate as defined by a cluster will be constructed. Hydrogen will enter the plenum upstream of the core support plate, flow through the core support plate and exhaust into the outlet plenum. The flow distribution and local pressure drops within the system will be measured.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	700 psig
Temperature:	140 to 530°R
Mass Flow:	0.02 to 0.2 lb/sec

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-4. c

TITLE: REFLECTOR EXIT PLENUM
FLOW DISTRIBUTION TESTS

OBJECTIVE: The objective of these tests is to determine the flow distribution in the beryllium reflector exit plenum. This information is required to verify the analysis and to define the flow rates and flow distribution within the reflector system.

DESCRIPTION OF TEST: A model will be constructed containing all the hardware and geometry which exists in the reflector exit plenum. Included in the model will be all channels and passages which conduct fluid to and away from the reflector exit plenum. Flow and pressure within the channels as well as within the plenum will be measured.

TEST PARAMETERS:

Fluid:	Air and Hydrogen
Pressure:	100 to 700 psig
Temperature:	530°R and 140 to 530°R
Mass Flow:	0.5 to 0.2 lb/sec

REFLECTOR EXIT PLENUM FLOW TEST FIXTURE

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1494

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-4. d

TITLE: INSTRUMENTATION PORT
QUALIFICATION TESTS

OBJECTIVE: The objective of these tests is to qualify the proposed seal block assemblies for use in the reactor pressure vessel for instrumentation lead penetration and for the emergency purge ports. The qualification tests will include determining the sealing integrity of the mechanical, the welded, and the brazed interfaces. This will be accomplished through hydrostatically, pneumatically, thermally, and mechanically generated material stresses.

DESCRIPTION OF TEST: Models will be constructed containing the seals and mechanical joints which occur in the instrumentation and emergency purge ports on the dome end of the reactor pressure vessel. The seals will be pressurized and the leakage rate measured before and after subjecting the hardware to a series of environmental tests.

TEST PARAMETERS:

Fluid:	Hydrogen and Helium
Pressure:	50 to 800 psig
Temperature:	140 to 520°R
Leak Rate:	Measured Variable

**CONFIDENTIAL
RESTRICTED DATA**

Atomic Energy Act - 1954

Instrumentation Port Qualification Test Fixture Brazed Joint

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-4. e

TITLE: REACTOR SEAL TESTS

OBJECTIVE: The objective of these tests is to determine the sealing effectiveness of the various seals currently planned for the reactor. The sealing effectiveness must be determined to ascertain by-pass leakage magnitudes. Seals occur between the core support plate and the forward end of the reflector, and also between the core support plate and the shield. This information is required to determine the magnitude of the leakage which can cause local perturbations in the core inlet temperature and should be accounted for to minimize fuel temperature variations.

DESCRIPTION OF TEST: A torus-shaped pressure vessel will be built into which mock-ups of the surrounding seal surfaces may be attached. Seal leakage magnitudes will be determined under ambient helium and/or hydrogen flow conditions for various pressures and pressure drops across the respective seals. The effects of seal preload deflection and eccentricity on leakage magnitudes will be determined as necessary. Seal dimensions will be recorded before and after each test series and general seal conditions noted.

TEST PARAMETERS:

Fluid:	Hydrogen and/or Helium
Inlet Pressure:	100 to 700 psia
Pressure Drop:	0 to 40 psi
Temperature:	530°R
Seal Deflections and Eccentricities.

Reactor Seal Test Fixture

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-5.a

TITLE: INTERSTITIAL GAP HEAT
TRANSFER TESTS

OBJECTIVE: The objective of these tests is to study heat transfer and boundary layer development in interstitial channels representative of those interstitial gaps found in the reactor. Heat transfer coefficients will be calculated and correlated with data obtained from previous studies on heat transfer in channels and tubes.

DESCRIPTION OF TEST: A 19 hole non-fueled element will be instrumented with thermocouples in all of its peripheral coolant channels to measure material temperatures at various axial locations. The shroud surrounding the element will be broached to provide a clearance representative of reactor flow gaps. The shroud will be instrumented with thermocouples to facilitate calculation of heat transfer coefficient along the gap. In addition, the shroud will contain nine viewholes located at three axial stations and angularly at 0°, 120° and 240°; through which the interior temperatures of the shroud will be observed.

TEST PARAMETERS:

Fluid:	Helium and/or Hydrogen
Pressure:	600 psi
Flow Rate:	.0005 to .005 lb/sec
Element Temperature Profile:	Variable by Using Preheated Gas
Interstitial Gaps:	.005 to .015 Inch

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-5. b

TITLE: INTERSTITIAL CORROSION
TESTS

OBJECTIVE: The objective of these tests is to measure the corrosion rate of graphite materials with dimensions representative of the interstitial and filler strip gaps in the reactor. Reactor environmental conditions of temperature and pressure are simulated. This information is required to predict the operational capability of reactors.

DESCRIPTION OF TEST: A test rig is in existence and others are being designed to incorporate various test sections representing the gaps expected to occur in the core between the filler strips, fuel elements, etc. ; and subjecting them to simulated reactor conditions. The slot sizes and materials are being simulated in the test models; however gap length varies from two inches long subjected to an isothermal condition to 12 inches long having a temperature profile.

TEST PARAMETERS:

Fluid:	Hydrogen
Pressure:	100 to 750 psia
Temperature:	530 to 5000°R
Mass Flow Rate:	0 to 0.02 lb/sec
Geometry:	(Variable)
Material:	(Variable)

CONFIDENTIAL
RESTRICTED DATA
 Atomic Energy Act - 1954

**Astronuclear
 Laboratory**
 WANL-TME-1494

① HOUSING	⑩ HEATER
② PIN	⑪ OUTER CAN
③ SEAL	⑫ NUT
④ CAP	⑬ CLAMP
⑤ PLUG	⑭ UPPER PLUG
⑥ LOWER PLUG	⑮ PIN
⑦ LOWER SEGMENT	⑯ UPPER SPECIMEN
⑧ INLET TUBE	⑰ THERMOCOUPLE
⑨ INSULATION	⑱ GRAPHITE SUPPORT BARREL

Interstitial Corrosion Test Fixture

CONFIDENTIAL
RESTRICTED DATA
 Atomic Energy Act - 1954

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-5. c

TITLE: REACTOR GRAPHITE
COMPONENT PERMEABILITY
TESTS

OBJECTIVE: The objective of these tests is to determine the permeability of fuel element material and the various types of graphite used in the reactor with and without various coatings and impregnations. This information is required to analyze the flow and corrosion which occurs within the reactor.

DESCRIPTION OF TEST: The block materials are to be machined into 1/4 inch thick by one inch diameter discs with and across the grain. Each segment will be mounted between plates. The pressure differential across the specimen will be varied and the leakage flow measured as a function of pressure and temperature.

TEST PARAMETERS:

Fluid:	Hydrogen
Inlet Pressure:	0 to 800 psia (Variable)
Inlet Temperature:	Ambient
Mass Flow Rate:	Measured Variable
Pressure Drop:	0 to 200 psi (Variable)
Material:	As Specified (Variable)

Reactor Graphite Component Permeability Test Fixture

FLUID FLOW TEST DESCRIPTION

CATEGORY: FFL-5. d

TITLE: MATERIAL INTERFACE AND
GAP FLOW TESTS

OBJECTIVE: The objective of these tests is to determine the flow and leakage characteristics of the various interfaces and gaps of similar and dissimilar materials within the reactor. These hydrogen flow characteristics, as a function of material combination, mechanical interface loading, surface finish, and area of contact for various flow conditions, must be known; for the complete analysis of reactor flows.

DESCRIPTION OF TEST: A test fixture will be designed into which material specimens can be inserted. Various combinations of reactor materials, such as graphite, beryllium, aluminum, titanium, stainless steel, etc. , will be tested. Various mechanical interface loadings will be imposed by the fixture. The surface finish and area of contact will be controlled in the manufacture of the test specimens.

TEST PARAMETERS:

Fluid:	Hydrogen
Inlet Pressure:	500 to 750 psia
Pressure Drop:	0 to 200 psia
Temperature:	140 to 540°R
Mechanical Loading:	To Be Specified
Surface Finish:	To Be Specified
Contact Area:	To Be Specified