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Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON JANUARY 16, 1968
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HELD WITH SNPO AT WANL ON JANUARY 16, 1968
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Classification cancelled or changed to
by authority of Doe
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INFORMATION CATEGORY
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WANL-TME-1745

January 25, 1968

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON JANUARY 16, 1968
(Title Unclassified)

ATTENDEES:

J. R. Andra	WANL	C. L. Meuche	WANL
A. Bournia	WANL	N. Norman	AGC
E. A. DeZubay	WANL	R. L. Oelrich	WANL
R. N. Eichbauer	WANL	W. J. Rowan	WANL
N. J. Ettenson	WANL	L. A. Salvador	WANL
H. J. Fix	WANL	W. A. Solie	WANL
W. J. Havener	WANL	J. A. Swanson	WANL
E. G. Igne	WANL	E. A. Watjen	WANL
G. A. Kalvin	SNPO-C	E. J. Ziurys	SNPO-C

The Monthly Development Test Program Review Meeting was held on January 16, 1968.

This report is divided into two discrete sections. The first section covers the activities of the Thermo-Flow Laboratory and the second, those of the Engineering Mechanics Laboratory. Table I of each section lists the tests performed during the reporting period and those planned for the next period. Discussions of the individual tests follow.

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SECTION A

MONTHLY REVIEW OF THERMO-FLOW LABORATORY TESTS

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TABLE I

THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (December, January)	PLANNED NEXT PERIOD (February)
<p>Tests for NRX-A6</p> <p>TFL-2.a Filler Strip Model - Continued drafting WANL-TME-1717.</p>	Issue WANL-TME-1717.
<p>Tests for XE-2</p> <p>TFL-6.c XE-2 Purge System Pressure Drop Test - Planning.</p>	Conduct Tests.
<p>Tests for R-1</p> <p>TFL-1.b Single Element Tests - Total Tests - 19</p> <ul style="list-style-type: none"> 1 - Long cold end chuck development. 10 - Hot end chuck development. 4 - High void elements at proposed R-1 Test Conditions. 1 - High void element at PEWEE Test Conditions. 3 - Low void elements (XE-2 O.D. coated) to evaluate tip corrosion. <p>TFL-1.d Fuel Element Orifices - Conducted hydriding tests of Zr orifices - element to orifice braze evaluation.</p>	<p>Tests of elements from Phases II-Fb, ID, IV-A, and IV-B.</p> <p>Conduct tests.</p>
<p>General Development Tests</p> <p>TFL-1.a Single Cluster Tests -</p> <ul style="list-style-type: none"> Continued procurement actions for PW-1 exit gas thermocouple and support tests. Continued development of the modified center element for PW tests and R-1 support stem tests. Continued model thermal-hydraulic analysis. 	Rebuild facility damaged by fire.

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TABLE I (Continued)

PERFORMED THIS PERIOD (December, January)	PLANNED NEXT PERIOD (February)
General Development Tests (Continued)	
TFL-1.b Single Element Tests - Total Tests - 4	
1 - Moly tube liner bore element evaluation test.	
1 - Test for emissivity studies.	
2 - Furnace checkout tests.	
Single Element Tests - Fuel element chilldown test rig complete.	Conduct tests.
TFL-2.a Filler Strip Model -	
Completed detail design for TFL-2.a. 0004 test of R-1 periphery.	
Continued thermal analysis for TFL-2.a. 0004.	Continue analysis.
Initiated procurement for all hardware for TFL-2.a. 0004, 5, and 6.	Expedite Procurements.
Procurement activity for FS-1 facility continued. Installation of facility approximately 20 percent complete prior to fire in test cells.	Replace equipment damaged by fire; continue installation of facility.
TFL-5.b Interstitial Corrosion - Completing installation.	Initiate testing.
TFL-5.c Reactor Graphite Permeability Tests - Tests in 18 inch furnace.	Conduct tests.
Facilities	
Liquid Hydrogen Facility at WANL.	Conduct checkout.

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TESTS FOR NRX-A6

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TFL-2.a Filler Strip Corrosion Tests

Preliminary reports from the NRX-A6 disassembly received from NRDS indicate that the behavior of the reactor periphery appears to be quite similar to that predicted by the TFL-2.a.0003 results. A report on the experimental results of TFL-2.a.0003 was in preparation and will be released next month as WANL-TME-1717, "TFL-2.a Filler Strip Corrosion Test: Simulated NRX-A6 Periphery".

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TESTS FOR XE-2

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TFL-6, c XE-2 Purge System Pressure Drop Test

Typical clusters will accompany the shipment of the XE-2. The air used to purge the XE-2 shipping container will also purge the vessels containing the clusters. These clusters will be used to evaluate the hydrating problem encountered by XE-1. Orifices will be used to obtain the desired flow through the cluster containers. In order to size the orifices, the pressure drop across the cluster containers must be determined. A test to accomplish this end will be performed on the actual hardware when it becomes available.

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TESTS FOR R-1

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TFL-1. b Single Element Process Development and Evaluation Tests

(C-RD) There were nineteen single element experiments conducted during this period. Eleven tests were conducted for chuck development. One test was an evaluation of a larger diameter cold end chuck to reduce the element surface temperature at the 15.1 inch station. Some temperature reduction was obtained and the chuck functioned well without overheating. Tests were conducted to evaluate a larger diameter, 3 inches, hot end chuck moved toward the cold end so that the temperature of the element could be read at the front edge of the chuck. Arcing was observed during tests when the power was reduced over a two minute period at the end of a test or cycle. Two tests were conducted to determine if a rapid power shut down would eliminate arcing. The arcing was eliminated, but the element failed in a subsequent test within two minutes due apparently to cracks in the element coating caused by the previous rapid power shut down. Reducing power over a seven minute period in another test reduced but did not eliminate arcing between the element and hot end chuck.

(U) Two tests were conducted to evaluate a three pin chuck. Arcing on the pins occurred probably during the down power ramp at the end of the tests. Examination of the graphite ring spring which loads the three pins, indicates that this component may have relaxed. A modified chuck with pins is being designed with a heavier graphite spring to maintain positive contact and parts are being fabricated in the shop.

(C-RD) Five tests were conducted with high void elements to evaluate them at proposed R-1 and PEWEE test conditions. Four tests were at R-1 conditions, and one was at PEWEE conditions. Loss of the hot end of the element occurred in all five tests, and an arcing at the furnace electrode occurred in the last test at PEWEE conditions.

(C-RD) After rebuilding the furnace, three tests were conducted to evaluate the hot ends of O.D. coated XE-2 elements at R-1 test conditions with two gap clearances around the exposed hot end element tip. The configurations tested were a 0.020 inch gap and a 0.007 inch gap. Although the narrow gap shows promise in reducing this hot end problem, additional tests are required to evaluate the effect of gap around the tip on element tip corrosion. During the last of these tests, the furnace electrode arced and a fire ensued causing damage to the test cells.

(U) After reactivation of the test cells, the tests planned for the next period include elements from Phases II-Fb, ID, IV-A, and IV-B.

TFL-1.d Fuel Element Orifice Calibration and Test

Fuel Element Orifice Hydriding

(U) A series of tests were performed to determine the effect of a hot hydrogen atmosphere on zirconium. This was done in order to partially determine the suitability of zirconium as a fuel element orifice material.

(U) Fuel element orifices, fabricated out of zirconium rod were inserted into clean 350 cc sampling bombs after being measured and weighed. The bombs were filled with hydrogen and sealed. The bomb was then placed in a furnace at test temperature for a timed interval. It was experimentally determined that a bomb at ambient temperature would take approximately 20 minutes to reach 1200°R in the furnace and 22 minutes from ambient temperature to 1600°F. After the test was completed, and the bomb cooled, the test specimen was removed from the bomb, measured and weighed. Bombs for tests 3 and 4 were opened after the test in the presence of a hydrogen detector. Both bombs contained hydrogen. Bomb 3 was opened approximately two hours after the test. Bomb 4 was opened approximately 19 hours after the test.

(U) A summary of the test time, temperature, specimen weight, and dimensions before and after the test is presented in Table II.

TABLE II
ZIRCONIUM ORIFICE HYDRIDE TEST

Test Number	1	2	3	4
Furnace Temperature	1200°R	1600°R	1600°R	1600°R
Time of Bomb in Furnace	1 hour	2 hours	4 hours	5.3 hours
Weight of Specimen Before Test	.356 grams	.346 grams	.352 grams	.348 grams
Weight of Specimen After Test	.356 grams	.349 grams	.354 grams	.348 grams
A Dimension Before Test	.0268 in.	.0314 in.	.0267 in.	.0304 in.
A Dimension After Test	.0268 in.	.0314 in.	.0269 in.	.0294 in.
B Dimension Before Test	.1239 in.	.1241 in.	.1240 in.	.1242 in.
B Dimension After Test	.1238 in.	.1241 in.	.1240 in.	.1242 in.
C Dimension Before Test	.0922 in.	.0923 in.	.0922 in.	.0928 in.
C Dimension After Test	.0922 in.	.0923 in.	.0922 in.	.0927 in.
D Dimension Before Test	.0293 in.	.0345 in.	.0302 in.	.0326 in.
D Dimension After Test	.0293 in.	.0345 in.	.0301 in.	.0326 in.

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The four test specimens have been sent to the metallurgical lab for sectioning and photomicrographs. The photomicrographs will reveal the degree of hydriding of the zirconium test pieces.

Fuel Element to Orifice Seal Tests

A test rig to evaluate the orifice to element braze joint has been designed and detailed. This test rig will determine the leak rate in each element flow channel individually.

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GENERAL DEVELOPMENT TESTS

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TFL-1.a Single Cluster Development Tests

(U) There were no tests conducted during this period. Procurement of the hardware for the PW-1 exit gas thermocouple and PW-1 axial support cluster tests continued in cooperation with LASL and Advanced Reactor Design. The dates of these tests are presently being integrated with the reactivation of the test cells damaged by a fire on January 11, 1968. The cluster flow system, instrumentation and controls must be repaired before this PEWEE testing can be accomplished.

(U) The evaluation of fire damage is in progress and new or replacement equipment is being procured as required. Preliminary inspection indicated that the primary components - heat exchanger, furnace, elbow, bus bar and switch - suffered only minor damage. Wire, tubing, pressure switches, thermocouple leads, and other fragile equipment must be replaced. The cell structure itself sustained damage to the roof beams. They are being replaced.

(U) In addition to PEWEE hardware procurement, the development of the modified center element continued. This element will be employed in the PEWEE tests if a "standoff" center element is chosen as a prime design. It will also be employed with the support stem in R-1 tests.

(U) The basic modified element design consists of a graphite cylinder flame spray coated with thorium oxide to act as an electrical insulator between the fuel elements and the center element. A source for the flame spraying of ThO_2 was found in the Metals Joining Group located at Westinghouse Research Laboratory. Security clearances for the personnel in this group are currently being obtained.

(C-RD) Parts for a back up design are being procured in the event the security clearances for the Westinghouse Research personnel cannot be obtained in time to meet the test schedule or in the event the flame sprayed ThO_2 design is not feasible. The back up design consists of an undercut graphite hexagonal center

(C-RD) element with small 0.040 inch x 0.250 inch chips of ThO_2 on the surface every several inches along the axial length of electrical insulation. Thorium oxide chips are being obtained from ceramics supplier.

(U) The thermal-hydraulic design of the model continued. Thermal Nuclear Design department is running several cases on their analytical model for heat transfer to the tie rod channel to determine a range of possible tie rod orifice sizes for use in the R-1 and PW-1 development tests.

TFL-1.b Single Element Process Development and Evaluation Tests

(U) Four experiments were conducted in the Single Element Furnace during this period.

(U) One test was conducted to determine if colloidal graphite, painted on the element surface at the points where temperature measurements are made, would give a different observed temperature reading. In this test and in several chuck development tests in which element surfaces were coated with colloidal graphite, temperatures measured were slightly higher on the colloidal graphite coated surfaces than on the adjacent base element surface indicating a slightly higher emissivity.

(C-RD) One test was conducted to evaluate an element with molybdenum tube liners, and two tests were conducted for furnace system check out.

Fuel Element Chilldown Test

(U) The flow loop, dewar fabrication and assembly, and a liquid nitrogen calibration run has been completed. The procedure has been prepared, and reviewed by the accident prevention administrator. The equipment is available to chill fuel elements to liquid nitrogen or liquid hydrogen temperatures prior to corrosion testing.

TFL-2.a Filler Strip Corrosion Tests

The detailed design of the test model for TFL-2.a. 0004 was essentially complete. This test will be the first in a series of developmental tests for the R-1 periphery. The thermal analysis for this model was also in progress using the CDC 6600 computer program to evaluate heater design and flow parameters, and to predict operating temperature profiles and gaps between components.

Procurement of the raw material for hardware for several builds was initiated. The machining of a complete set of hardware for the first test TFL-2.a. 0004, was also initiated. This hardware should be available for a test date in late March or early April.

Construction of the filler strip test facility, FS-1, was on schedule for a February 15 check-out date prior to the fire. The fire destroyed already accomplished work on the pneumatic control and data acquisition system and on the thermocouple system. Cooling water piping suffered minor damage. Based on the cell damage, a new furnace checkout date of mid March appears likely.

The control consoles, both electrical and pneumatic, were being fabricated on schedule and were not damaged by the fire. The work is about 50 percent complete. Procurement actions are also complete and critical items are being expedited from vendors.

TFL-5.b Interstitial Corrosion Tests

The concentrated effort on the 12 inch furnace installation continued during this report period.

Completed laboratory tasks include mounting and wiring of temperature recording instruments, installation of the bus system, pressure and control check-out of gas and water systems, and wiring of the control circuit for the cell ventilation system.

Fabrication of the furnace stand and vessel including related water and gas piping is completed, and the entire package has been successfully pressure tested to a helium pressure of 1000 psig. The assembly has been received from the Machine Shop and has been installed in the test cell.

At present, the furnace is being instrumented with thermocouples which are being connected to the temperature recording instruments. When this task is completed, electrode connections will be made, the internal parts of the furnace will be assembled, and checkout runs will commence.

TFL-5. c Reactor Graphite Permeability Tests

18 Inch Furnace

Preliminary analysis was made on the test data obtained for the impedance of a grafoil sleeve around the periphery of an unfueled fuel element. This configuration is representative of that which might be used at the aft end of the reactor to reduce or prevent interstitial flow. It appears that the flow at ambient temperature is reduced by a factor of 1.8 when the specimen is cycled from room temperature to 3700°R and back to room temperature. The tests show a need for further investigation of the performance of grafoil in thin annular passages.

Three permeability tests were attempted in the 18 inch furnace; but in each test the seals unwound and leakage occurred. The cold end chuck of the heater has not been sliding fully in the electrode jaws, and as a result helical heater stresses are relieved by twisting. Heater coils have also been deformed. A hairpin helical heater is being fabricated. This alternate heater design will eliminate heater damage, provide a more rapid test specimen changeover, and eliminate the source of test specimen unwinding. In the meantime, a spiral spring system was fabricated that will provide a torque on the seal system throughout the test. The hot end furnace heat exchanger failed at its striker plate weld. A combination heat exchanger and test specimen support plate will replace the present heat exchanger in future permeability tests.

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WANL Liquid Hydrogen Facility

Effort is proceeding on the installation of the temporary WANL liquid hydrogen facility on schedule. The piping and wiring connections to the vaporizer have been completed. Final installation awaits receipt of the vacuum jacketed piping.

The purchase order for the electric vaporizer has been placed and the vacuum jacketed piping for the permanent facility is out for bids. Effort is proceeding on the architectural drawings necessary for the dikes, foundations, and deluge system.

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SECTION B
MONTHLY REVIEW OF ENGINEERING MECHANICS TESTS

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ENGINEERING MECHANICS TESTING

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B2

<u>PERFORMED THIS PERIOD</u> (Dec. 1, 1967 - Jan. 15, 1968)	<u>PLANNED NEXT PERIOD</u> (Jan. 16, 1968 - Feb. 26, 1968)
<u>GANGED DRIVE (EML-A.4)</u> Band Spotweld Tests Preliminary Decoupler Shear Pin Tests	<u>GANGED DRIVE (EML-A.4)</u> Continue Testing Continue Testing 3 Drum Facility Checkout
<u>LATERAL SUPPORT & SEALS (EML-D.5)</u> High "G" Level Partial Core Test	<u>LATERAL SUPPORT & SEALS (EML-D.5)</u> None Static Test of Seal Candidate Materials Dynamic Tests of Seal Candidate Materials
<u>CORE PERIPHERY (EML-E.1)</u> Pyrofoil Thermal Expansion Test Special Wrapper Evaluation Test	<u>CORE PERIPHERY (EML-E.1)</u> Continue Testing None
<u>SUPPORT STEMS (EML-C.3)</u> Grafoil Seal Expansion Test	<u>SHIELD (EML-F.2)</u> Shield Element Thermal Shock Test
	<u>SUPPORT STEMS (EML-C.3)</u> Continue Testing Liner Tube Burst Test Tensile Strength Test

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PERFORMED THIS PERIOD
(Dec. 1, 1967 - Jan. 15, 1968)PLANNED NEXT PERIOD
(Jan. 16, 1968 - Feb. 26, 1968)COMPOSITE SUPPORT (EML-C.2)

Pyrofoil Seal Leak Test
Element Forward End Joint Strength Tests
Bundled Furnace Checkout

COMPOSITE SUPPORT (EML-C.2)

None
None
None
Short Cluster Creep Tests
Short Cluster Interface Bonding Tests
Short Cluster High Temperature Load Tests
Pedestal Thermal Shock Tests

ANTICRITICALITY SYSTEM (EML-J.1)

Poison Wire Withdrawal

ANTICRITICALITY SYSTEM (EML-J.1)

None

RESONANT SURVEY (EML-H.1)

XECF Transverse and Longitudinal
Vibration Tests

RESONANT SURVEY (EML-H.1)

XECF Turbine Inlet Line Vibration Tests

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NUCLEAR SUBSYSTEM
MECHANICAL COMPONENTS TESTS

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GANGED DRIVE (EML-A.4)

Band Spotweld Tests

(U) A test program to provide preliminary information on the structural integrity of a spotwelded attachment configuration for ganged drum bands has been initiated. The test program includes tensile and cyclic tests and utilizes the titanium band material which was furnished by the WANL Materials Group.

(U) Three ambient temperature tensile tests to failure have been performed on the Wiedemann tensile testing machine. The first specimen failed at a tensile load of 986 lbs with failure occurring in the tensile area away from the spotwelded regions as shown in Figure 1a. The second and third specimens failed in the spotwelded region at loads of 933 and 700 lbs respectively. A typical spotweld failure is depicted in Figure 1b. Tests are continuing.

Preliminary Decoupler Shear Pin Tests

(U) Preliminary actuator shear pin decoupler tests were completed. The purpose of these tests was to determine the range of torque required to shear the pin and to determine if galling or hang up would occur upon continued rotation after pin shearing. Six aluminum pins of .1406 nominal O.D. were sheared in a simple shaft and tube configuration having diameter clearances of .002 to .004 and .004 to .006 inches. All shafts, tubes and shear pins were thoroughly cleaned and the shaft and tube mating surface diameters, length of engagements, and pin hole and pin diameter for each test assembly were measured and recorded. Figure 2 shows the components prior to testing.

FIGURE 1a
FAILURE OF TEST SPECIMEN
IN TENSILE REGION.

FIGURE 1b
TYPICAL WELD FAILURE

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FIGURE 2
ACTUATOR SHEAR PIN TEST COMPONENTS

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(U) Five shafts were lubricated. One from each clearance group was lubricated with Neolube per Paragraph 3.4 and 3.5 of PS 294604. One from the $\frac{.004}{.006}$ clearance group was lubricated by dipping in a solution containing 5 grams of Molybdenite (MoS_2) (M8565-3) and 25 cc of 190 proof alcohol and one from the $\frac{.002}{.004}$ clearance group was lubricated by hand burnishing with powdered Molybdenite (MoS_2) using a clean lint-free cloth. In addition, one shaft from each clearance group was not lubricated to serve as a base line so that the value of lubrication could be established.

(U) The torque required to shear the pins ranged from 800 ± 50 in. lbs. to $900 \pm$ in. lbs. The rotation torques after shearing each pin were measured with a torque wrench while rotating the shaft for 10 cycles from 0° to 180° and return. The minimum to maximum rotation torques recorded ranged from 0 to 18.6 lbs. Figures 3 and 4 show components after pin shearing and 10 cycles $0 - 180 - 0$ degrees rotation.

(U) Use of the powdered Molybdenite (MoS_2) lubricant resulted in the lowest torques upon continued shaft rotation after pin shearing and it will be used to lubricate all the shafts in the final actuator shear pin tests. These final tests will employ a torque transducer which in conjunction with a strain gage bridge will record torque on an X-Y recorder. This will reduce the present tolerance of ± 50 in. lbs introduced by the hand torque wrench.

LATERAL SUPPORT & SEALS (EML-D.5)

High "G" Level Partial Core Test

(U) Vibration tests were performed on an A6 type lateral support system at inputs exceeding the design level of 4 g. A predetermined.

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FIGURE 3a
NEOLUBE LUBRICATED
COMPONENTS AFTER TEST

FIGURE 3b
NEOLUBE LUBRICATED
COMPONENTS AFTER TEST

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FIGURE 4a
MOLYBDENITE LUBRICATED
COMPONENTS AFTER TEST

FIGURE 4b
MOLYBDENITE LUBRICATED
COMPONENTS AFTER TEST

(U) maximum test limit of 50 mils relative displacement between the core and reflector was established. This limit was reached at the 4-1/2 g input and testing was therefore limited to that level. Testing was performed in the frequency range between 5 and 100 cps.

(U) Upon disassembly, it was found that two second row seal segments (Figure 5) had broken. The greatest motion and highest loading condition should have existed in the fourth row of segments and therefore immediate failure explanation is not apparent. Analysis is continuing while the partial core is being rebuilt with 360° angle seals as part of the continuing R-1 seal development program.

CORE PERIPHERY (EML-E.1)

Pyrofoil Thermal Expansion Test

(U) During development testing of the NRX-A6 periphery design, a series of pyrofoil expansion tests was completed using graphite thermal expansion logs to obtain 1.1% strains. A new series of pyrofoil expansion tests were conducted to obtain data on the expansion of the foil to strains as high as 2.4%. In addition, a new developmental embossed pyrofoil was also tested. The embossing is done by wrapping a forty (40) mesh screen around the processing rolls and running standard PDS 30182-2 foil through a final run. Post-test photographs of each type foil are shown in Figure 6.

(U) The embossed foil is presently available only in six (6) inch widths and this necessitated a re-design of the expansion log apparatus used in the test series. In addition, graphite logs providing high thermal core coefficients were required for the higher strains. The first

FIGURE 5
BROKEN SEAL SEGMENTS

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FIGURE 6a
PYROFOIL STRAIN TESTS

FIGURE 6b
PYROFOIL STRAIN TESTS

(U) series of tests was conducted on a Speer Carbon SX5 log that produced calculated strains of 1.5 to 1.6% at 4800°R and the second series on a Poco Graphite AXF-5Q log that produced calculated strains of 2.2 to 2.4% at 4800°R. The design of the log and holding fixture used in the test are shown being loaded into the furnace in Figure 7.

(U) Test results are shown on Table I, and indicate that the upper limit of strains has not been fully explored for either type of grafoil. The embossed foil has successfully withstood all of the test conditions shown on the table, while one specimen on the flat foil broke during one test under a lengthwise strain of 2.3%. A new test series is presently underway to produce higher strains in both foils by reducing the width of the test section.

Special Wrapper Evaluation Test

(C-RD) A total of sixty (60) minutes testing has been completed on molybdenum foil installed as an outer wrapper. This concept has potential reactor application as a means of reducing corrosion caused by hydrogen in-flow over hot-exposed wrapper surfaces.

(C-RD) This test series was conducted to observe the condition of the molybdenum foil after being subjected to simulated reactor conditions of carbiding environment, temperature, core thermal expansion and pressure drop across the wrapper.

(C-RD) The total wrapper consisted of nine (9) preformed layers of 0.0055 inch PDS 30182-2 grafoil, joined with butt joints to form the basic wrapper with a single continuous layer 0.001 inch preformed moly-form on the outside. Both the foil and moly-foil were installed between the fuel elements and the filler strips as shown in Figure 8. This shows

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FIGURE 7
PYROFOIL STRAIN TEST APPARATUS

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TABLE I

			Inner Layer			Outer Layer			
Test No.	Calculated Strain, %	Foil Type	Wrap Direction	Measured Set, %	Results	Wrap Direction	Measured Set, %	Results	
Series 1	1	1.6	Flat	LW	1.16	No break	CW	1.34	No break
	2	1.6	Flat	LW	.67	No break	CW	.67	No break
	3	1.6	Flat	CW	1.00	No break	LW	1.00	No break
	4	1.6	Emb.	LW	.995	No break	CW	1.16	No break
	5	1.6	Emb.	CW	1.33	No break	LW	1.33	No break
Series 2	6	2.3	Flat	LW	1.68	No break	CW	1.66	No break
	7	2.3	Flat	CW	1.67	No break	LW	Break at 2 places 1-3/4" from radius 1-1-1/2" lg.	
	8	2.3	Emb.	LW	2.48	No break	CW	2.31	No break
	9	2.3	Emb.	CW	2.0	No break	LW	2.14	No break

KEY:

LW = Lengthwise i.e. with direction of rolling
 CW = Crosswise i.e. across direction of rolling
 Flat = Foil - PDS 30182-2
 Emb. = Foil - PDS 30182-2 embossed

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FIGURE 8
CORE PERIPHERY SECTOR WITH MOLY FOIL

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the core section mounted in the test container with the filler strips moved back to show the molybdenum foil. The build is being disassembled and results of the test will be reported during the next period.

SUPPORT STEMS (EML-C.3)

Grafoil Seal Expansion Test

(U) The first in the series of grafoil seal tests were performed to determine a means of calculating the stress in a central element which is developed during assembly of grafoil seals. These sleeves will be used to seal the annulus bounded by the walls of the central element I.D. and the outside diameter of the liner tube. This is similar to the design which exists at cold end of the NRX liner tube. Equations are readily available which define the stresses in a thick walled cylinder. By running these tests using a cylinder configuration and then the actual central element, a form factor will be determined which can be used to calculate element stresses.

(U) A schematic sketch of the test assembly is shown in Figure 9a. Axial loads were applied to the ends of the grafoil seal wedges until failure of cylinder occurred at 390 lbs. The failed components are shown in Figure 9b. Buckling of the liner tube was noted and can also be seen in Figure 9b. This was caused by the grafoil material being forced into the space between the liner tube and the aluminum fitting and its occurrence is not significant to the test results.

Additional tests using strain gaged specimens will be performed.

COMPOSITE SUPPORT

Pyrofoil Seal Leak Test

(C-RD) The pedestal design proposed for use in the PeeWee reactor includes a LASL type composite cup which bears against the WANL

FIGURE 9a
 GRAFOIL SEAL EXPANSION TEST

FIGURE 9b
 COMPONENTS USED IN SEAL
 EXPANSION TESTS

(C-RD)

tapered support washer. The design includes a seal between the I.D. of the cup and the O.D. of the outer sleeve which is made by stacking eight pyrofoil washers as shown in Figure 10. Room temperature tests were conducted to demonstrate the effectiveness of this seal. The test configuration consisted of a regular protection cup pyrofoils, pedestal, tapered washer and a simulated outer sleeve; but a pyro-washer was substituted for the insulating cup and a steel tube for the inner protection sleeve.

(U)

A fitting was designed to pressurize the protection cup area above the pyrofoils while subjecting the assembly to loading at room temperature in the Wiedemann machine. An axial load of 350 lbs was used and a helium gas pressure of ten psig employed to simulate the pressure differential.

(U)

Six runs were made evaluating the 8 foil seal. In addition six and seven foil seals were tested. In all but one run, the seal was gas tight with no leakage detected on a flowmeter and the pressure was maintained for an hour without measurable drop. An investigation into the case where leakage developed revealed that two of the pyrofoils were torn during assembly.

(U)

For further evaluation of the design the outer sleeve was shimmed away from the pyrofoils a distance of 10 mils. Under loading, this gap was filled by deformation of the pyrofoils and the seal was effective at pressure differentials up to 20 psig. However, without loading leakage developed above 5 psi differential pressure and the leak path was established to be through the larger diameter pyrofoil layers and up the sides of the protection cup.

FIGURE 10
PEEWEE PEDESTAL DESIGN SHOWN
ON RIGHT WITH TEST HARDWARE
SHOWN ON THE LEFT

(U) Another series of tests was conducted with ten and thirty mil gaps between the sleeve and the small diameter pyrofoil washers and less than .1 cc/mm leakage was recorded. Finally, the inner sleeve was removed and a leak tight seal was still maintained.

(U) These tests showed that the pyrofoil washers perform well as a seal at room temperature under single or repeated loadings; however, care must be exercised during assembly to avoid tearing.

(U) The necessity for evaluated temperature is being determined. Past experience with foils at temperature has shown that the seal will not be degraded on the way up to temperature; however, on cooldown, the foil may not follow the contraction and may leak. Testing at temperature would determine the leakage after repeated loadings and temperature cycles.

Element Forward End Joint Strength Tests

(C-RD) One of the alternate concepts being considered for reactor cluster support is an element stand-off design where the central and fuel elements are bonded at the cold end and only the central element contacts the pedestal. Testing was conducted on cementing materials which could be used in the PeeWee reactor should it be desirable to demonstrate this concept in PeeWee.

(C-RD) A test series was originated using three inch long element sections. The elements were cemented so that the center element protruded one quarter inch above the fueled elements thereby giving a 2.75 inch long cement joint and a calculated area of 1.2 square inches. Data show that the bond strengths of Code 9 elements bonded to a center element with Silastic RTV vary between 62.5 lbs/in² and 167 lbs/in². Tests using Codes 6 and 3 elements resulted in similar ultimate shearing strengths.

(C-RD) Several processing and base material variations were also checked and a complete tabulation of all tests is given in Table II. Silastic could not meet the desired shear strengths of 800-1000 psi regardless of the technique or base material employed.

(U) A single specimen (Sample 33) was joined with epoxy cement EPY 500 and included in the test series. This specimen broke at an ultimate load of 3600 lbs giving a shear strength of 1500 psi. Discussions are presently being held relative to additional testing of EPY 500 joints.

Bundled Furnace Checkout

(U) The high temperature bundling furnace has been completely checked out at operating conditions during the past report period. A test was run with an axial load of 10,000 lbs pressure of 250 psi, bundling load of 400 lbs, and a temperature of 5000°R.

The bundling furnace is now qualified to begin short cluster pedestal testing.

ANTICRITICALITY SYSTEM (EML-J.1)

Poison Wire Withdrawal Tests

(U) A group of tests were performed to obtain basic experimental information required for analyzing the safety limits of the poison wire system. One condition under consideration requires information concerning the magnitude of forces that could withdraw the poison wire from a core which is submerged in water. Such an event could conceivably occur during a misfiring at launch which would leave the nuclear stage in shallow water. Tests were performed to determine the buoyancy of the poison wires and the forces needed to remove these wires from an element.

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TABLE II
ELEMENT CEMENT JOINT DATA

Uncoated

Code 9 Bonded to Single Hole Center Element

$$A = 1.2 \text{ in}^2 = .434 \times 2.75$$

<u>Sample No.</u>	<u>Cemented Total Bond</u>	<u>Thickness Per Face</u>	<u>Lateral Curing Load No.</u>	<u>Ultimate Load No.</u>	<u>Ult. Stress psi</u>
					$\sigma = P/2/A$
1	.0003 in	.00015 in.	100	220	92
2	.0006 in.	.0003 in.	100	100	80
3	.0012 in.	.0006 in.	100	220	92
8	.0019 in.	.00095 in.	0	220	92
9	.0019 in.	.00095 in.	0	230	96
10	.0008 in.	.0004 in.	0	280	117
15	.0004 in.	.0002 in.	60	230	96
16	.0003 in.	.00015 in.	20	225	93.7
17	.0003 in.	.00015 in.	20	162	67.5
18	.0002 in.	.0001 in.	80	400	167
19	.0005 in.	.00025 in.	20	155	64.5
20	.0002 in.	.0001 in.	20	160	66.7
21	.0005 in.	.00025 in.	40	180	75.0
22	.0004 in.	.0002 in.	0	215	89.5
23	.0005 in.	.00025 in.	0	150	62.5
24	.0004 in.	.0002 in.	0	175	73
25	.0003 in.	.00015 in.	0	210	87.5

Uncoated

Code 9 Bonded to Single Hole Center Element

26	.0005 in.	.00025 in.	80	180	75
27	.0004 in.	.0002 in.	80	240	100

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TABLE II (continued)

<u>Sample No.</u>	<u>Total Bond</u>	<u>Thickness Per Face</u>	<u>Lateral Curing Load No.</u>	<u>Ultimate Load No.</u>	<u>Ult. Stress psi</u>
4	.003 in.	.0015 in.	0	300	125

Coated

Code 3 Bonded to Single Hole Center Element

5	.0024 in.	.0012 in.	0	300	125
6	.0024 in.	.0012 in.	0	320	133
11	.0002 in.	.0001 in.	100	225	93.7
12	.0002 in.	.0001 in.	0	185	77
13	.002 in.	.001 in.	20	150	62.5

3 Aluminum Hex Shaped Stock Bonded With Silastic

29	---	---	0	180	75
----	-----	-----	---	-----	----

3 Graphite Hex Shaped Stock Bonded With Silastic With Masking Tape

30	---	---	0	215	89
----	-----	-----	---	-----	----

3 Graphite Hex Stock - Silastic Coated, Surface Wiped, and Silastic Coated, Wrung and Air Cured

31	---	---	0	340	141
----	-----	-----	---	-----	-----

3 Graphite Hex Stock - Silastic Coated, Surface Wiped, Air Cured at 2 Hours, Silastic Coated, Wrung and Air Cured

32	---	---	0	520	206
----	-----	-----	---	-----	-----

3 Graphite Hex Stock - Epoxy 500 Coated, Oven Cured 1 Hour at 350°F

33	---	---	0	3600	1500
----	-----	-----	---	------	------

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(U) The average weight in air of each of six poison wires was $0.435^{+.006}_{-.008}$ oz. and in water $0.283^{+.005}_{-.004}$ oz. The six wires were inserted into an element and terminated at an adapter fitting which allowed all wires to be withdrawn simultaneously. The wires were pulled from a fuel element at 1 inch per second and at 1 inch per 24 hours. with the assembly dry and then repeated submerged in water.

(U) The results of the dry tests showed that the forces required to withdraw the poison wires were decreased for the slower rate of pull. 45.3 oz were required to break friction at 1 inch per second and 32.6 oz at 1 inch per 24 hours. Similarly, with the fuel element and poison wires submerged in water, the slower rate of pull took 33.7 oz while the faster rate required 38.4 oz. The need for additional data is being reviewed.

RESONANT SURVEY (EML-H.1)

XECF Transverse and Longitudinal Vibration Tests

(U) Resonant survey tests were conducted on the XECF engine and test data will be used to determine resonant frequencies, motions and interactions between the major engine components. The installation of the engine in the ETS-1 facility is shown in Figure 11. Horizontal and vertical vibratory loads were applied to the nozzle-pressure vessel flange at 3° - 45° as shown in Figure 12. For the longitudinal tests the shaker was moved downward on the support structure and rotated about the pivot until the line of excitation was at 45° from the horizontal. Sweep tests from 5 to 1500 cps were performed at each shaker position with strain gages on the drive rod used to maintain a constant force level during each run. A maximum acceleration of 1G on any of 16 accelerometers displayed on oscillographs was selected as a limiting

FIGURE 11
XECF ENGINE IN ETS-1 FACILITY

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FIGURE 12
POSITION OF SHAKER FOR
TRANSVERSE VIBRATION TEST AT 3°-45'

(U) condition. The maximum force attained was 60 lbs. After each group of sweep tests, the data was reviewed and dwell tests were performed at the frequencies where there was a build up of accelerations. The dwell frequency periods were held for a sufficient time to collect data on a digital printout system which had a capability of recording amplitude and phase angles for 54 transducer pickups.

(U) In addition, damping investigations were conducted at certain frequencies by operating the shaker at a constant force level and then abruptly reducing the excitation force to zero.

The preliminary interpretation of the data indicates the following:

(U) 1. The resonance at 14-16 cps appears to be the first cantilever mode of the XECF structure. Also at 16 cps large motions of the turbine inlet line are probably caused by a resonant condition. The indicated second cantilever mode of the XECF structure was 52 cps. This frequency could also be a pump discharge line resonance. The first two bending modes had been calculated to be 13.2 and 40.7 cps by AGC.

(U) 2. All previous hot tests of reactors have encountered conical nozzle resonances at 228 and 237 cps. This test again identified these resonances. Although 237 cps is the major resonance of the nozzle, the 228 cps resonance had a greater effect causing an amplification on the core of 3 to 1. This frequency also excites the turbine inlet line.

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(U)

3. The nozzle was excited at 384 and 452 cps. The 452 cps frequency appears to be a longitudinal nozzle resonance which in turn excites the pump discharge line.

(U)

4. The frequency 657 cps seems to be a bending mode of the pressure vessel and has definite effects on the core. At this frequency, the core acceleration is ten times that of the input. This could be a pitching mode of the pressure vessel and further detailed data evaluation is required.

(U)

5. The damping tests show that at 703 cps there was approximately a 10 second decay time. This is interrupted as a localized effect of the support block clearances. The displacement amplitude at this frequency would be less than 2×10^{-5} in.

(U)

6. High accelerations occurred on the pressure vessel at 1238 cps. This is unexplained at this time.

(U)

7. At 1238 cps the turbine inlet line exceeded 1 "G" with an input acceleration of .05 "G". This is an amplification of 20 to 1.

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