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100 AREAS TECHNICAL ACTIVITIES REPORT - PHYSICS

MAY, 1950

PILL PHYSICS GROUP - A. B. Carson

Power Level Increases

The power level at B area was raised from 275 MW to 290 MW on May 5, in accordance with P.T.-105-337-P. Some difficulty was encountered in holding the higher level due to the limitations placed on water temperature rise in the 0.240 zone, to prevent excessive thinble temperatures.

The power level at E area was raised from 370 MW to 385 MW on May 24, and from 385 MW to 400 MW on May 31, in accordance with P.T.-105-302-P. Additional P-10 loadings in the far side during the month improved the flux distribution so that this increase in power could be made without exceeding the temperature rise limitations placed on the central orifice zone to prevent local boiling.

Circulating Gas Composition Changes

The carbon dioxide concentration in the circulating gas at D area was raised to a nominal 100% during the period of operation between April 25 and May 8, in accordance with P.T.-105-168-P, Supplement "E". Some production was lost following start-up due to power cut-backs necessitated by the 45°C temperature rise limitation imposed on the .240 zone at 100% CO₂. However, during equilibrium 300 MW operation at present, the maximum observed temperature rise in the 0.240 zone is less than 15°C.

At F area the carbon dioxide concentration was increased from 60% to 80% during the period April 27 to May 10 in accordance with P.T.-105-168-P, Supplement "I". Considerable rod manipulation had to be performed to prevent excessive rates of temperature rise on the graphite thermocouples, and to keep from exceeding the temperature rise limitations placed on .240 zone tubes at

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80% CO₂. A central graphite temperature rise of about 25°C for the 20% increase in CO₂ and a reactivity effect corresponding to 1.25 1h/°C were noted.

Down-time Limitations

The conditions which govern the allowable down-time of the pile after which start-up may be made without resorting to temporary poison loadings have changed so much in recent months that it seems advisable to include a current summary in this report. For average push size and equilibrium rod balance a first indication would be obtained about 23 hours after the unit is half-way down at B and F areas. At D area this would be about one hour longer. In order to keep the reactivity transient within the power of the control rod system, the maximum level to which the pile power can be raised after a minimum time start-up is about 200 MW. In the terminology previously used this corresponds to a maximum down-time for full power start-up of about 22 hours.

In practice it is possible to get to equilibrium following a minimum length shutdown with a loss of production due to power cutbacks for reactivity considerations of only 300 to 500 MWE. The length of the shutdown can be extended to 20 to 30 hours before the production loss due to these considerations reaches the 2000 MWE or so typical of poison column start-up operation.

At H pile under typical conditions the minimum down-time is about 18 hours from half-power to first indication, while the maximum down-time is in excess of 36 hours, and under favorable loading conditions, infinite.

Test Facilities

Some special request material was found to be stuck in hole #7 of the B facility at D following failure of the cooling water supply and resulting operation at high temperature. During the shutdown of May 8 an attempt was made to remove the stuck samples by engaging them while the pile was still quite warm. The ORNL-83 tin sample was withdrawn with no great difficulty under these conditions. The ORNL-86 sample next behind it still remained stuck, and during attempts to free it, the retrieving rod employed broke off inside the hole. On the following shutdown an unsuccessful attempt was made to disengage and recover the broken rod. When the water supply was again turned on, water coming out of the B facility indicated that hole #7 had been punctured. At present it is thought that either the facility will be replaced or that the punctured hole will be plugged and the rest of the facility returned to normal usage.

At F area during the shutdown of May 23, the rod of the E hole test facility which had been binding to such an extent as to be inoperable was redressed and the hole lightly reamed. This procedure cured the difficulty for the present and the facility is now back in normal operation.

Shipment of High Exposure Material

A decision was reached in December, 1949, by representatives of interested sites to include a 50 slug sample of Harford irradiated slugs of the highest possible exposure in a test program arranged to determine the isotopic ratio and other pertinent data of the product obtained from Chalk River irradiations. The

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processing of the slugs was to be performed in the Redox pilot plant at Oak Ridge. Their proposed schedule called for the Hanford material to be delivered there with at least 90 days cooling by the first week in June. The cooling period conditions limited the choice of material to that pushed before March 1. A survey of available material indicated that there was one tube from B area pushed in November, 1949, which had inadvertently been carried to an average exposure of about 525 MWD/ST, while four tubes from D area had been carried to exposures ranging from 483 MWD/ST to 518 MWD/ST under P.T.-105-278-P, for study of irradiation effects at higher exposures. This material was tagged and set aside for examination by Technical. The material from B area was inadvertently shipped to 200 area for processing at one time but was recovered at considerable trouble and expense. A revision to the Chalk River program increased the number of requested pieces from 50 to 70, and to fill this order the cooling requirements were crowded a bit so that two higher exposure P.T.-278 tubes pushed at D area on 3-8-50 could be included. Using these sources, 70 pieces were obtained, 18 from B area and 52 from D area whose maximum exposure was 751 MWD/ST and whose average exposure was 717 MWD/ST. While waiting for shipment the 52 pieces at D, although well tagged and labelled, were shipped to B by mistake and upon return were mixed with miscellaneous recent discharge material and shipped to 200 area for processing. When the mistake was discovered, the material was shipped back from 200 area. By a combination of canning data, wrap instrument marks, and weasel readings, 30 of the more desirable of the 52 pieces were recovered. The remaining 14 were made up from material previously discarded because of slightly lower exposure. The final 70 piece batch now awaiting shipment still has a maximum exposure of 751 MWD/ST, but the average has dropped to 711 MWD/ST, and there is an increase in the probable error in the exposure data from perhaps 5% to probably 10%.

Special Request Summary

Number of Special Requests discharged from the piles in May	9
Number of Special Requests charged into the piles in May	8
Number of Special Requests on hand to be irradiated	22
Number of P-10-A pieces discharged during May	232
Number of P-10-A pieces charged during May	381

There are at present 45 inhours taken up in materials testing irradiations, 78 in Isotope Production irradiations, and 11 in General Research irradiations.

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Reactivity Balance

The reactivity status of the piles at the beginning and end of the month of May is summarized below.

	<u>B Area</u>		<u>D Area</u>		<u>F Area</u>		<u>H Area</u>	
	<u>4-30</u>	<u>5-31</u>	<u>4-30</u>	<u>5-31</u>	<u>4-28</u>	<u>5-31</u>	<u>4-30</u>	<u>5-31</u>
Rods	65	70	76	86	80	92	225	190
Xenon	458	466	469	469	545	543	617	633
P-10-A	457	454	385	385	276	279	264	327
Mat. Testing	13	13	5	5	27	27	0	0
Other SR	27	22	55	55	15	15	0	0
Plant Asst.	0	0	46	47	0	0	5	5
"p" Program	118	103	104	104	116	110	0	0.5
"p" Columns	0	0	0	0	0	0	55	54
Dummy Cols.	0	0	11	23	27	27	0	0
Corr. for C ₀	-240	-251*	-275	-300**	-263	-285**	-130	-150*
	898	877	876	874	823	846	1036	1106

* At B and H the overall coefficient contributions were revised to correspond to higher pile power levels.

** At D and F the overall coefficient contributions were revised to conform with observed reactivity effects of increased CO₂ concentration.

The reactivity effects noted were in rough agreement with the expected effect of variations in product concentrations.

P-11 PROJECT - F. E. Kruesi

Experimental

During the previous report period the eight inch diameter cylindrical reactor unit was filled to a height of 15.25 inches with plutonium nitrate at a concentration of 77.4 grams Pu/liter without obtaining criticality. Since that time further solution additions were made until a maximum of 18.94 inches (~ 1250 grams) was reached, this being the limit of the reactor unit. The system was sub-critical at this height. Inverse multiplication-solution height extrapolation to criticality could not be made with sufficient accuracy to ascertain whether an infinitely tall eight inch reactor unit can be made critical under the conditions of this experiment.

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The system was first made critical on May 8, 1950. Criticality was determined initially in the ten inch reactor unit with a solution concentration of 77.4 grams Pu/liter. Determinations were made of the effectiveness of the control rod, reentrant tube, and piston positioning before proceeding with experiments at higher (more optimum) hydrogen to plutonium ratios. The following table summarizes critical data obtained during the month. Corrections have been made for the void introduced by the control rod in the experiments at 77.4 and 62.4 grams Pu/liter, however, no correction was necessary for the determination at 49.26 grams Pu/liter due to a control rod modification to eliminate the void. All experiments were concluded after complete withdrawal of the reentrant tube.

Concentration (grams Pu/liter)	77.4	62.4	49.3
Critical height (inches)	9.67	10.65	12.80
Corrected critical height (inches)	9.47	10.39	12.40
Corrected critical volume (liters)	12.19	13.37	15.95
Corrected critical mass (grams)	943	834	787

Theoretical - G. M. Muller

While the results so far obtained on the critical height of the ten inch water tamped cylinder at three different concentrations are not sufficient (on the basis of presently known theory) to determine the exact nuclear constants of plutonium, it appears quite certain that the Feld-Slotin value for the minimum critical mass is too low.

The reasons for this are as follows. Assuming that plutonium has a thermal absorption cross-section of 1150 barns, the Feld Slotin experiment requires, on the basis of Greuling's LA-493 theory, that $\bar{\nu}_{Pu}$ (the number of neutrons produced per capture in Pu) have a value of about 2.11; lower values of $\bar{\nu}_{Pu}$ lead to higher critical masses. On the other hand, comparisons of our three data with those obtained at Oak Ridge (K-343) for UO_2F_2 solutions under similar conditions shows, by a single physical argument, that $\bar{\nu}_{Pu}$ must be less than 2.02. A somewhat more refined argument, combining empirical data with LA-493 theory, seems to indicate that $\bar{\nu}_{Pu} = 1.98$; this is the value commonly accepted in the project literature. As more experimental evidence becomes available, it should be possible to determine $\bar{\nu}_{Pu}$ quite accurately; a separate report will be issued on this subject at the appropriate time.

Equipment Modification

A remotely operated piston drive was installed to facilitate experimental progress. A double selsyn indicating system and thymatrol drive allows precise setting of the piston to about .010 inches.

A fast response automatic trip device has been added to the present instrumentation system. This device is coupled into the primary scram circuit and is a scintillation-photomultiplier gamma detecting instrument.

As the original control rod was found to be too weak when used in tall cylindrical geometries, it has been replaced by a 36 square inch cadmium plate which can be remotely positioned under the reactor unit. The new rod apparently will be satisfactory for the determinations contemplated.

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EXPERIMENTAL PHYSICS GROUP - E. B. Montgomery

Test Pile

A. J Slug Testing

During May, 2900 "J" slugs were received. Since the quality of the "J" material has become more uniform it has been feasible to sample heats of these slugs on a statistical basis and reduce materially the amount of reactivity testing.

As the reactivity of the slug is the best measure of its uranium content, the test pile results can be used for material accountability by the producer and by Hanford. In order to calibrate this measurement four special slugs were fabricated at Oak Ridge for test pile measurement and subsequent complete chemical analysis. These slugs were made up to contain 2%, 5%, 9% and 12% ^{235}U .

Table I - Measurement of Reactivity of Four J Slugs

<u>Heat No.</u>	<u>Piece No.</u>	<u>% U²³⁵ (Nominal)</u>	<u>Δh (305)</u>
243	1	2.0	+ 4.57
244	1	5.0	+ 11.13
250	1	9.0	+ 16.67
251	1	12.0	+ 19.39

Table II - The Following Three Pieces Were Returned to Oak Ridge For Analyses of U Content

<u>Heat No.</u>	<u>Piece No.</u>	<u>Δh (305)</u>
111	15	+ 16.03
112	1	+ 16.63
113	19	+ 14.54

The complete record of "J" slug testing from the beginning through May 31, 1950, is shown in the following table.

Table III - Status of "J" Slugs Through May 31, 1950

<u>Shipment No.</u>	<u>No. Slugs in Shipment</u>	<u>No. Slugs Canned</u>	<u>305 Tested</u>				<u>No. Slugs Accepted</u>
			<u>No. Slugs Tested</u>		<u>No. Slugs Rejected</u>		
			<u>Bare</u>	<u>Canned</u>	<u>Bare</u>	<u>Canned</u>	
1	12	12	0	12	*	0	12
2	300	300	0	289	*	19	279.
3	300	300	0	247	*	33	214
4	900	820	820	737	80	6*	760
5	12	0	12	0	0	--	12
6	1000	931	725	419	69	0	860
7	1500	1478	391	284	22	0	1187
8	1400	--	--	--	--	--	--

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- * These slugs were canned prior to 305 testing.
- ** The first 108 slugs from this shipment were canned prior to 305 testing - these are from that group.
- *** Ten of those slugs were returned to Oak Ridge at their request. The remaining two slugs were used here for special testing in the DR pile.
- **** Final testing of the canned pieces not yet complete.

B. Testing of 4.25 Inch "Z" Pieces

Testing of the new 4.25 inch length "Z" pieces was started on May 31, 1950. The front and back stringers were utilized increasing the number of tests from between twenty and twenty-five pieces to between seventy and eighty pieces per day.

C. Special Work Requests

One special work request (No. 144) was authorized during May. This was to determine the danger coefficient of two types of silicone grease for lubricating the 105 pile vertical rod guides. Both greases are satisfactory for this purpose so far as reactivity is concerned.

Table IV

Grease	dih (305)/gram
DC-41	- 0.011
DC-Value Seal "A"	- 0.034

B-10 Work in DR Pile

A. Experimental Pile No. 1

The first experiment in DR was designed to find the critical dimensions of a pile built of a combination of J and Z slugs. The exact combination of J and Z slugs was quite complex and was achieved by alternating two types of tube loadings and staggering their positions in the rows so that a total of four tube types resulted if the position in the tube was considered. One of the tube loads contained 6 J pieces and 3 Z's while the other contained 4 Z pieces with 6 J pieces. This arrangement was necessitated by the desire to prevent laminations of slug types in a vertical side to side plane. The depth of the loading was fixed by a prediction of dry critical at about 7.3 layers as cubical symmetry was desired. The pile was captured about the No. 5 horizontal shim rod which was to be the primary control rod prior to reaching critical. A 0.5 curie Ra-Be source was centered in a graphite stringer in the B test hole, two lattice units below the control rod. The instrumentation used was described in last month's report.

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The loading of the pile alternated above and below the central control rod of the pile after the first two rows. Each row consisted of nine tubes. The approach to critical was monitored by the instruments listed in the last report. In addition, four indium foils were irradiated in the "B" test hole as each half row or layer was finished. Plots of the reciprocal of the change in the counts per minute versus the number of layers loaded gave a good extrapolation to critical.

As the validity of this extrapolation increased it was seen that critical would exceed twelve layers. When the ninth layer was finished it was decided to widen the pile to ten tubes per layer. Critical was reached at between 12.7 and 12.8 layers on 4-29-50. In order to increase the reactivity of the pile two more tubes were added making a total of thirteen layers of ten tubes each. At this time the excess reactivity was about 27 inhours.

Just prior to critical and at many times since, foil traverses have been made. Traverses to determine the effective size of the pile, the neutron distribution in cells and slugs, and the power level of the pile have given rise to a large mass of data which can't be considered in detail here.

After critical was reached the control rods were calibrated to provide adequate control at a level of several watts for foil irradiations. Danger coefficient measurements of various combinations of J and Z slugs were made by comparing period measurements of the "standard bare pile" with the periods of the pile with the sample inserted in a tube.

Measurements of the effect of "staggering" of J and Z positions gave rise to several unexpected variables in experimental measurements. Diurnal variations in the bare pile reactivity have resulted in additional measurements of the effect of pile atmosphere on reactivity, of water pressure on reactivity, small errors in positioning of charges, etc., etc.

B. Experimental Pile No. 2

After some 130 period measurements and eight groups of traverses involving several hundred foils water was added to the pile and the pile was loaded to wet critical using the same techniques as for the dry pile.

Water was introduced into one tube of the dry pile to estimate the size of the wet pile. After this, water was added to two rows at a time until the entire pile was submerged and surrounded by two or three layers of water filled tubes.

Wet critical was reached on 5-16-50 with a pile width of thirteen tubes 15.7 layers high traverses were made to define the effective dimensions. Measurements of the effect of the water blanket were also made. Then this pile was dismantled.

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C. Experimental Pile No. 3

This experiment was designed to provide more information regarding the behavior of the J-Z lattice after loading into the H pile. A central core of natural uranium nine layers high by nine tubes wide of nineteen slugs per tube was loaded into the DR pile centering on the B test hole. A blanket of alternating J-Z slugs with a ratio of two J slugs for each Z slug was placed around the uranium core. This pile, loaded to wet critical necessitated a blanket about 1.9 layers thick or a total of 96 tubes before critical was reached. The three tubes in each corner of layer number two were not loaded. This pile is surrounded by a single layer of water filled tubes.

Traverses of the pile were made in the B test hole and along a central tube from front to back.

Instrument Development

All instrument development work for this month centered on a dynamic pulse counter utilizing a watt-hour meter as a pulse counter. Theoretically this counter has promise of giving good accuracy when used in place of a scaler. New possibilities of its use are appearing frequently. The latest being the hope of its being used for recording the summation of pulse heights. With the substitution of a torsion suspension a rate meter with little friction and drag as possible.

Paul F. Gast
PILE TECHNOLOGY DIVISION

PF, Gast: jr

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