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May 20, 1947

COPY 1 OF 1, SERIES 11

100 AREAS TECHNICAL ACTIVITIES REPORT - PHYSICS

APRIL, 1947

Pile AREAS - U. M. Staebler

B Pile

A foil test was made in tube 1363 B on April 9. Two foils were irradiated producing results of 105.2 and 105.4 neutrons/cm²/sec. The average of 105.3 neutrons/cm²/sec indicates that no change in the reactivity of the B Pile has taken place since the last foil test. The gas purity for the test was 98.9 per cent.

D Pile

Summary

A power coefficient test was performed with the D Pile on April 1. The calibration of A Rod was checked in the region between 18 and 76 inches out in connection with this test. The resulting calibration curve was used to evaluate the coefficient test of March 7, as well as the one of April 1. The power coefficients obtained from these two tests are not significantly different from those obtained by means of similar tests six and nine months ago but the graphite relaxation period has increased by about 40 per cent during this time. The local graphite periods as measured by thermocouples in the graphite have increased by about 28 per cent over the same time interval.

The D Pile was scrammed by a power failure on April 14. The control rods were holding 52 inhours at the time of the shutdown. All rods were out of the pile in 36 minutes but the power level reached only 154 MW before the pile lost its excess reactivity.

Charges in five of the permanent poison tubes containing Special Request Material were changed during the month. In addition, Special Request material was charged into two tubes outside of the permanent poison pattern.

The D Pile realized a net gain of 13 inhours in cold, clean reactivity during the month.

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Details

Coefficient Tests

The power level of the D Pile was lowered by 29 MW for a period of ten hours on April 1. The calibration of A Rod was checked from 18 to 76 inches out by comparing rod motion with expected reactivity changes following this period of operation at reduced power. The resulting calibration curve indicates a reduction of about 29 per cent in the effectiveness of the rod over this region. It is not possible to say definitely whether this reduction in effectiveness is a flattening of the calibration curve in the particular region covered or whether it represents an overall loss in the effectiveness of the rod along its entire path. The following values were obtained from the coefficient tests of March 7 and April 1 by means of the revised A Rod calibration curve.

<u>Date</u>	<u>Coefficient</u>	<u>From Drop</u>	<u>From Rise</u>	<u>Average</u>
March 7, 1947	Overall coefficient, C_0	0.35 1h/MW	0.32 1h/MW	0.34 1h/MW
	Graphite " " C_G	0.60 "	0.58 "	0.59 "
	Metal " " C_M	-0.25 "	-0.26 "	-0.25 "
	Graphite period	72 minutes	74 minutes	73 minutes
April 1, 1947	Overall coefficient, C_0	0.37 1h/MW	0.41 1h/MW	0.39 1h/MW
	Graphite " " C_G	0.60 "	0.64 "	0.62 "
	Metal " " C_M	-0.23 "	-0.23 "	-0.23 "
	Graphite period	82 minutes	83 minutes	82 minutes

The values reported above for the various power coefficients are, within experimental error, in agreement with corresponding values obtained from coefficient tests of July 1, and November 1, 1946, although the metal and graphite coefficients differ from results for the test of December 27, 1946. The graphite relaxation period for each of these three most recent previous tests has been 60 ± 3 minutes; thus, the values reported above represent increases of about 22 and 37 percent respectively. The reason for this continued increase in graphite relaxation period without a corresponding increase in the graphite and overall power coefficients is not understood.

A comparison of graphite relaxation periods obtained from recent coefficient tests with those obtained from thermocouples in the graphite is given below.

<u>Date</u>	<u>Coefficient Test Value</u>	<u>Date</u>	<u>Thermocouple Values</u>			
			<u>11 G</u>	<u>13 G</u>	<u>14 G</u>	<u>17 G</u>
12-27-46	60 minutes	1-2-47	87	87	92	81
3-7-47	73 "	3-9-47	102	101	108	94
4-1-47	82 "	4-6-47	102	100	102	101

During the four-month period covered by the above table the overall value of the graphite period as measured by reactivity changes in connection with coefficient tests increased 37 per cent but the local graphite periods measured by actual temperature changes in the vicinity of thermocouples increased only 16 per cent.

Automatic Shutdown - April 14

Due to losses in reactivity associated with the build up of xenon poison and the cooling of the graphite following a shutdown of the pile there is a limit to the length of time a pile may remain down and still have enough excess

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reactivity available to return to normal operating power. This time limit naturally depends upon the amount of excess reactivity available at the time of the shutdown as well as upon the operating level and the power coefficients of the pile. The D Pile was scrammed on April 14 with 52 inhours of excess reactivity held in the rods. The rods were all out of the pile 36 minutes after the scram and the power level started rising but it reached only 154 MW then stopped rising and started dropping at a gradually increasing rate. This experience is in agreement with expected pile behavior based on xenon equations and most recent values for the pile's power coefficients and graphite period.

The following table gives the length of time the rods can be in the pile and still allow recovery from the scram. Actually the estimates are based on normal operation at 200 MW (F Pile) but recent scram experiences indicate that the values are fairly reliable for either pile.

Inhours in rods at time of scram (Equilibrium)	Pile will recover if rods are out within	Pile will not even start if rods are in .....
30 inhours	13 minutes	44 minutes
40 "	19 "	53 "
50 "	25 "	63 "
60 "	31 "	73 "
70 "	38 "	83 "

Between these limits it is to be expected that the pile would start rising but it is questionable whether it would be possible to complete the return to normal power.

Special Request Material

The following table summarizes the charging and discharging of material covered by the Special Request Program during the month.

Date	Tube	Discharged No. Pieces	S. R. No.	Material	Charged No. Pieces	S. R. No.	Mat.
4-6-47	3677 D	32	Regular metal		1 each	34 - 38	See P.T. 105-98-P
4-15-47	3266	1	29-1	P ₂ O ₅	1	39	U235 - Al
4-29-47	1569	27	15-11	LiF	27	15-1	LiF
4-29-47	2666	29	15-11	LiF	29	15-11	LiF
4-29-47	2682	34	15-11	LiF	34	15-11	LiF
4-29-47	2374	34	15-11	LiF	34	15-11	LiF
4-29-47	3179	41	3-2	Th	31	3-3	Th

Reactivity Balance

The reactivity of the D Pile at the beginning and at the end of this report period is given in the following table.

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	<u>3-31-47</u>	<u>4-29-47</u>
Amount held in rods	55 inhours	58 inhours
Amount held in xenon	492 "	492 "
Amount held in Special Requests		
Inside poison pattern	221 "	221 "
Outside poison pattern	25 "	25 "
Amount held in "F" columns	57 "	57 "
Amount held in Bismuth columns	49 "	49 "
Amount held in dummy columns	2 "	2 "
Due to overall power coefficient	<u>-95</u> "	<u>-95</u> "
Total cold, clean reactivity	806 "	819 "

The above table indicates a net gain of 13 inhours in the cold, clean reactivity for the D Pile during the month. Rates of gain in reactivity of 0.8 to 1.1 inhours per day were observed during periods of equilibrium operation.

D Pile

Summary

A power coefficient test was performed with the F Pile on April 2. The value obtained for the overall power coefficient is 18 per cent greater than that obtained for the D Pile on April 1. The graphite relaxation periods are about equal although the accumulated exposure on the D Pile is about 20 per cent greater than for the F Pile. These are further evidences of differences in the graphite characteristics of the two piles due either to original properties or to exposure conditions.

An investigation of the effect of poison moments in rods and columns on the horizontal and vertical dipole temperature moments of the F Pile since September, 1946, has led to the following conclusions.

1. On the average, a change of about 25 inhour lattice units in the poison moment will produce a one per cent change in the corresponding temperature moment.
2. The plots of effective poison moments vs. temperature moments as each is now measured do not pass through the origin but are displaced 85 inhour lattice units in the case of the horizontal dipole and 160 inhour lattice units in the case of the vertical dipole.

Only two tubes in the F Pile were charged with Special Request Material during the month, one inside the poison pattern and one outside the poison pattern.

A net gain of 13 inhours in cold clean reactivity was realized by the F Pile during the month if the overall coefficient is assumed to have remained constant.

Details

Coefficient Test - Graphite Periods

The power level of the F Pile was lowered by 28 MW for a period of five hours on April 2. Analysis of data obtained during and after this period of operation at reduced level gave the following results.

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<u>Coefficient</u>	<u>Drop</u>	<u>Rise</u>	<u>Average</u>
Graphite coefficient, C_G	0.66 1h/MW	0.67 1h/MW	0.66 1h/MW
Metal " " C	-0.20 "	-0.21 "	-0.20 "
Overall " " C	0.46 "	0.46 "	0.46 "
graphite period	80 minutes	86 minutes	83 minutes

It is of interest to note that the graphite relaxation period increased by about 24 per cent between December 18, 1946, and April 2, 1947, while the average local period as measured after shutdowns of the pile by thermocouples in the graphite increased by only 6 per cent over the same interval. Representative periods determined from thermocouple data are tabulated below.

<u>Date</u>	<u>13 0</u>	<u>14 0</u>	<u>16 0</u>
12-11-46	87 minutes	84 minutes	79 minutes
12-26-46	88 "	84 "	81 "
1-8-47	90 "	84 "	82 "
1-22-47	90 "	82 "	81 "
1-29-47	89 "	80 "	78 "
2-12-47	92 "	87 "	83 "
2-26-47	93 "	82 "	83 "
3-9-47	94 "	86 "	82 "
3-16-47	94 "	84 "	83 "
3-23-47	95 "	87 "	84 "
4-6-47	95 "	88 "	85 "

Poison Moments vs. Temperature Moments

A study was undertaken to revise present practices regarding adjustment of control rods and poison columns to improve the pile's temperature distribution in view of current pile conditions and experiences. The present system is based on Document #7-2654, "Procedure for Improving Temperature Distribution via Rods and Columns", Wheeler and Menegus to Jordan, 9-27-45. This investigation was concerned almost entirely with the horizontal and vertical dipole moments of the poison and temperature distribution. Several revisions in the original procedure are recommended. They include the following.

1. Expand the circle of tubes used in calculating temperature moments by a radius of one lattice unit.
2. Make the correction for rod positions in terms of poison moment rather than changes in temperature moment. Plots of the values of A and 9 Rods in terms of the vertical and horizontal dipole poison moments have been prepared on the basis of the most recent calibrations for these rods.
3. Correct the poison moments assigned to various poison columns for the effective poisoning value of that column as compared to its nominal value.

Graphs of effective poison moment (including rods) vs. temperature moment for both horizontal and vertical directions have been prepared from data obtained during equilibrium operation at various times since September, 1946. Although the individual points exhibit considerable scattering there is a rather well established slope in each case. These graphs lead to the following relationships:

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Horizontal Dipole: -23 inhour lattice units = one per cent change in temperature moment.

Vertical Dipole: -27 inhour lattice units = one per cent change in temperature moment.

The plot for the horizontal dipole is displaced from the origin by 85 ih L.U. and the plot for the vertical dipole is displaced from the origin by 160 ih L.U. The fact that the two plots do not pass through the origin may be due to lack of symmetry in the quality of material making up the pile, it may be due to an incorrect allowance for the effect of control rods, or it may be due to local shadowing differing from the average shadowing correction made. A more detailed report of the results of this study and the suggested revisions in the analysis of poison and temperature moments is in preparation.

Special Request Material

The following changes in the loading of material covered by the Special Request Program were made during the month.

Date	Tube	Discharged		Mat.	Charged		Material	
		No.	Pieces		No.	Pieces		
4-23-47	2074 F	1		14-1	21 - U	1	41	Cu ₂ Sn
4-23-47	2066 F	23		15-11	Lif	23	15-11	Lif

Reactivity Balance

The reactivity of the F Pile at the end of this report period is compared with that reported for the end of last month in the following table.

	3-31-47	4-29-47
Amount held in rods	59 inhours	64 inhours
Amount held in xenon	426 "	426 "
Amount held in Special Requests		
• Inside poison pattern	199 "	203 "
Outside poison pattern	30 "	26 "
Amount held in ²³⁵ U columns	50 "	50 "
Amount held in Bismuth columns	67 "	72 "
Amount held in dummy tubes	5 "	5 "
Due to overall power coefficient	-78 "	-78 "
Total cold, clean reactivity	758 "	771 "

The above comparison indicates a net gain of 13 inhours in the cold, clean reactivity of the F Pile for the month. It should be noted that no change has been allowed in the value for the overall power coefficient in spite of the fact that the value obtained from the test of April 2 was 0.46 ih/MW instead of the 0.39 ih/MW used. The difference between these two values would cancel the observed reactivity gain. It is felt that the coefficient does not change so abruptly but that the true gain in inhours is somewhere between these two extremes.

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GENERAL PHYSICS - J. M. West

Billet Egg Testing

A total of 124 lots of Billet eggs have now been tested at H.E.W. as compared with 71 lots at the end of March. The average value of the differences in test results (H.E.W. minus Argonne) is now -0.0101 percent delta k, representing only a very slight change from -0.0108 reported last month. Thirty test results at H.E.W. indicated higher reactivity values than those reported by Argonne while 94 results were lower. The average of the absolute magnitudes of the differences between H.E.W. and Argonne results is ± 0.0152 percent delta k.

The number of comparisons between H.E.W. and Argonne tests is probably large enough to constitute a good statistical sample. No major changes in trends are expected as long as present methods of testing are maintained. The consistently lower value for delta k at H.E.W. is probably within the limits of uncertainty of the reactivity value of the reference standard (lot no. 1331-P). This lot has been tested only once by Argonne. It has been shipped back to them for additional tests which will determine its reactivity relative to their standard more precisely. In the meantime, lot no. 1474-P, which has been compared with lot no. 1331-P ten times, is being used as a standard here.

The Atomic Energy Commission desires data on the relative precisions of Billet egg tests at Argonne and H.E.W. before transferring the entire testing program to H.E.W. Precision limits have accordingly been determined here, by making a series of duplicate tests. Each of six lots was tested at least six times. The tests were completely independent, and were made on at least three different days. The results obtained for delta k percent were as follows.

Results of Repeated Tests

Lot No.	Box No.	Delta k Percent					
		March 10	March 11	March 14	April 2	April 3	April 4
1474-P	645-E		-0.025		-0.030	-0.024	-0.019
					-0.040	-0.020	-0.020
					-0.028	-0.027	-0.030
1471-P	642-E		-0.041		-0.033	-0.027	-0.026
			-0.038		-0.039	-0.025	-0.026
1493-TX	647-E			-0.098	-0.096	-0.095	-0.094
				-0.093	-0.089	-0.100	-0.093
1468-TX	643-E	-0.121	-0.124		-0.109	-0.110	-0.113
					-0.107	-0.120	-0.109
1470-TX	645-E	-0.132			-0.148	-0.144	-0.140
					-0.144	-0.152	-0.142
1494-TX	648-E			-0.105	-0.106	-0.106	-0.104
				-0.102	-0.106	-0.106	-0.102

The results in the foregoing table were analyzed by the Statistics Group to obtain precision limits. It was found that the result of a given test will differ from the correct result, as obtained from a large number of tests, by less than ± 0.014 percent delta k in 99 percent of the cases. The 49 cases considered in determining the precision limits are sufficient to establish the

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- limits, with 99 percent certainty between ± 0.011 and ± 0.018 percent delta k.

The same lots (lot 1331-P was substituted for lot 1474-P as explained heretofore) were shipped to Argonne for a similar series of tests. When the results of their tests are reported, precision limits will be calculated and a direct comparison of the relative precisions of the two piles can be made.

Control Rod Calibration - Investigation of "Ripples"

Previous experiments have shown the existence of periodic variations in control rod sensitivity as a function of rod position. These ripples occur at about 2 1/8 inch intervals and represent changes of 25-30 percent in apparent sensitivity of the rod. The points of low sensitivity were found to correspond to rod positions such that the tip of the rod was passing through the space between vertical cracks in the graphite layers above and below the rod channel. Perturbations also seemed to exist in the neighborhood of cracks in the graphite liner of the rod channel itself. These observations seemed to indicate reduced neutron flux densities in the immediate vicinity of cracks in the graphite. Such a decrease in flux should be detectable by experimental methods completely independent of the control rod. On April 9, an experiment was performed to measure the influence of cracks on flux density. The decrease in reactivity of the pile as a result of placing a strip of cadmium in various positions relative to cracks in graphite was used as a measure of the neutron flux at the point in question. The cadmium strip (about 1/4" x 4" x 1/64") was first placed in a vertical position in the crack between two adjacent solid blocks in test stringer No. 12. The strip was centrally located with respect to the sides of the graphite blocks (4 1/2" x 4 1/2" x 48"). The decrease in reactivity with this arrangement was about 2 inches. A split block was then substituted for the solid block. This split block was a combination of two pieces machined from two separate full size graphite blocks so that the combined dimensions were the same as those of one solid block. In making this split block only one surface was machined. This left the other face unaltered. In this way the effect of surface concentration of impurities, if any, could be compared with that of the machined surfaces which were made up of graphite from the centers of the bars. The two machined bars were placed, first with the new surfaces together, then with the old ones together. The cadmium strip was placed along the crack at the junction between the two bars in each instance. The effect of the cadmium on the reactivity was found to be the same in all cases. The flux at a given point in the pile apparently is not affected by the presence of a close tolerance crack in the graphite nearby.

The only remaining explanation of the cyclic variation in rod behavior seemed to be that the Selayn position indicator does not measure rod position accurately. Prior to discovery of the "ripples", spot checks had been made by both the Instrument and Technical Departments to determine whether the Selayn is reliable. These checks were made by comparing the reading of the Selayn with the measured position of the rod and by observing differences in Selayn reading corresponding to movements of the rod by one inch or more. These checks did not reveal any errors in the Selayn. With the advent of ripples and the failure to explain them as being due to cracks in graphite, a more careful examination of the Selayn was needed. This time, errors could be detected more readily, since the positions of the rod corresponding to crests and troughs of the ripples were known, and the necessity for making measurements over very small intervals (0.2 inch or less) because of the sharpness of the decrease in apparent sensitivity, was recognized.

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A series of measurements of rod movement were made with a micrometer, as rod settings varying by 0.1 inch were made by means of the Selsyn receiver in the control room. The results indicated that in the regions which appeared to have high sensitivity, the rod moved as much as 0.110" in some instances while the Selsyn indicated a shift of 0.100". In regions of low sensitivity the movement was 6 to 10 percent low. The average movement over intervals of several inches was correctly represented by the Selsyn.

Several measurements of Selsyn versus micrometer movement were repeated to determine the reproducibility of this method of checking. It was found that a difference of 0.003 inches or 3 percent of the 0.1 inch interval was quite common in repeated tests. This difference is probably due to a combination of (1) visual errors in setting the Selsyn, and (2) lack of reproducible response of the Selsyn to rod movements, even over the same intervals.

When the ratio of actual rod movement to Selsyn movement was plotted against rod position, a series of "ripples" was obtained with a period of about 2 1/8 inches. The ratio of the maximum to minimum was not as great as the indicated variations in control rod sensitivity obtained earlier, however. Considerable uncertainty is connected with both methods of measuring the magnitude of the ripples. Errors in the Selsyn system account for at least one-half, and possibly all, of the magnitude of the ripples.

By means of calibration charts which have been in use since February 12, satisfactory testing is being done in spite of the "ripples". When the pressure of the present full scale testing program is relieved it may be desirable to eliminate the ripples, however. This can be accomplished in several ways, by means of either direct reading calipers, or remote indicators of the synchro type, or combinations of both. The new system should be capable of indicating the rod position to the nearest 0.001 inch. An error of 0.001 inch in rod position corresponds to an error of 0.001 inhour reactivity.

New Rules for Metal Testing

A list of rules to follow in testing metal in the 305 pile was prepared by the Technical Department and adopted by the P Department (Document No. 3-5445, April 16, 1947, West to Maider). Improved precision is expected to result from adoption of these procedures.

GENERAL PHYSICS - H. A. Jexler

Production Test 105-1-P

Capsule tube No. 2385-F was pushed on April 23, the graphite exposure being 1401 MD/CT. Capsules were changed into tube No. 1384-F on April 30. This is a new capsule tube. A set of graphite samples was removed from the "B" Test Hole of the F Pile on April 23 after 1465 MD/CT exposure (899 in the B Pile plus 566 in the F Pile).

Production Test 105-35-P

The first set of samples was removed from tube No. 3469-D on April 6 after 103 MD/CT exposure in an oxygen atmosphere. The samples exposed in helium and carbon dioxide were removed April 14 after 117 MD/CT. When the helium tube was opened, the tube was very wet, indicating the helium supply was wet. The helium used was from "A" tank in the 115 Bldg. and was supposedly dry helium. Since the effect of water on graphite under pile conditions is unknown, it is not possible to evaluate the effect of O₂ and CO₂ on graphite under pile conditions.

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Additional samples were charged into the helium tubes on April 27 when the CO₂ and He samples were recharged, and a drying system was added to the helium supply.

Laboratory measurements for stored energy show that the temperatures of exposure of the samples in the oxygen atmosphere to be 220 ± 5°C. and in the helium and carbon dioxide to be 245 ± 5°C. Annealing tests in the laboratory differ markedly from the data obtained on these samples. These samples show annealing beyond 450°C. which would not have been the case for samples annealed as high as 300°C. in the laboratory. The samples in CO₂ and oxygen showed the most annealing in this region.

No significant difference was noticed in the length change measurements of the three tubes. This may be due to the presence of water in the helium supply.

The results obtained for length change, stored energy, thermal conductivity and electrical resistance are given in the following table:

Test Hole Exp. MD/CT	Process Tube Exp. MD/CT	Process Tube No.	Atmos- phere	Dimen. Change %	Wt. Loss %	Initial		Final		S.E. Cal/gr
						Ko/K	R/Ro	Ko/K	R/Ro	
0	102	3469	O ₂	-.005	.055	-	-	2.23	2.11	0
446	102	3469	O ₂	-.13	.034	20.1	4.02	16.2	3.61	
1110	102	3469	O ₂	-.19	0-	25.3	4.04	26.3	3.72	
1182	102	3469	O ₂	-.12	.118	23.5	3.93	25.6	3.64	15.1
0	117	3478	He	-.009	.018	-	-	1.85	2.14	0
446	117	3478	He	-.13	.007	20.1	4.06	12.5	3.63	
1110	117	3478	He	-.19	-	26.1	3.87	18.7	3.54	
1182	117	3478	He	-.14	.015	26.2	3.74	23.9	3.52	13.9
0	117	3574	CO ₂	-.005	.030	-	-	2.10	2.23	
446	117	3574	CO ₂	-.14	.022	19.8	4.03	12.6	3.71	
1110	117	3574	CO ₂	-.17	-	26.2	3.93	18.3	3.79	
1182	117	3574	CO ₂	-.15	.037	23.2	3.72	28.1	3.48	11.8

Paul F. Gast
P. F. Gast
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