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WANL-TME-1797

Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON MAY 1, 1968
(Title Unclassified)

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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON MAY 1, 1968
(Title Unclassified)

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

Classification cancelled (or changed to)

by authority of

by H. F. C. TIC, date SEP 11 1973

E. A. DeZubay

E. A. DeZubay, Manager
Thermo-Flow Laboratory

SPECIAL REVIEW DETERMINATION	REVISIONS	Class.	Date
	TR	U	4-7-82
Class: <u>U</u>			

C. L. Meuche 5/14/68
C. L. Meuche, Manager
Engineering Mechanics

INFORMATION CATEGORY

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E. A. DeZubay
Authorized Classifier

5/14
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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON MAY 1, 1968
(U)

E. A. DeZubay	WANL	C. L. Meuche	WANL
R. N. Eichbauer	WANL	D. F. Miller	WANL
N. J. Ettenson	WANL	N. Norman	AGC
H. J. Fix	WANL	R. L. Oelrich	WANL
W. J. Havener	WANL	W. J. Rowan	WANL
I. Helms	SNPO-W	L. A. Salvador	WANL
R. Holman	WANL	B. H. Stahl	WANL
G. Kalvin	SNPO-C	F. G. Tauch	WANL
I. E. Kanter	WANL	D. C. Thompson	WANL
D. L. Ledbetter	AGC	E. A. Watjen	WANL

The Monthly Development Test Program Review Meeting was held on May 1, 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

TABLE I
THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (April)

PLANNED NEXT PERIOD (May)

Tests for NRX-A6		
TFL-3.a	Control Drum Flow Impedance - Completed testing.	Issue report.
TFL-3.f	Reflector Thermal Transient Test - Continue fabrication.	Initiate testing.
Tests for PW-1		
TFL-1.a	Cluster Tests - Procurement of hardware for: Furnace Checkout Tests, PW-1 Support Test, LASL Thermocouple Test.	Checkout CL-1 furnace and related systems. Assemble PW-1 and LASL clusters for test.
TFL-1.b	Single Element Tests - Total - 38 17 - PEWEE production elements (including 1 LASL element) at A6.04 conditions. 21 - PEWEE production elements (including 1 LASL element) at P1.02 conditions.	No additional tests planned.
Tests for R-1		
TFL-1.b	Single Element Tests - 28 2 - Test and chuck development cyclic tests at A6.04 conditions with E-8 chucks (XE-2 elements). 2 - Test and chuck development non-cycle tests at R1.07 conditions with E-8 chucks (XE-2 elements). 7 - Test and chuck development cyclic tests with 3 fingered broached chucks at A6.04 or R1.07 conditions (XE-2 elements). 5 - Test and chuck development cyclic tests with 3 fingered insert chucks at A6.04 or R1.07 conditions (XE-2 elements). 12 - Test and chuck development tests, cyclic and non-cyclic with 3 fingered chucks at R1.07 conditions (high void elements).	Conduct additional tests including multiple cycle and chuck and development tests.
TFL-1.d	Fuel Element Orifice Tests - Assemble model.	Conduct tests.

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TABLE I (Continued)

PERFORMED THIS PERIOD (April)

PLANNED NEXT PERIOD (May)

Tests for R-1 (Continued)

TFL-2. a Core Periphery Test -
Design review for TFL-2. a. 0004, 5, and 6.
Assembly of checkout model TFL-2. a. 0003b.
FS-1 furnace assembly.
Hardware procurement for TFL-2. a. 0004, 5, and 6.
Hydraulic analysis of seal system.

Continue procurement, analysis, and assembly work.

General Development Tests

TFL-1. b Single Element Tests - Total - 68
11 - Phase II-Fb elements at R1. 07 conditions and 20-minute cycles.
40 - Phase IV-B elements at R1. 07 conditions: 23 non-cycles, 2 20-minute cycles, 15 10-minute cycles.
10 - Phase GP-72 elements at R1. 07 conditions and 10-minute cycles.
1 - Test for cyclic furnace checkout
3 - II-Ga high expansion graphite elements tests.
3 - Tests of high void elements with cylindrical graphite collars on hot end.

Additional tests of Phases II-Ga and IV-B elements.

TFL-5. b Interstitial Corrosion Tests - Assembled and checked out.

Conduct tests.

Facilities

WANL - LH₂ Facility.

WANL Cell 1 and 2 Reactivation

Completed CL-1 installation.
FS-1 installation 75% complete.
Drafting CL-1 procedures.

Checkout CL-1 facility.
Continue FS-1 facility installation.
Complete CL-1 procedures.

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TESTS FOR NRX-A6

TFL-3. a Control Drum Flow Tests

Hydrogen flow tests were conducted on the spare NRX-A6 control drum by the Thermo-Flow Laboratory at the WANHES Test Facility. The purpose of the tests was to determine the degree of correlation between the mathematical model and experimental data. This provides aid toward the resolution of the NRX-A6 reflector ring cracking problem.

The tests were conducted for the control drum in a full flow configuration and full flow with transverse slits. The slits are located at the outer control drum-reflector webs between the middle and end reflector rings. They have an 8 mil gap for a 90° angle with respect to the control drum axial centerline.

The test conditions included the same inlet mach number and the same flow rate as occurs in the reactor. The temperature of the hydrogen gas was generally around 495°R .

The results of flow tests 4 and 5 are presented as the data for (1) full flow and (2) full flow with slits respectively (Figures 1 and 2). The data for the first three tests has been rejected in favor of the latter tests because of some flow instability problems encountered during the earlier tests. The instability was caused by pressure and flow control valve cycling.

Plotted data of inlet plenum density times control drum pressure drop versus flow rate is shown on the Figures 1 and 2. The data is shown relative to the analytically predicted data points supplied by the Thermal and Nuclear Design Group. The plots show that for a given density times pressure drop, the experimental full flow is approximately 10.8% lower than the analytically predicted flow and the experimental full flow with transverse slits is about 8.1% lower than the predicted flow without slits.

The model has been disassembled and sent to storage. A report summarizing the test results is complete except for the figures. Data tape plots of each parameter versus time is available in the Thermo-Flow Laboratory for review.

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FIGURE 1

INLET PLENUM DENSITY x DRUM PRESSURE DROP VS FLOW RATE
BASED ON PHOTOGRAPHED DATA FROM RUN 4 - FULL FLOW

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FIGURE 2

INLET PLENUM DENSITY x DRUM PRESSURE DROP VS FLOW RATE
BASED ON PHOTOGRAPHED DATA FROM RUN 5 - SLIT FLOW

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TFL-3. f Reflector Flow Distribution Tests

The fixturing for this test is 90% complete except for the thermocouple instrumentation supports. The design of the instrumentation set-up is complete and fabrication has begun. Strain gauge instrumentating is progressing. Tests should begin within the next report period.

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TESTS FOR PW-1

TFL-1.a Single Cluster Development Tests

Hardware procurement for the furnace checkout test, the LASL exit gas thermocouple test, and the PEWEE axial support system test received major emphasis. The checkout test will be performed with NRX-A6 hardware using a modified center element design. This design employs chips of thoria to provide the electrical insulation between the graphite center element and the fuel elements. All hardware for this build was on hand with the exception of the thoria chips. Labor problems at the vendor's plant delayed shipment of the pre-cut insulators. Fabrication and shipment are being expedited so that the checkout cluster can be assembled early next period.

Cluster hardware for the LASL exit gas thermocouple build was received from Los Alamos. This included forty unfueled elements (fabricated with composite tips) as well as pedestals, protection cups, central elements, and related hardware. The pre-assembled tie rod-exit gas thermocouple assemblies were also received. The first cluster will be assembled next month for a test series early in June.

All of the hardware for the tests of the WANL clusters for PW-1 was received and inventoried. The initial cluster will be assembled next period in preparation for a test series early in June.

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

Thirty-eight single element corrosion tests were conducted during this period.

Seventeen PEWEE production elements (including one LASL element) were corrosion tested at A6.04 test conditions.

Twenty-one PEWEE production elements (including one LASL element) were corrosion tested at P1.02 test conditions.

These tests completed the corrosion testing program for PEWEE production elements.

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TESTS FOR R-1

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

(U) Twenty-eight single element experiments were conducted in the single element corrosion furnaces for Test and Chuck Development.

(U) Four tests were conducted on XE-2 non-O. D. coated elements at A6. 04 and R1. 07 test conditions with the E-8, helium blanket, hot end chucks.

(U) Twelve cyclic tests were conducted on XE-2 non-O. D. coated elements at A6. 04 and R1. 07 test conditions employing 3 fingered hot end chucks.

(C-RD) Twelve cyclic and single cycle tests were completed at R1. 07 test conditions with 3 fingered hot end chucks using high void elements. In one of the twelve cyclic tests, a high void element was tested at R1. 07 conditions with the corrosion furnace being opened after each 10 minute cycle. Photographs of the hot end of the element were made without removing the fuel element to determine when and how the hot end corrosion was occurring. Figure 3 shows the hot end of the element after each cycle of a multiple cycle test and indicates that corrosion begins on the corners and proceeds inward until the complete BAR surface is corroded away.

(U) On the basis of the chuck development testing program, an improved hot end chuck for cyclic testing, the 3 fingered design, was developed. This chuck was employed in the cyclic testing of elements from Phases GP-72 and IV-B.

(U) Additional cyclic chuck and test development tests are planned for the next period.

TFL-1d. Orifice Calibration and Test

(U) The purpose of this test is to evaluate the orifice to element seal braze. The orifices will be fabricated from 416 stainless steel. The orifice will be blank with a braze groove machined in the outside diameter of the orifice outlet. An intermediate temperature braze alloy will be used. The test specimen is a one inch segment of element with blank orifices brazed in its flow channels. Four test specimens will be subjected to the test sequence. The test sequence consists of the following: (1) gross leak rate determination, (2) thermal shock, (3) gross leak

BEFORE TEST

AFTER 1st CYCLE

AFTER 2nd CYCLE

AFTER 3rd CYCLE

AFTER 4.3 MINUTES
OF 4th CYCLE

FIGURE 3

SEQUENTIAL PICTURES OF HOT END OF FUEL ELEMENT
AFTER EACH 10 MINUTE CYCLE AT R1.07 TEST CONDITIONS

- rate determination, and (4) individual channel leak rate determination. The leak rate determination will be done with hydrogen at ambient temperatures at 675 psig with differential pressures across the braze seal of 10, 30, 50, 70, and 90 psid. The
- (U) thermal shock test will consist of heating the specimen to 1600° for 10 minutes, and then submerging it in a liquid nitrogen bath until it reaches 140°R. The test rig has been fabricated. The test loop is 90% completed. The Materials Laboratory is preparing the specimens.

TFL-2. a Core Periphery Test

- One of the characteristics of the core periphery test is the requirement for early definition of test objectives so that long lead time hardware can be procured on a schedule consistent with reactor component test demand dates. In order to
- (C-RD) provide this test definition, a design review was held on April 1 to define a tentative schedule and plan for the R-1 core periphery tests. The following plan will be used as the basic program guide for this series of tests.

Test TFL-2. a. 0004a

1. Model Configuration
- a. Basic assembly per drawing WT 701736.
- b. Z-type pre-formed liners.
- c. Coated inner core.
- (C-RD) d. Simulated elements and filler strips to give 105° and 135° wrapper bends.
- e. Coated or uncoated simulated elements (TFL has both types on order).
- f. Uncoated filler strips.
- g. 0.125-inch thick pyrotile; 0.180-inch nominal wrapper thickness.
- h. Seal schedule to be determined.

2. Test Plan

- a. Cyclic test with helium at 2500°R wrapper O.D. temperature to evaluate effect of cyclic-high temperature operation on strain in wrapper.
- b. Partial disassembly down to and including one to two layers of foil to evaluate condition of wrapper O.D.

3. Items Requiring Definition

- a. Coated versus uncoated elements.
- b. Pressure distribution on inside and outside of wrapper.
- c. Gap distribution in model and in reactor design.
- d. Operating pressure distribution and seal flow channels for model.

Test TFL-2. a. 0004b

1. Model Configuration

(C-RD)

- a. Reassembly of TFL-2. a. 0004a.
- b. Seals to be changed to incorporate schedule for operation with hydrogen.

2. Test Plan.

- a. Corrosion test at 2500°R wrapper O.D. control temperature with hydrogen for 75 minutes at full power and 10 recycles.
- b. Complete disassembly and inspection.
- c. Wrapper I.D. temperature to be off-design (about 4100°R).

3. Items Requiring Definition

(Same as for TFL-2. a. 0004a)

Test TFL-2. a. 0005

1. Model Configuration

- a. Basic model per WT 701736 or equivalent with all components and assembly details basically the same as TFL-2. a. 0004b.

- b. Gap distribution, seal schedule, and pertinent assembly details to be revised, if necessary, based on experience with TFL-2. a. 0004b.
- 2. Test Plan
 - a. Corrosion test at 4750°R wrapper I. D. control temperature with hydrogen for 75 minutes at full power and 10 recycles.
 - b. Complete disassembly and inspection.
 - c. Wrapper O. D. temperature to be off-design (about 3000°R).
- 3. Items Requiring Definition
(Same as for TFL-2. a. 0004a)

Test TFL-2. a. 0006

- (C-RD)
 - 1. Model Configuration
 - a. Basic design as in TFL-2. a. 0004 with modifications below.
 - b. 0.240-inch thick pyrofoil wrapper and 0.125-inch thick tile.
 - c. Coating of simulated elements to final R-1 specifications.
 - d. Seal schedule to be defined.
 - e. Other modifications to fit final R-1 design.
 - 2. Test Plan
 - a. Cyclic test for 75 minutes with 10 recycles with hydrogen to evaluate effect of strain and corrosion.
 - b. Attempt to control wrapper I. D. at 4750°R and O. D. at 2500°R.
 - c. Complete disassembly and inspection.
 - 3. Items Requiring Definition
Final R-1 design details for core periphery.

(U) The TFL-2. a. 0003b facility checkout model was assembled nearly to completion and will be inserted in the FS-1 next month. This furnace has been assembled and trial-inserted into Cell 1 for final measurement of bus bar, piping, and water conduit connections to the furnace.

Hardware procurement for the three planned builds continued. The present status is as follows:

TFL-2.a.0004 - All hardware including coated parts are on hand. The
(C-RD) Z-type pre-formed liners are being fabricated in the vendor's shop.

TFL-2.a.0005 - All hardware for the model is available. Core and element coating is required. The Z-type liners are not available.

TFL-2.a.0006 - All raw material has been ordered.

(U) The thermal-hydraulic analysis of the model continued. The primary basis of present analysis is the data from test TFL-2.a.0003 of the NRX-A6 periphery. Present efforts are directed to understanding the pressure distributions encountered in the seal system during that test. It appears that porous flow through the reflector may account for an anomaly in the seal pressure distribution. Efforts are being made to account for this phenomenon in the computer model.

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GENERAL DEVELOPMENT TESTS

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

(U) Sixty-eight single element corrosion tests were conducted during this period.

(C-RD) Eleven tests of Phase II-Fb elements were conducted at R1.07 test conditions for planned three 20 minute cycles.

(C-RD) Forty Phase IV-B elements were corrosion tested at R1.07 test conditions; twenty-three for single cycle tests, two for 20 minute cycles, and fifteen for 10 minute cycles.

(C-RD) Ten tests were conducted with GP-72 elements at R1.07 conditions for multiple 10 minute cycles.

(C-RD) Three tests of high void elements with brazed collars, three tests of elements from Phase II-Ga (high expansion graphite matrix), and one furnace cyclic checkout test were also conducted.

(U) Tests planned for the next period include evaluation of elements from Phases IV-B and II-Ga.

TFL-5. b Interstitial Corrosion Tests

(U) The 12-inch furnace has been completely assembled and its control system tuned to a given set of test conditions. All checks and dry runs have been completed in preparation for a power test which will take place after the test procedure has been approved.

(U) Additional test fixtures to test embossed "Grafoil" corrosion characteristics have been requested.

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FACILITIES
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ACTION ITEMS

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WANL Liquid Hydrogen Facility

Installation of the WANL Liquid Hydrogen Facility is proceeding on schedule. The concrete for the diking and foundations has been installed. The electric vaporizer was received on April 11, 1968. The 5,000 gallon dewar is ready for relocation to WANL on May 2, 1968.

WANL Cells 1 and 2 Reactivation

The CL-1 furnace, flow loop, control systems, and data acquisition systems are installed and ready for checkout of subsystems. A full scale cluster test will be performed early next period to checkout the complete facility.

Procedures for operating the cluster facility are being drafted.

The FS-1 core periphery facility is about 75% complete. Following reactivation of the cluster facility, all construction effort will be concentrated on this installation to expedite the startup of the furnace and subsequent use on R-1 tests.

ACTION ITEMS

A request by SNPO-C for a safety review on the 20,000 gallon dewar installation was made. This review is to be scheduled when operating procedures are available for this installation, probably in early August.

A review was requested by SNPO-C of the gas content of the helium trailer which was returned after its 5 year ICC required pressure test. The desired information to be reviewed on trailer 12605 is

1. Gas composition after purge procedure and prior to helium fill.
2. Gas composition after helium fill and prior to delivery to WANL.
3. Gas composition on delivery to WANL.

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SECTION B
MONTHLY REVIEW OF ENGINEERING MECHANICS TESTS

TABLE I

ENGINEERING MECHANICS LABORATORY	
PERFORMED THIS PERIOD (March 29, 1968 - April 30, 1968)	PLANNED NEXT PERIOD (May 1, 1968 - May 31, 1968)
TESTS IN SUPPORT OF R-1	
<u>REFLECTOR SYSTEM TESTS</u>	<u>REFLECTOR SYSTEM TESTS</u>
	A.4 Conduct 3 Drum System Test A.4 Conduct Actuator Decoupler Shear Pin Tests
<u>FUEL ELEMENT TESTS</u>	<u>FUEL ELEMENT TESTS</u>
B.1 Fuel Element Tension Tests	B.1 Central Element and Fuel Element Tension
B.1 Central Element Compression/Creep	
B.2 Forward End Cement Joint Tests	B.1 Fuel Element Bending
<u>AXIAL SUPPORT SYSTEM TESTS</u>	<u>AXIAL SUPPORT SYSTEM TESTS</u>
C.1 PEWEE-1 Pedestal/Element Tests	C.1 PEWEE-1 Proof Tests
C.2 Thermal Shock Tests	C.2 Thermal Shock Tests Development
	C.3 Conduct Interface Friction Tests
<u>CORE ASSEMBLY TESTING</u>	<u>CORE ASSEMBLY TESTING</u>
G.2 Partial Length Core Dynamic Tests (Flat Seal Design)	G.2 Partial Length Core Dynamic Tests (Flat Seal Design)
	D.2 Lateral Support Component Tests (Flat & Angled Seal Design)

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TABLE I
(continued)

PERFORMED THIS PERIOD (March 29, 1968 - April 30, 1968)	PLANNED NEXT PERIOD (May 1, 1968 - May 31, 1968)
TESTS IN SUPPORT OF R-1	
<u>ANTICRITICALITY SYSTEM TESTS</u> J.1 Poison Wire End Fitting Test <u>SUPPORT STEM TESTS</u> L.2 Grafoil Liner Tube Seal Tests <u>CENTRAL & EXTENSION SHIELD</u>	<u>ANTICRITICALITY SYSTEM TESTS</u> J.1 Poison Wire Withdrawal <u>SUPPORT STEM TESTS</u> L.1 Liner Tube Burst Test L.1 Aft Welded End Burst Test <u>CENTRAL & EXTENSION SHIELD</u> M.1 Conduct Shield Material Thermal Shock Test
TESTS IN SUPPORT OF NRX & XE	
<u>REFLECTOR SYSTEM TESTS</u> WOL Fracture Toughness Test	<u>REFLECTOR SYSTEM TESTS</u> Continue WOL Tests Continue Fabrication of BiAxial Test Specimens

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TESTS IN SUPPORT OF R-1

FUEL ELEMENT TESTS

EML-B.1 Fuel Element Tension Tests

(U) A program comparing GEM and GED coated elements under room temperature tension loads was initiated and completed during the last period. The tests were conducted in the cluster bundling fixture which uses a cluster of ten inch long elements with the test specimen at the center. This fixture is shown in Figure 1. The six peripheral elements, instrumented with strain gages, were loaded in compression and then bundled by the hydraulic cylinders. The compressive load was then released which, through the friction lockup of the assembly, caused the test element to be strained.

(U) Test results are tabulated in Table II. The GEM coated elements failed at strains slightly in excess of 2000 microinches strain while the GED coated elements did not fail at strains up to 4000 microinches. Testing could not continue beyond the 4000 microinch strain level because attempts to apply higher axial loads on the bundling elements, thereby imposing greater strain on the specimen, resulted in failure of several of the bundling elements and the test was stopped.

EML-B.1 Central Element Compression/Creep

(U) PEWEE-1 central elements (939J029) were tested in compression at both room temperature and at elevated temperatures. The room temperature tests consisted of loading three-inch lengths of the central elements to failure while recording the deflection of a two-inch gage length. The elevated temperature tests were conducted at 4300°R and 4600°R, with test loads of 250 lbs and 400 lbs at each temperature. The

FIGURE 1
TEST ARRANGEMENT USED TO EVALUATE TENSILE
STRAINS OF GEM AND GED COATED ELEMENTS
EML-B.1

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TABLE II

<u>Element Serial Number</u>	<u>Location (Station)</u>	<u>Coating</u>	<u>Ultimate Strain (Micro-Inch/Inch)</u>
525-10-57132	15 - 25	GEM	2140
525-10-57241	21-1/2 - 31-1/2	GEM	2100
525-10-57069	21-1/2 - 31-1/2	GEM	2400
525-10-57057	15 - 25	GEM	2070
525-10-57247	17-1/2 - 27-1/2	GED	4105*
525-10-57191	17-1/2 - 27-1/2	GED	4230*
525-10-57090	17-1/2 - 27-1/2	GED	4120*
525-10-57148	17-1/2 - 27-1/2	GED	**

* Maximum strain obtained - specimen did not fail.

** Clustering elements failed attempting to impose higher axial loads. Specimen not tested.

(This Page is Unclassified)

(U) test procedure for these tests was to apply the test load rapidly (3 to 5 seconds) and then maintain it for one hour at temperature with continuous recording of the deflection of the 2" gage length.

Two specimens were tested at room temperature. The first specimen indicated an initial, incomplete failure at a load of 890 lbs. (5050 psi based on an area of .176 inch²). The strain at this time was .0028 inch/inch and the loading was continued until the ultimate failure occurred at a load of 1270 lbs. (7200 psi) with a strain of .0063 inch/inch. The second was continuously loaded until the ultimate failure, which occurred at a load of 1320 lbs. (7500 psi) and a strain of .0039 inch/inch. Both specimens exhibited the same type of failure; that is, the crushing of one of the bearing surfaces as shown in Figure 2. Meaningful elastic modulus values could not be obtained from the load-deflection curves which were generated. However, a secant modulus was established based on the point of initial failure for the first specimen and based on the ultimate failure of the second specimen. Values of 1.80×10^6 psi, and 1.92×10^6 psi, respectively, were obtained.

(U) The elevated temperature tests were primarily intended to determine the creep deformation characteristics of the central elements as functions of load and temperature. The deflection-time curves which were recorded for these specimens indicate that at 4300°R, almost all the creep deformation is complete in the first ten minutes under load regardless of the load level. At 4600°R, it took approximately sixteen minutes to reach this point, again, independent of the load level. Table III summarizes the other pertinent results obtained to date.

(U) Tests are continuing at 4900°R and load levels of 250 and 400 lbs.

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FIGURE 2
TYPICAL CENTRAL ELEMENT ROOM TEMPERATURE COMPRESSIVE FAILURE
EML-B.1

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TABLE III

SUMMARY OF RESULTS

	Temperature = 4300°R		Temperature = 4600°R	
	Load = 250 lbs	Load = 400 lbs	Load = 250 lbs	Load = 400 lbs
Strain Resulting From Initial Loading	.001 in/in	.003 in/in.	.001 in/in	.003 in/in
Additional Creep Strain Under Load	.001 in/in	.0045 in/in	.006 in/in	.010 in/in
Change in Overall Length	-.0003 in	-.0024 in	-.0034 in	-.0080 in
Change in Across Flats Dimension	+.0005 in	+.0005 in	+.0005 in	+.0005 in

EML-B.2 Forward End Cement Joint Tests

(U) The program to evaluate the cold end cluster support design using EPY 500 Epoxy Cement was continued during the last period. The program consists of two main parts:

- (U) 1. Evaluate the strength of the joint at room temperature, 400°F and 500°F.
- (U) 2. Develop a technique for removal of the cement that could be used for disassembly, if required.

(CRD) Graphite samples were prepared for shear strength tests by cementing two, nineteen hole fueled elements, three inches long to the opposite faces of a three-inch long single hole center element. The fixture shown in Figure 3a was used to maintain alignment and consistent loads during the cementing and curing operations. Tests were made at room temperature, 400°F and 500°F utilizing the test setup shown in Figure 3b. A tabulation of shear strength test results at these test temperatures is given in Table IV. The minimum shear stress at 500°F test temperature was 510 psi and the average of twelve samples tested at 500°F was 750 psi.

(U) The most favorable technique found to separate cemented joints was to heat the cemented elements at 800°F for one hour and furnace cool at a rate of 50°F per hour. Cemented samples subjected to this environment were completely separated, and the decomposed cement residue was easily wiped off. The element surface and the elements were not affected.

FIGURE 3a
APPARATUS FOR MAKING FORWARD END CEMENT JOINTS
EML-B.2

FIGURE 3b
TEST SETUP USED FOR LOADING FORWARD END CEMENT JOINT SPECIMENS
EML-B.2

TABLE IV
BOND SHEAR STRENGTHS OF EPY 500 CEMENTED ELEMENTS

Test Sample No.	Test Temp. °F	Curing Conditions		Failure Conditions		
		Load Lb.	Thickness Mil	Load Lb	Area Square In	Stress psi
45	R.T.	0	3.9	3380	2.17	1555**
46	R.T.	0	4.5	3430	2.17	1580**
47	R.T.	0	5.0	3460	2.17	1590**
30	400	0	4.5	2220	1.95	1135*
31	400	0	4.1	2600	1.95	1330*
32	400	0	4.1	1930	1.95	990
33	500	0	4.1	970	1.91	510
34	500	0	3.0	1360	1.91	710
35	500	0	5.0	1570	2.04	770
42	500	50	4.0	2280	2.08	1095
43	500	50	4.0	1520	1.91	795
44	500	50	3.5	1930	2.07	930
36	500	0	1.7	1350	2.17	620
37	500	0	2.1	1740	2.00	870
38	500	0	2.4	1470	2.17	680
39	500	50	1.8	1430	2.17	660
40	500	50	2.2	1500	2.08	720
41	500	50	2.1	1350	2.08	650

** Test discontinued after crushing of center element.

* Partial failure through fueled element along with bond failure.
All samples cured at 250°F at four hours.

AXIAL SUPPORT SYSTEM TESTS

EML-C.1 PEWEE-1/Pedestal Element Tests

(U) Last month a report was made on a crack found on the tip of one of the elements used on the pedestal tests. Micro and macro photographs of the cracked area were included in the minutes of the meeting (WANL-TME-1774)

(U) As a result of this finding, all of the elements used in the pedestal test series were re-examined and other tips were found with identical cracks. To obtain required data on a timely basis all of these element specimens were made to early development hardware drawings. Many used ATJ transition sections, and are not wholly representative of the tip design and/or processing conditions to be used for the PEWEE-1 reactor.

(U) The findings were reviewed with both Design and Fuel Development personnel, and a program was established to verify that cracks do not exist on PEWEE-1 production grade elements. This program is underway and includes examination of PEWEE-1 elements from the corrosion tests as well as elements in an as-brazed condition. Also, room temperature, thermal cycle, and the creep tests will be repeated on reactor grade elements and pedestal assemblies of PEWEE-1 design.

EML-C.2 Thermal Shock Tests

(U) Five thermal shock tests utilizing both the heatup and cooldown features of the thermal shock fixture were conducted during the period.

Gas temperature changes averaged $2000^{\circ}\text{R}/\text{sec}$ on heatup and $5000^{\circ}\text{R}/\text{sec}$ on cooldown. Corresponding specimen responses were $200^{\circ}\text{R}/\text{sec}$ and $300^{\circ}\text{R}/\text{sec}$. Thermal gradients from the OD to the ID of the specimens ranged from 250°R on heatup to 500°R on cooldown. Test details are given in Table V.

TABLE V
THERMAL SHOCK TEST DURING SECOND QUARTER CY 1968

(u)

Test No.	Specimen	Cycles	Max °R Specimen Temp.	Max. Gas Rate R/sec	HEATUP		COOLDOWN		Remarks
					O.D. to I.D.	$\Delta T(1)$	O.D. to I.D.	$\Delta T(1)$	
1	.9 in NbC composite cylinder	5	4300	Unknown	200-300		Unknown	Unknown	Specimen Undamaged
2	.9 in. NbC composite cylinder	3	4200	Unknown	200-300		Unknown	300	Specimen Undamaged
3	.7 in. NbC composite cylinder	5	4200	2000	250		5000	500	Specimen Undamaged
4	.7 in. Partially bored NbC composite cylinder	7	4300	2000	250 ⁽²⁾		5000	Unknown ⁽²⁾	Split in Half
5	.7 in NbC composite cylinder	8	3500	Unknown	Unknown		Unknown	Unknown	Radial crack through

NOTE: All temperatures are measured values.

1. O.D. to I.D. measurements made with thermocouple in blind holes drilled within .010" of the respective surface.
2. O.D. thermocouple located in peripheral flow hole.

- (U) The specimens were special NbC composite cylinders designed specifically for thermocouple checkout with exception of the fourth test, which was a rejected partially-bored pedestal.

- (U) The rejected pedestal and one of the special cylinders with a .7 inch height (Tests 4 and 5) cracked radially as shown in Figure 4. Conditions for these tests were similar to the other tests except for the number of cycles. Tests 4 and 5 were subjected to 7 and 8 continuous cycles, respectively. The thick cross sections of these specimens result in much higher stresses than would be expected in the actual pedestal design and no conclusions should be drawn from these tests relative to pedestal cracks. However, all further tests will be cycled to determine whether a low cycle fatigue problem may exist. Thermocouples positioned in blind holes proved to be considerably more reliable than those mounted in flow holes - but failures still occur. Continued testing with maximum redundancy will be required to generate confidence in indicated transients and specimen gradients.

CORE ASSEMBLY TESTING

EML-G.2 Partial Length Core Dynamic Tests (Flat Seal Design)

- (CRD) The first series of dynamic tests to evaluate a flat seal lateral support system design for the R-1 reactor was performed. The partial length core was supported in the outer reflector ring by two rows of flat seals with each row containing a one-piece outer seal and twelve 30° inner seal segments, as shown in last month's report (TME-1774). The graphite core weight was reduced to 253 lbs to simulate the approximate weight loading a two row support system configuration. Test results will then be extrapolated for the reactor configuration.

REJECTED PARTIAL BORED PEDESTAL

CRACKED SPECIAL COMPOSITE TEST CYLINDER

FIGURE 4
EML-C.2

(U) A photograph of the test setup with the reflector supported on four oil film slip tables and driven by a 10,000 lb thruster is shown in Figure 5. The transducers shown were used to measure reflector accelerations, core accelerations, and relative displacements between the core and reflector.

(CRD) The assembly was vibrated at 1.5 g and 50 cps for a total of 75 minutes to determine any delamination or wear tendencies of the Carbitex outer ring due to the dynamic forces. No breakaway was noted at this level and after a disassembly and inspection of the components, no delamination or excessive wear was found on the Carbitex rings.

(U) The core is being reassembled to perform vibration tests at higher input levels and to more thoroughly investigate the dynamic characteristics of the lateral support system.

ANTICRITICALITY SYSTEM TESTS

EML-J.1 Poison Wire End Fitting Test

(U) The poison wire design will require an end fitting or forming operation to contain the poison beads on the central wire. Static tests were performed on two possible end fitting configurations to determine their structural adequacy and failure mode. These are described as "cup" and "crimped" ends and are shown in Figure 6.

(U) The test rig used to apply tensile loads to the test specimens is shown in Figure 7. The output signals from the load cell and displacement transducer were recorded on an X-Y recorder.

(U) Four stainless steel wires, two annealed and two cold rolled, were assembled with the cup end fitting placed over a "U" shape bend in the poison wire and then tested. The results of the tests using the stainless steel wire are shown in the following table.

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FIGURE 5
ARRANGEMENT FOR VIBRATING A TWO ROW
LATERAL SUPPORT SYSTEM
EML-G.2

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B20

(U) CUP TYPE END FITTING

CRIMP TYPE END FITTING

FIGURE 6
 EML-J.1

FIGURE 7
R-1 POISON WIRE CUP
TYPE END FITTING
DEVELOPMENT TEST RIG
EML-J.1

DETAIL A
UPPER FIXTURE-WIRE TEST

DETAIL B
LOWER FIXTURE-WIRE TEST

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(U)

<u>Specimen Description</u>	<u>Spring Rate-lbs/in</u>	<u>Yield-lb</u>	<u>Failure Load - lbs</u>
Cup-Cold Worked 304 SS Wire	625	17	27.5
Cup-Cold Worked 304 SS Wire	775	19.5	22.5
Cup-Annealed 304 SS Wire	625	14	15.5
Cup-Annealed 304 SS Wire	1050 (655)	14.5	19.5

(U) All specimens were four inches in length except for the last specimen which was two inches long. Since the spring rate is proportional to the length of the specimen, the 1050 lb/inch value is corrected to 655 lb/inch. As would be expected, the spring rate of the annealed and cold worked specimens were all approximately equal with the yield and failure loads slightly larger for the cold rolled specimens. The mode of failure for the annealed material is shown in Figure 8.

(U) The cold rolled stainless steel wire failure differed and was due to the straightening of the bend and the eventual slippage of the fitting from the wire. This same mode of failure was also noted during the tests of the titanium wire and both crimped and cup type configurations. A crimped assembly before and after testing is shown in Figure 9 and a summary of the test results for the titanium material is given in the following table.

(U)

<u>Description</u>	<u>Spring Rate lbs-in</u>	<u>Load at Yield-lbs</u>	<u>Failure Load - lbs</u>
Crimped-Ti	600	31.0	25
Crimped-Ti	900	30.0	25.5
Cup-Ti	567	8.5	15.5
Cup-Ti	500	11.5	13.0

FIGURE 8
MODE OF FAILURE FOR ANNEALED MATERIAL
IN CUP END FITTING
EML-J.1

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FIGURE 9
MODE OF FAILURE FOR CRIMPED END FITTING
EML-J.1

- (U) A significant result of these tests is that the crimped configuration was able to carry the larger loads. However, in all cases, the failure load was many times greater than the load expected in operation.

SUPPORT STEM TESTS

EML-L.2 Grafoil Liner Tube Seal Tests

- (CRD) Static tests were performed to measure the frictional forces developed between the mating surfaces on the central element, grafoil seal and liner tube. The basic design information will be used to determine forces on the R-1 stem.

- (CRD) Four cases were studied and in each, the grafoil seals were forced to slip against the adjacent surfaces. Schematic sketches of the loading schemes are shown in Figures 10a, 10b, and 10c. In Figure 10a, the axial loads were applied directly to the tie rod. This type of loading was used for two of the cases tested. In one of these, the preload spring was set for 15 lbs of force and in the other, the spring was not used. Figure 10b shows the case in which axial load was applied through the liner tube and Figure 10c the case in which a fixture was used to slide the seal on both the inside and outside surfaces of the grafoil seals.

The results of the four cases tested are shown in the following table.

FIGURE 10a
 (U) TEST SETUP TO STUDY FRICTION FORCES ON OUTSIDE DIAMETER OF GRAFOIL SEALS

FIGURE 10b
 TEST SETUP TO STUDY FRICTION FORCES ON INSIDE DIAMETER OF GRAFOIL SEALS

FIGURE 10c
 TEST SETUP TO STUDY FRICTION FORCES ON INSIDE AND OUTSIDE OF GRAFOIL SEALS

(CRD)

<u>Case</u>	<u>No. of Spec</u>	<u>Surfaces Studied</u>	<u>Seating Force at Assembly-lb</u>	<u>Axial Spring Load on Seals</u>	<u>No. of Cycles</u>	<u>Min. & Max. Axial Breakaway Loads (lbs)</u>
I	3	OD of Seal and ID of Element	40	15	10	5 to 9.5
II	1	OD of Liner Tube and ID of Seal	40	0	10	16 to 28.5
III	2	Combination of Case I and II	40	0	10	18 to 46.0
IV	1	OD of Seal & ID of Element	40	0	10	7 to 14

(U) The static and dynamic force variations relative to the number of cycles performed are shown in Figures 11 and 12 for specific tests. The dynamic force is the magnitude of average load during slipping of the seals.

Conclusions gained from the data are:

- (U)
- 1) The axial preload spring does not affect the frictional forces on the outside diameter of the seal.
 - 2) The frictional forces developed on the inside diameter of the seal are approximately three times the values at the outside diameter.
 - 3) The magnitude of the breakaway forces were always minimum during the first cycle and increase to the maximum level at the tenth cycle. This phenomenon will be investigated further after the final design is established.

FIGURE 11a
 FRICTION FORCES DEVELOPED ON OUTSIDE DIAMETER
 OF GRAFOIL LINER TUBE SEALS
 CASE I

FIGURE 11b
 FRICTION FORCES DEVELOPED ON INSIDE DIAMETER
 OF GRAFOIL LINER TUBE SEALS
 CASE II

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FIGURE 12a
FRICTION FORCES DEVELOPED ON INSIDE & OUTSIDE
DIAMETERS OF GRAFOIL LINER TUBE SEALS
CASE III

FIGURE 12b
FRICTION FORCES DEVELOPED ON OUTSIDE DIAMETER
OF GRAFOIL LINER TUBE SEALS
CASE 4

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TESTS IN SUPPORT OF NRX & XE

(This Page is Unclassified)

REFLECTOR SYSTEM TESTS

WOL Fracture Toughness Test

(U) Three tests were conducted on WOL specimens fabricated from NRX-A6 ring material, pressing number 4055.

(U) One test was conducted to determine the opening mode plane strain fracture toughness K_{IC} at -320°F for comparison with previously run specimens made from S-200 block pressed material. The K_{IC} was about $14.9 \text{ ksi } \sqrt{\text{in.}}$ and lies within the normal scatter range of the previously performed tests.

(U) Two tests were run on WOL specimens by first heating to 860°R , preloading by insertion of a wedge, and then gradually reducing the temperature to 140°R and inspecting for failure. One specimen was loaded to 2500 pounds and the other to 2800 pounds prior to insertion of the wedge. The loads after wedge insertion were 2250 and 2100 pounds respectively. Inspection after reducing the temperature from 860°R to 140°R revealed that no failure of the specimens had occurred and tests are continuing with increased preloads.

(U) The spare NRX-A6 beryllium reflector ring was instrumented with 20 strain gages in preparation for the "Thermal and Strain Response Test".

Westinghouse Electric Corporation

Astronuclear Laboratory

Route 51

Box 10864 Pittsburgh Pa 15236

Telephone 892 5600

EM-7524

MAY 22 1968

* Mr. J. L. Dooling
NERVA Subcontract Manager
Department 7140
Aerojet-General Corporation
Post Office Box 15847
Sacramento, California 95813

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Subject: Transmittal of WANL-TME-1797, "Notes of Monthly Development Test Program Review Meeting Held With SNPO at WANL on May 1, 1968", (Title Unclassified), May 20, 1968.

Dear Mr. Dooling:

Transmitted for your information are ten (10) copies of the subject report.

Respectfully,

ORIGINAL SIGNED BY
W. H. ARNOLD
W. H. Arnold, Jr.
Program Manager
NERVA Nuclear Subsystem

CLM/mjh

Encl.

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