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WANL-TME-1808

Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON JUNE 4, 1968
(Title Unclassified)

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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
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Classification cancelled (or changed to)
by authority of H. F. C. TIC, date **SEP 11 1973**

E. A. DeZubay
E. A. DeZubay, Manager
Thermo-Flow Laboratory

~~INFORMATION CATEGORY~~
~~Confidential - Restricted~~
~~Authorized Classifier~~

J. L. Meuche 6/14/68
J. L. Meuche, Manager
Engineering Mechanics

SPECIAL REVIEW FINAL DETERMINATION	Reviewers	Class.	Date
	TR	U	4-8-82
Class: <u>U</u>			

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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON JUNE 4, 1968
(Title Unclassified)

Attendees:

E. L. Brickman	WANL	J. T. Malarky	WANL
R. N. Eichbauer	WANL	C. L. Meuche	WANL
N. J. Ettenson	WANL	W. E. Murr	WANL
H. J. Fix	WANL	N. A. Norman	AGC
W. J. Havener	WANL	R. L. Oelrich	WANL
H. H. Hoffman	SNPO-C	B. H. Stahl	WANL
G. A. Kalvin, Jr.	SNPO-C	J. A. Swanson	WANL
J. L. Koetting	WANL	F. G. Tauch	WANL

The Monthly Development Test Program Review Meeting was held on June 4, 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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WANL-TME-1808

SECTION A

MONTHLY REVIEW OF THERMO-FLOW LABORATORY TESTS

TABLE I

THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (May)

PLANNED NEXT PERIOD (June)

Tests for NRX-A6

TFL-3. f Reflector Thermal Transient Test - Continue fabrication. Initiate testing.

Tests for PW-1

TFL-1. a Cluster Tests

Two facility checkout runs were performed.

Modify test facility flow loop for improved stability. Re-run a checkout cluster. Assemble and test LASL cluster.

LASL Center elements modified for exit gas thermocouple tests.

PEWEE loaded center element concept tested as part of furnace checkout.

Develop, assemble, and test PEWEE clusters.

Tests for R-1

TFL-1. d Fuel Element Orifice Tests - Checkout of model. Initiate testing.

TFL-2. a Core Periphery Test -

Mock-ups of TFL-2. a. 0004 inner core and simulated elements complete.

Liner fabricating technique developed.

Model TFL-2. a. 0003b complete. Orificed pressure chamber complete.

FS-1 furnace assembly started.

Hardware procured for TFL-2. a. 0004 and 5.

Test orificed pressure chamber and continue assembly work.

TFL-6. d Flow Tube Spool Seal Leak Test - Design Model.

Complete fabrication and initiate testing.

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TABLE I (Continued)

PERFORMED THIS PERIOD (May)

PLANNED NEXT PERIOD (June)

General Development Tests

TFL-1.b Single Element Tests - Total - 42

- 4 - A6C Part II A6 characterization test plan.
- 1 - A6C Part II Verification - test using an XE-2 type element.
- 7 - II-Ga high expansion graphite elements:
 - 3 - at A6.04 conditions.
 - 3 - at R1.07 conditions non-cycled.
 - 1 - at R1.07 conditions 10 minute cycles.
- 27 - Phase IV-B elements at R1.07 conditions: 16 non-cycled, 11 10-minute cycles.
- 1 - Test of high void element with cylindrical graphite collar on hot end at R1.07 conditions.
- 1 - Test for furnace checkout.
- 1 - Test at A6.04 cycle conditions with low He pressure, i. e., 5 psi above exit hydrogen pressure.

LASL exchange tests and tests of Phase IV-B elements, Phase II-Ga elements, Y-12 high expansion matrix development elements, and graphite collar elements.

TFL-5.b Interstitial Corrosion Tests - Initiate Testing.

Continue testing.

Facilities

WANL - LH₂ Facility.

WANHES - LH₂ Facility.

Water Injection system 90% complete.

He trailer used for air service checked out satisfactorily before use at WANL.

FS-1 installation 80% complete.

Initial checkout tests on CL-1 started.

Complete installation and conduct tests.

Continue FS-1 installation.

Operate CL-1.

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TESTS FOR NRX-A6

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TFL-3. f Reflector Thermal Transient Test

Strain gage instrumentation of the spare reflector ring is complete. The test fixture is complete except for the devices for holding the thermocouples in position. All the thermocouples were checked individually at 32°, 68°, 120°, 180°, and 210° F. Deviation from standard NBS curves was almost non-existent; generally 0° to 0.05° deviation. Wiring of the electric drive motor and heater elements is in progress. Testing should be initiated in the next report period.

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TESTS FOR PW-1

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TFL-1.a Single Cluster Development Tests

Two checkout tests were performed during this period. The first test used a standard A6 cluster build and the second test was with the PEWEE center element with the thorium oxide chips.

The LASL exit gas thermocouple cluster model was being assembled when the pyrolytic graphite cup broke during handling. Inspection of the remaining two cups revealed they were in such condition as to possibly jeopardize the successful evaluation of the exit gas thermocouple. LASL decided to replace the three cups; the new ones were received June 3, 1968.

The cold end and the three counterbores of the center elements were machined to drawing dimensions. The cluster build and first test cycle are scheduled for completion the week ending June 8, 1968.

Electrical arcing problems were experienced in the initial tests of the modified center element design (using thorium oxide chips) for the PEWEE furnace tests. Rounding of the corners where the arcs originated might solve the problem. Alternate methods of assembling the cluster are being pursued. Model development, assembly, and test will follow the LASL exit gas thermocouple tests.

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TESTS FOR R-1

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TFL-1. d Orifice Calibration and Test

Assembly of the flow loop and checkout of the fuel element orifice model has been completed. Testing of specimens to determine gross fuel element orifice leakage will be initiated pending availability of test specimens. Additional effort is being expended to enable the measurement of individual orifice leakage.

TFL-2. a Core Periphery Test

A mock up assembly of the inner core and simulated elements for the purpose of determining gaps on test model TFL-2. a. 0004a has been completed. The Z-liner fabrication development technique has been completed. The liners are expected by June 15, 1968. Assembly of the model will begin about June 15 and will require 3 to 4 weeks.

A Thermo-Flow Laboratory technician is working with Reactor Assembly on a Z-liner mock-up assembly to insure this test model being assembled the same as the reactor.

Checkout model TFL-2. a. 0003b is complete and ready to be tested when the facility is complete. An orificed pressure changer simulating a model has been fabricated to set-up the flows of the facility prior to committing a model for test.

Alternate periphery designs are being followed, but the present plans are as stated in WANL-TME-1797.

The filler strip furnace assembly has been started and will be complete within two weeks.

All of the hardware for test models TFL-2. a. 0004 and 5 except the Z-liners have been procured.

TFL-6. d Flow Tube Spool Seal Leak Test

The purpose of this test is to determine the hydrogen leakage across the seals in the fore and aft end of the flow tube spacer spool. Three seal configurations

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TFL-6.d Flow Tube Spool Seal Leak Test (Continued)

will be tested: (1) metal to metal; (2) gold plated "V" rings; and (3) gold plated "O" ring. The test fixture has been designed and the layout completed. The material has been ordered and will be sent to the shop for fabrication when the test fixture detail drawings are complete. Preliminary results should be available by July 5, 1968.

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GENERAL DEVELOPMENT TESTS

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

(U) Forty-two single element corrosion tests were conducted during this period.

Twenty-seven fuel elements from Phase IV-B were corrosion tested, sixteen for single cycle tests and eleven for 10 minute cycles. Seven tests were conducted as part of Phase II-Ga, high expansion matrix development. Three tests were at (C-RD) A6.04 conditions, three at R1.07 conditions for single cycles, and one for 10 minute cycles at R1.07 conditions. Four tests of elements for A6C Part II, NRX-A6 characterization test plan, were conducted. In addition, one test of an XE-2 element for A6C Part II verification was completed.

One test of a high void element with a cylindrical graphite collar on the hot end at R1.07 conditions was conducted to complete the initial test series. A (U) furnace checkout test was conducted, and one element was evaluated at A6.04 cyclic conditions with a low helium atmosphere pressure, i. e. , 5 psi above the furnace exit pressure.

TFL-5. b Interstitial Corrosion Tests

The 12-inch furnace test procedure received a conditional approval from the WANL Safety Committee which was the only clearance required for the first test. The first build contained a standard 0.006 inch thick x 1.00 inch wide x 2 inch long uncoated flow slot. The specimen was tested at 650 psig and 2900°F (U) with a hydrogen flow rate of 14,000 std cc/min. The test conditions were maintained for 15 minutes. The results of the test did not match extrapolated data due to melting of the thermocouple stainless steel transition sections and failure of the can extension "V" seal allowing helium to pass through the specimen. A repeat of this test is being prepared at the request of the analysis section.

The area where the "V" seal failed has been seal welded and thermocouples (U) with the proper length moly sheath are now available and are presently being installed in the specimen.

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FACILITIES

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Installation of the WANL Liquid Hydrogen Facility has been slowed down due to the adverse weather conditions. The installation of the deluge system is about 3 weeks behind schedule. Parallel installation of the vaporizers has been initiated but is encountering delays in the area where coordination with the deluge piping is involved.

The WANHES facility has been redesigned as a result of the requirement for a 100,000 gallon water tank. In addition, it has been decided not to relocate the Linde Vaporizer. Due to these modifications, the package has been resubmitted for bids.

The installation of the water injection system for cooling the high temperature exhaust gases from the single element furnace at WANL is 90 percent complete. Effort planned for next period includes completion of the installation and conducting checkout tests of the complete system.

The helium trailer, number 12605, used for air service was purged, filled with helium by AIRCO and delivered to WANL for use. AIRCO personnel were contacted and indicated that before filling the trailer had been purged with dry nitrogen and 10,000 scf of helium. An analysis before filling showed 2.5 ppm oxygen and 3.0 ppm water. After filling the trailer, the analysis was 1.8 ppm oxygen and 1.2 ppm water. Before being released for use at WANL, personnel from the Physical Sciences Laboratory sampled and analyzed the contents of helium trailer 12605 and determined the oxygen concentration to be 1.5 ppm and water 32 ppm. Since the dew point of the helium gas with 32 ppm water was below -60°F , the trailer was released for use at WANL. The discrepancy in the moisture analysis between AIRCO and WANL was probably due to accumulated moisture in the WANL sampling arrangement.

The cluster facility (CL-1) construction phase was completed. On May 15, emergency, safety, and operating procedures were reviewed in depth with all

concerned operating personnel. The Safety Committee has reviewed the preliminary procedures, and have final ones for approval.

A number of unexpected problems developed in the final stages of reactivating the CL-1 test stand and during the first two checkout tests. During the furnace cooling water pressure check, a leak was discovered in the striker plate. A new striker plate modified to improve water film heat transfer coefficients was fabricated. When the striker plate was removed, the tubes in the heat exchanger were inspected; several were found blocked and some tubes buckled.

Heat exchanger tubes were fabricated, installed, and the system hydrostatically tested to 200 psig. The heat exchanger and new striker plate were installed in the test cell.

All the checkout work necessary for a CL-1 facility test was completed and an NRX-A6 checkout cluster was installed in the furnace and test TFL-1.a.0022a was initiated. Flow instabilities were noticed in the hydrogen system during cold flow but were reduced to small oscillations when power was applied. The test was terminated before reaching full power due to an instrumentation line arcing at the top end of the furnace.

A second furnace checkout run, TFL-1.a.0022b, was conducted. Flow system instabilities in cold flow still presented a problem. Power was applied to determine if the system was still unstable when the model was brought to temperature, however, arcing occurred in the center element area necessitating a premature shutdown. A post test critique was held on May 28 analyzing available data. Decisions were made to resize two valve trims in secondary systems and install the Grove pressure reducing regulators at the inlet to the helium and hydrogen flow systems. All anomalies discovered during the checkout run were repaired and the facility is being prepared for another checkout run.

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The FS-1 core periphery facility is about 80% complete. A brief progress status follows.

1. Flow loop welding is complete except for connecting helium and hydrogen exit lines. All components have been installed except orifice plates.
2. The Westinghouse supplied bus bar extension is about 50% complete.
3. Thermocouple system installation is complete except for patch cables from the model.
4. The electrical console must be tied into the existing system.
5. Pneumatic controls systems, plumbing of transmitter panel, and high pressure lines in the flow system are 50% complete.
6. Plumbing of air lines is 90% complete. Plumbing of water system lines and hoses are 50% complete.

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SECTION B
MONTHLY REVIEW OF ENGINEERING MECHANICS TESTS

TABLE I

ENGINEERING MECHANICS LABORATORY	
PERFORMED THIS PERIOD (May 1, 1968 - May 31, 1968)	PLANNED NEXT PERIOD (June 1, 1968 - June 16, 1968)
TESTS IN SUPPORT OF R-1	
<u>REFLECTOR SYSTEM TESTS</u> A.2 Beryllium Properties Tests A.4 Three Drum System Checkout A.4 Actuator Shear Pin Test <u>FUEL ELEMENT TESTS</u> B.1 Compression Testing of Central Elements B.1 Compression Testing of Fueled Elements B.1 Tension Testing Central Elements B.1 Tension Testing of Fuel Elements <u>AXIAL SUPPORT SYSTEM TESTS</u> C.3 Interface Friction Tests C.5 Secondary Support Evaluation Tests <u>CORE PERIPHERY TESTING</u> E.1 Periphery Axial Impedance Test	<u>REFLECTOR SYSTEM TESTS</u> A.2 Continue Beryllium Properties Tests A.4 Three Drum System Cycling Tests <u>FUEL ELEMENT TESTS</u> B.1 Continue Tension Testing of Central Elements B.1 Continue Tension Testing of Fuel Elements B.1 Fuel Element Deflection Tests <u>AXIAL SUPPORT SYSTEM TESTS</u> C.3 Continue Interface Friction Tests C.2 Thermal Shock Test Development <u>CORE PERIPHERY TESTING</u> E.1 Continue Periphery Axial Impedance Test

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TABLE I
(continued)

PERFORMED THIS PERIOD (May 1, 1968 - May 31, 1968)	PERFORMED THIS PERIOD (June 1, 1968 - June 16, 1968)
TESTS IN SUPPORT OF R-1	
<u>CORE ASSEMBLY TESTING</u> G.2 Partial Length Core Dynamic Test (Flat Seal) <u>ANTICRITICALITY SYSTEM TESTS</u> <u>SUPPORT STEM TESTS</u> L.1 Liner Tube Burst Test L.1 Burst Test of Stem Welded Aft End Assembly	<u>CORE ASSEMBLY TESTING</u> D.2 Lateral Support Component Tests (Flat and Angle Seals) <u>ANTICRITICALITY SYSTEM TESTS</u> J.1 Poison Wire Withdrawal Tests <u>SUPPORT STEM TESTS</u> L.1 Continue Liner Tube Burst Test L.1 Continue Burst Test of Stem Welded Aft End Assembly
TESTS IN SUPPORT OF NRX & XE	
Neutron Detector Tests Control Drum Shaft Torsion Tests Scram Spring Tests	Continue Neutron Detector Tests Control Drum Scram Test Continue Control Drum Shaft Torsion Tests

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TESTS IN SUPPORT OF R-1

REFLECTOR SYSTEM TESTS

EML-A.2 Beryllium Properties Tests

(U) Testing was continued on wedge open load (WOL) beryllium specimens. Application of a preload to the specimen by means of a threaded steel bolt forced against a beryllium pin was tried in an attempt to maintain a load on the specimen notch. The use of a simple wedge was previously found to be unsuccessful. In this new procedure, a load is applied through the pin and bolt assembly with the specimen heated to approximately 450°F. This is accomplished by preloading the specimen with the tensile machine, wedging the specimen, removing the tensile load and turning the bolt to contact the pin. The tensile load is again applied and the wedge removed. The tensile load is then removed and the pin-bolt picks up the load. To date this method has also not been successful in maintaining a steady load with time. Other techniques will be tried.

(U) Eight double cantilever beam (DCB) specimens were machined and are ready for additional tests at cryogenic temperatures. Four specimens were made from A-6 material and four from S-200 block material.

(U) Also, three biaxial specimens have been completed and are expected to be tested in the next period.

EML-A.4 Three Drum System Checkout

(U) Preliminary tests have been conducted on the 3 drum test fixture. These were primarily to check out the system function and to determine decoupler spring hysteresis. Considerable difference was

(U) apparent when the hysteresis curves were plotted for the springs. This difference is thought to be attributable in part to the read out equipment and in part to differences in spring coil interface friction. A recheck of the spring hysteresis will be conducted.

(U) The stainless steel bands which will be used pending receipt and instrumentation of the titanium bands are currently being strain gaged in preparation for some preliminary drum response and band strain tests.

(U) The titanium bands are currently in WANL inspection and should be available for use during the next period.

EML-A.4 Actuator Shear Pin Test

(U) Shear pin decoupler tests were continued during the period. Aluminum pins of .1406 nominal O.D. were sheared at ambient and cryogenic temperatures.

(U) The torque required to shear six pins at ambient temperature ranged from 775 in.lb to 850 in. lbs. Two pins were sheared at 1050 in. lbs and 1075 in. lbs at 140°R temperature.

(U) The rotation torques after shearing each pin were measured while rotating the shaft from 0° to 180° and return. The minimum to maximum rotation torques recorded at ambient temperature ranged from 0 to 40 in. lbs. and at 140°R temperature ranged from 0 to 26 in. lbs.

(U) Figure 1 shows the typical appearance of the shaft and spline after shearing and 10 cycles of 0 - 180° - 0 rotation.

(U) The test program is being re-evaluated since slight wear of the shaft and coupling does appear to occur upon each successive test and

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FIGURE 1
DECOUPLER SHAFT AND SPLINE AFTER PIN SHEARING
AND CYCLIC OPERATION
EML-A.4

- (U) the drag torques after pin shearing become questionable. Design of simple test pieces to simulate the actual shaft-coupling interface only is in work. This will allow a new shaft-coupling combination to be used for each test.

FUEL ELEMENT TESTS

EML-B.1 Compression Testing of Central Elements

- (U) The compression-creep tests of the PEWEE-1 central elements initiated last month were completed during this month. Tests were performed at 4900°R at load levels of 250 and 400 lbs. In addition to these tests, three tests were performed at the 400 lbs. load level at each of the three test temperatures (4300°R, 4600°R and 4900°R).

- (U) The procedure for these tests was as described previously; that is, once temperature equilibrium was attained, the test load was applied rapidly, (approximately five seconds) while recording the deflection of a two-inch gage length. The test load was then maintained for one hour with a continuous recording of the deflection of the gage length.

TABLE II
CENTRAL ELEMENT COMPRESSION CREEP TEST RESULTS

(CRD)	Temp. (°R)	4900		4300	4600	4900
	Load (lbs)	250	400	400	400	400
	Strain resulting from initial loading (in/in)	.001	.004	.0004	.0006	.0008
	Additional creep strain under load (in/in)	.005	.013	.0009	.0015	.0050
	Change in overall length (in)	-.0059	-.0091	-.0021	-.0043	-.0168
	Change in across flats dimension (in)	+.0012	+.0011	+.0007	+.0006	+.0007

EML-B.1 Compression Testing of Fueled Elements

(U) Compression testing of PEWEE-1 fueled elements has been initiated. The purpose of these tests is to determine the ultimate compressive strength and related properties of the several candidate fuel elements at room temperature and at 4100°R.

(U) The test specimens are of three-inch long sections taken from various axial locations in the fuel element. All testing is being done in the EML 6 x 10 high temperature furnace. The test procedure consists of applying a 50 lb. axial compressive load to the specimen to establish a zero point for the optical extensometer, then loading to failure at a head travel rate of 0.02 in/min with simultaneous recording of load and deflection on an X-Y recorder. The data to date indicates an average compressive ultimate strength of approximately 10,000 psi at room temperature and a compressive ultimate strength of approximately 14,000 psi at 4100°R, for all matrix types tested. The results of compression testing are summarized in Table III and IV. Additional tests are being performed at 4100°R to complete the test program. As expected, the specimens exhibited brittle fracture failure at both room temperature and at 4100°R, with the exception of two (Table IV, Specimens 525-57085 and 525-57287) which exhibited excessive deformation at 4100°R without fracturing. This type of behavior is expected at higher temperatures (above 4800°R), but is unusual at 4100°R and no explanation for the ductile behavior of these two specimens is available at this time.

TABLE III
FUEL ELEMENT COMPRESSION TEST DATA
ROOM TEMPERATURE

(U)

<u>S/N</u>	<u>Type</u> ⁽²⁾	<u>Specimen Location</u>	<u>Ultimate Stress (psi)</u>	<u>Ultimate Strain (in/in)</u>	<u>Compressive Modulus of Elasticity (psi)</u>
525-57135	G05	3-6	9,550	.0041	2.19×10^6
525-57255	G05	44-47	11,300	.0048	1.65×10^6
525-57039	G06	23-26	9,900	.0061	1.69×10^6
525-57159	G06	3-6	10,700	.005*	2.00×10^6
525-57085	G21	0-3	9,850	.0082	1.42×10^6
		44-47	13,650	.0055	2.27×10^6
525-57122	G21	0-3	9,850	.009*	1.40×10^6
		3-6	8,350	.0076	1.24×10^6
477-58665	G24	0-3	10,350	.0074	1.54×10^6
		23-26	9,850	.0026	5.16×10^6
477-58667	G24	0-3	10,100	.008*	1.62×10^6
		44-47	11,400	.0018	5.08×10^6
525-57287	G25	0-3	9,850	.008*	1.33×10^6
		3-6	6,650	.0040	1.80×10^6
525-57297	G25	0-3	10,900	.0088	1.29×10^6
		23-26	12,300	.0047	2.46×10^6
477-58642	G04	23-26	11,200	.0050	2.48×10^6
477-58643	G04	44-47	12,000	.004*	2.78×10^6

*Estimated (1)

NOTE: (1) Estimated ultimate strain values extrapolated from load-deflection curves. Tracking of targets was interrupted prior to failure when target was no longer distinguishable from background.

(2) Type Identification:

<u>Type</u>	<u>Matrix</u>	<u>Coating</u>	<u>Manufacturer</u>
G04	NbC Additive	GED	WNCO
G05	Standard	GED	WNCO
G06	Nb Resinate	GED	WNCO
G21	Nb Resinate	GEM	WEFF
G24	NbC Additive	GEM	WEFF
G25	Standard	GEM	WEFF

TABLE IV
FUEL ELEMENT COMPRESSION TEST DATA
4100°R

(U)

<u>S/N</u>	<u>Type</u> ⁽²⁾	<u>Specimen Location</u>	<u>Ultimate Stress (psi)</u>	<u>Ultimate Strain (in/in)</u>	<u>Compressive Modulus of Elasticity (psi)</u>
525-57135	G05	44-47	14,000	.017*	3.01×10^6
525-57255	G05	23-26	14,950	.0228	2.76×10^6
525-57039	G06	3-6	12,650	.014*	1.25×10^6
525-57159	G06	44-47	14,350	.0245	2.62×10^6
525-57085	G21	23-26	13,850**	.019*	2.36×10^6
525-57122	G21	44-47	16,900	.025*	4.22×10^6
477-58665	G24	3-6	15,600	.028*	1.55×10^6
477-58667	G24	23-26	13,850	.0090	1.63×10^6
525-57287	G25	44-47	14,500**	.015*	1.84×10^6
525-57297	G25	3-6	14,900	.0212	1.59×10^6
477-58642	G04	3-6	13,600	.030*	2.05×10^6
477-58643	G04	23-26	14,050	.021*	1.69×10^6

* Estimated Ultimate Strain (1)

** Maximum Load, Specimen Did Not Fail

Note: (1) Estimated ultimate strain values extrapolated from load-deflection curves. Tracking of targets was interrupted prior to failure when target was no longer distinguishable from background.

(2) Type Identification:

<u>Type</u>	<u>Matrix</u>	<u>Coating</u>	<u>Manufacturer</u>
G04	NbC Additive	GED	WNCO
G05	Standard	GED	WNCO
G06	Nb Resinate	GED	WNCO
G21	Nb Resinate	GEM	WEFF
G24	NbC Additive	GEM	WEFF
G25	Standard	GEM	WEFF

EML-B.1 Tension Testing of Central Elements

(U) The structural properties of PEWEE-1 central elements at various temperatures from ambient to 4100°R are being determined to establish design margins and confirm material properties used in structural analyses. Tests are being performed on central element sections approximately 17 inches long. Gripping the central elements in the tension test fixture invariably caused crushing of one or more element faces. Attempts to build up crush resistance by insertion of a graphite plug into the central element bore also were unsuccessful since similar failures still occurred at very low loads (150 lbs).

(U) Consequently, testing employing this fixturing has been suspended pending further analysis.

(U) A group of six specimens ~~was~~ tested at room temperature in the friction lock-up rig which permits the measurement of strain to failure. Results of the friction lock-up tests are inconclusive. Three of the six specimens failed at strains of approximately 1100 micro in/in and the other three did not fail after strains in excess of 4000 micro in/in. In both cases where two specimens were taken from the same element, one specimen failed at the low strain level and the other survived the high strain level. At the present time, no explanation can be given for the behavior anomalies, although the presence of pre-test cracks or flaws in specimens is suspected. An investigation of the pre-test inspection data is underway to determine whether such flaws had been detected.

EML B.1 Tension Testing of Fuel Elements

(U) Room temperature tensile testing of 17 inch long full cross-section fuel element sections was initiated to determine the ultimate tensile strength of fueled elements and establish design margins. The results of these room temperature tests on seven samples are shown in Table V. It should be noted that all seven samples failed in the specimen grips. Consequently, the strength values reported can not be considered as indicative of the true ultimate strength of the fuel elements.

(U) Tensile testing of 17 inch long full cross section fuel elements at 4100°R test temperature was also initiated and two major problems were uncovered by this testing: 1) At the 4100°R test temperature, test specimens slipped in the grips at less than ultimate loading, and 2) The system employed for obtaining specimen deflection data did not respond as planned. Both of these problems are under investigation and require solution before ultimate strength data on full element cross sections can be obtained.

AXIAL SUPPORT SYSTEM TESTS

EML C.3 Interface Friction Tests

(U) Tests of NbC coated composite specimens, from PEWEE reactor grade material, were made in hydrogen to determine friction forces and coating damage that occurs at elevated temperatures under pressure contact.

(U) Initially the specimens were simultaneously displaced and heated to test temperature. At temperature, the specimens, were permitted to remain motionless for approximately 5 minutes, and during cooldown the specimens were again displaced.

TABLE V
FUEL ELEMENT TENSION TEST RESULTS
ROOM TEMPERATURE

(U)

<u>S/N</u>	<u>Type</u> ⁽¹⁾	<u>Stress at Failure (psi)</u>	<u>Strain at Failure (in/in)</u>	<u>Modulus of Elasticity (psi)</u>
525-57255	G05	1680	.0011	1.36×10^6
525-57039	G06	2060	.0010	1.57×10^6
525-57159	G06	2030	.0009	1.58×10^6
525-57085	G21	1840	.0011	1.58×10^6
525-57122	G21	1760	.0009	1.57×10^6
477-58665	G24	2400	.0016	1.80×10^6
477-58667	G24	2460	.0008	1.88×10^6

NOTE: (1) Type Identification:

<u>Type</u>	<u>Matrix</u>	<u>Coating</u>	<u>Manufacturer</u>
G04	NbC Additive	GED	WNCO
G05	Standard	GED	WNCO
G06	Nb Resinate	GED	WNCO
G21	Nb Resinate	GEM	WEFF
G24	NbC Additive	GEM	WEFF
G25	Standard	GEM	WEFF

(U) One test was performed at 4400°R temperature and contact pressure of 200 psi, and two tests were performed at 4400°R temperature and contact pressure of 300 psi.

(U) With contact pressure of 200 psi the breakaway load ratio (ratio of load to slide the specimens to the load that holds the specimens in contact) was 1.8. With a constant pressure of 300 psi the breakaway load ratios were respectively 1.5 and 2.0.

(U) Visual examination of the specimens revealed that the NbC coating was damaged and the parent material was exposed for the test where the breakaway load ratio was 2.0. The coating damage occurred at peaks of surface irregularities. No significant damage of the coating was observed for the other two tests.

(U) Additional tests will be performed on specimens of matched surface smoothness.

EML-C.5 Secondary Support Evaluation Tests

(U) A single test was performed to evaluate a possible candidate design of an element secondary axial support. In the design, a tang on the side of the orifice plate would react axial cluster loads.

(U) A disc was machined from 6061-0 aluminum to the same configurations as the orifice plate, except for a small tang, that extended from one side. The plate and orifice plugs were cemented to the end of a 19-hole element.

(U) The test specimen was sandwiched between two 19-hole elements with the tang protruding from the side of the element as shown in Figure 2. The test specimen and holding fixture were placed in a universal testing machine, and axial loads applied. The arrangement is shown in Figure 3.

FIGURE 2
ASSEMBLY SECONDARY SUPPORT TEST
EML-C.5

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FIGURE 3
TEST ARRANGEMENT FOR CANDIDATE ELEMENT
SECONDARY SUPPORT EVALUATION
EML-C.5

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- (U) A force of 145 lbs was required to yield the material at the base of the cantilever tang. The glue joint held, and no breakage of the element occurred. Figure 4 shows the specimen after the test. In the R-1 design, the part would not be subjected to loads greater than 100 lbs.

CORE PERIPHERY

EML-E.1 Periphery Axial Impedance Test

- (U) Objectives of the periphery wrapper impedance tests are to evaluate and compare the axial impedance between various candidate wrapper butt and lap joints at ambient and reactor operating temperatures under equivalent axial differential pressures and bundling loads. In addition, the axial gaps occurring between periphery components will be evaluated at nominal reactor temperatures to determine thermal expansion effects upon leak rates.

- (U) Preliminary tests have been conducted in the bundling furnace with the "on ends" or "saw tooth" configuration with no joints in the wrapper specimen. The specimen consisted of twenty-eight layers (.154 in.) of 5.5 mil thick PDS 30182-2 flat grafoil sandwiched between two cylinder halves machined to the periphery "on ends" (sawtooth) geometry on the centerface. See Figure 5. The cylinders were bundled radially at 30 and 60 psig per square inch of foil and pressure differentials of 26.5, 37 and 48 psid Helium were applied axially to the foil pack. The leak rate along the foil measured at the exit end to minimize fixture leakage effects. The entire test setup is shown in Figure 6.

- (U) Test data to date shows a trend of decreasing leak rates at increasing temperature which indicates that the thermal expansion of the

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FIGURE 4
SECONDARY SUPPORT TANG AFTER TEST
EML C.5

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FIGURE 5
WRAPPER SPECIMEN AND FIXTURE
EML-E.1

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FIGURE 6
AXIAL IMPEDANCE SPECIMEN ASSEMBLY
EML-E.1

(U) fixture, a possible cause of wrapper hammocking, has little effect on the leak rate. Post-test examination also revealed no deterioration or tearing of the grafoil.

CORE ASSEMBLY TESTING

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

(CRD) The flat seal design for the R-1 lateral support system was evaluated in the partial length core test fixture. The purpose of the dynamic tests in this fixture was to provide basic design information on the breakaway and motion characteristics of the candidate designs. Since similar tests were conducted on angled type seals, a direct comparison was made between the two major candidate designs. The strength and wear of PO3 graphite and carbitex materials were also determined. A schematic sketch of the lateral support system previously shown in TME-1774 is repeated in Figure 7. A 253 lb graphite cylinder representing a solid core was supported in the partial length reflector by two rows of seal segments. Each row contained a one piece carbitex outer seal and twelve 30° PO3 graphite inner seals. Radial loads were applied to the inner seals by helical springs equal to a 3.2 psi bundling pressure. The reflector which was supported on four oil film slip tables was vibrated with a 10,000 lb thruster. A photograph of the setup is shown in Figure 8.

(CRD) Discrete frequency dwell tests were performed in the range from 10 to 100 cps at input levels varying from 1.6 to 5 g's. Output signals from four accelerometers and a displacement transducer were monitored on tape and on oscillograph recorders. The response of the core is typical

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FIGURE 7
CANDIDATE FLAT SEAL DESIGN FOR
LATERAL SUPPORT SYSTEM
EML-G.2

FIGURE 8
TEST SETUP FOR DYNAMIC TESTS OF CANDIDATE
LATERAL SUPPORT SEAL DESIGN
EML-G.2

(CRD)

of the classical mass spring damped system. From the recorded traces, breakaway was first noticed at 2.4 g's. The static tests had indicated that the expected breakaway would occur at 2.2 g. A summary plot of the relative motions between the core and reflector at the various acceleration input levels is presented in Figure 9. The rapid increase in the relative displacement of the core to reflector that was noted during the tests of the angle type seals did not occur. Because of a 1 inch displacement limitation in the thruster system, the 5 g test was limited to 10 cps. The motion at the frequencies tested are similar to the previous NRX flat seal tests and analog studies.

(U)

The friction forces appeared to increase as evidenced by a reduced relative displacement when the 12 cps dwell was repeated near the end of the tests. Strain gages on the outer seal ring showed no measurable stress above the 10μ inch per inch noise level.

(U)

A disassembly and inspection revealed no failures or wear.

SUPPORT STEM TESTS

EML-L.1

Liner Tube Burst Test

(U)

Six stainless steel 347 and six Inconel 718 simulated indented liner tubes were hydraulically pressure tested at room temperature in the test fixture shown in Figure 10.

(U)

The test specimen, Figure 11, was inserted into a steel cylinder and the entire assembly was placed in a concrete block safety cubicle. Pressure lines were routed through the wall to an accumulator, pressure transducer safety valve and high pressure pump. The signals from the

FIGURE 9
RELATIVE DISPLACEMENT INCREASE AT VARIOUS
INPUT ACCELERATIONS AND FREQUENCIES
EML- G.2

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FIGURE 10
SETUP FOR TESTS TO 4000 PSI PRESSURE
EML-L.1

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FIGURE 11
SETUP IN SAFETY CUBICLE
EML-L.1

(U) pressure transducer were monitored with a pen recorder. In this way exact pressure fluctuation could be noted below 4000 psi. Each specimen was cycled to internal pressure levels of 1200, 1600, 2000, 2400, 2800, 3200, 3600 and 4000 psi. The pressure increments were maintained for one minute and the level was returned to ambient. Figure 12 shows the locations where measurements of the outside diameter and the outside surface across each of the five indentations were made. None of the twelve specimens tested were affected by the pressure level to 3600 psig.

(U) The pre- and post-inspections of the stainless steel specimens after the 4000 psi run revealed only one dimensional change. This was an eight mil increase in the external measurement from 0.3750 to 0.3830 inches at a center dimple indentation which also was manufactured five mils deeper than was called for on the drawing. For the six inconel specimens, the pre- and post-inspections have revealed a maximum dimensional change of about four mils from 0.3795 to .3838 inches.

EML-L.2 Burst Test of Stem Welded Aft End Assembly

(U) Nine welded aft end assemblies were pressure tested to failure and burst at various pressures from 10,000 to 15,000 psi.

(U) Figure 13 shows typical failures at the electron beam weld, which attached the closure cap to the support nut. On only one failure the electron beam weld joint between the support nut and liner tube occurred. Although burst was at 14,000 psi, visual examination showed an incomplete penetration. The source of incomplete penetration will be eliminated for reactor grade hardware by use of a mechanical feed system. Even with this penetration discrepancy the pressure exceeded reactor conditions by a factor of more than ten.

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FIGURE 12
LINER TUBE TEST SPECIMEN
EML-L.1

FIGURE 13
FAILURES OF THREE AFT END WELDED ASSEMBLIES
EML L.2

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(U) Prior to the failure tests, the specimens were cycled from ambient to 900 psig. At 900 psig of each cycle, the pressure was held for one minute. A visual examination of the specimens has shown no evidence of a mechanical failure.

(U) The same test setup used for the Liner Tube Pressure Test was used. Traces of the pressure cycling were viewed on the pen recorder but since all specimens failed at pressure levels in excess of the transducers' 4000 psi limitation, it was necessary to remove the transducer from the system and note pressures on the dial indicators. Because of the relatively high pressure at burst compared to reactor operation, a precise time history was not needed. Burst occurred on all specimens at pressure levels ten times greater than those expected during operation.

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TESTS IN SUPPORT OF NRX & XE

Neutron Detector Tests

(U) Three detectors are to be mounted on the XE pressure vessel closure to detect and measure the neutron intensity.

(U) A test program to determine the sensitivity of nitrogen and helium gas filled neutron detectors at cryogenic temperatures was completed. The tests were performed at WANEF Radiation Calibration Facility.

(U) The test consisted of subjecting the gas filled detectors to various temperatures while in a neutron field. The output currents from the detectors, the neutron intensity and detector temperatures were plotted against time. Cryogenic temperatures were obtained by using a liquid nitrogen shielded-liquid helium research dewar. The detector was lowered into the liquid helium reservoir to obtain the desired temperatures down to $60 \pm 10^{\circ}\text{R}$.

(U) Results of the tests indicate that the sensitivity of the nitrogen gas filled detector is drastically reduced at $60 \pm 10^{\circ}\text{R}$. At this temperature the nitrogen gas has already liquified causing the observed drop in sensitivity. A similar detector filled with helium gas shows that the sensitivity is not significantly affected at $60 \pm 10^{\circ}\text{R}$. All proposed neutron detectors for the XE engine will be helium gas filled.

Control Drum Shaft Torsion Tests

(U) Torsional tests to failure were performed on a reactor dome end shaft P/N 937J394 H01C and on a simulated shaft having the same dimensions at the shaft undercut as the reactor dome end shaft. The purpose of these tests was to determine the ultimate strength of the

(U) 6061-T6 dome end shaft material at ambient temperature. The tests were run on a standard commercial 5000 pound inch torsion machine located at Westinghouse Research Laboratory.

(U) For the reactor dome end shaft test, the components consisted of the dome end shaft, the spline coupling where the torque load was applied, the four shaft to drum bolts and locking devices and a flange to which the dome end shaft was attached. This flange was rigidly mounted to a torque load cell which was mounted to the torque machine. For the simulated shaft test, the only component required was the shaft itself as the standard machine grips could be used.

(U) Instrumentation consisted of a load cell to record the torque and a protractor to measure the angular displacement. Before the reactor dome end shaft test was run, a line parallel to the shaft axis was drawn on the indexing spline tooth, across the spline relief groove and on the bearing shoulder. This line was used as a reference line to be visually checked after the test to see if any noticeable angular deformation occurred away from the spline relief groove. No observable deformation was found in the line after the shaft failed. The shaft flange was also indexed with respect to the reacting flange to determine if any motion occurred in the four bolts after the shaft failed. Again no observable deformation between the shaft flange and reacting flange occurred. This indicates that almost all of the deformation occurred in the spline relief.

(U) Torque and angular displacement was recorded by the load cell and machine protractor for the simulated shaft test. Indications are that some slippage occurred in the machine grips and a different angular displacement measuring method will be used on the remaining 3 simulated shafts to be tested.

(U) Results of these tests are shown in Figure 13.

FIGURE 13
CONTROL DRUM SHAFT TORSION TEST RESULTS

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Scram Spring Tests

(U) Cycling tests were conducted on two scram springs, Part No. 978D559 H01D, to determine the effect of a chemical milling operation on the spring material characteristics. One spring, SN A51450 was in the as-received condition, the other SN A51453 was chemically milled. Both springs were subjected to 1000 cycles (0 - 180° - 0) each at ambient and -320°F. Visual and dye penetrant examination revealed no detrimental effects of the cycling on either spring.

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