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Westinghouse Astronuclear Laboratory

MASTER

PRELIMINARY INTERELEMENT CORROSION STUDY

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GROUP 1
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52

Test Series HHT-6
PRELIMINARY INTERELEMENT CORROSION STUDY
(Title Unclassified)

MASTER

by
R. J. Steffen

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Approved By

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Classification cancelled for change to
by authority of DOC
by H.A. E. J.C. J.C. SEP 10 1973

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ABSTRACT

One of the factors which determines the power level and operating time of the reactor core is the extent of the corrosion on the outside surfaces of the fueled and unfueled elements exposed to the interelement flow of hydrogen. To understand this problem, data must be obtained on the corrosion in small interstices so that the controlling parameters can be better understood and the rate at which the corrosion takes place can be more accurately predicted. This report describes a test used to study hydrogen corrosion in the interstices between unfueled graphite fuel elements.

To obtain data on the first phase of this program, a test rig was designed to test an NRX-A fuel element in contact with other fuel elements on all sides. A solid graphite unfueled element is mounted in a manner to allow flow along two opposite flats of the element and no flow along the four remaining flats. The gap thickness is considered one of the variables during the test program.

The test described was run at 3500°R for 30 minutes, with hydrogen flowing through the 0.002-inch gap at the rate of 0.000381 lb/sec. Post-mortem examination showed local areas of corrosion toward the exit end of the flow channels. Weight changes, although small, showed that the larger portion of the weight was lost on component hardware rather than on the test specimen itself. Evidence of hydrogen passing through the porous graphite parts is also present.

Data contained in the report show excellent temperature, flow and pressure control, and uniform temperature distributions.

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INTRODUCTION

Information available on the hydrogen carbon reaction is limited in the sense that the reaction kinetics and the flow in the small gaps and slots characteristic of the NERVA Reactor are not well understood. The hot run of the NRX-A2 reactor indicated areas where graphite hydrogen corrosion limited the life of critical reactor parts which in turn would have limited the life of the entire reactor. The potential damage to the reactor by the hydrogen-graphite reaction fully justifies programs to better understand the process and investigation of ways to inhibit the reaction.

The test series herein described was made to obtain preliminary data in simulated reactor core geometries. The configuration used was one simulating the interelement gaps. Accurate predictions of corrosion rates in configurations of this type, by theoretical methods, depend upon experimental data to substantiate assumptions made regarding flow, geometry, and kinetic characteristics. Test fixtures which accurately simulate actual conditions greatly simplify the task of comparison with results from analytical studies.

Corrosion data for this program is to be obtained in various slots ranging in widths from 0.001 inches to 0.006 inches. Material temperatures will be limited in the initial runs to 3500°R. The inlet pressure is 200 psig. The hydrogen flow rate is held constant during the run allowing ΔP to change as corrosion in the passage takes place. The test specimen is a solid hex (Cheswick type) non-fueled element contained in an HLM-85 graphite fixture.

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This fixture is placed inside an HLM-85 graphite heater element which heats the fixture and preheats the gas entering the fixture. All surfaces exposed to hot hydrogen that are not part of the actual test flow passage are to be coated with Tungsten-Varcum coating to prevent corrosion in other areas. For the initial test the Tungsten-Varcum coating was omitted in certain surfaces.

Analysis of the preliminary data obtained on a fixture containing a flow passage 0.002 inches wide demonstrated the feasibility of the test series. The examination also revealed areas where changes are necessary to obtain greater accuracy in this data. These changes, discussed in detail in the text, cover such areas as coating component hardware, gas preheat, and temperature measurement.

The system performed adequately and will not require changes for future tests. The desired flow and inlet pressure can be achieved with no problem. The required operating temperature of the specimen midplane of 3500°R was read out at 3509°R. The temperature gradient is parabolic--the midplane being the hottest point and the exit being the coolest. Evidence of hydrogen porosity was present on the specimen holder, indicating that impregnation is necessary.

EXPERIMENTAL EQUIPMENT

Figure 1 is an excerpt from Sheet 1 of Drawing NT701464.* This figure shows the furnace in cross-section. Note that assembly 102 located below the furnace layout was the fuel element configuration tested.

* The rig is detailed on Drawings NT701182 and NT701464.

Assembly 101 is a filler strip test. The test fixture is contained in a copper water jacket which in turn is contained in a stainless steel pressure vessel housing. This housing is 10.75 inches in diameter and 21.75 inches long. (Figure 2). The hydrogen flow entering is directed through four inlet ports. These ports and an internal annular plenum chamber aid in the establishment of a uniform flow distribution.

The heat exchanger, shown in Figure 3, surrounding the outer barrel, is constructed of two concentric pieces of copper pipe, the inner piece machined with 300 shallow axial grooves with fins between. When assembled, the outer copper barrel encloses the grooves by fitting to the lands. Water flows into an inlet plenum chamber of the exchanger from a 1-inch supply line. From the inlet plenum chamber, water flows through the coolant passages in the same direction as the hydrogen flow through the corrosion test piece. These passages 0.031 inches wide by 0.038 inches deep, exhaust into an outlet plenum chamber. Seven copper-constantan thermocouples measure water temperatures in the heat exchanger and read out on a multipoint recorder. An HLM-85 graphite support barrel, Figure 4, is contained in the copper water jacket. This barrel is sealed at the inlet of the rig by a silicone rubber O-ring to eliminate leakage around the outside. Axial preheater holes were incorporated in the original barrel design but a failure in this barrel gave cause to temporarily eliminate them.

Four C/A thermocouples are positioned at 90° intervals in the graphite support barrel at an axial location of 11.24 inches and a radial location of 1.93 inches. These thermocouples are used to monitor the support barrel temperatures for control and safety purposes, and are continuously printed out by

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a multipoint recorder. The barrel supports the test fixture (Figure 5) inside the heater element, Figure 6.

The heater element of HLM-85 graphite has two identical electrical circuits in parallel, which extend for 180° of the cylindrical geometry. Each circuit branches from the common graphite terminals into which the copper electrodes are threaded. The water-cooled electrodes extend through the inlet end of the pressure vessel as shown in Figure 6. Silicone rubber O-rings fitted on boron nitride sleeves seal against hydrogen pressure. The boron nitride sleeves insulate the electrodes from the pressure vessel inlet flange. When the test rig is under pressure, the terminal end of the heater element seats on a stack of marinite and aluminum oxide plates which serve as a heat barrier, an electrical insulator, a mechanical stop, and a centering device for the heater element.

The test fixture consists of a solid hex Cheswick type unfueled graphite element contained in a split HLM-85 specimen holder. The holder is hand fit to the test specimen in a manner that allows flow along two opposite flats of the element and no flow along the four remaining flats. Flow is minimized along the remaining four flats by maintaining very close fits. Figure 7 shows the test fixture in cross-section and Figure 8 shows the hydrogen flow paths. The specimen holder threads into the graphite seal housing which seals against external leakage and supports the test fixture in the support barrel. A graphite clamp cylinder containing graphite set screws, fits over the holder and maintains the integrity of the flow path when heat is applied. The graphite nozzle is placed on top of the specimen and held in

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place by the graphite lock nut. All parts of the fixture are fabricated from HLM-85 graphite. The nozzle evenly distributes the inlet flow and also bottoms the specimen on the seal contained in the seal housing. Figure 5 shows the test fixture fully assembled. Figure 9 shows the test fixture with the clamp cylinder removed. The molybdenum radiation shields located in the lock nut are used to protect the C/A inlet gas thermocouple from radiation in the radial direction. The thermocouple itself (Figure 10) has a tantalum hood which protects the head from radiation in the axial direction. Three tungsten-tungsten 26% Re thermocouples measure material temperature at the inlet, mid-plane, and the exit of the specimen. The exit gas temperature is recorded by a C/A thermocouple which is shielded from radiation from surrounding surfaces. Figures 1 and 7 show the location of the material temperature thermocouples.

Figure 11 shows a partial disassembly of the test fixture up to the test piece housing. Figure 12 shows the complete disassembly of the test fixture. The specimen is approximately 6 inches long; however, the length of the specimen holder that contacts the specimen is 3.25 inches long. This 3.25-inch length was chosen because the temperature distribution of the heater element (Figure 6) is fairly flat over this length. All surfaces of the test fixture that are not considered part of the corrosion experiment have been coated with a Tungsten-Varcum paint and then cured at high temperature to form a tungsten carbide coating to inhibit corrosion in these areas. Figure 13 is a complete disassembly of the test fixture after this coating process was completed. Machine work performed on the initial test fixture,

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to reduce the diameter by 3/16 inches, removed this coating from the lock nut and clamp cylinder.

The heater element has been coated with pyrolytic graphite in the hot zone and Tungsten-Varcum in the cooler areas. This coating minimizes contamination of the inlet gas with methane which would inhibit any corrosion taking place in the test section zone.

The grain direction of the graphite used in the fabrication of the components for all the test fixtures is in the axial direction so that there will be no problem of differential expansion. Inlet pressure and exit pressure are measured by static pressure taps located in the inlet plenum and exit plenum of the furnace respectively.

DEVELOPMENT AND OPERATION

The preliminary test series will consist of eight tests covering four different flow channel widths. These widths are 0.001, 0.002, 0.004, and 0.006 inches. Each build will be run at the following conditions:

Inlet Pressure	200 psig
Material temperature	3500°R midplane
Test section ΔP	Constant

Flow rate and power input were varied to obtain the desired conditions of pressure differential and material temperature. The preliminary test reported herein was run on a fixture containing a 0.002-inch flow channel. Prior to each test a data sheet shown in Figure 14 was filled out on each assembly. This data sheet contains the dimension and weight history of the assembly prior to and after the test.

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Critical dimensions describing the flow channel were taken at 1/4-inch intervals with a dial indicator graduated in 0.0001 inches. Measurements of the specimen were taken with a standard 1-inch micrometer. Small parts of the assembly were weighed on a balance accurate to ± 0.0002 gm, and the large components were weighed on a balance accurate to ± 0.2 gm. The total assembly was weighed after the individual parts were assembled. The weight of the heater element was also recorded prior to and after the test.

After the test the weighing process was accomplished first, weighing the total fixture and then each component as it was disassembled. The dimensional checks were accomplished last.

The furnace is installed in a system of flow controls and data indicating and recording instruments. The flow control system is shown in Figure 15. Automatic valves control the pressure of hydrogen gas supplied to and exhausted from the test piece. Pressure levels as high as 250 psig and pressure differentials as high as 10 psid can be obtained. The hydrogen flow through the test piece is measured by means of a calibrated sharp-edged orifice. Pressure and temperature upstream and pressure differential across the orifice are measured. Water flow is regulated by a pneumatic valve and a rotameter measured and indicated the flow. Orifice data, water flow, test section ΔP , test time, spot material temperatures, delivery pressure, and power readings are taken visually and recorded as read on the log sheet shown in Figure 16. Figure 16A contains a tabulation of time, material temperatures, gas temperature, and power levels as read from the recording instruments.

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A view of the control room is shown in Figure 17. The electric power for the system is supplied by two direct current Westinghouse industrial welders in parallel capable of supplying up to 80 kw (Figure 18). Two water cooled leads conduct current from the welder bus bars to the electrodes on the rig. Figure 19 shows the flow and electrical control panel. Power is calculated from measurements of current through and voltage drop across the heater element. A high-resistance direct current voltmeter in parallel with the element measures the voltage. A millivolt meter in parallel with a shunt calibrated to read a 50 millivolt drop from 2000 amperes measures the current. All flow connections to the test piece contain a section of plastic tubing at least 6-inches long to isolate the test piece.

RESULTS

Figure 20 is a curve showing the specimen temperature power input relation on start-up. Helium gas used to bring the fixture to the desired temperature and flow rate. When operating conditions are reached, an instrument check is made and the hydrogen gas is turned on. Note that the temperature distribution started out to be a straight line from specimen inlet to outlet but changed to a parabolic shape at design temperature, as anticipated. This pattern conforms to the temperature distribution of the heating element, as determined in previous testing. End effects are responsible for the parabolic shape of the heater temperature distribution.

Figure 21 is the temperature distribution along the axis of the specimen at the start, midpoint, and end of the 30-minute hydrogen run. At the start

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of the run, temperatures decreased slightly when the hydrogen was turned on. Small increases in power brought the temperatures to the desired level. The temperature distribution was held quite constant during the test, as shown by the 15-degree variation from the midpoint of the test to the conclusion.

Figure 22 shows the exhaust helium gas temperature versus power input profile on start-up. The inlet gas temperature is not shown because the thermocouple was in contact with the molybdenum radiation shields or the inlet material temperature thermocouple or both, and recorded temperatures of the test fixture lock nut. These high temperatures rapidly drove this reading outside the range of the recording instrument and no reliable data was obtained. Hydrogen flow rates and exhaust gas temperatures were very constant at 0.000381 lb/sec and 1500°R throughout the duration of the run.

Figure 23 shows the test fixture as it appeared when removed from the furnace. Hydrogen corrosion is evident on the lock nut and the clamp cylinder. A weight check of the complete assembly showed a total weight loss of 1.1 gm. From Figure 14, showing the complete dimensional and weight history, it is evident that the larger weight losses occurred on the component hardware which was first exposed to the hydrogen gas and was operating at a higher temperature than the test specimen. This corrosion tended to contaminate the incoming hydrogen with methane, reducing the corrosion in the flow channels. Another source of methane was the heater which had a weight loss of 3.6 gm. Figure 24 shows corrosion toward the inlet end where the fresh hydrogen passed over the heater element. Figures 25 and 26 show the corrosion pattern on the specimen at the exhaust end of the flow channel. The corrosion started about 0.5 inches from the exit of the flow channel and extended approximately 0.75 inches downstream

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from the exit. The line splitting the corrosion in half prior to the outlet of the channel was caused by a slight cocking of the test specimen holder. Small amounts of corrosion are visible around the inlet of the flow channel, but almost the full length of channel appears to be unaffected. Figure 27 is a close-up of one of the corrosion areas at the exit, and extending into the flow channel. The figure clearly shows the separating line in the flow channel and the corrosion downstream of the channel. Attack of the Tungsten-Varcum coating is also shown.

A possible explanation for the lack of corrosion in the length of the channel is that perhaps a boundary layer existed which contained an equilibrium concentration of methane which would protect the surface of the graphite from corrosion. It is also possible due to the temperature gradient along the specimen, that the hydrogen became saturated with methane upon entrance into the flow channel. As the gas passed to a region of cooler surface, the equilibrium concentration changed due to surface temperature change and the hydrogen was again capable of causing corrosion at the outlet end. Other explanations can be found in porous flow through the graphite specimen holder which could deliver fresh hydrogen to the exhaust plenum chamber.

Figure 28 shows corrosion on the nozzle section prior to the inlet plenum of the flow channel. This part was coated with the Tungsten-Varcum coating. Figure 29 shows the inlet end of the specimen which was corroded in a cross pattern by the inlet flow. This end of the specimen was also coated with Tungsten-Varcum.

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Figure 30 is the total disassembly showing the corrosion pattern on the side of the specimen. The surfaces where the test specimen holder sections sealed together are clean, ruling out the possibility of inflow of hydrogen gas. If there had been inflow, these surfaces would have shown local corroded areas.

Close examination of the data sheet showing weight and dimensional history of the test fixture hardware shows the weight loss of the test specimen to be 0.08 gm. Dimensions of the specimen show measurable changes at the inlet and outlet areas of the flow channel, but measurements in between these points show variations that are outside the range of accuracy of the measuring instrument. The lower portion of the test specimen holder shows a weight loss of 0.03 gm. The dimensions of the holder show an increase in dimension for the first quarter-inch and then a slight decrease in dimension possibly due to deposition of graphite on the surface. The upper portion of the test specimen holder shows a weight loss of 0.054 gm. The dimensions of this portion of the fixture show a general increase in dimension.

Support hardware located in the inlet gas stream showed weight loss; components located in the cooler exhaust area showed slight weight increases. This weight and dimensional history shows that there is corrosion taking place in the test fixture and it shows approximately where the corrosion is located.

An inlet hydrogen gas sample was taken prior to the conclusion of the run. This sample was taken to determine the methane concentration of the inlet gas produced by the corrosion of the test fixture support hardware. A hydrocarbon analyzer indicated that the methane concentration of the sample was

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425 parts per million. Calculations of equilibrium concentration based on surface temperatures showed that the concentration measured at the inlet plenum of the test fixture was well below equilibrium indicating the gas was capable of corrosion. This is substantiated by the fact that component hardware showed corrosion prior to the inlet of the flow channel. A sampling tap was not yet available to measure the concentration of the exhaust gas.

CONCLUSIONS

The results of this preliminary test are significant in that they demonstrate the feasibility of a test program of this nature and show that the existing support hardware is adequate to perform tests in a well-controlled manner.

Conclusions drawn from this test are:

- 1) satisfactory performance of furnace and related components,
- 2) corrosion results were obtained using a fixture which was not coated on the outer surface, and
- 3) the test demonstrated the need for all the component hardware to be impregnated and coated.

RECOMMENDATIONS

The results have also pointed out modifications that should be made to increase the reliability of the data and improve the overall performance of the test rig. Through these results the following recommendation have been developed.

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- 1) Niobium carbide coat all hardware up to the flow channels to eliminate methane contamination of the inlet gas by corrosion of this hardware.
- 2) Impregnate all graphite parts exposed to a pressure differential to eliminate porous flow of hydrogen to the exhaust plenum of the furnace.
- 3) Redesign the inlet gas thermocouple so that a more accurate measurement of inlet gas temperature can be obtained.
- 4) Incorporate a system which will allow inlet and outlet gas samples to be taken at intervals throughout the test.
- 5) Run the test specimen at higher temperatures approaching 4500°R so the corrosion obtained will be great enough to be accurately measured, producing reliable data for the calculation of corrosion rates.
- 6) Incorporate an internal or an external gas preheater in the system to obtain higher inlet gas temperatures.

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Figure 1

Excerpt From Print No. NT701464 Furnace Layout

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Figure 2
Pressure Vessel Housing and Water Jacket

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Figure 3
Copper Heat Exchanger

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Figure 4

HLM-85 Graphite Support Barrel

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Figure 5
Assembly of Test Fixture

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Figure 6

Heater Element Mounted on Inlet Flange

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Figure 7

Interelement Corrosion Test Fixture

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Figure 8

Interelement Corrosion Test Fixture

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Figure 9

Assembly With Clamping Cylinder Removed

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Figure 10
Inlet Gas Thermocouple

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Figure 11

Partial Disassembly of Test Fixture Up To The Test Piece Holder

Figure 12

Complete Disassembly of Test Fixture

Figure 13

Tungsten Carbide Coated Test Fixture

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FLUID FLOW LAB

DATA SHEET

HHT-6 INTERSTITIAL CORROSION TEST

BUILD NO 508-1

TEST RECORD BOOK NO 1887809 RUN NO 1 SHEET 1 OF 1
TIME OF DAY 1300 Hrs. DATE 12 MARCH 65
ENGINEER R.J. STEFFEN OPERATOR E. SOLTIS
BAR PRESSURE @ OF TEST GAS
SUPPLY PRESSURE BEFORE PSI SUPPLY FLOW IF AFTER PSI
SUPPLY TEMP BEFORE OF SUPPLY TEMP AFTER OF
VACUUM PRIOR TO TEST IN HG
VACUUM AFTER TESTING IN HG

CONFIGURATION DIMENSION A .002 NO. OF TEST CELLS 508-1

ORIFICE SIZE ORIFICE DI .076 INCH

Figure 14

Fluid Flow Laboratory Log Sheet
HHT-6 Interstitial Corrosion Test

REMARKS
Dimensions taken at A and P were taken partially on coated and uncoated surface, due to the use of flat head mic.

ITEM NO	CONFIGURATION	A	B	C	D	E	F	G	H	J	K	L	M	N	P	WEIGHT
	PRIOR TO TEST	7572	7543	7544	7545	7545	7545	7543	7543	7543	7542	754	7541	754	7563	AFTER DIM CHECK 91.9218
	AFTER TEST	7539	7544	7547	7545	7544	7545	7545	7545	7545	7546	7544	7543	754	7545	BEFORE DIM CHECK 91.8441

REMARKS
Flow path clearance between element and element holder .0015". This dimension taken with filler gage.

ITEM NO	CONFIGURATION	A	B	C	D	E	F	G	H	J	K	L	M	N	P	WEIGHT
	PRIOR TO TEST	7595	7593	7598	7608	7608	7605	7605	7601	7601	7586	7593	7598	7595	7595	AFTER DIM CHECK 87.2643
	AFTER TEST	7596	7596	7586	75925	7599	760	75975	7591	7591	7593	7591	7586	7586	7584	BEFORE DIM CHECK 87.2324

REMARKS
Total wt. of assembly before test = 609.9 gms
" " " after test = 608.8 gms
Heating element wt. before test = 976.9 gms
" " " after test = 973.3 gms.

ITEM NO	CONFIGURATION	A	B	C	D	E	F	G	H	J	K	L	M	N	P	WEIGHT
	PRIOR TO TEST	7585	7588	758	75822	75811	75809	7582	75823	75823	7582	75817	75816	75802	75802	AFTER DIM CHECK 84.4935
	AFTER TEST	7593	7588	7585	75865	7586	7587	7583	75828	75845	7583	75823	75833	7583	75843	BEFORE DIM CHECK 84.4393

ITEM NO	WEIGHT	SEAL	REMARKS
	311	312	401
AFTER DIM CHECK & BEFORE TEST	49.3	145.2	100.0
AFTER TEST & BEFORE DIM CHECK	48.9196	144.9465	100.2236

* ASSY NO

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Figure 15
Flow Control System

POINT	TIME	AET*	P OI	ΔP OI	H ₂ O FLOW	ΔP I-2	P I	P E	T MT2	P IR	P OR	POWER INFT		REMARKS
			PSIG	IN H ₂ O	GPM	PSID	PSIG	PSIG	MV	PSIG	PSIG	VOLTS	AMPS	
			Hot He Run on New build with 3/16" taken off the clamp cylinder, seal housing, and lock nut.											
1	1225		202	16.0	2.0	2.7	-	-	-	1700	260	-	-	cold.
	1230	Power ON												
1	1233	3	202	16.5	2.0	2.9	-	-	.10	1700	260	3.7	130	
2	1238	8	203	13.5	2.0	2.7	-	-	.47	1700	260	5.6	220	
3	1242	12	202	16.5	2.0	3.3	-	-	1.35	1700	260	7.9	320	
4	1246	16	203	14.5	1.9	3.9	-	-	4.05	1700	260	10.3	420	
5	1251	21	203	14.5	1.9	4.4	-	-	7.78	1700	260	13.2	525	
6	1258	28	202	14.5	1.9	5.3	-	-	14.58	1700	260	16.3	620	
7	1305	35	203	14.5	2.0	6.2	-	-	19.6	1690	260	20.3	725	
8	1312	42	203	15.5	2.0	7.0	-	-	23.55	1690	260	24.5	820	
9	1323	53	204	16.5	1.9	8.2	-	-	27.5	1690	260	28.25	930	
10	1325	Hydrogen ON												
11	1328	3	204	14.5	1.9	5.2	-	-	26.57	1300	260	28.5	930	
12	1330	5	202	16.5	2.0	5.7	-	-	26.52	1300	260	28.75	940	
13	1334	9	204	15.0	1.8	5.4	-	-	27.33	1300	260	30.0	975	
14	1338	13	204	14.8	1.9	5.6	-	-	27.71	1300	260	30.5	980	
15	1342	17	203	15.0	2.0	5.6	-	-	27.8	1300	260	30.5	982	
16	1346	21	203	15.0	1.9	5.6	-	-	27.72	1300	260	30.25	978	
17	1350	25	203	15.0	1.8	5.6	-	-	27.82	1300	260	30.5	985	
18	1354	29	203	15.25	1.9	5.6	-	-	27.82	1300	260	30.75	980	
	1355	30 H ₂ Sample Taken (inlet)												
	1356	31 He ON H ₂ OFF. Power Increase												
	1402	Power off												

* ACCUMULATED ELAPSED TIME IN MINUTES

FLUID FLOW LAB

LOG SHEET

HHT-6 INTERSTITIAL CORROSION

TEST

BUILD NO 508-1

TEST RECORD BOOK NO 1887808 RUN NO 1 SHEET 1 OF 1

TIME OF DAY 1200 hrs DATE 27 March 65

ENGINEER R.J. Steffen OPERATOR B. Horn, E. Saltis

BAR PRESSURE 29.67 @ 78 °F TEST GAS He and H₂

SUPPLY PRESSURE BEFORE 1300 PSI SUPPLY PRESSURE AFTER 1300 PSI

SUPPLY TEMP BEFORE 58 °F SUPPLY TEMP AFTER 58 °F

VACUUM PRIOR TO TESTING 28 INHG

VACUUM AFTER TESTING 28 INHG

CONFIGURATION

DIMENSION A .002 INCHES TYPICAL

ASSEMBLY NO.

508-1

ORIFICE SIZE

ORIFICE Ø .016 INCHES

Figure 16

Fluid Flow Laboratory Data Sheet
HHT-6 Interstitial Corrosion Tests

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WANI-TME-1138

Point Number	Elapsed Time	T ₁	T ₂	T ₃	G T ₂	Power
	Min.	°R	°R	°R	°R	Watts
1	3		570		520	481
2	8		710		560	1,232
3	12		926		605	2,528
4	16	1368	1302	1170	690	4,326
5	21	1830	1750	1550	800	6,930
6	28	2321	2300	2000	930	10,106
7	35	2721	2724	2426	1060	14,717
8	42	3020	3085	2755	1210	20,090
9	53	3338	3425	3120	1392	26,737
10	0	Hydrogen Gas On.				
11	3	3248	3343	3047	1390	26,505
12	5	3260	3345	3043	1370	27,025
13	9	3348	3420	3125	1390	29,250
14	13	3370	3451	3145	1428	29,890
15	17	3378	3455	3153	1435	29,951
16	21	3370	3447	3142	1435	29,585
17	25	3388	3460	3157	1439	30,043
18	29	3390	3465	3157	1441	30,135
19	30	Hydrogen Gas Off.				

Figure 16A

Data Tabulation Build 508-1 Run 1

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Astronuclear
Laboratory
WANI-TME-1138

Figure 17
Control Room

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Atomic Energy Act - 1954

Figure 18
D.C. Power Supply

Astronuclear
Laboratory
WANT-TME-1138

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Atomic Energy Act - 1954

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Laboratory

WANL-TME-1138

Flow and Electrical Control Panel

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Atomic Energy Act - 1954

Figure 20

Temperature vs Axial Station for Start-Up Power Levels Using Helium

Figure 21

Temperature Distribution of Specimen During 30 Minute Hydrogen Run

Figure 22

Helium Exhaust Gas Temperature vs Power During Start-Up

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WANT-TME-1138
Astronuclear
Laboratory

Figure 23

Fixture as Removed From The Furnace

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Figure 24

Heater Element After Test

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Figure 25

Close-Up of Corrosion Pattern on Specimen

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Figure 26

Close-Up of Corrosion Pattern on Specimen

Figure 27
Magnified Photo of Specimen Corrosion Pattern

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Figure 28

Nozzle Section Corrosion

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Figure 29

Corrosion on Test Specimen Inlet End

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Figure 30
Total Disassembly After Test

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[Faint, illegible markings]

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