CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

Records

SNPO-C

WANL-TME-1416
April, 1966

Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING HELD WITH SNPO AT WANL ON MARCH 30, 1966
(Title Unclassified)

MASTER

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

DISCLAIMER

~~CONFIDENTIAL~~
~~RESTRICTED DATA~~
~~Atomic Energy Act -~~

Astronuclear Laboratory

WANL-TME-1416
April, 1966

34
45

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING HELD WITH SNPO AT WANL ON MARCH 30, 1966

(Title Unclassified)

Westinghouse Electric Corporation
Astronuclear Laboratory
P.O. Box 10864
Pittsburgh, Pennsylvania 15236

Classification cancelled ~~(or changed to~~
by authority of DOE
by 18 J.C. TIC, date SEP 10 1973

E. A. DeZubay, Manager
Fluid Flow Laboratory

~~INFORMATION CATEGORY~~
~~Confidential Restricted Data~~
~~Authorized Classifier 4/13/66 Date~~

W. J. Rowan, Manager
Engineering Mechanics

~~GROUP-1~~
~~Excluded From Automatic Downgrading and Declassification~~

SPECIAL REREVIEW FINAL DETERMINATION
Class: U

Reviewers	Class.	Date
JRP	U	4-22-82

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

~~CONFIDENTIAL~~
~~RESTRICTED DATA~~
~~Atomic Energy Act - 1954~~

LIST OF FIGURES

Astronuclear Laboratory

WANL-TME-1416

Notes of Monthly Development Test Program Review Meeting Held With SNPO at WANL on March 30, 1966

Attendees:

N. J. Bifano	WANL	S. V. Libbing	WANL
E. A. DeZubay	WANL	J. S. Olinger	WANL
H. J. Fix	WANL	R. L. Ramp	WANL
W. J. Havener	WANL	W. J. Rowan	WANL
H. Hoffman	SNPO-C	R. M. Saccocio	WANL
G. Kalvin	SNPO-C	J. J. Schreiber	WANL
I. E. Kanter	WANL	D. C. Thompson	WANL
V. G. Kelly	WANL	E. A. Watjen	WANL
L. Larson	AGC		

The Monthly Development Test Program Review Meeting was held on March 30, 1966, at WANL.

Lists of the tests performed and planned by the Engineering Mechanics and Fluid Flow Laboratories were distributed to those in attendance. These schedules are shown in Tables I and II.

The individual tests were then discussed in the order as shown.

TABLE I

Fluid Flow Test Schedule

Test	PERFORMED THIS PERIOD	PLANNED NEXT PERIOD
Tests for NRX-A5		
HHT-2	Skirtless Block and Cup Tested for 64 Minutes	
HHT-4	16-a Skirtless Block - Arcing Failure	Sixty Minute Test on Skirtless Block
	16-b Skirtless Block - Arcing Failure	
	17-a Skirtless Block - Insulator Failure	Total 40 Minutes on Pre-Cracked Block
HHT-7	Build 4 Test 2 - Model Assembly Completed	Test Model
FFL-18	Single Seal Test	
	Fit NRX-A6 Joint but Testing Preempted	Run NRX-A6 Joint
FFL-23	Nozzle Interface Seals	
	Completed Second Test on Each Seal	
FFL-27	Instrumentation Port Seals	
	Completed Tests on Purge Boot Seals	
	Initiated Testing of T/C Seals	Complete Tests of T/C Seals
Tests for NRX-A6		
FFL-8	Drum Bearing Impedance	
	Completed Fabrication and Flow Tested the Design and Alternate	Continue Program with New Impedance Design
FFL-29	NRX-A6 Single Seal	
	Continued Fabrication	Assemble Model and Initiate Testing
FFL-31	Baffle Effectiveness	
	Completed Fabrication	
	Assembled Model and Initiated Testing	Complete Testing
FFL-32	Capsule Impedance and Seal Tests	
	Design and Fabricate Model	Conduct Impedance Tests
General Development		
HHT-2	Pin Hole Tests	Continue Pin Hole Tests
	Chuck Development for Cluster Tests	

TABLE I (CONTINUED)

PERFORMED THIS PERIOD		PLANNED NEXT PERIOD
General Development (Continued)		
HHT-2	Chuck Development	Continue Chuck Development
	High Void Fraction Element	Continue High Void Fraction
	High Expansion Element	
HHT-4	13-c Cold End Chuck Development	Continue Chuck Upgrading
	18-a Cold End Chuck Development	
HHT-6	Isothermal Gap Test	Conduct Tests on Uncoated Slot for Pressure Effect
	Hardware Fabrication Complete	
HHT-7	Build 4 Tests 3 and 4	Continue Development and Procurement for Build 4 Tests 3 and 4
Facilities		
Large Site Vaporizer - Qualification Tests Discontinued		Complete Qualification Tests
Thermocouple Furnace - Power Test Run		Continue Testing

TABLE II

Engineering Mechanics Test Schedule

PERFORMED THIS PERIOD		PLANNED NEXT PERIOD	
NRX-A5 and XE Tests			
EML-75	Filler Strip Coating Tests, Cocked Pyrotile Tests	EML-55	XECF Resonance Survey
EML-76	Control Drum Scram Spring	EML-67	Fuel Element Coating Test
EML-78	Dome End Seal Test	EML-76	Control Drum Spring Test
EML-88	Control Drum Bow Tests	EML-94	Radial Expansion Testing
EML-94	Reactor Assembly Anomaly Simulations; 162 Keyed Element Test		
NRX-A6 Tests			
EML-60	Fuel Element Pinhole Tests	EML-60	Fuel Element Pinhole Tests
EML-67	Fuel Element Lateral Creep Tests	EML-70	Coated Cups and Washer Tests, Bundling Tests
EML-70	Protection Cups & Tab-Tipped Tests Seven Cluster Assembly Tests	EML-78	Forward End Seal
EML-86	Lateral Support System Procurement; Plunger Capsule Development Tests	EML-82	Beryllium Thermal Shock and Strain Cycling Test
		EML-86	Complete Lateral Support System Test Fixtures
Development Tests			
EML-61	Graphite Tie Rod Specimen Tests, Coating Adherence Studies	EML-61	Graphite Experimental Rod Tests

Astronuclear Laboratory

WANL-TME-1416

TESTS FOR NRX-A5 AND XE

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

HHT-1 Quality Control Fuel Element and Block

During the period February 24, 1966 through March 28, 1966, a total of 96 corrosion tests were run. The tests consisted of one Quality Control test of a Cheswick A-5 element, one Quality Control test of a Cheswick A-6 element, 38 sixty minute life tests and 56 process control tests. Of the 38 sixty minute life tests, the following results were obtained:

No. of Elements	Total Test Time
12	60 Min.
8	50 to 60 Min.
4	40 to 50 Min.
5	30 to 40 Min.
3	20 to 30 Min.
6	Aborted Because of Chuck Failure
38	

Tubes and blocks were tested with the elements.

HHT-2 Single Element Process Development and Evaluation Tests

A sixty minute test, designed to evaluate a pyro cup of the A-6 design, was made with a skirtless block. The test was made in three 20 minute cycles. A fourth cycle was attempted but had to be terminated because of a broken chuck. After the first 20 minute run, many hair line cracks were observed on the cup. These cracks appeared to become more pronounced after each cycle but at the end of the test the cup still looked good (Figure 1). Additional testing is planned.

HHT-4 Single Cluster Development Tests

Three corrosion tests of the skirtless support block configuration were attempted but had to be terminated during the initial power ramp because of inter-element arcing and element cracking. The results of the entire test series were

FIGURE 1

PROTECTION CUP USED IN SINGLE ELEMENT TEST

HHT-4 (Con't) compiled and reviewed in order to determine the cause of the premature shutdowns. After a thorough examination of all the data, the probable causes of the failures were attributed to thermal expansions (both radial and axial). The insulators, because of repeated use, may have deteriorated and contributed to the high failure rate. Prior to assembly and test of additional clusters, the following modifications to the hardware were made: modification of the cold end electrode in the furnace to insure better alignment; increased clearances on lateral supports and chucks to allow for greater thermal expansion; and improved center element insulators. It has been found that a gap of 15 mils on the cold end and a 30 mil gap on the hot end is necessary to allow for thermal expansion of the model. A 40 minute test on a precracked A-5 block is planned as the first test in April.

HHT-7 Filler Strip Corrosion Test

The model for Build 4 Test 2 (Figure 2) is assembled and will be run as soon as a 60 minute test on a skirtless block can be completed. During this delay, a redesign of the stainless steel jacket and upper insulating chuck has been made to provide a better inlet end sealing arrangement between the helium atmosphere and the reflector. This new design is expected to be incorporated into the model before the test date. The model is planned for installation in the furnace during April.

A reflector system layout study was completed for the Gas Injection Model.

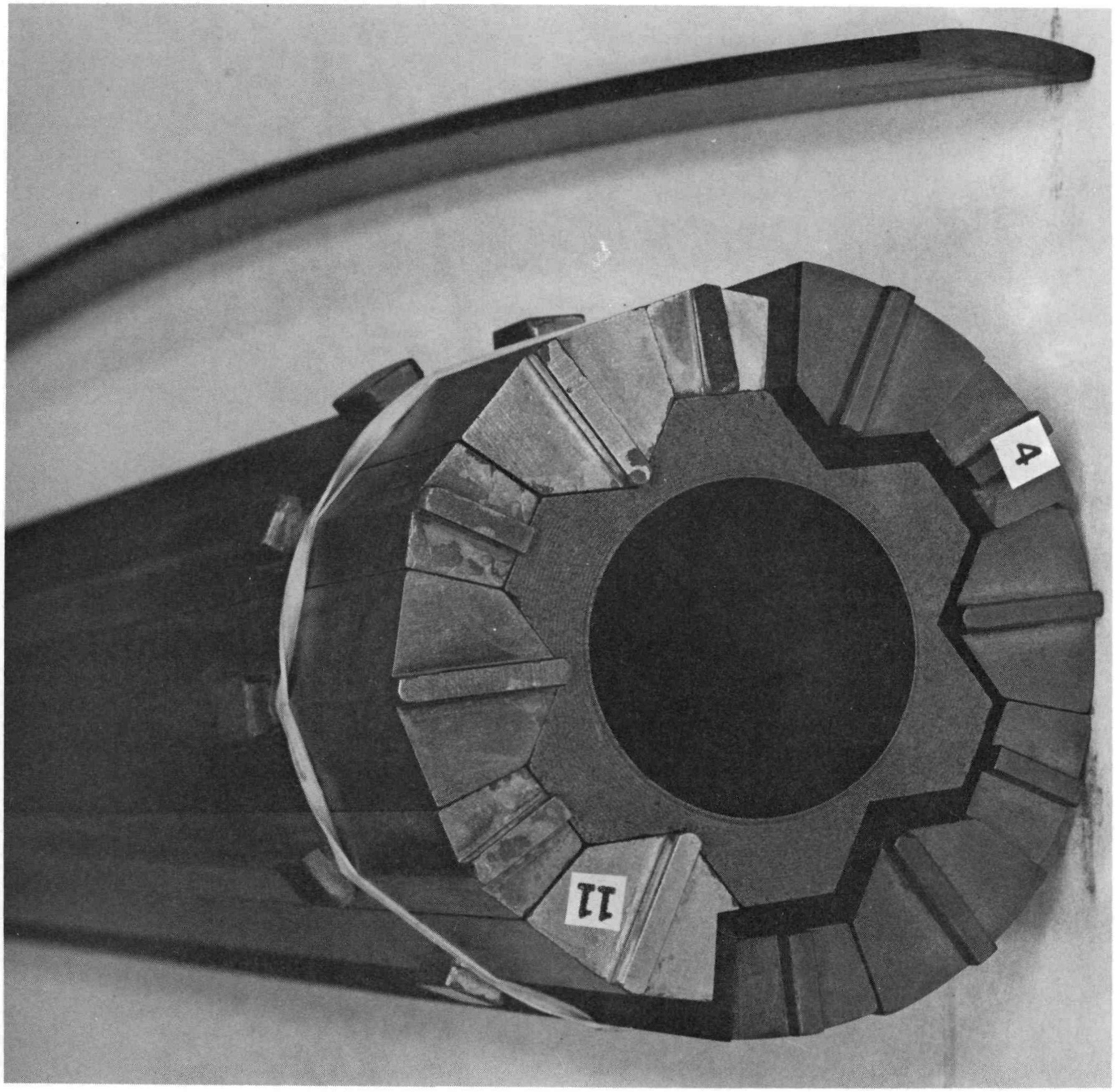


FIGURE 2

HHT-7 MODEL TO BE USED FOR BUILD 4 TEST 2

FFL-18 Single Seal NRX-A5 Tests

Two sets of A-5 segments, containing extra joints of A-6 dimensions with ramp clearances of .000 and .002 inches, have been fabricated and fit to the fixture. The rig has been assembled with the segment containing the .000 inch clearance joint and is ready to run.

FFL-23 Nozzle Interface Seal Performance Test

The four seals which were tested in February have been retested to see if the data is repeatable. Seals No. 1, 2, and 3 repeated the data to within 3%. Attempts to improve the sealing qualities of Nos. 2 and 3 by rapid increases of pressure differential were not successful. Seal No. 4 did not repeat its initial data. The second run data more closely matches that of Seals No. 2 and 3. Attempts to repeat the original data by rapid increases of pressure differential were not successful. The sealing levels of all seals are acceptable.

FFL-27 NRX-A5 Instrumentation Port Qualification Tests

The leak tests on the purge boot seals have been completed. They were tested with 200 psi helium at ambient temperatures with the bolts torqued at 30 in. lbs. The leakage rate was found to be 4×10^{-3} scc/sec. The tests will be followed with thermal cycling from ambient to liquid nitrogen temperature.

The thermocouple seals were checked at ambient temperature with 200 psig helium. The leakage rate was less than 5×10^{-3} scc/sec. The same seals were then subjected to 12 thermal cycles from ambient to 800°F.

EML-75 Friction Tests of Reactor Components

a) Filler Strip Tests

Tests were performed to determine whether specimens cut from NRX-A5 production run filler strips exhibited the same coating wear characteristics as specimens made from coating development material. Filler strip specimens from each of the nine production runs and pyrotile specimens were held in contact in a hydrogen environment and subjected to the simultaneous temperature and relative motion cycles expected during reactor testing. The contact pressure, maximum temperature and relative motion were fifteen psi, 4300°R and 0.188 inches, respectively.

The coating adherence of production run 1 filler strips was found to be very poor (see Figure 3a), and these strips were not considered to be suitable for use in the reactor. The coating adherence of the specimens from the other production runs was entirely satisfactory (see Figure 3b) and similar to that observed in tests of development material.

b) NRX-A5 Cocked Pyrotile Test

Tests were performed at ambient and operating temperatures to determine whether a cocked pyrotile condition observed in the assembled NRX-A5 reactor could cause damage of the pyrotile or support block surface in contact with it. Pyrotile and support block specimens were held in the contact condition expected during reactor operation and displaced relative to each other to simulate the relative motion expected during the planned reactor tests.

A test at ambient conditions was performed in order to obtain indications of the effects of the observed cocked pyrotile condition as rapidly as possible. In this test a 0.010 inch thick shim was inserted under one edge of a pyrotile specimen 3/4 inch long so that a line contact between the other edge of the pyrotile and the support block contact surface was obtained.

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

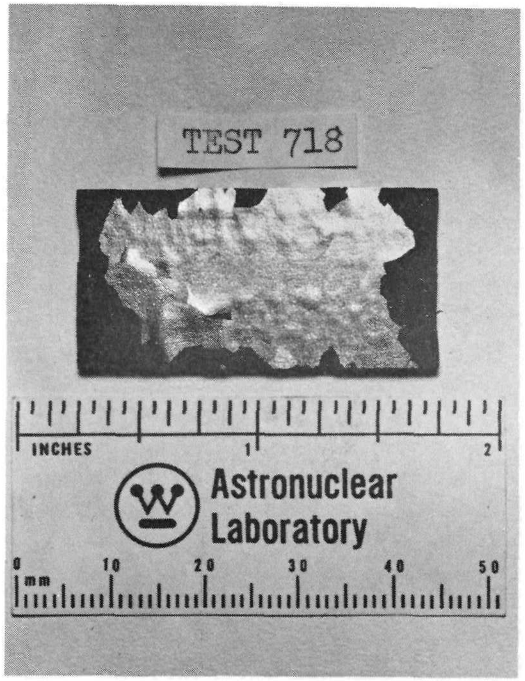


FIGURE 3a
FILLER STRIP SPECIMEN
EML-75

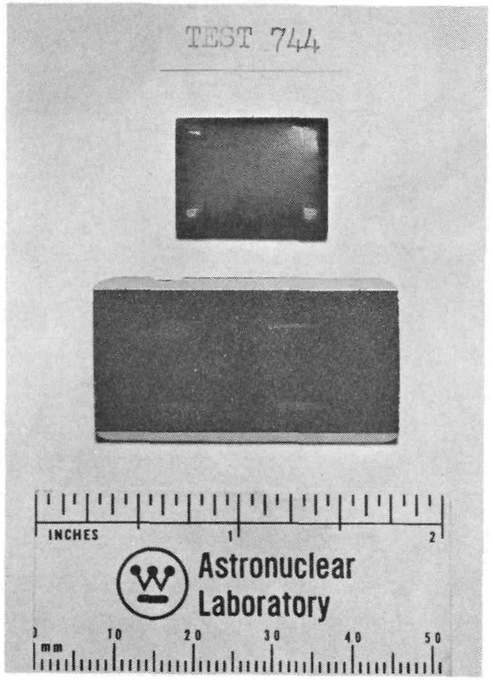


FIGURE 3b
FILLER STRIP SPECIMEN
TYPICAL OF RUNS No. 2-9
EML-75

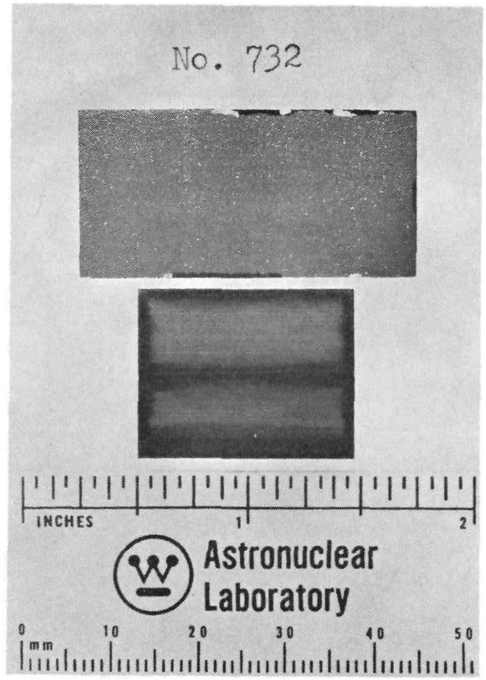


FIGURE 4
PYROTILE SPECIMEN
EML-75

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

The specimens were held in contact with a load of 200 lb and displaced 1/8 of an inch relative to each other. A 200 lb contract load was used because it was felt that this load would be higher than any contact load that would be developed during reactor testing. No damage of either the support block or contacting pyrotile edge was observed after the test.

After additional information was developed regarding the pyrotile and support block contact which would develop during reactor operation as a result of the observed cocked pyrotile condition, another test was performed at operating temperature conditions. The pyrotile specimen for this test was also 3/4 inches long and was machined with pads at three of the corners so that the bearing condition between the pyrotile and support block expected during reactor operation would be reproduced at the remaining pyrotile corner. The specimens were held in contact with a normal force of 20 lb and subjected to the simultaneous thermal and displacement cycling expected during reactor testing. The normal force applied at the pyrotile corner in contact with the support block (5 lb) was higher than the calculated normal force that would be developed when the support block coating was hot enough to suffer damage (2-3.5 lb). Although some burnishing of the support block coating surface in contact with the pyrotile corner was observed after the test (see Figure 4), no damage of either the support block coating or pyrotile occurred.

EML-76 Reactor Hardware Static and Dynamic Tests

Fatigue tests of the XE-1 engine control drum scram spring and attachment hardware (see Figure 5) were performed at ambient temperature and 140°R. The tests at 140°R were performed by immersing the test components in liquid nitrogen. The spring was cycled 1000 times through displacements of 0 to 180° in each test. No permanent set or damage of the spring or attachment hardware was observed in the post-test inspections.

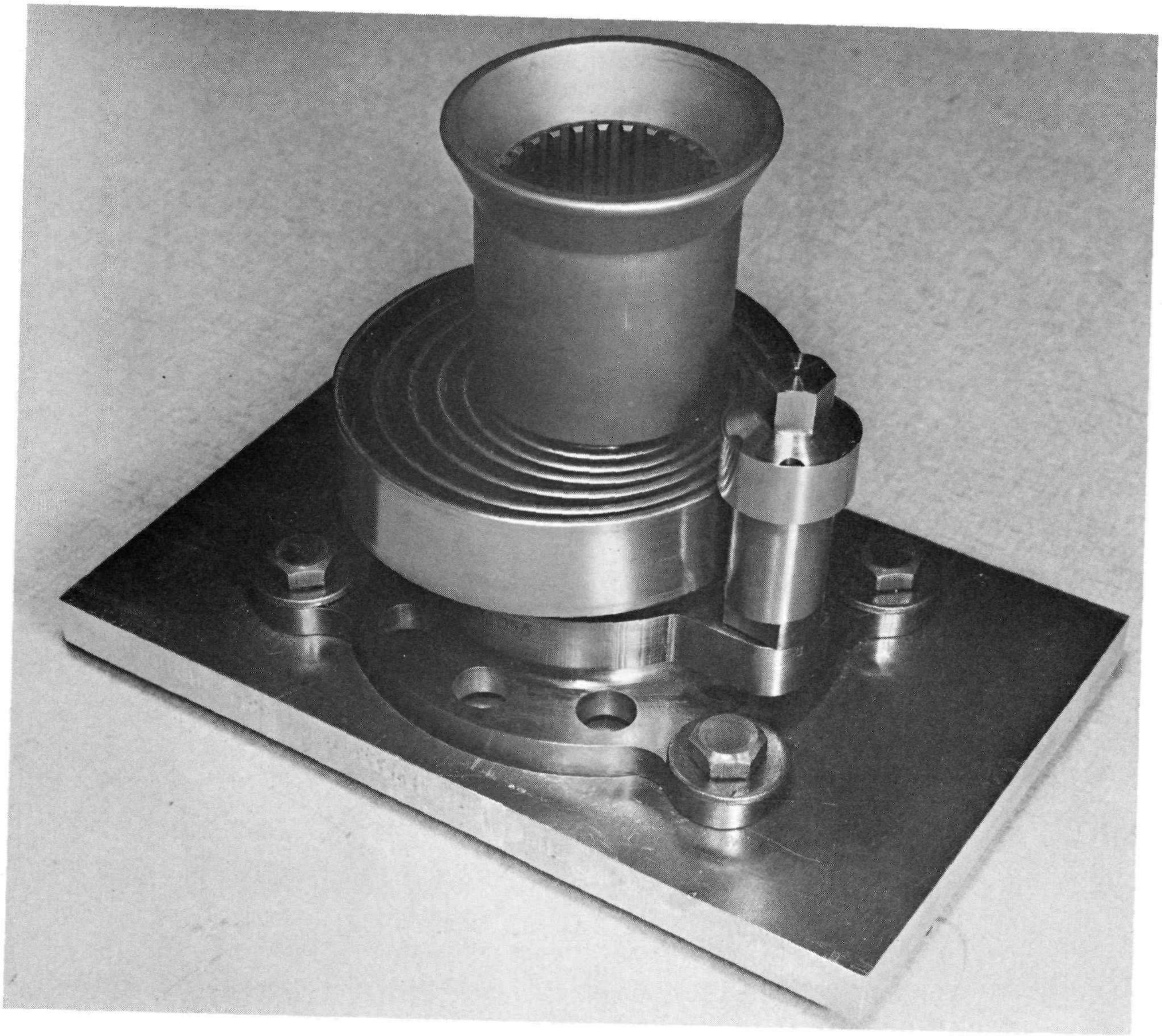


FIGURE 5

CONTROL DRUM SCRAM SPRING
EML-76

EML-78 Dome End Seal Test

A test of the NRX-A5 reactor dome end seal shown in Figure 6 was performed to determine the maximum leakage that would occur during reactor operation. The test was performed in the test rig shown in Figure 7 with helium at ambient temperature and reactor pressure conditions. The maximum possible eccentricity between the seal and core periphery, .080 inches, was reproduced in the test assembly in order to simulate the most unfavorable assembly condition which could occur in the reactor.

The maximum measured helium leakage when converted to hydrogen leakage at reactor temperature conditions was about 1 lb/sec. This value lies within the maximum leakage band predicted for the seal. This data will be used to perform a more accurate analysis of the gas flow during reactor operation.

EML-88 Insulated Control Drum Bow Tests

WANL-TME-1408, "NRX-A5 Control Drum Bow Tests", was issued during this period. The results of the tests indicated that neither the startup flow ramp nor the drum initial temperature should have an important influence on the thermal bow during the planned NRX-A5 tests;and the maximum bow, excluding nuclear effects, should be less than 0.020 inches. Preliminary calculations indicate that the effects of nuclear heating should not significantly increase the maximum bow beyond 0.020.

EML-94 Buffer Periphery Testing

a) NRX-A5 Reactor Assembly Anomaly Simulation

As noted previously, tests were performed to study the cocked pyrotile condition observed in the assembly of NRX-A5. The partial length core test rig was modified in an effort to demonstrate the effect of a periphery interference which occurred. A slight twist in a number 5 filler strip at one of the transition joints between the cold and hot buffered periphery created an

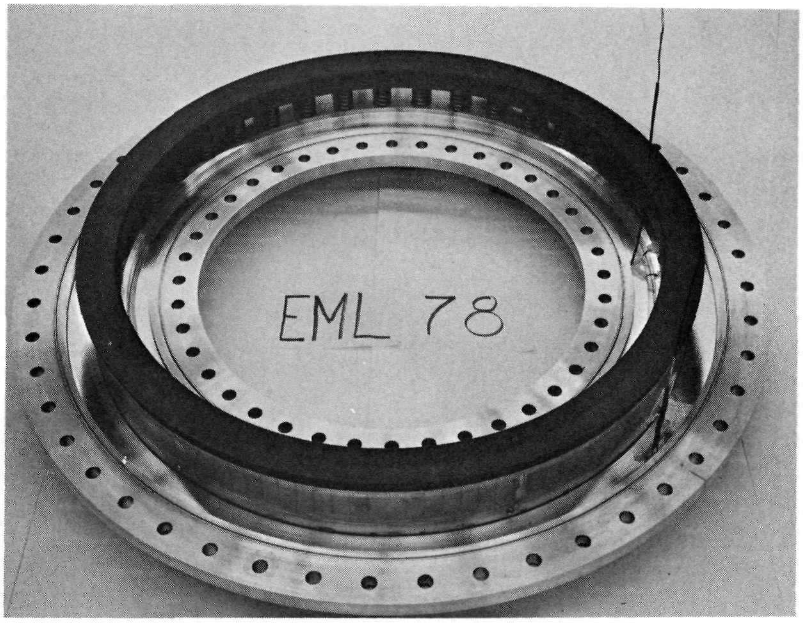


FIGURE 6
DOME END SEAL
EML-78

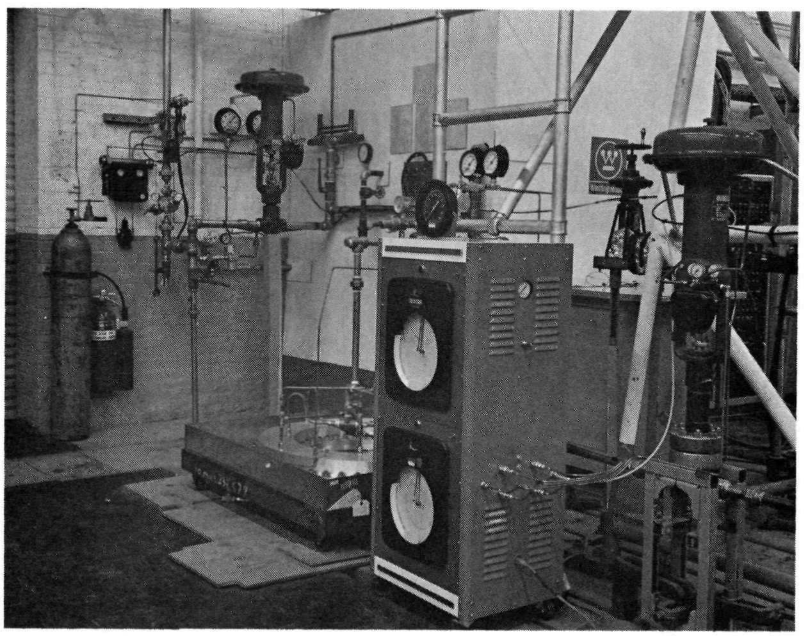


FIGURE 7
DOME END SEAL TEST SETUP
EML-78

interference beteen a J-5 support block and the tile edge at the end of the number 5 filler strip. One area of concern was the durability of the number 4 filler strip under the added bending moment that would be set up under reactor loading conditions. Interferences to more than twice that measured in the A5 assembly were introduced in the test model with no structural damage. Gaps and filler strip displacements created in the test core are shown in Figures 8 and 9.

b) <u>Static Test of The Buffer Periphery Type Filler Strips</u>

A static load test was completed on the buffer design with 120 keys brazed to regular elements and 42 keyed partial elements. Axial loads applied by hydraulic cylinders were used to simulate a pressure drop across the filler strips. Loads were varied in increments equivalent to a 3-3/4 psi pressure drop across the core. Initial failure occurred at 232.5 psi pressure drop (180% of expected operating conditions for the A5 reactor) to one filler strip located at each core band coupling. The other failures to the filler strips were attributed to the redistribution of forces resulting from the primary failure. An inspection of all filler strips and keyed elements revealed no other damage.

Since future reactors will be unbanded, the recess which weakens the filler strips in the region of the core band coupling will not exist. An additional test was performed where these weakened filler strips were not loaded. The initial failure under this condition occurred at an equivalent loading of 285 psi pressure drop across the filler strips.

GAP FORMATION BETWEEN ELEMENTS & FILLER STRIPS
DUE TO INTERFERENCE BETWEEN TILE INTERFACES OF 4 & 5 FILLER STRIPS
10 PSI BUNDLING

EML-94

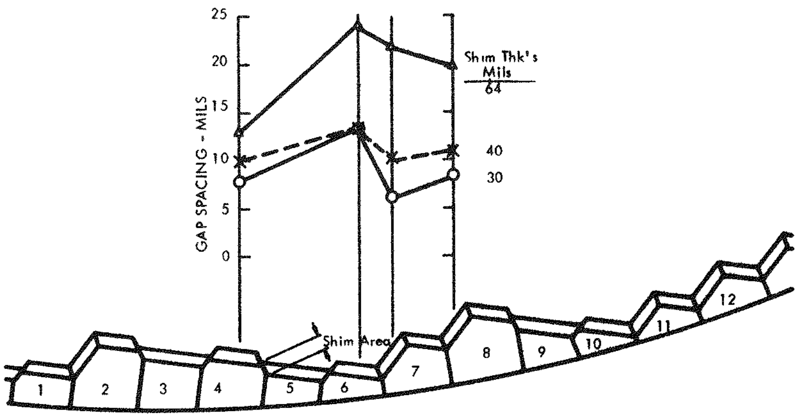


FIGURE 8

CORE PERIPHERY UNDER CONDITIONS SIMULATING A-5 ASSEMBLY ANOMALY
EML-94

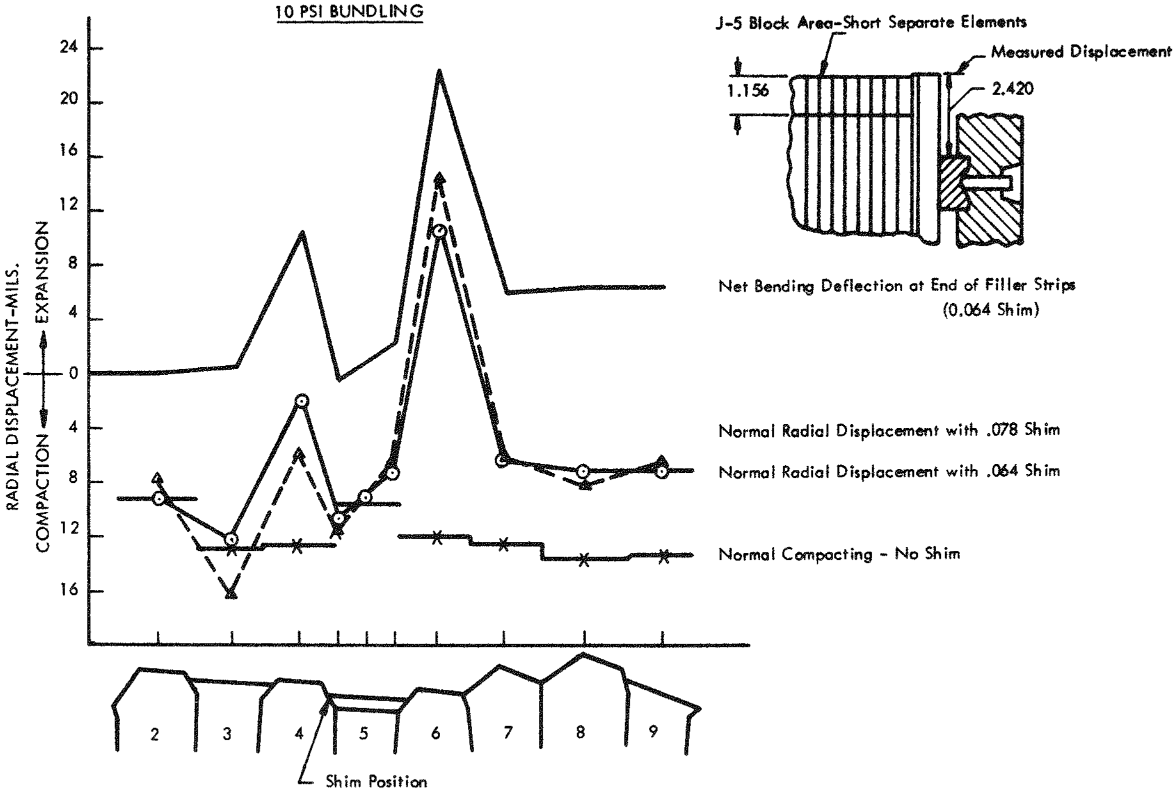


FIGURE 9

Astronuclear Laboratory

WANL-TME-1416

TESTS FOR NRX-A6

~~CONFIDENTIAL~~
~~RESTRICTED DATA~~
~~Atomic Energy Act - 1954~~

FFL-8 Control Drum Flow Tests

Fabrication of the test fixture, Figures 10 and 11, was completed and flow tested. A bearing, which is comparable to the NRX-A6 requirement, was obtained. The fixture was assembled to measure flow as a function of the pressure drop across the nozzle end drum bearing and drum cap mounted impedance ring. The clearances between the impedance ring and the bearing were set at 0.003 inch radially and 0.030 inch axially. The hydrogen gas was supplied to the fixture inlet at 720 psig at ambient temperature. The flow range was from 0.002 lb/sec to 0.020 lb/sec in .001 lb. increments. The measured pressure drop was from 0.1 to 6.5 psid. The fixture was retested with 0.003 inch radial clearance and 0.008 inch axial clearance between the impedance ring and the bearing. The smaller axial clearance raised the impedance loss coefficient from 0.9 to 1.5. The design coefficient was assumed to be 2.25 to 2.50 for the required flow balance.

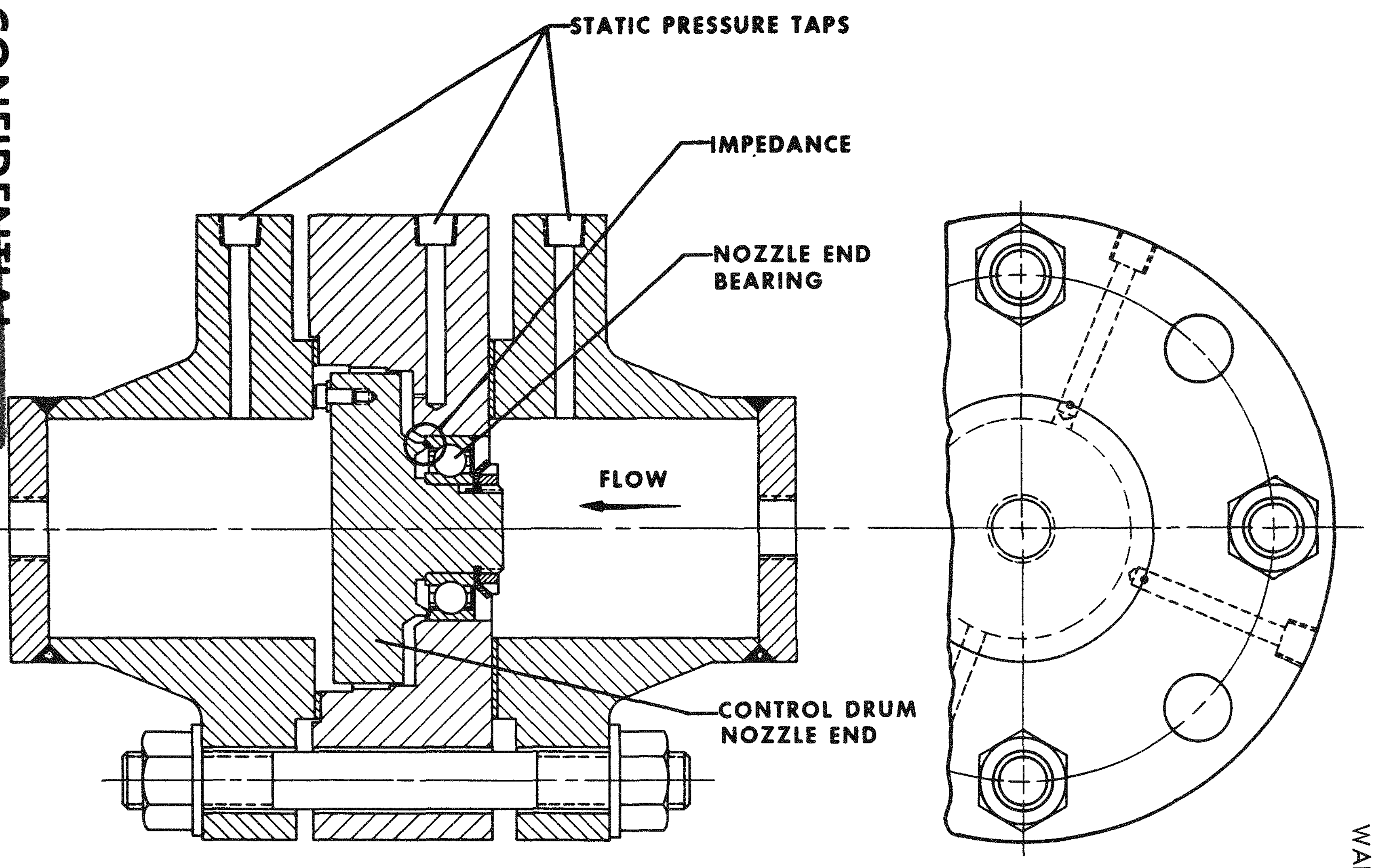
A redesigned control drum nozzle end shaft was fabricated and tested. The new design included a second step ring to double the length of the impedance ring. It was tested twice, both times using an 0.003 inch radial gap, with an 0.030 inch axial gap in the first test and an 0.019 inch axial gap in the second test. The loss coefficients in the two tests were 1.5 and 1.8 respectively. Testing will continue on a new design to obtain the required loss coefficient of 2.5.

FFL-29 NRX-A6 Single Seal Tests

Fabrication of the hardware for the test model is continuing and should be received in April. The seals have already been received. The test is scheduled for May 15, 1966.

FFL-31 Baffle Effectiveness

The test fixture, Figures 12, 13 and 14 was to be completed and tested by March 15, 1966. Arcing problems, however, caused the buss to short out and



NRX-A6 CONTROL DRUM IMPEDANCE FLOW TEST FIXTURE

610991-1C

FIGURE 10

CONTROL DRUM BEARING IMPEDANCE MODEL

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

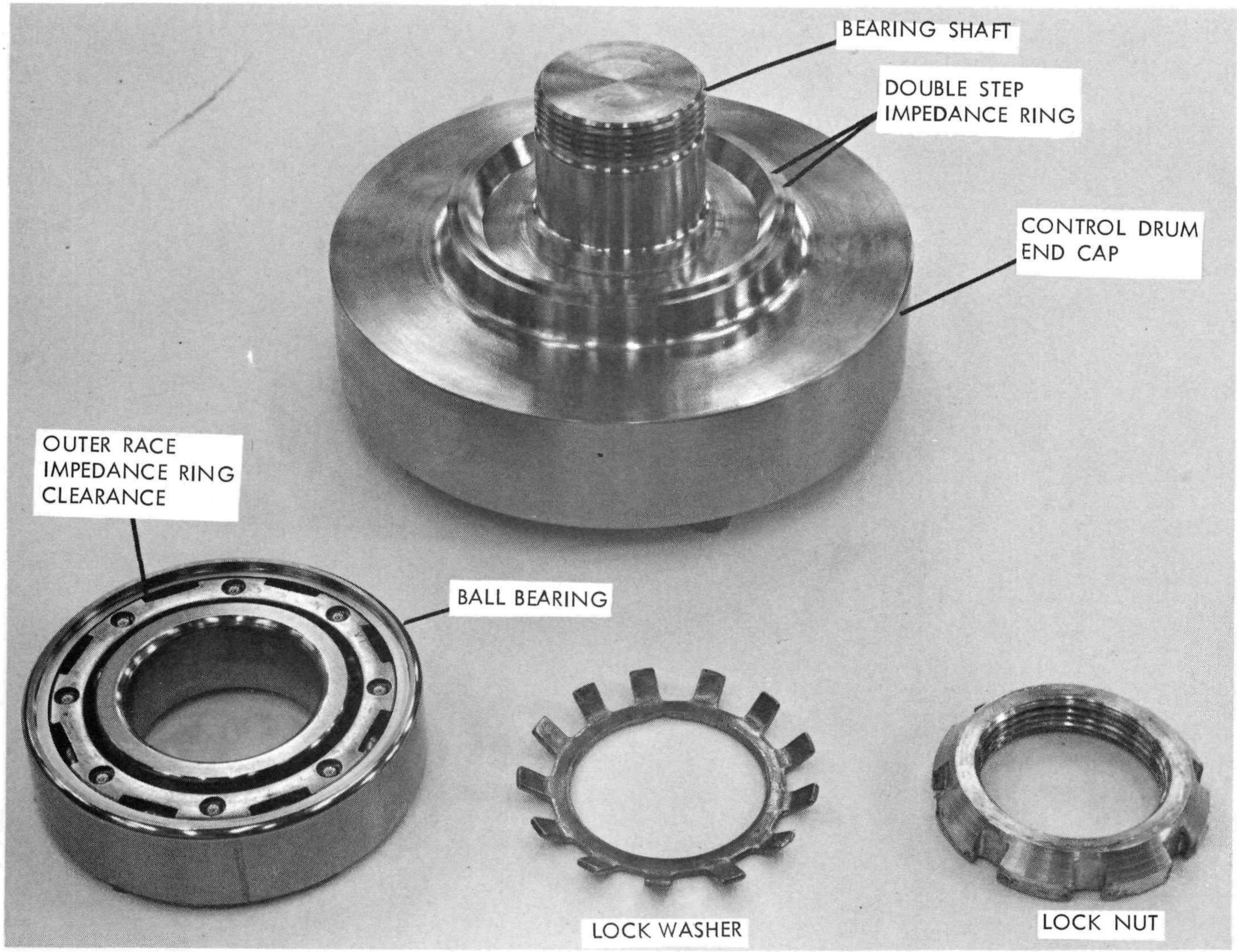


FIGURE 11

CONTROL DRUM BEARING IMPEDANCE MODEL HARDWARE

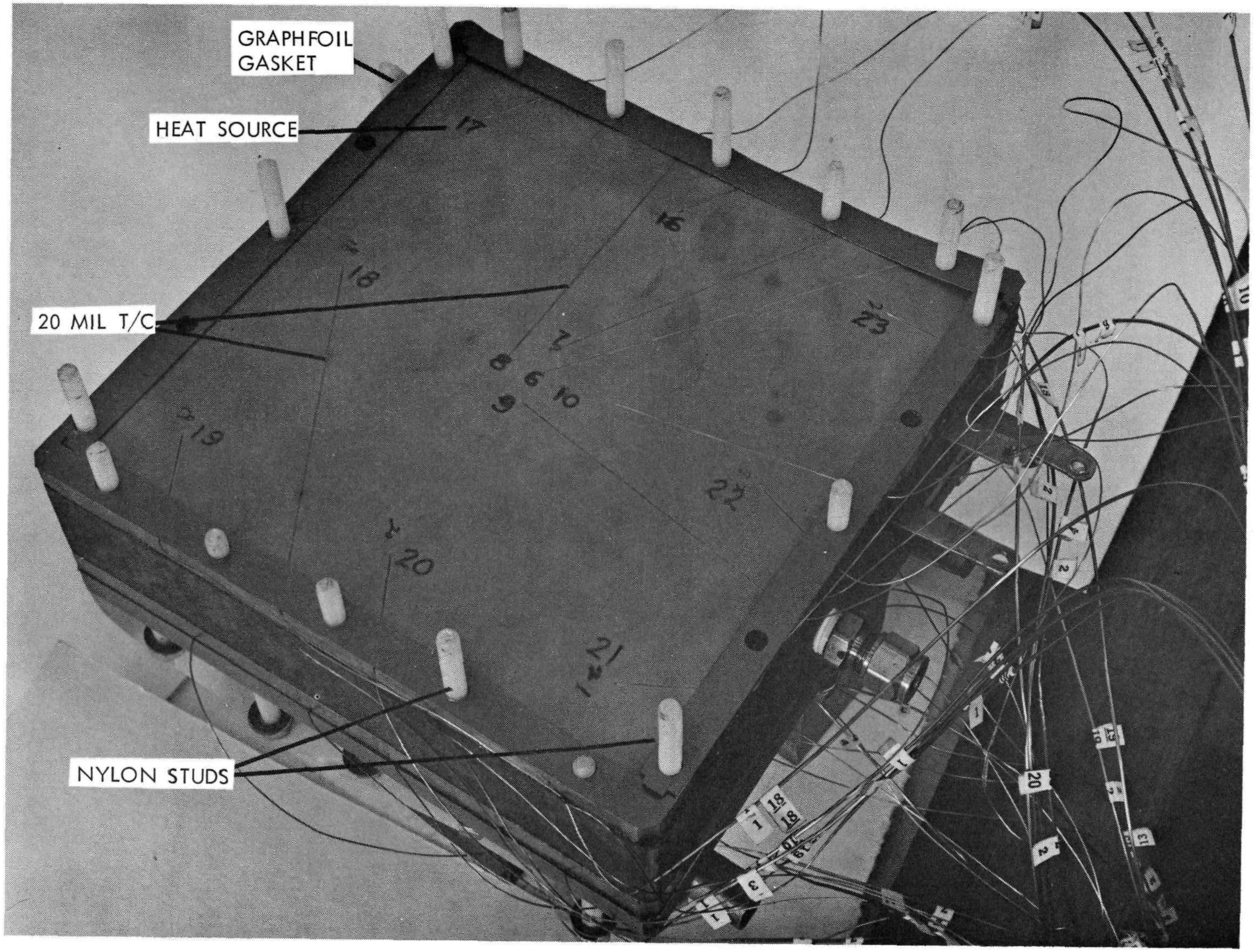


FIGURE 12

HEAT SOURCE PLATE WITH THERMOCOUPLES USED FOR BAFFLE EFFECTIVENESS

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

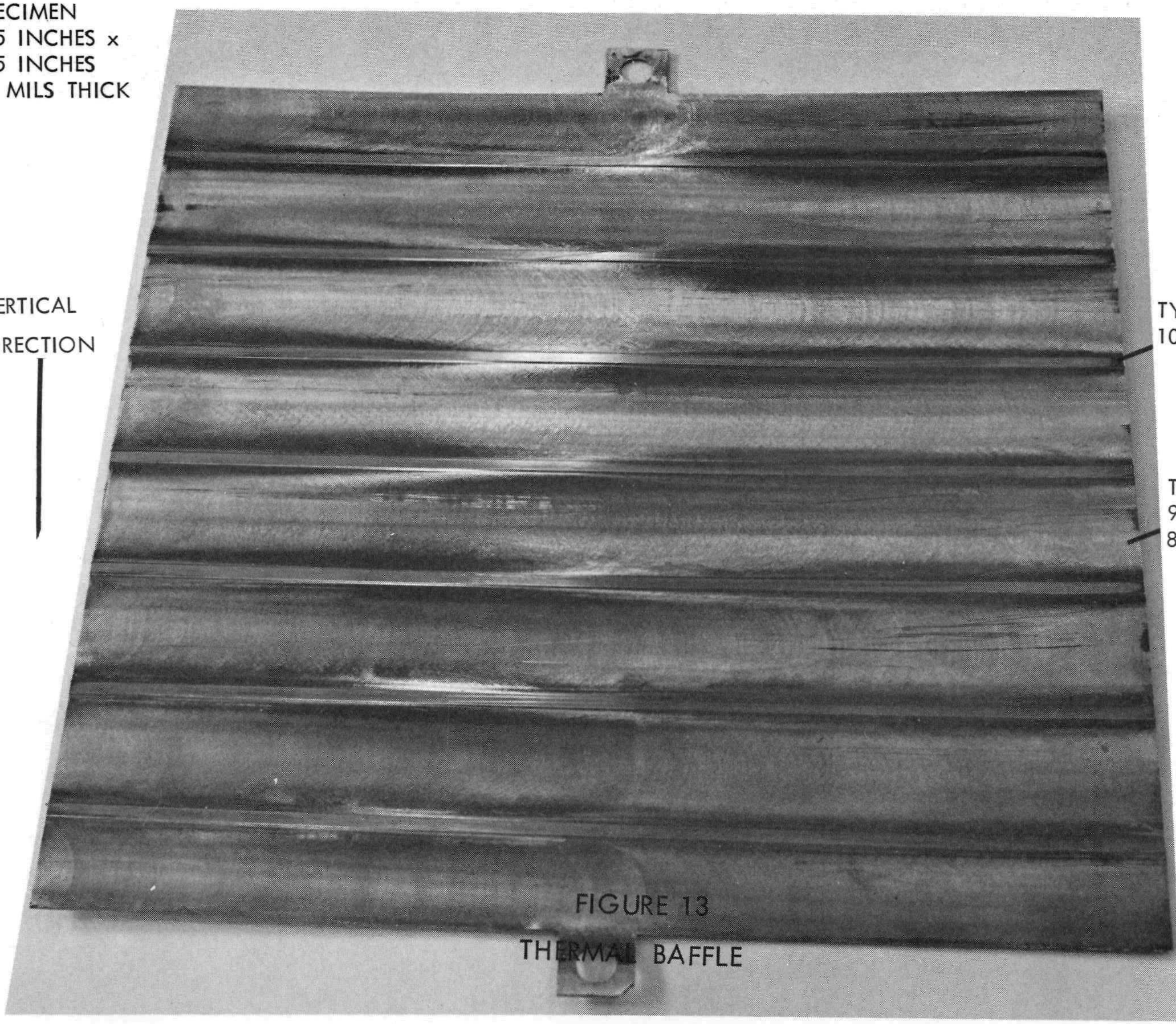


FIGURE 13
THERMAL BAFFLE

Astronuclear
Laboratory

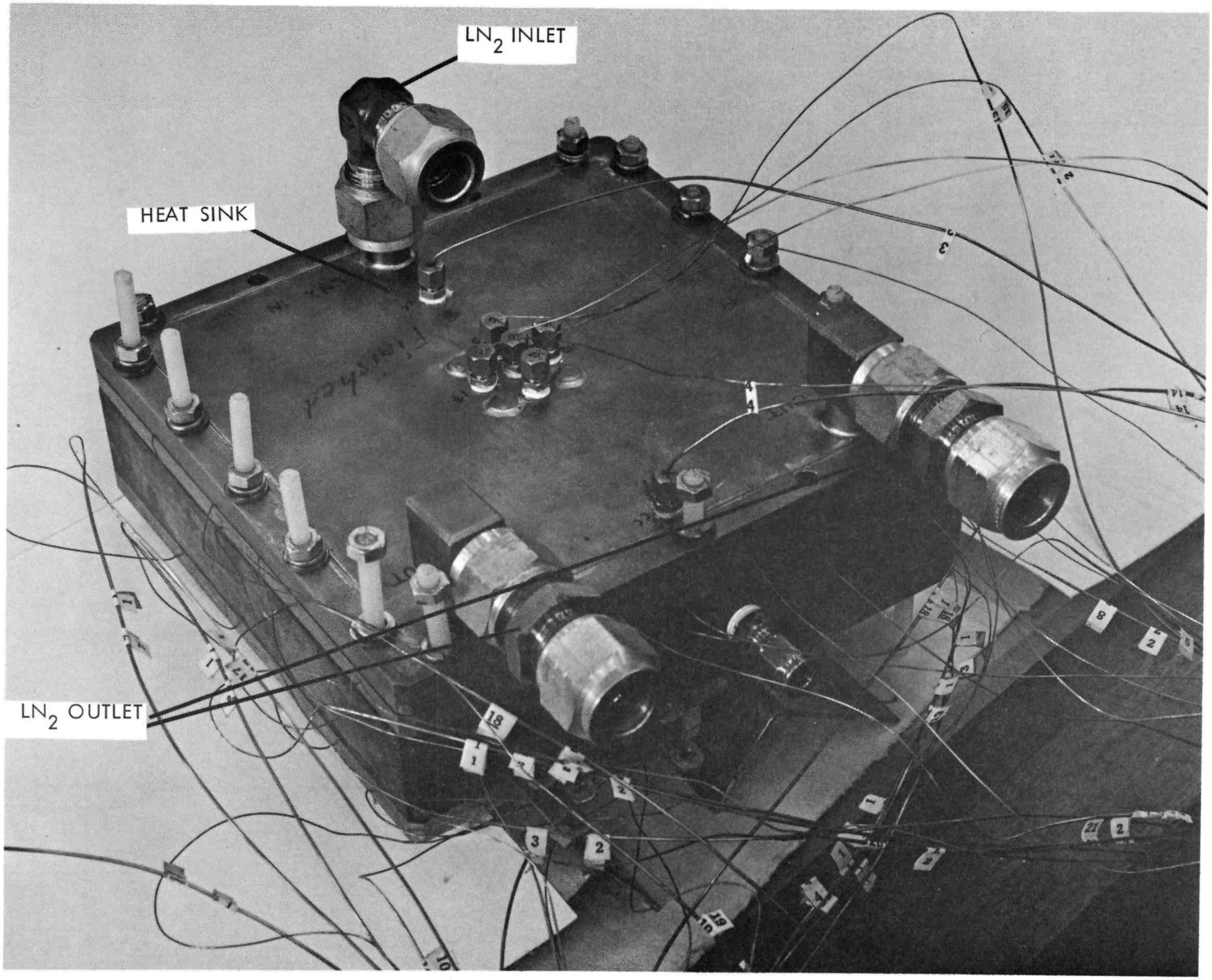


FIGURE 14

LIQUID NITROGEN SINK PLATES FOR THERMAL BAFFLE

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

FFL-31 (Con't) testing was not completed. The fixture was reassembled and checked out on March 23, 1966. The preliminary data indicated that the chromel-alumel thermocouple inaccuracies, though low, prove significant when dealing with the small temperature drops used to measure heat flux, encountered at the present power level. In order to reduce the chromel-alumel thermocouple inaccuracies, a test will be conducted using water as a sink and further efforts will be made to eliminate the possibility of heat source end losses. It is also planned to go to higher power levels using a 440 volt power supply. The coefficient obtained on preliminary tests appears acceptable in that it is less than the maximum acceptable value.

FFL-32 <u>Plunger Pin Capsule Leakage and Flow Impedance</u>

The model, Figures 15 and 16 , has been fabricated and checked out and is ready to test. The model consists of a stainless steel block with three capsule cavities machined in it, and an axial flow hole perpendicular to the cavities. Simulated capsules having outside dimensions representative of the reactor are inserted into the block. The cavity of primary interest is the one in the center. The other two cavities are included to insure proper flow development. Capsule impedance and seal leakage tests will be conducted in April.

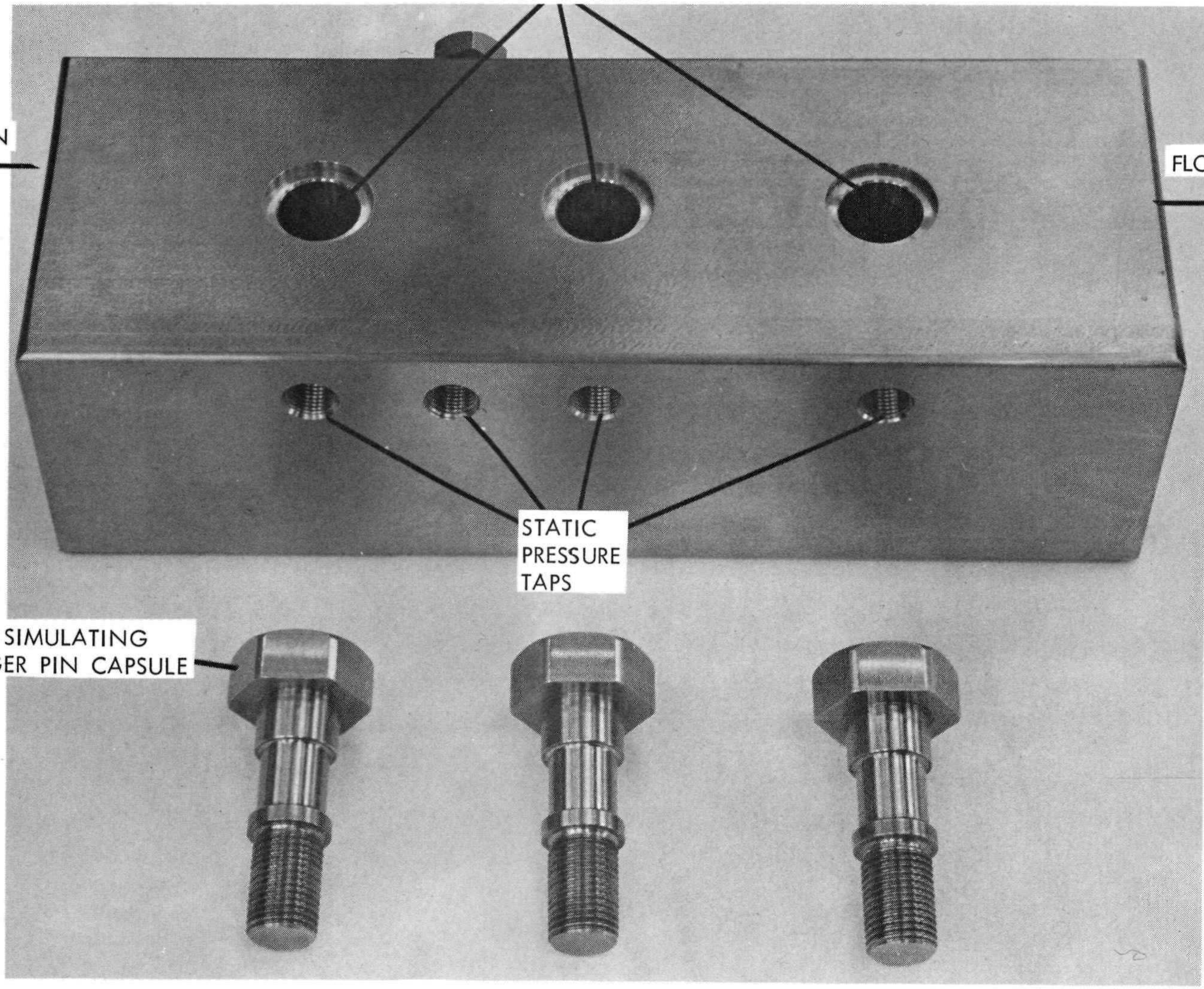


FIGURE 15

MODEL USED FOR PLUNGER PIN CAPSULE FLOW IMPEDANCE TESTING

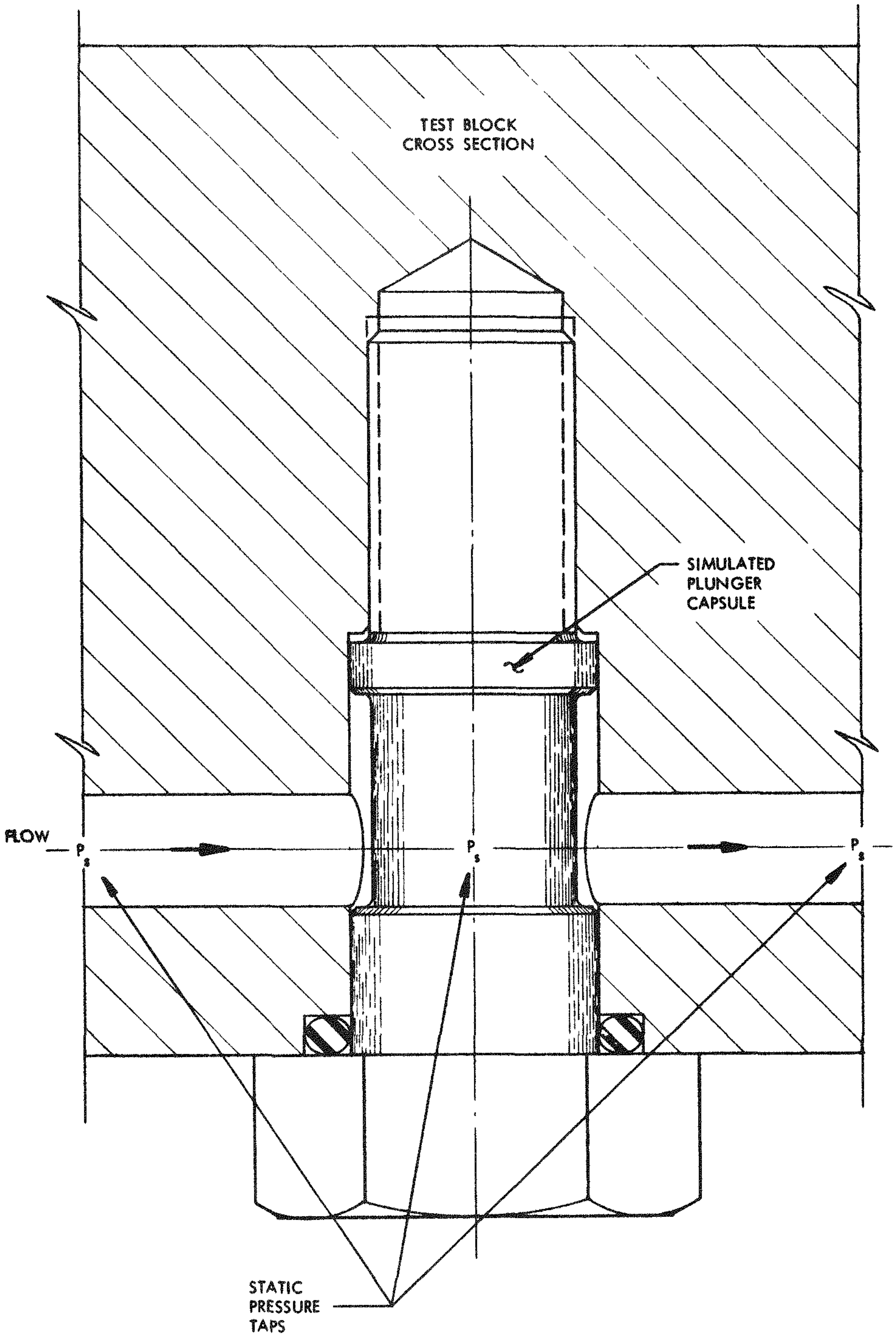


FIGURE 16

CROSS SECTION OF TYPICAL CAVITY IN
PLUNGER PIN CAPSULE FLOW IMPEDANCE MODEL

EML-60 Core Effective Gap Tests

A series of tests were performed utilizing the Core Effective Gap Test setup to measure the flow-through and the effect on local interelement core pressure of pinholes. Two elements each containing a single machined 60 mil pinhole were placed within the core. These pinholes were located axially at 8 and 35 inches. The pinhole bore to interelement pressure ratio was varied for different lateral bundling and flow conditions.

The measured flow rate through each pinhole varied from 1×10^{-5} to 7×10^{-5} lb/sec for helium with a ΔP across each pinhole of 30 psi. The flow impedance was greater when the interelement pressure exceeded the element bore pressure.

The bore pressure of each element containing a pinhole was externally controlled. This was accomplished by sealing both ends of the element and inserting a tube into the pinhole bore. The bore flow rate and consequently the pinhole flow rate were measured using an orifice meter.

With a core head pressure of 100 psig and a pressure drop of 35 psi the bore pressure of each pinhole was alternately set at 100 and at 65 psig. This set the bore pressure at each pinhole both above and below the local interelement pressure.

A second test was performed to measure pinhole flow impedance as a function of the interelement to bore pressure ratio. With no axial pressure gradient, the following pressure ratios were established:

Core Pressure	Pinhole Bore Pressure
0 psig	Varied from 10 to 40 psig
Varied from 40 to 10 psig	0 psig

The results showed that a greater flow rate and a greater effect on interelement pressure occurs when the bore pressure exceeds interelement pressure. At a ΔP of 30 psi between bore pressure and interelement the two comparable flow rates are 7.1×10^{-5} versus 2.6×10^{-5} lb/sec.

Additional tests that will investigate the pinhole size and location are being planned.

EML-67 Fuel Element Aft End Lateral Creep Test

A test program was conducted to study the magnitude of creep in the fuel elements that can be expected under reactor operating conditions. The cantilevered aft end of an element can be subjected to a lateral load at temperature due to welding to the support block or due to welding to the support block or due to lateral support effects near the periphery of the reactor. This condition could cause a permanent element bow which could provide interstitial gaps for interelement gas flow.

Sections of fuel elements were clamped on one end in a graphite test fixture with a free cantilever length of 2.5 inches. Loads of 25 and 50 lb were applied with line contact one inch from the free end of the element. Element temperatures of 4300°R, 4400°R and 4500°R were investigated in a helium gas atmosphere. Creep measurements were made by retaining the "clamp" portion of the element on a flat surface and measuring the deflection at the "free" end of the element.

The test results are summar'zed in Table III. In general, increasing the load or temperature resulted in increased creep deformation. These results will be used by the Analysis Department in various theoretical studies, i.e., corrosion determination since the creep could cause a permanent element bow which could provide interstitial gaps for interelement gas flow.

EML-70 Blockless Support Systems and Components

a) Protection Cups and Tab-Tipped Elements

Previous tests at room temperature on uncoated ATJ graphite cups supported on only three skirtless tab-tipped elements showed that failure occurred in the cup at 1465 lb. When two similar cups (one uncoated and the other coated with niobium carbide) were supported on two tab tips, failures in the cups occurred at 1000 and 775 lb, respectively. The test on the coated cup showed the adverse effect of the protective coating on its strength.

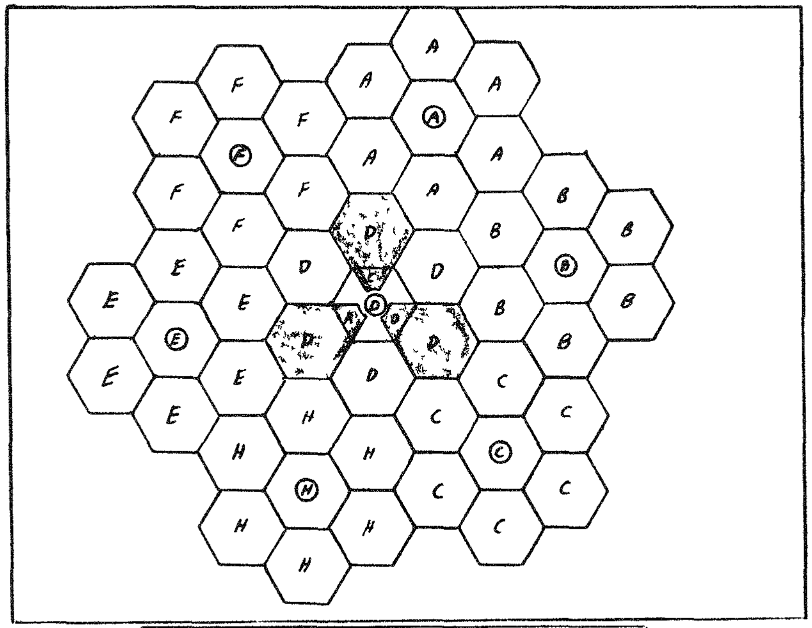
Protection cups and support washers were then machined from higher strength graphite materials such as PO3 and TS699. Tests were only performed on one uncoated PO3 cup and support washer at room temperature. In the first test, the cup was supported on only three tab-tipped elements and failure occurred in one of the tab-tipped elements at a load of 1710 lb. Failure occurred along the full length of the key portion of the tab through the adjacent first row of holes in the fuel element. Failure began by cracking on the load interface between the cup and element near the outer bearing edge of the cup.

The same cup was then supported on two new tab-tipped elements and again failure occurred in one of the tab-tipped elements in a manner similar to that described above but at a load of 1345 lb.

The apparatus or tab tips will be modified to establish the strength of the PO3 and TS699 graphite protection cups and support washers. Several cups and washers are in the process of being coated and it is anticipated that tests will be completed in April.

b) Seven Cluster Assembly Tests

A room temperature bundling test was completed on the seven cluster assembly to show the effects of loss of one tie rod. In this test, all seven tie rods were loaded and the distribution load along the length of the elements was determined. After collecting data for the 500 lb load, the center tie rod was backed off so that the load went to zero. Distribution of load on the elements was then obtained. Figure 17 shows the seven cluster assembly and the location of the three keyed elements used in the center cluster. The tie rod loads are tabulated below the figure. Note that for a load of 300 lb, applied to each tie rod, the sum of the tie rod loads is 2071 lb as opposed to a total of 2100 applied. With the cluster loaded to 500 lb the highest tie rod load is 540 lb and the lowest 359 lb at the center tie rod. When the center tie rod is reduced to zero, there is a corresponding increase on each of the adjacent tie rods and again the sum approximates closely the total applied load. Figures 18a and 18b show the distribution of load along the length of the elements. In Figure 18a the data from element "D" with key "A" has been plotted. The upper curve is the distribution obtained with load on all seven tie rods. When the center tie rod was unloaded, the load across the key went from about 160 lb to about 33 lb with a smaller reduction at Station 13. Little or no change in load is observed beyond the 13 inch station. Figure 18b is a plot of the distribution obtained for element "D" with key "C" and again shows a large reduction in the load across the key with unloading of the center tie rod. This test is significant because it had previously been thought that loss of a tie rod would result in a substantial increase in the load carried by the keys of the alternate support cluster design. These results show that the opposite is true; that the loads will be reduced across the key and redistributed to adjacent elements and tie rods. These results will be used to define the design criteria for the alternate support system.



Tie Rod	Axial Load/Cluster 300 lb	500 lb	500 lb
A	360	526	588
B	322	534	597
C	324	540	607
D	212	359	0
E	296	507	575
F	301	518	586
H	256	514	578
Sum	2071	3498	3531
Total Applied	2100	3500	3500

FIGURE 17

SEVEN CLUSTER ASSEMBLY WITH TIE ROD AXIAL LOADS

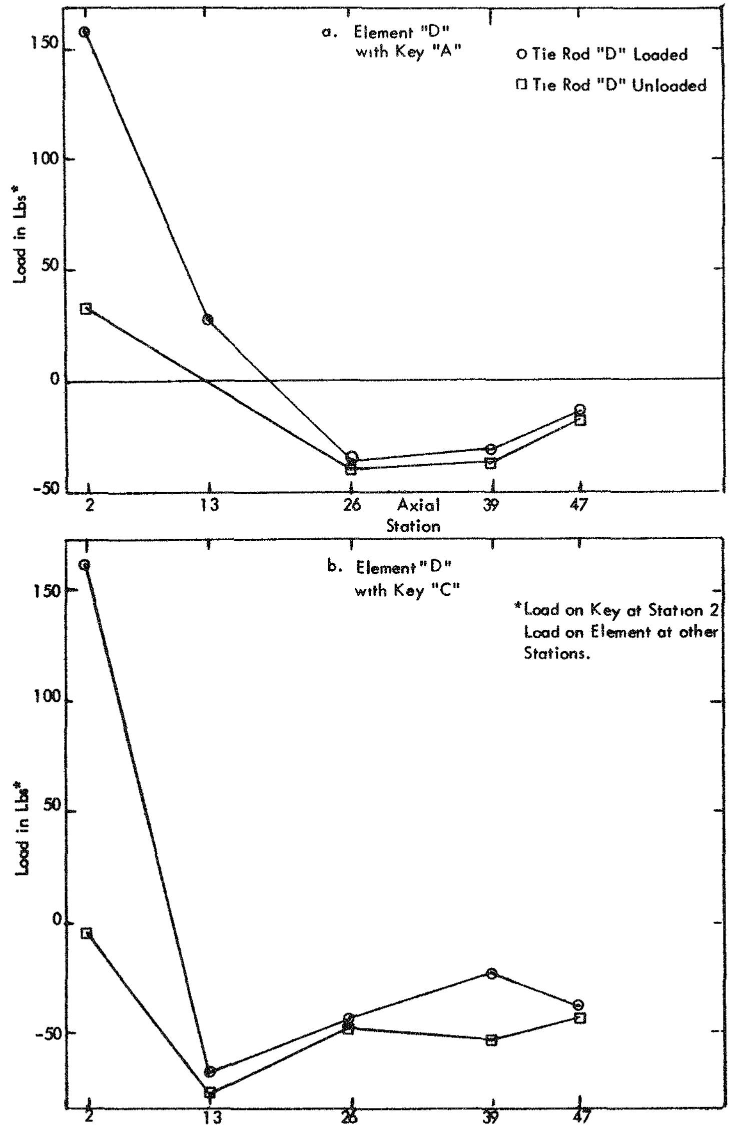


FIGURE 18

DISTRIBUTION OF AXIAL LOAD
ALONG KEYED ELEMENTS

Astronuclear Laboratory
WANL-TME-1416

EML-86 Lateral Support System Tests

a) NRX-A6 Lateral Support System Tests

Static loading test figures have been fabricated and the dynamic loading ring should be available during the next period. Procurement of test hardware is continuing.

b) Plunger Capsule Development Tests

Tests to determine mechanical properties of the NRX-A6 plunger capsule assembly with aluminum seals were completed during this period. The assembly was mounted in a Be Test Block that had been used in the previous Copper Seals Tests. The following tests were performed with results indicated below:

1. A test to determine the relationship between assembly torque and capsule tension force. The tensile load in the capsule due to 100 lb torque is 700 lb.
2. Leakage tests were run by pressurizing the annulus between the capsule and test block with 200 psig helium gas at ambient temperatures. Results indicate that the seals can contain this gas pressure without leakage with an assembly torque of 120 in./lb.
3. Leakage tests were performed with the test assembly immersed in LN_2 ($-320^{\circ}F$). Results indicate a pressure drop from 200 psig to 194 psig in 30 minutes or an average pressure drop of 0.2 psig per minute. This is an order of magnitude lower than the allowable leakage rate.

This test is being conducted on a continuing basis in conjunction with the Design effort in order to develop an acceptable plunger capsule assembly.

TABLE III

TABLE OF TEST RESULTS

Fueled Specimen Section of Element No.	Test Time (min)	Lateral Load (lb)	Temperature (^{o}K)	Maximum Lateral Creep (mils)
18899	30	25	4300	4.7
18899	30	50	4300	12.6
18899*	30	25	4400	8.0
18899	30	25	4400	10.0
18899	30	50	4400	25.0
18899	30	25	4500	20.7
96875	30	25	4500	19.2
18899*	30	50	4500	20.5
18899	30	50	4500	25.2

*These two specimens were previously tested in a preliminary setup at an unknown load with negligible deformation.

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1416

GENERAL DEVELOPMENT

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

HHT-2 Single Element Process Development and Evaluation Tests

1. Pin Hole Tests

Two tests were run with a 30 mil orifice in the center channel. Both tests were terminated due to chuck cracking and subsequent arcing. A third test was run with a 22.5 mil orifice in the center channel. The test ran for 13 minutes and then failed at the 26 inch station with a weight loss of 50 grams.

2. Chuck Development for Cluster Tests

Five hydrogen corrosion tests were performed in the single element furnace, with various cold end chuck radial gap configurations, to obtain data that is applicable to the cluster model. The first test was a helium flow test at full temperature (MB) using a cold end chuck which had an 0.5 inch radial gap filled with graphite cloth wrapping. The test ran normally with no difficulties. The second test was similar to the first but with hydrogen coolant and used an 0.25 inch radial gap. No difficulties were experienced. The third test was run with a five mil radial gap between the cold end chuck and the retainer. Mating surfaces were coated with a molybdenum disulphide spray substance to reduce sliding friction. The test was normal in all respects, no difficulties were encountered in the cold end chuck sliding surfaces. The fourth test was similar to the third but with a copper bearing graphite solution used in place of the molybdenum spray. Some arcing was noted at the sliding surfaces. The fifth test was run with a 7.5 mil radial gap between cold end chuck and retainer. Sliding surfaces were coated with molybdenum spray. Arcing occurred between the chuck and retainer and the test was curtailed before reaching steady state.

HHT-2 (Con't)

3. Chuck Development

An experimental hot end chuck was designed and built to allow loading of elements with oversized nozzle ends. Three graphite fingers, which are clamped to the side of the element with a snap spring, provide the electrical contact. The finger segment method of making electrical contact with the hot end of the element will eliminate the arcing problem caused by having to broach solid hex chucks oversized to accommodate elements with built up hot ends. This new chuck has been used in three 10+10 tests and all parts look good.

4. High Void Fraction Element

Four high void fraction elements were tested at 1BM temperature conditions. The elements were externally coated. Two elements had 110 mil holes. The first one failed after three minutes at full power and the second one ran for 20 minutes with a weight loss of four grams. The other two elements had 115 mil holes. They both failed in the center of the element after three minutes at full power. Inspection of the elements showed many cracks in the webs.

5. High Expansion Element

A high expansion element was tested with a special high expansion hot end chuck. This element was run at 1MB 10+10 conditions. Weight loss for the 20 minutes at temperature and 500 scfm hydrogen flow rate was 10.9 grams. A second test was run for 30 minutes at MB conditions, with a standard three pin hot end chuck and a standard cold end chuck which was spring loaded in both directions. Weight loss was nine grams for this time period. The use of the two different chucks apparently had no effect on the operation.

HHT-4 Single Cluster Development Tests

1. Cold End Chuck Development

A cluster test was conducted to evaluate several changes in the cluster support hardware designed to relieve radial and axial stresses and to facilitate free movement of the sliding chuck at the cold end. The tie rod exit gas temperature indicated a rapidly rising temperature after about six minutes of power operation and the test was terminated. Post test examination showed cracked elements on the aft end to be the cause of the overheating. Arcing observed on the cold end chuck was minor.

A second cluster test was conducted in a short series of hardware development tests to provide reliable cluster support hardware for future tests. An NRX-A5 skirtless block and protection cup were employed in the assembly. The cold end chuck consisted of a graphite cloth-wrapped chuck with an "O"-ring gas seal. Hot end chucking and support hardware dimensions were relieved by 10 mils to provide for cluster expansion. Testing at power continued for 10 minutes with gas at 3000°R for three minutes before the test was terminated as a result of arcing and overheating of the cold end chuck. No breakage, other than the cold end chuck, was noted and the same cluster will be employed in a third development test with an improved cold chuck design.

HHT-6 Interstitial Corrosion Tests

1. Isothermal Gap Test

The hardware fabrication is complete for the test model which will be used to test uncoated slots for pressure effect. Testing will begin the first week of April, 1966.

HHT-7 Filler Strip Corrosion Test

1. Build 4 Tests 3 and 4

Two different hot buffer test models will be used in Build 4 Tests 3 and 4. Test 3 will be run under standard conditions and Test 4 will be run under gas injection conditions. To date the preliminary reflector design layout has been completed and is being reviewed by Reactor Analysis who will specify the expected operating conditions. The reflector material will be selected on the basis of the operating conditions. The hot buffer filler strips and insulating tile are on order.

EML-61 Tie Rod Evaluation Tests

Redesigned specimens machined from one of the original 1/2 inch diameter test rods permitted the application of bending stress levels sufficiently high to produce failures within the capability of the test equipment. The results obtained indicated a very flat S/N curve, where failure occurs in a relatively few cycles (10^4 - 10^5) or runs indefintely without failure. This is indicative of a material that essentially behaves elastically up to fracture. Test results indicated that the endurance limit is in the order of 32,000 psi.

Coating adherence studies were carried out on a short length of 1/2 and 3/8 inch diameter rods. A three mil NbC coating was applied by WAFF. These were then heated to 4300°R for fifteen minutes in He atmosphere in the test furnace. Adherence of the coating to the specimens appeared good. Hair-line cracks were in evidence similar to those noted on standard graphite.

Methods of applying axial loads to rods of this type will be investigated in future tests.

Astronuclear Laboratory

WANL-TME-1416

FACILITIES

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

Large Site Vaporizer

Qualification tests on the vaporizer have been discontinued because of hose leaks. Tests will be resumed upon completion of repair of the hoses.

Thermocouple Furnace

The furnace was operated successfully for 30 minutes at a maximum temperature on the heater element of about 4000°F using a power input of less than 60 KW. The furnace was run with helium using a graphite felt insulating assembly. A pressure of 600 psi and total flow of approximately 0.01 lbs/sec were the steady state conditions.