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Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON NOVEMBER 30, 1967
(Title Unclassified)

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

SPECIAL REFERENCE	CLASS IS	Class	Date
DETERMINATION	DBW	u	3-2-82
Class: u			

Classification cancelled or changed to
by authority of DOZ
by H. J. C. TIC, date SEP 10 1973

E. A. DeZubay, Manager
Thermo-Flow Laboratory

~~INFORMATION CATEGORY
CONFIDENTIAL - RD~~

~~12/18/67
Authorized Classifier Date~~

C. L. Meuche, Manager
Engineering Mechanics Laboratory

~~GROUP - I~~

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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON NOVEMBER 30, 1967
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ATTENDEES:

E. A. DeZubay	WANL	J. Malarky	WANL
R. N. Eichbauer	WANL	C. L. Meuche	WANL
N. J. Ettenson	WANL	N. Norman	AGC
E. Fatzer	WANL	E. Pianka	WANL
H. Fix	WANL	M. J. Rieb	AGC
O. Gormley	WANL	W. J. Rowan	WANL
W. J. Havener	WANL	L. A. Salvador	WANL
H. Hoffman	SNPO	F. G. Tauch	WANL
G. A. Kalvin	SNPO-C	D. C. Thompson	WANL
I. E. Kanter	WANL		

The Monthly Development Test Program Review Meeting was held on November 30, 1967.

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 EXPERIMENTS

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TABLE 1

THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (November)		PLANNED NEXT PERIOD (December)
<u>Tests for NRX-A6</u>		
TFL-1, b	De-Pressurization Effect - Tests complete.	No activity.
TFL-2, a	Filler Strip Model Drafted WANL-TME-1717. Completed data analysis on TFL-2, a, 0003. Released data to TND for analysis.	Publish WANL-TME-1717. Liaison with TND on data evaluation.
<u>Tests for XE-1</u>		
TFL-1, b	Single Element Tests - Total Tests - 16 2 - XE-1 Phase III profile, checkout tests (unfueled, noncoated elements) 10 - XE-1 Phase III simulation tests 4 - XE-1 full power simulation tests	
<u>Tests for XE-2</u>		
TFL-1, a	Cluster Environment Test Inventoried all model hardware required for XE-2 environmental simulation.	
<u>Tests for R-1</u>		
TFL-1, b	Single Element Tests - Total Tests - 2 Long cold end chuck development tests.	Tests of high void elements from Phase I-D, Phase IV-A, and Phase IV-B. Continuation of chuck and furnace development tests.
<u>General Development Tests</u>		
TFL-1, a	Single Cluster Tests Conducted test TFL-1, a, 0020 (coated cluster) for 21.3 minutes at full power. Thermal-hydraulic analysis of model partially completed to permit proper sizing of tie rod channel orifice and reliable calculation of mixed mean temperature. Modified center element designed to permit "stand-off" support evaluation.	Conduct TFL-1, a, 0021 at high temperature profile. Complete thermal-hydraulic analysis of cluster model. Evaluate modified center element design in full cluster test.

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TABLE 1 (Continued)

THERMO-FLOW LABORATORY TEST SCHEDULE (Continued)

PERFORMED THIS PERIOD (November)		PLANNED NEXT PERIOD (December)
General Development Tests (Continued)		
TFL-1. a	Single Cluster Tests (Con't) Design and procurement activity of the 9 MW facility continued. Continued procurement of hardware for LASL exit gas thermocouple and composite support development tests.	Continue design and procurement of 9 MW furnace and related hardware.
TFL-1. b	Single Element Tests - Total Tests - 4 2 - NRX-A6 O. D. coated element evaluation tests 1 - Furnace development test, shield temperature measurements 1 - Furnace checkout test.	
TFL-2. a	Filler Strip Model Layout studies of alternate foil configurations completed. Preliminary thermal analysis completed to size tile and foil thickness and match to heater. Final proposed design reviewed with ARD and TND. Completed design for FS-1 gas and water flow systems, control consoles and auxiliary supports and equipment.	Complete detail drawings. Initiate procurement of hardware. Continue thermal analysis of model. Continue procurement and installation of FS-1 facility.
TFL-5. b	Interstitial Corrosion Tests 12-Inch Furnace - Hydrottested.	Conduct check-out.
TFL-5. c	Reactor Graphite Permeability Tests Grafoil Swelling - Test Completed.	Test aft end impedance.

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TESTS FOR NRX-A6

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

- (U) Additional tests were conducted with short enriched specimens to determine the effects of rapid de-pressurization of fuel elements on the integrity of the coating and the elements.

- (C-RD) Test numbers 18 and 19 were conducted in a configuration which attempted to permit only hydrogen flow through the element webs. Their decay time from 750 to 350 psig was 2.025 and 36.65 seconds respectively. No fuel beads or coating particles were observed. The one-half section permeability data before and after test 18 was 4.0, 4.0 before and 4.9, 4.6 after. For test 19, it was 9.6, 11.0 before and 9.9, 11.0 after. It is felt that the difference is not significant and that part of the difference may lie in the permeability instrument.

- (C-RD) Two element segments were hydrolyzed. They were tested in a bore blow-down and a web flow configuration. The seals for these tests were not as effective as desired because of corner chips and corner crumbling. Despite this, no evidence of coating or fuel beads was found. Hydrolyzing had little effect on the Y-12 element as far as permeability (4.1, 4.1 before hydrolyzing, 4.1, 4.2 after hydrolyzing); however, the WNCO segment showed slight increase in permeability (44.2, 62.0 before hydrolyzing, 50.0, 66.0 after hydrolyzing). Permeability tests have shown no increase in permeability.

- (U) A table summarizing all of the results is presented in Figure 1.

- (U) This completes the activity on the test program.

TFL-2.a Filler Strip Corrosion Tests

- (U) Reduction and compilation of the test data from test TFL-2.a.0003 of the simulated NRX-A6 periphery was completed and the data was released to Thermal-Nuclear Design (TND) Department for further analysis. The data was analyzed and correlated by Thermo-Flow Laboratory to the extent necessary to make a meaningful and workable compilation for others. TND, in turn, is analyzing the data with the goals of comparing their own analytical results with the

Source Identification Serial Number	Total U ₂₃₅ per Element (Enriched) Grams	Segment Zone Identification	Test Sequence Number	1/2 Zone Permeability 10 psig Helium				Filter α Count CPM		Filter Plus Gasket Weight (GMS)			Specimen Weight (Grams)			Decay Time 750 psig to 350 psig (Second)		Fuel Beads Observ. Quan- tity	Coating Observ. Quantity
				Before	After	Before	After	Before	After	Change	Before	After	Change						
Y-12 76136	113.78	0X-8X	3	3.6	3.5	3.5	3.5	1	35	17.447	17.449	+ .002	109.706	109.706	0	1.09	Free	None	None
		11X-19X	18	4.0	4.0	4.9	4.6	15	460	17.479	17.486	+ .007 ^G	112.848	112.846	- .002	2.025	Web	None	None
		22X-30X	20	4.1	4.1	4.1	4.2	48	7135	17.322	18.657	+1.335	113.619	113.619	- .298	0.041	Bore-Hyd	None	None
		33X-41X	2	4.0	3.7	3.8	3.6	---	118	17.526	17.526	0	114.240	114.240	- .004	1.06	Free	None	None
		44X-52X	1	0.0	11.3	0.0	11.7	0	----	17.474	17.478	+ .004	111.653	111.653	- .002	1.06	Free	None	None
Y-12 76184	116.66	0X-8X	4	5.4	5.2	4.6	4.6	2	171	17.470	17.474	+ .004	110.314	110.312	- .002	1.09	Free	None	None
		11X-19X	15	4.0	4.0	4.1/4.6	3.5/4.6	6	95	17.583	17.593	+ .010	113.989	114.005	+ .016 ^{VG}	0.59	Web	None	None
		22X-30X	5	4.4	4.6	4.1	4.2	3	78	17.466	17.469	+ .003	113.605	113.608	+ .003	1.07	Free	None	None
		33X-41X	13	9.9	4.1	9.9	3.8	1	477	17.576	17.579	+ .003	113.308	113.304	+ .004	0.0225	Free	None	None
		44X-52X	6	4.6	8.0	4.2	7.8	4	25	17.460	17.464	+ .004	110.241	110.244	+ .003	1.085	Free	None	None
WNCO 33771	114.04	0X-8X	7	6.6	7.2	6.6	6.9	4	63	17.504	17.505	+ .001	107.042	107.044	+ .002	1.09	Free	None	None
		11X-19X	19	9.6	11.0	9.9	11.0	33	437	17.528	17.546	+ .018 ^G	108.496	108.498	+ .002	36.65	Web	None	None
		22X-30X	8	23.2	30.5	23.2	29.5	1	15	17.538	17.537	- .001	110.115	110.118	+ .003	1.11	Free	None	None
		33X-41X	22	50.0	66.0	56.0	66.0	158	8598	17.560	17.587	+ .027 ^G	109.984	109.987	+ .003	0.5/0.2/7.4	Web-Hyd	None	None
		44X-52X	9	34.3	50.0	32.0	50.0	1	21	17.576	17.477	+ .001	111.084	111.087	+ .003	1.1	Free	None	None
WNCO 33775	118.13	0X-8X	10	13.2	15.3	12.5	13.6	3	10	17.556	17.558	+ .002	107.218	107.216	- .002	1.09	Free	None	None
		11X-19X	16	15.6	17.7	16.0	17.3	7	32	17.527	17.479	- .048	108.803	108.840	+ .037 ^{VG}	0.64	Web	None	None
		22X-30X	11	18.0	21.1	19.0	20.2	1	51	17.507	17.515	+ .008	110.484	110.489	+ .005	1.11	Free	None	None
		33X-41X	14	22.4	22.4	23.2	22.4	10	147	17.410	17.412	+ .002	112.246	112.244	- .002	0.0245	Free	None	Yes 5.002 .003
		44X-52X	12	12.9	19.3	14.9	21.5	1	11	17.478	17.481	+ .003	111.153	111.145	- .008	1.07	Free	None	None
33775	118.13	11X-19X	17	17.3	17.3	15.3	17.7	9	87	17.558	17.564	+ .006	108.849	108.849	+ .028 ^{VG}	Steady- State	Web	None	None
76136	113.78	22X-30X	21	4.2	4.2	4.4	4.6	60	1054	17.534	17.545	+ .011 ^G	109.360	109.360	+ .001	0.035	Bore-Hyd	None	None

- ◇ One hour soak.
◇ No specific soak time.
□ Specimen cycled 3 times (gasket replacement, compression increase)
VG Vacuum grease
G Grafoil gasket particles

FIGURE 1
DEPRESSURIZATION EFFECTS
TABLE OF MEASUREMENTS AND OBSERVATIONS

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TFL-2.a.0003 experiment as well as making a three-way comparison between the analytical predictions, experimental results, and actual NRX-A6 behavior. Such a process will result in increased confidence in the analytical model for corrosion of the periphery and will provide more data on which the next experimental model can be designed to provide a better simulation of the reactor periphery than is presently achieved.

The data released for analysis included all radial and axial temperature profiles in the model, temperature-time histories of various components, pressure profile in the seal system, flow rates of hydrogen and helium, axial filler and tile gap profiles, and calculated grafoil temperatures. Also available for analysis and inspection are skiagraphs of each wrapper layer, graphical maps of corrosion areas on tile and filler strips, and photographs of all components. In addition, a summary graph of equivalent corrosion time versus temperature was completed for the outside surface of the grafoil wrapper as shown in Figure 2. These values of equivalent time at each reference temperature were calculated for each of six axial planes on the basis of temperature-time histories for the grafoil outside diameter at each station. The test temperatures for the grafoil were calculated from measured temperatures in the inner core and filler strips and known heat fluxes and thermal conductivities of the components.

The "equivalent corrosion time" presented in Figure 2 is, in a sense, a normalizing variable which takes into account the temperature fluctuations and transients during the test. It represents the amount of time at a reference temperature, T_o , that would produce the same amount of corrosion as experienced over the entire test profile of temperature versus time. This calculation is based on the kinetic data presently available for the reaction of pure hydrogen and grafoil to produce methane and acetylene. A computer code was written for the CDC 6600 computer to perform the equivalent corrosion analysis.

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FIGURE 2
TEMPERATURE-EQUIVALENT TIME
FOR THE GRAFOIL WRAPPER (TEST TFL-2a. 0003)

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In addition to the equivalent time computer code, two additional codes were written for the thermal analysis of the TFL-2.a. 0003 test data. One program calculates the radial and axial temperatures in various components of the model (filler strips, inner core, heater, insulating tile, and wrapper) based on heater flux, gas flow rates, and thermal conductivities and other material properties. A second calculates the magnitude of filler gaps and tile gaps under operating conditions based on temperature profiles in the components.

The drafting of WANL-TME-1717, "TFL-2.a Filler Strip Corrosion Test: Simulated NRX-A6 Periphery," summarizing the results of test TFL-2.a. 0003 neared completion. It will be published next month.

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TESTS FOR XE-1

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

(C-RD) Sixteen tests were conducted to complete the XE-1 simulation series. In order to conduct this XE-1 simulation series, it was necessary, due to the low flow rates and exit pressures (109 scfm and 50 psig), to change the hydrogen flow and pressure control valve. Two checkout tests were conducted with non-fueled, uncoated elements to check out the control system and develop the techniques required to rapidly change flow rates and exit pressures as required for simulation of the XE-1 Phase III test. The next two tests were conducted with the same uncoated NRX-A5 element with the XE-1 Phase III test simulated profile, nominal surface temperature of 2320°R at 48.6 inches, maximum 2690°R. The element lost 0.1 gms in each test. The same element was re-tested a third time with the first 15.75 minute hold conducted at the Phase III profile conditions to measure the exit gas temperature and the remainder of the test at a surface temperature 200°F higher than the XE-1 Phase III profile. The weight loss for this test was 0.3 gms.

(C-RD) A second NRX-A5 uncoated element, tested at the 200°F higher surface temperature, failed at 91.5 minutes of the scheduled 132 minute test due to corrosion at the hot end, and the weight loss was 10.6 gms. However, this element had experienced an over-temperature of approximately 1000°F for five seconds at the beginning of the test, and this excursion apparently resulted in a decreased cross section due to corrosion with excessive internal temperatures at the hot end from the beginning of the test until failure occurred. Two additional tests of uncoated elements were completed at a level 200°F higher than the XE-1 Phase III profile with weight losses of 0.2 and 0.7 gms.

(C-RD) Two coated elements were tested at the XE-1 Phase III 200°F higher profile after having had mechanical defects placed in the bores at the 48 inch station. The elements completed the planned times with weight losses of 1.5 and 3.6 grams.

(C-RD) These two elements were then tested at XE-1 full power conditions, 485 scfm flow, 4275°R surface temperature, 560 psig exit pressure, $\Delta P_{20} = 10$, and failed after 4.3 and 8.0 minutes respectively. Failures in both elements occurred at the point of the defects, 48 inches.

(C-RD) In order to evaluate the performance of hydrolyzed elements, two coated NRX-A3 elements obtained from Y-12 were tested at the XE-1 Phase III 200°F higher profile conditions, and the element weight losses after completion of the tests were 2.7 and 2.9 gms. These A-3 elements were then re-tested at XE-1 full power conditions and completed 16.6 and 18.3 minutes respectively with weight losses of 21.1 and 59.8 gms. Pinhole counts were 62 and 185 respectively with failures occurring at about the 23 inch stations.

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TESTS FOR XE-2

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TFL-1.a Cluster Environment Test

Surplus hardware, most of which was used in previous TFL-2.a periphery tests, was inventoried and put aside for a possible XE-2 environmental simulation test. This test has been proposed as a means of studying the problem of element deterioration on long storage, a condition hypothesized as the cause of the debris found in the XE-1 reactor after storage and shipment. This proposed test is being reviewed and prepared for approval.

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TESTS FOR R-1

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

(U) Two tests were conducted with low and high voids, to evaluate a long, 13 inch, cold end chuck in an attempt to reduce the cold end surface temperature. Temperature reductions were obtained but excessive heat was generated in the chuck. Larger diameter chucks are being fabricated and will be tested.

The Chuck Development Program was discussed and the outline is as follows:

1. Cold End Chuck.
 - A. Standard chuck is 5-1/2 inches long. Chucks of 7, 8, 9, 11, 13, and 17 inches are available from previous testing.
 - B. After chuck length is determined, then the complete retainer chuck arrangement will be modified to aid installation and removal.
2. Conducting Paper Models to Understand Current Paths.
 - A. Standard chuck.
 - B. Shaped broached insert.
3. Modification to Existing Hot End Chucks.
 - A. External fins to direct current path but provide mechanical strength.
 - B. Scalloped inlet to distribute current by varying resistance.
 - C. Internal threads to vary current carrying areas.
 - D. High resistance graphite with any or all of the above configurations.
(Grade CEQ-5 times resistivity - molded lampblack - base processed at 5070°F).
 - E. Relocate hot end retainer to modify current path to electrode.
 - F. Modify electrode cable connections.
4. New Hot End Chuck Designs.
 - A. Chuck shell with:
 - 1) Two inch broached insert. This will allow a chuck cost reduction and will permit obtaining a stock of broached inserts to standard sizes.

(C-RD)

- 2) Shaped broached inserts to control current division.
- 3) Individual broached 1/2 inch sections.
 - a) More accurate broach by shop.
 - b) Establish gaps between pieces to distribute points at which current will leave element.
 - c) Varying resistance materials.
- 4) Split fingers (1/2 inch pieces) with spring and back-up by solid broached piece. Use (b) and (c) above.

(C-RD)

- B. Double contact chuck.
 - 1) Double parallel path with first path using split fingers.
 - 2) Varying parallel paths resistances.
- C. Brush type chuck.
 - 1) High temperature loading device.
 - 2) New hot end electrode.
 - 3) Modify furnace to allow cold loading device.

5. Guard Heater with Water Cooled Shield.

(U) Tests planned for the next period include tests of high void elements from Phase I-D, Phase IV-A, and Phase IV-B. The chuck and furnace development tests will also be continued.

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GENERAL DEVELOPMENT TESTS

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TFL-1.a Single Cluster Development Tests

(U) Test TFL-1.a.0020 was conducted on November 14, 1967 as a developmental vehicle which contained several experiments. The primary purpose was to determine the feasibility of using externally coated elements in the TFL-1.a cluster test. A second experiment involved the mounting of several material samples in the exhaust stream to determine the capability of boron nitride and beryllium oxide to withstand a high temperature hydrogen environment. Finally, a number of thermocapsules and a tungsten/tungsten-26% rhenium thermocouple were placed in the exit gas diffuser to measure the graphite diffuser temperature and the temperature of the molybdenum liner in the diffuser.

(C-RD) The test cluster was at full power for 21.3 minutes at a hydrogen flow rate of 0.12 lbs/sec and an exit gas temperature of 4350°R based on a measured mixed mean temperature of 4070°R. The tie rod exit gas at full power was 1064°R while the element temperature at station 43 was 4450°R. The surface temperatures were measured by optical pyrometer on a surface from which coating had been removed prior to the test. A power level of 2.09 megawatts was employed and the cluster was under power for 34 minutes including up and down power ramps.

(C-RD) The use of externally coated elements in the cluster model was shown to be feasible at the test temperatures. Figure 3 shows the elements after the test and illustrate that no bonding between elements or severe coating degradation occurred. The samples of materials in the 4070°R exhaust stream illustrated that beryllium oxide was capable of withstanding the high temperatures of the hydrogen stream. A weight loss of 18 percent was measured for the sample but the dimensions remained stable. The boron nitride did not adequately endure the environment. It lost 37 percent of its weight and was dimensionally distorted after the test. The diffuser experiments showed that the entire diffuser is approximately isothermal; there were no measurable axial temperature gradients. The wall temperatures were between 3600°R and 3900°R. The molybdenum liner temperature was about 3600°R.

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POST TEST
FFL-1a.00 20a
EXTERNAL FLATS

POST TEST
FFL-1a.00 20a
INTERNAL FLATS

FIGURE 3

EXTERNALLY COATED FUEL ELEMENTS
FROM TEST TFL-1a. 0020

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(C-RD)

Design and development efforts for the high temperature (4800°R) testing of clusters for future reactors and for development tests were intensified. The design of a center element which can carry the entire axial load of the cluster (about 650 lbf) under full power received major emphasis. This center element will be required if a "standoff" support design is chosen for R-1. This standoff design is an alternate to the prime R-1 design which can be used if the composite tips on the fuel and the composite pedestals are incompatible from a thermal expansion standpoint. The standoff design provides for the center element to carry the cluster load with no contact between the fuel elements and the pedestal. In the TFL-1a model this requirement is complicated by the fact that the center element must be electrically insulated from the fuel elements over its entire length. Three designs are currently being evaluated. These are:

1. Flame spraying of an insulator coating of zirconium oxide, magnesium oxide, or beryllium oxide on the outside surface of the center element.
2. Attaching chips of beryllium oxide along the external flats of the center element.
3. Fabricating the element from boron nitride clad with pyrolytic graphite tile.

(U)

In addition to the center element development work, analytical thermal-hydraulic models of the TFL-1a model are being made to provide a means of sizing the tie rod bushing orifice and to provide an analytical prediction of heat input into the tie rod channel. These parameters are necessary in order to determine the flow split between the tie rod channel and fuel element channels so that a proper heat balance of the model can be made. The heat balance then permits an accurate calculation of mixed mean exit gas temperature on which the cluster power tests are controlled.

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The design and procurement of the 9 megawatt cluster facility continued. Procurement of the furnace, transition elbow and other major hardware components received major emphasis.

Procurement actions for hardware for the forthcoming tests of the LASL exit gas thermocouple and PEEWEE support system continued.

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

Two tests were conducted for evaluation of NRX-A6 O.D. coated elements.

Tests were for 2 and 5 minutes at power at NRX-A6 screening test conditions.

(U)

These elements will be sectioned and evaluated by Fuel Development.

One test was conducted to obtain moly shield temperatures at NRX-A6

(U)

screening test conditions, and a second test was conducted to check out the gas control system after the XE-1 simulation test series.

TFL-2. a Filler Strip Corrosion Test

Design layout studies of several alternate model configurations were completed to determine in which way the necessary reactor parameters could best be simulated for the first of the reactor periphery development tests. In conjunction with these studies, some preliminary thermal analyses were made in order to estimate the thicknesses of the grafoil wrapper and pyrolytic graphite insulating tile required to match existing heater capacity to radial heat flux and temperatures in the model components. Based on these studies, a design review was held with Thermal Nuclear Design and Advanced Reactor Design to reach agreement on a model design for the series of periphery development tests so that procurement of hardware could be initiated.

(U)

One of the critical areas of concern was the temperature environmental simulation for the grafoil wrapper. Based on the current reactor design, the model should be capable of providing a temperature of 4750°R on the inside surface and a temperature of 3000°R on the outer surface. Thermal analysis of the model indicates that the current heater capacity can maintain these limits if specific thicknesses of foil and insulating tile are employed. The range of thicknesses for the foil wrapper is 180 to 200 mils with a minimum tile thickness of 125 mils. These limits were accepted at the design review.

(C-RD)

(CRD) A second critical area was the angular geometry of the foil wrapper. It has been suggested that bends in the foil can result in increased corrosion because of "feathering" of the foil at the bend. In the reactor, all bends will be 120 degrees. In the TFL-2a model it is not practical to provide a 120 degree bend at gaps adjacent to the inside face of the foil and at gaps adjacent to the outside. The following combinations of bend angle are feasible:

INSIDE SURFACE (Adjacent to Interelement Gap)	OUTSIDE SURFACE (Adjacent to Filler Gap)
120°	90°
150°	120°
130-135°	100-105°

The latter nominal range was selected as the design for the first developmental test model.

Other design criteria which were specified at the design review include:

- (CRD)
1. Control of the test to maintain 4750°R on the inside of the grafoil wrapper at the hottest station.
 2. 60 minute duration test.
 3. Possible use of one mil metal foil samples on the outside face of the wrapper.

(U) The design and procurement of the FS-1 furnace, flow systems, and controls to be used for the TFL-2a tests continued. Drawings of the major components and installations were completed. These include the gas and cooling water flow diagrams, electrical control console schematics and layouts, structural steel for supporting the furnace, and others. The layout of the data acquisition and control equipment in the control room was also specified to facilitate test operation and future use of the FM/MX data acquisition system mounted in the mobile trailer. Procurement of components for these systems continued.

TFL-5. b Interstitial Corrosion Tests

(U) A concentrated effort on the 12-inch furnace installation continued. Completed laboratory tasks include the gas loop, water loop, control console and mounting of stand tracks on the test cell floor. Mounting of temperature recording instruments is 65% complete. Bus bar installation is 50% complete. Fabrication of the furnace body and internal components is 95% complete. The only item left to be fabricated are heater elements and electrode insulators.

(U) The furnace vessel was successfully hydrotested to 1500 psig. Some minor problems were encountered but were solved by re-machining of two sealing surfaces. The vessel was successfully pressure checked with helium to 1000 psig. No problems were encountered and the reuse capability of the metal "V" seals was proven.

(U) Assembly of the pressure vessel stand is 50% complete. When this assembly is complete, the vessel will be mounted and work will begin on the fabrication of the gas and water piping systems.

TFL-5. c Reactor Graphite Permeability Tests

(C-RD) A test was conducted to determine the impedance of a graphite sleeve around the periphery of an unfueled fuel element. This configuration was representative of that which might be used at the aft end of the reactor to reduce or prevent interstitial flow. A test was conducted initially at ambient temperature and pressure levels of 50, 210, and 350 psig. The pressure drop was varied from 0 to 200 inches of water. The temperature was then increased to 2100°F and with the pressure at 350 psi and the DP varied from 0 to 200 inches of water. Similar points were obtained up to 3100°F. The test was then repeated at conditions identical to the initial ambient test. Data from this test is being analyzed.

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A graphite permeability test was conducted on a 14" specimen having a 1" outer diameter and 1/4" inner diameter. The test was conducted with helium at 350 psia and approximately 3300°F. The specimen failed due to thermal expansion midway thru the test. Despite this mid test failure, a large amount of data was obtained which may provide initial data for a parametric study of sonic and subsonic permeable flow as a function of pressure ratio and wall thickness.

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SECTION B
MONTHLY REVIEW OF ENGINEERING MECHANICS TESTS

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ENGINEERING MECHANICS TESTING

Performed This Period (November 1967)

Planned Next Period (December 1967)

Tests for R-1		Tests for R-1	
A.4	GANGED DRIVE TEST Decoupler Spring Material Tensile Test Drive Band Fatigue Tests	A.4	GANGED DRIVE TEST Actuator Decoupler Shear Pin Test
C.2	CLUSTER DEVELOPMENT TESTS Pedestal Thermal Shock Test	B.3	FUEL ELEMENT INSTRUMENTATION Poison Wire Buoyancy Test
C.3	MECHANICAL TESTS OF SUPPORT STEMS Stem Component Test Preparation	C.2	CLUSTER DEVELOPMENT TESTS Pedestal Thermal Shock Test
D.5	PARTIAL CORE DYNAMIC TEST Lateral Support Test Fixture Modification	C.3	MECHANICAL TESTS OF SUPPORT STEMS Stem Component Tests
E.1	CORE PERIPHERY TEMPERATURE TESTS Metal Wrapper Evaluation Test	D.5	PARTIAL CORE DYNAMIC TEST Lateral Support System Development Test
F.1	PLENUM FEED MANIFOLD Stem Thread Sealing Test	E.1	CORE PERIPHERY TEMPERATURE TESTS Metal Wrapper Evaluation Test
		F.2	SHIELD SLUG DEVELOPMENT Shield Element Thermal Shock Test
Facilities			
A.4	GANGED DRIVE TEST Three Drum Facility Installation	A.4	GANGED DRIVE TEST Three Drum Facility Check-Out
C.4	BUNDLED CLUSTERS Bundling Furnace Check-Out	C.4	BUNDLED CLUSTERS Complete Bundling Furnace Check-Out
		H.1	RESONANT SURVEY Conduct Tests at NRDS

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TESTS FOR R-1

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EML-A.4 GANGED DRIVE TEST

Decoupler Spring Material Tensile Test

(U) Raymond Spring Company, the selected vendor for the ganged drive decoupler spring indicated that the spring loop could be formed with the material in the full hard condition. To demonstrate his forming capability, the vendor submitted a sample for verification. This sample, a 301 stainless steel tensile test specimen fabricated from a candidate decoupler spring material was tested to failure in a standard tensile testing machine. The specimen cross section dimensions were 0.0625 inches thick by 0.50 inches wide with a gage length of 3.00 inches. The specimen was instrumented with two longitudinal and two transverse strain gages located back to back.

 Data from the test indicates the following:

(U) Ultimate tensile strength = 184,000 psi
 .2% tensile yield strength = 163,400 psi
 Modulus of elasticity in tension = 25.2×10^6 psi
 Poisson's ratio = 0.3
 Hardness = 44 (Rockwell C)

 These data indicate that the sample did not conform to the specification of the material to be used for the spring which has a guaranteed 200,000 psi minimum yield.

(U) The spring vendor will provide additional samples to show that the loop can be formed in specification grade (extra full hard) material.

Drive Band Fatigue Tests

(U) Two non-specification grade titanium bands .600 inches wide by .011 inches thick with sides ground and finished parallel were prepared for fatigue testing by cementing doubler plates to the cable clamp end with epoxy cement. This cementing procedure had proven successful on tensile specimens tested previously.

(U) Two strain gages were mounted opposite each other at the band edges to facilitate band alignment and assure true axial band preload.

Band no. 1 failed at the point of tangency after 20,398 cycles with a 345 pound preload. This is the predicted point of failure. Band no. 2 failed in an abnormal manner near the cable clamp end after 9,177 cycles with a 230 pound preload. These failure locations are shown in Figure 1.

These tests accomplished their purpose which was to completely check out the fixture. However, because of the random failure locations experienced which are related to material and/or processing conditions, no further band fatigue testing will be conducted until specification grade bands are received.

EML-C.2 CLUSTER DEVELOPMENT TESTS

Pedestal Thermal Shock Test

(U) The nineteen (19) element thermal shock heat exchanger and load application assembly has been installed in the 6 x 54 furnace and two (2) sustained high temperature shakedown tests were conducted.

The purpose of these tests was:

- (U)
- (a) develop standard operating procedures for the load assembly,
 - (b) determine heat exchanger and furnace pressures at various helium flow rates during steady state and shock conditions,
 - (c) determine the maximum temperature achievable in the specimen,
 - (d) establish heat-up rates.

The specimen was an ATJ graphite pedestal (LASL design) with forty-two

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FIGURE 1

TITANIUM BAND FAILURE LOCATIONS
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(U) (42) flow holes. It was instrumented with four (4) thermocouples, one in the top of the load block, two (2) in the pedestal flow holes and one on the pedestal I.D. This is shown in Figure 2.

(U) The test procedure consisted of heating the furnace to 4500°R with the specimen in the cool zone 5" below the nineteen (19) element heat exchanger. When at steady state temperature, the hydraulic ram, screw jacks and VIDAR Data System were actuated simultaneously. The load block seated on the exhaust end of the heat exchanger in nine seconds and a 100 pound load was applied. When a positive load was indicated, the helium inlet solenoid opened, dumping helium through the heat exchanger and thermally shocking the specimen. Figure 3 shows the test arrangement in detail.

The shakedown tests revealed the following:

- (U)
1. The ram - screw load application system functioned satisfactorily.
 2. The heat exchanger and furnace pressures during steady state and shocking conditions were relatively low indicating little or no leakage from the heat exchanger into the furnace.
 3. The maximum temperature in the specimen was 4050°R (heat exchanger at 4400°R) and was achieved at an average rate of 130°R/sec (Figure 4).
 4. The load block thermocouple indicated the same temperature as the lower end of the heat exchanger. However, a 300°R temperature difference existed between the load block and the specimen.
 5. No cracks were observed in the specimens after either test.

(U) In general, the C2 thermal shock fixture performed satisfactorily and only minor design changes are required to realize simulated reactor heatups of 150°R/sec to 4500°R under tie rod load conditions. These are modifying the load block to decrease the ΔT between it and the specimen and eliminating a downstream restriction to increase temperature heat-up rates.

FIGURE 2
THERMOCOUPLE ARRANGEMENT
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FIGURE 3
THERMAL SHOCK TEST ARRANGEMENT
EML- C.2

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FIGURE 4
THERMAL SHOCK OF GRAPH
PEDESTAL TEST NO. 2 CYCLE 4 & 5
EML-C.2

EML-C.3 MECHANICAL TESTS OF SUPPORT STEMS

Stem Component Test Preparation

(U) Three test fixtures were designed and are being fabricated for the development testing required to provide basic design information for the support stem. A summary of the tests is shown in Table I.

(U) Figure 5 is a schematic sketch of the arrangement to be used for applying hydraulic pressures to the indented liner tubes. The short length specimens and heavy walled outer safety container will be surrounded by a concrete enclosure for safety. The pressures will be applied in a cyclic manner prior to increasing the loading to failure. Output signals from strain gages attached to the specimen will be plotted against pressure levels.

(U) The second fixture, Figure 6, will be used to determine design information relating to the stresses in the liner tube and graphite element developed during the assembly of the NRX type liner tube seals. The axial load on the sleeves result in a wedging action at the mating surfaces which forces the grafoil material against the graphite element and the outer wall of the liner tube. These tests will be performed on various candidate designs. The study will be used to select diameters and wall thicknesses of the components.

(U) The structural integrity of the threads at the nozzle end of the stem will be determined by using the third test arrangement shown in Figure 7. A universal testing machine will be used to apply a tension load until failure is noted.

(U) The three tests will all be performed on short length specimens and will be repeated on the various candidate designs. Other material strength, sealing adequacy and manufacturing feasibility tests are currently being defined.

TABLE I
Stem Assembly Development
Required Fixtures for Short Specimen Tests

Item	Condition	Fixture	Instrumentation	Purpose
Pressure and Burst Tests	a) Welded Aft End Assemblies 1) Pressure from 0-900 psig for 20 cycles at room temp. 2) Pressure to failure	Fig. 5	1) Stress coat 2) Strain gage 3) Pressure gages & transducers 4) Oscillograph	Determine: 1) Mode of failure 2) Margin of safety 3) Strains 4) Photomicrograph of welds
	b) Indented Liner Tubes Pressurized at Room Temp.			
Grafoil Seal Expansion Tests	Axial Loading in Compression	Fig. 6	1) Loading machine 2) X-Y Plotter	1) Load versus deflection curves 2) Mode of failure
Stem Strength	Liner Tube Specimens Threaded at Ends. Axial Loads Applied in Tension.	Fig. 7	3) Stress coat 4) Strain gages	3) Margin of safety 4) Strains

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FIGURE 5
 Liner Tube Pressure Test
 EML-C.3

FIGURE 6
 Grafoil Seal Mechanical Test
 EML-C.3

FIGURE 7
 Stem and Thread Material
 Strength Test Setup
 EML-C.3

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EML-D.5

PARTIAL CORE DYNAMIC TEST

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Lateral Support Test Fixture Modification

(U) As noted in last month's report, a misalignment exists between the simulated core mass and the outer reflector of the partial core. Jacking bolts were added to the base plate of the reflector support fixture at locations shown in Figure 8. This now allows the core and reflector to be made concentric by using these bolts to adjust the planes of the base plate and the top of the reflector.

(U) Upon completion of these adjustments the assembly will be vibrated at levels greater than 4 g to define breakaway. The tests will be terminated after g levels are sufficient to cause a relative displacement of 50 mils between the core and reflector. This relative displacement was selected as being adequate to study the motion of the core at the breakaway condition without incurring the risk of test rig damage. These and future tests will be used to evaluate the candidate designs for the R1 reactor.

EML-E.1

CORE PERIPHERY TEMPERATURE TESTS

Metal Wrapper Evaluation Test

(CRD) The design of the R-1 core calls for a grafoil wrapper between the elements and filler strips. Corrosion of this wrapper is a potential problem and one way to greatly minimize it is to use an impervious metal wrapper which will inhibit the flow of H₂ over the foil.

(CRD) A wrapper expansion test is presently underway to investigate the suitability of a moly-foil wrapper as a corrosion barrier on the cold side of the grafoil core wrapper. The object of this test is to investigate the ability of the moly foil to withstand the core expansion in a high temperature carbiding environment.

(CRD) The wrapper is being tested in the existing EML-E.1 rig. All the hardware being used is left over from the NRX testing and has been modified

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FIGURE 8
LATERAL SUPPORT SYSTEM TEST SETUP
EML-D.5

(CRD) to make the sector appropriate for advanced reactor testing. Nine (9) preformed layers of 0.0055" grafoil joined with the butt joints form the basic wrapper, and a single continuous layer of 0.001" preformed moly foil serves as the outside layer. Petrolatum was used to hold each of the wrapper layers in place during initial assembly. The periphery is completed with the modified filler strips and seal segments and ten (10) thermocouples are used to establish the temperature conditions in the periphery. Figure 9 shows the partially assembled test rig.

(CRD) Temperatures of 3900°R on the hot side and 3200°R on the cold side of the wrapper assembly have been attained. The cold side temperature compares favorably with that expected for the R-1 reactor. The 35 psi difference across the wrapper is the same as that expected across the R-1 wrapper.

(CRD) The wrapper now has an accumulated ten (10) minutes of time at temperature and another cycle is presently underway. Present plans are to run for sixty (60) minutes total time at temperature.

EML-F.1 PLENUM FEED MANIFOLD

Stem Thread Sealing Test

(U) Data from the NR-1 stem thread sealing test indicates that the RTV 891 sealant should be acceptable for sealing threads of the R-1 cluster assembly. Leaks were initially detected in two of eight seals tested, but reruns of these two seals indicate that the test fixture assembly was the cause. Therefore, no leakage is anticipated in use of RTV 891 at 535°R and 140°R with pressure differentials of 0 - 1200 psid.

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FIGURE 9
CORE PERIPHERY SECTOR WITH MOLY FOIL
EML-E.1

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EML-A.4 GANGED DRIVE TEST

Three Drum Facility Installation

(U) The test facility installation is approximately 80% complete. More machining time has been required than originally anticipated and the test installation assembly has kept pace with the fabrication. The fabrication of decoupler parts is approximately 30% complete with the more difficult parts currently being machined. Test rig checkout and preliminary testing will be completed this month.

EML-C.4 BUNDLED CLUSTERS

Bundling Furnace Check-Out

(U) Two types of checkout runs were made on the high temperature bundling furnace. The first was performed with a simulated cluster to prepare for the receipt of the actual specimens. The purpose was to check the bundling action of the lateral loading elements through ranges of temperature and loadings desired for test programs. The temperature of the dummy cluster was raised to 4700°R with an axial loading of 400 lbs, and a bundling load of 400 lbs per rod. This is applied to six (6) bundling rods pushing on shoes 3/4" x 2" in area giving a contact pressure of 267 lbs per square inch. Figure 10 shows the bundling arrangement.

(U) The equipment performed as expected and no damage was incurred from expansion and contraction of the bundling rods. Further tests are planned using the water-cooled plunger to check the cooling of the welded section at the higher temperature involved. This plunger will be used for cluster axial loading.

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FIGURE 10

View Looking Into Bundling Furnace. The Six Bundling Rods
and Load Shoes are Shown Bearing Against the Cluster.

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(U) The second test was a maximum capability one for the furnace and was run in two (2) phases. The first was a cold pressurization run and the second was a maximum load, temperature and pressure run.

(U) The cold pressurization test was run with the simulated PEEWEE hardware and involved only nominal loads. The furnace pressure was increased in fifty (50) psi increments to 250 psi using the high pressure helium system in both manual and automatic control. During this phase, it was found that:

1. The operating procedure required some minor changes.
2. A leak existed in a plug in one of the loading rams.
- (U) 3. The automatic pressure control system for high pressure helium was not properly adjusted for pressure control.

(U) The changes required by the above were made and a simulated cluster of nine (9) solid elements was placed in the furnace. An axial load of 10,000 psi was applied, and the pressure gradually increased to 250 psi and placed on automatic. A nominal bundling load of 10 psi was applied while the specimen was heated to 5000°R. After reaching 5000°R, a bundling load of 1530 lbs was applied and the furnace put on automatic temperature control. Shortly thereafter a fluctuation in the power meters indicated a possible problem with the heating element and the test was terminated. This problem was found to be caused by carbon deposits shorting out the heater element legs and the carbon was traced to a failed sight port tube. This sight port tube will be repaired and the test repeated.