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By Authority of CS-PR-2
DS ZENK 1-31-94
By DM Eick 5-5-94
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March 13, 1947

100 AREAS TECHNICAL ACTIVITIES REPORT - PHYSICS
FEBRUARY 1947

PILE AREAS - U. M. STAEBLER

B Pile

A foil test was made in Tube 1363 B on February 12, 1947. The average nvt was 106.5 neutrons/cm²/sec with a gas purity of 99.2 per cent. This result is slightly higher than reported last month, but more nearly in agreement with previously reported values. It indicates that no significant change has taken place in the B Pile reactivity.

D Pile

Summary

The D Pile has experienced difficulties in the operation of the No. 2 Horizontal Rod similar to those previously reported for the F Pile. The rod withdrawal order for operation following shutdowns has been altered because of this difficulty and now conforms with the withdrawal order in use for the F Pile; i.e., 2, 8, 5, 4, 6, 7, 8, 9, and A.

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The helium gas thermometer in "C" experimental hole indicates a central graphite temperature 30 to 40° C. higher than recorded by the central thermocouples.

The apparent thermal conductivity of graphite in the D Pile has dropped to 1/38 of its original value after an exposure of 1175 MD's per adjacent ton of metal.

The loadings of eight of the poison columns were changed during the month. In addition, special materials were charged into four tubes outside of the permanent poison pattern.

The D Pile showed an average rate of gain of 0.7 inhour per day during 10 days of operation with the xenon poison at equilibrium. The net change in cold, clean reactivity for the month shows a loss of two inhours.

Details

Graphite Temperatures

The "B" Test Hole of the D Pile operated for a short while in October, 1946 without water cooling. Laboratory measurements made by H. A. Fowler on graphite samples which remained in the hole during this period of operation indicated annealing at temperatures of 215 to 225° C. (See Document No. 7-5801, "100 Areas Technical Activities Report - Physics January, 1947"). Central graphite thermocouples indicated ambient pile temperature to be 175-180° C. The readings of the helium gas thermometer in "C" Test Hole have been checked for this period. This instrument recorded a graphite temperature of 205 to 210° C. Since any leak in the system would tend to make these readings low, it is felt that the graphite temperature in the test hole was at least this high. The gas thermometer currently reads about 235° C. as compared with thermocouple readings of about 190° C. The gas thermometer agrees satisfactorily with inlet water temperatures when the pile is shut down. This suggests that the calibration of the thermocouples may have changed as a result of exposure to pile radiations.

Apparent Thermal Conductivity of Graphite

Calculations of the apparent thermal conductivity of the graphite in the D Pile have been brought up to date. Results from January, 1946 to August, 1946 were reported in Document No. 7-4861, "Apparent Thermal Conductivity of Graphite in 105 D Unit", August 8, 1946, W. K. Woods and U. K. Staebler to File. Trends indicated by these earlier calculations have continued. The conductivity has now dropped to 1/38 of its original value after an exposure of 1175 MD's per adjacent ton of metal. These results are based on an average of the apparent conductivity calculated for graphite in the vicinity of each of the six central thermocouples.

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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			Charged		
		No. Pieces	S.R.No.	Material	No. Pieces	S.R.No.	Material
2-4-47	3169-D	30	13-2	Be ₃ N ₂	40	13-3	Be ₃ N ₂
2-4-47	2066-D	27	15-10	LiF	40	13-3	Be ₃ N ₂
2-4-47	2062-D	24	15-10	LiF	40	13-3	Be ₃ N ₂
2-4-47	1474-D	27	15-10	LiF	40	13-3	Be ₃ N ₂
2-4-47	1569-D	26	15-10	LiF	Poison	column	3L - 2P
2-4-47	1579-D	23	15-10	LiF	Poison	column	2L - 2P
2-4-47	3274-D	27	15-10	LiF	Poison	column	2L - 1P
2-4-47	3179-D	32	15-10	LiF	Poison	column	3L - 2P
2-4-47	3266-D	32	--	U	3	28-A,	Fe
						29-A, U	P ₂ O ₆
2-25-47	3179-D	--	--	3L - 2P	41	3-2	Th

In addition to the special charges listed above, three process tubes, 3469-D, 3574-D, and 3-28-D, were charged with graphite samples as outlined in Production Test No. 105-85-P, "Exposure of Graphite Samples". This was done on February 11, 1947.

Reactivity Balance

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

	1-31-47	2-28-47
Amount held in rods.	46 inhours	59 inhours
Amount held in xenon	492 inhours	492 inhours
Amount held in Special Requests.		
Inside the poison pattern	292 inhours	172 inhours
Outside the poison pattern.	0 inhours	3 inhours
Amount held in Plant Assistance Irradiations	0 inhours	15 inhours
Amount held in "P" columns	28 inhours	113 inhours
Amount held in bismuth columns	44 inhours	44 inhours
Amount held in dummy columns	2 inhours	2 inhours
Due to overall power coefficient	-95 inhours	-95 inhours
Total cold, clean reactivity	809 inhours	807 inhours

When the xenon poison was at equilibrium during periods of operations between shutdowns the pile gained reactivity at rates of from 0.7 to 1.3 inhours per day. The losses in connection with metal discharges account for the net loss of two inhours in cold, clean reactivity.

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F Pile

SUMMARY

Evidence that the overall power coefficient of the piles is a function of the power level and of the xenon concentration has been accumulating since the shutdown of the F Pile. This evidence has been studied in an effort to derive the nature and the magnitude of the dependence. It has been possible to improve the performance of charts for predicting critical rod positions after a shutdown by applying an empirical correction. It appears that a variation in xenon cross-section with neutron energy will account for some of the effects noted, but it is very doubtful if the magnitude of this correction could be sufficient to explain all of the observations to date.

A revised calculation of the factor for converting MD exposure to product concentration as a function of the product concentration has been made. Agreement is now obtained with the average value observed for this factor at H.E.W.; i.e., 0.93 at 200 grams of Pu per standard ton.

Charges in nine tubes in the permanent poison pattern were changed during the month. In addition, special request material was charged into two tubes outside of the permanent poison pattern.

The F Pile gained three inhours in cold, clean reactivity during the month.

Details

Dependence of C_0 Upon Pile Conditions

It has been assumed that the overall power coefficient, C_0 , remains constant over the range of conditions encountered during normal pile operation, including shutdowns. Two cases have arisen which indicate that this is not true.

a) Xenon-Free Test of 11-7-46, (Production Test No. 105-78-7).

Values of the power coefficients obtained in this test ($C_0 = 0.93$ ih/MW, $C_1 = 1.26$ ih/MW, and $C_2 = -0.33$ ih/MW) at low power level and very low xenon concentration are considerably different from those obtained in the vicinity of 200 MW with the xenon concentration at equilibrium for this power. ($C_0 = 0.40$ ih/MW, $C_1 = 0.65$ ih/MW, and $C_2 = -0.25$ ih/MW).

b) Predictions of the rod configuration for pile start-ups prove to be up to 30 inhours in error when it is assumed that C_0 is constant over the power change and that the pile loses reactivity in going from 200 MW to zero power equal to C_0 times 200.

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On the basis of this evidence it appears that C_H and C_G may depend upon power level, xenon concentration, or both. The first consideration was to correct the prediction chart to give better agreement with observed start-up conditions. The observed data from start-ups were plotted; the abscissa, x , was taken as the reactivity held in the rods at the time of the start-up plus the excess reactivity indicated by the start-up period. The ordinate, y , was taken as the calculated change in xenon concentration from equilibrium at shutdown to the time of the start-up period, plus the reactivity held in the rods at equilibrium. The plot is, within reasonable limits, a straight line represented by the equation $x = 0.8 y + 57$. This relation was used to revise the prediction charts mentioned above and has resulted in predictions within five inhours of the observed results at start-up since that time.

Any development of equations for expressing C_G , C_H , or C_I in terms of the xenon concentration and the power level require assumptions as to the form of the functions. Thus far, it has not been possible to develop equations which will fit all available information.

A possible explanation of the dependence of power coefficients on xenon concentration would be the assumption that the absorption cross-section of xenon varies with neutron energy and, thus, with graphite temperature. A resonance peak in the xenon cross-section would be required to account for the observed difference over the range of operating temperatures.

When the B Pile was shut down an attempt was made to evaluate the constants of the xenon equations, but no consistent set of values could be found that would fit all of the data obtained. This difficulty could be resolved by assuming that the xenon cross-section varied with temperature. Empirical equations were obtained for the constants in terms of power level. An attempt was made to see if these equations could account for the different values of power coefficients obtained in the tests of 11-7-46, (0 to 36 kW, xenon free), and 11-18-46, (200 to 170 MW). Although the corrections seemed to be in the right direction, they were not of sufficient magnitude to account for the observed difference.

Conversion Factor MD to Pu

The variation in the factor for converting megawatt days of exposure to grams of Pu as a function of concentration of Pu has been calculated using equations developed in Document No. 7-2733, "Final Report on Production Test No. 105-11-P", L. Marshall to File, October 4, 1945. Constants used in the calculation were the same as those given in the above document, except that a value of 200 MEV was assumed for the energy absorbed by the pile per fission. The following table summarizes results of these calculations.

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Grams Pu per Metric Ton

Grams Pu/Megawatt Days

9.02	0.992
19.46	0.980
48.45	0.969
95.60	0.956
142.4	0.949
187.0	0.935
231.3	0.925
274.1	0.914

The assay of all product received to date in the 200 Area indicates a factor of 0.93 between megawatt days delivered and product received. The above calculations give a value in agreement with this observation at a concentration of 200 grams of product per standard ton.

Special Request Material

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

Date	Tube	No. Pieces	Discharged		Charged		
			S.R.No.	Material	No. Pieces	S.R. No.	Material
2-12-47	3274-F	34	13-1	Be ₃ N ₂	44	13-3	Be ₃ N ₂
2-12-47	3179-F	25	15-10	LiF	Poison	Column	2L - 1P
2-12-47	2682-F	25	15-9	LiF	Poison	Column	2L - 1P
2-12-47	2666-F	30	13-2	Be ₃ N ₂	46	13-3	Be ₃ N ₂
2-12-47	2082-F	25	15-9	LiF	Poison	Column	2L - 1P
2-12-47	1579-F	25	15-9-10	LiF	Poison	Column	2L - 1P
2-12-47	1569-F	23	15-9	LiF	Poison	Column	2L - 1P
2-12-47	1474-F	19	15-9	LiF	35	13-4	Be ₃ N ₂
2-12-47	1772-F	--	--	U	1	28	Fe
2-12-47	1755-F	--	--	U	1	30	Be
2-26-47	2066-F	23	15-10	LiF	23	15-11	LiF

Reactivity Balance

The reactivity of the F Pile is given in the following table at the last points of equilibrium in this and the previous report period.

	1-29-47	2-26-47
Amount held in the rods	47 inhours	50 inhours
Amount held in xenon	427 inhours	427 inhours
Amount held in Special Requests . . .		
Inside poison pattern	262 inhours	134 inhours
Outside poison pattern	26 inhours	30 inhours
Amount held in "P" columns	0 inhours	124 inhours
Amount held in bismuth columns . . .	61 inhours	61 inhours
Amount held in dummy columns	5 inhours	5 inhours
Due to overall power coefficient . .	-78 inhours	-78 inhours
Total cold, clean reactivity	750 inhours	753 inhours

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The preceding table indicates a net gain of three inhours of cold, clean reactivity for the month.

GENERAL PHYSICS - J. M. WEST

Test Pile Performance

The existence of previously unsuspected "ripples" in the control rod sensitivity curve has definitely been established. The ripples were found by determining the amount of withdrawal of the control rod required to compensate for the addition of a constant amount of neutron absorber. Many such determinations were made, by establishing the critical position of the control rod at any desired point by means of the shim rod. The amount of neutron absorber used required an average movement of the control rod of about 0.2 inches. Two complete lattice units have been investigated. The periodic variation in sensitivity of the control rod repeats itself every 2.72 ± 0.1 inches. The extreme variations in sensitivity cover a range of about 25 per cent. The shape of each ripple is roughly parabolic, with a fairly constant sensitivity over a range of about 1 inch in the center of each ripple. The sensitivity decreases very rapidly with position in the neighborhood of the junction between successive ripples.

Blueprints of test pile structure show that the points of minimum sensitivity of the control rod occur as the rod passes cracks between adjacent blocks in the surrounding graphite. The graphite blocks (4 x 4 x 49 inches) in the layers above and below the control rod channel have their long axes horizontal and perpendicular to the control rod. The blocks in the same layer with the control rod are also perpendicular to the control rod channel and are staggered so that they overlap the joints in the graphite blocks in the layers above and below. These blocks stop about nine inches away from the control rod channel. The intervening gap is filled with two rows of graphite blocks running parallel to the rod channel. Alternate layers are staggered throughout the pile, so that the control rod crosses planes containing cracks in every other layer. The planes occur at $2-1/8$ inch intervals.

The exact mechanism by which the control rod sensitivity is decreased so sharply as it passes cracks in the graphite structure is not thoroughly understood. It is known that in the process of manufacturing graphite blocks, impurities tend to migrate toward the surface. The greater amount of impurity at the junction between successive blocks may be responsible for lower flux and, consequently, lower rod sensitivity at this point.

A new rod calibration chart, including the ripples, has been re-prepared and put into service. The inhour values corresponding to atmospheric pressure variations as indicated by the aneroid barometer have been shown to be too low, by a factor of 1.06. A redetermination of the relative sensitivities of the level and differential galvanometers

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indicated the need for changing the drift factor to 0.0037 inhours per mm. drift in a three-minute period. All of the aforementioned changes have been tried and found to produce great improvement in the reproducibility of test pile results.

As a check on the accuracy of the testpile in measuring reactivity effects, a sample of T2 metal was tested repeatedly against a standard sample on four different days. Two different operators were used, to determine whether any dispersion of results could be attributed to operator differences. The reproducibility of results was found to be good. The values obtained in eight tests on February 19 were as follows:

<u>Time</u>	<u>Operator A</u>	<u>Operator B</u>
9:00 A.M.	-0.258 inhours	-0.252 inhours
11:00 A.M.	-0.268 inhours	-0.268 inhours
1:00 P.M.	-0.266 inhours	-0.258 inhours
3:00 P.M.	-0.255 inhours	-0.246 inhours

Average = -0.258 inhours

Results obtained on the other three days were similarly consistent. It is believed that the test pile is now satisfactory for normal testing purposes.

Special Requests

The following material was included in the February 18 shipment:

<u>Request No.</u>	<u>Amount</u>
15-7	13 slugs
15-8	49 slugs
15-10	106 slugs
15-2	30 slugs
11	1 sample

All shipping containers were satisfactory from the radiation standpoint.

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GENERAL PHYSICS - HP A. FOWLER

Production Test 105-85-P

Graphite samples were charged into process tubes 3460, 8478, and 3574 at the D Pile on February 11, 1947. Each tube contained 10 graphite pieces 4.0" x 0.426" and 10 pieces 1.0" x 0.426". Four of each size pieces were previously unexposed, 3 were exposed 446 MD/CT, 2 were exposed 1110 MD/CT and one 1182 MD/CT. Atmospheres of oxygen, carbon dioxide, and helium will be maintained in the three tubes respectively. The pieces will be removed and measured for expansion after an exposure of eight to ten weeks.

Production Test 105-1-P

A set of 25 graphite samples of various exposures were prepared to be sent to Dr. Harker for x-ray diffraction studies. Each sample consists of 3 pieces 0.426 inch diameter and 0.020" x 0.002" thick.

An Interim Report is being written on Production Test 105-1-P summarizing the work which has been done during the past year.

PFM/lh

Paul F. Gast
P. F. Gast
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