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COPY 1 OF 1, SERIES W
February 12, 1947

100 AREAS TECHNICAL ACTIVITIES REPORT - PHYSICS

JANUARY - 1947

D File - E. B. Montgomery

Summary

Four routine shutdowns were experienced during the month. A measurable amount of the excess reactivity held in the control rods at the first of the month has been lost in the decrease in the average accumulated exposure of all the metal in the pile.

The vertical safety rod guides have been measured for vertical alignment by the Maintenance Department. A definite pattern has been found in the misalignment of the guides.

The horizontal rod thimbles were borescoped on January 2, 1947 to see if any leaks were present. No leaks were observed but No. 2 Rod and No. 8 Rod had heavy gouge marks along the longitudinal axes. Several thimbles contained white corrosion.

During the month two new bismuth tubes were established, 2871-D and 2877-D. This now gives the desired pattern of ten bismuth tubes.

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7-5801
2-12-47

A foil test was made at 100-B on 1-9-47 giving slightly lower results than on the two previous occasions.

Two papoose tubes containing three samples each were discharged and recharged with six samples in each tube.

A dittoed form has been given to the P Department in 100-D to afford a quick and simple method of computing the fraction of the pile pushed.

Details

Reactivity Status

The reactivity status of the 100-D Pile on the last day of December 1946 and the last of January 1947, is given below:

Date	12-31-46	1-31-47
Inhours held in rods	64 inhours	46 inhours
Inhours absorbed in xenon	492 "	492 "
Inhours absorbed in special request	320 "	292 "
Inhours absorbed in P Column	0 "	28 "
Inhours absorbed in Bi Column	34 "	44 "
Inhours held in lead peripheral tubes	2 "	2 "
	<u>912</u>	<u>904</u>
Overall coefficient (0.38 ih/mw)	-95	-95
Total cold, clean	817 inhours	809 inhours

The gains found during November and December (about 25 ih.) were mostly due to the higher-than-usual average accumulated exposure of all the tubes in the unit because there were only four shutdowns during this two-month period. During January there have been four shutdowns which caused a drop in the average accumulated exposure; hence a loss of 8 ih. in the total reactivity.

The pile reactivity on January 25 illustrates this effect strikingly. The last of the month's four shutdowns occurred on 1-21-47. Seventy-two hours after this time the reactivity in the rods was slightly less than 40 ih. which would indicate a loss of 14 inhours instead of the 8 which is seen in the above table.

Special Requests

Only three special request tubes were discharged during the month. Only two were replaced with special request material. The third one being replaced with a regular lead and cadmium poison column. The changes are tabulated below:

Tube No.	Date Charged	No. Pieces	S.R.No.	Present Load	No. Pieces	Present Charge Date
2374-D	11-26-46	34	15-9 & 10	15-10	36	1-14-47
2682-D	11-26-46	36	15-9	"PM	31-SF	1-14-47
2686-D	11-26-46	31	15-9	15-10	42	1-14-47

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2-12-47

Bismuth Columns

Two new bismuth columns were added in Tubes 2871-D and 2877-D on January 7, 1947. Each contains 50 pieces. They were loaded inside the P Column zone so the temperature rise of these tubes will be about 15% higher than the required minimum. At the same time, three older bismuth tubes (1976-D, 2786-D, and 2086-D) were discharged and reloaded with 50 pieces each. This leaves 5 old Bi tubes which are to be reloaded with 50 pieces each to make the 100-D Pile conform to the desired schedule.

100-B Foil Measurements

The 100-B foil test was made in Tube 1363-B on 1-9-47. The average nvt was slightly lower than the December measurement, being 103.1 neutrons/cm.²/sec. The gas purity was 99.1%.

F Pile - U. M. Staebler

Summary

The F Pile experienced difficulties with the operation of safety rods, both horizontal and vertical, during the month. These difficulties can be directly attributed to distortions in the pile structure brought about by the expansion of the graphite.

The horizontal rods withdrawal order has been modified to limit the use of No. 2 Rod which is still not operating satisfactorily. A calibration of the rods for this revised order was calculated from data obtained following the shutdown of January 22.

The A Rod calibration curve obtained in connection with the coefficient test of December 18, 1946 has been compared with similar curves obtained from rod movement as the pile approaches xenon equilibrium following regular shutdowns. Both sources yield a calibration curve which is flattened in the region from 100 inches out to all in so that the total strength of A Rod now appears to be about 51 inhours.

Consideration has been given to revision of the present practice of shutting down the pile whenever a grade Y critical power condition arises. It is possible to operate at a reduced level such that normal operation could be resumed at any time regardless of the duration of the critical power condition.

The F Pile gained 6 inhours in cold clean reactivity during the month.

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Details

Safety Rods

The No. 2 horizontal rod was replaced during the shutdown of January 8, but the new rod was found to bind and scratch also, so was not put into normal service. The "kick plate" on the No. 2 rod thimble was filed during the shutdown of January 22, but no improvement in the operation of the rod was achieved. A vertical traverse of the thimble was made on January 29. The real source of the trouble was found to be bowing of the thimble in the active lattice of the pile due to graphite expansion. A maximum displacement of 1.3 inches was measured with a rise of 0.6 inch in the first three feet of travel beyond the shield of the pile. Plans for correcting this condition are under consideration. The horizontal rod withdrawal order has been modified as a result of this difficulty with No. 2 Rod. The rods are now being withdrawn in the following order: 2, 8, 6, 4, 6, 7, 8, 9, A.

Measurements have been made on all vertical rods to determine how much off vertical they hang due to the tilting of the rod guides. The amount of this tilt ranges to a maximum of 0.067 inches per foot for No. 36 Rod which has been the chief source of trouble and which has been tied out of the pile throughout the month. Rod No. 35 has also been observed to stick and is now tied out of the pile. The average tilt of rod guides nearest the front face, (10 through 14), is only 0.025 inches per foot, while those nearest the discharge face, (34 through 38) have an average tilt of 0.056 inches per foot.

Rod Calibrations

The revised horizontal rod withdrawal order was calibrated by comparing xenon calculations with rod movements observed following the shutdown of January 22. The strength of B Rod was found to be about 22 inhours less than that of No. 2 Rod, (2 rod = 50 ih, B Rod = 28 ih), but the individual calibration curves for subsequent rods in the insertion order do not appear to be appreciably changed as a result of the substitution of B Rod for No. 2 Rod in the order.

Extensive study of rod calibration curves obtained by means of xenon transients during the past two months has led to the following conclusions:

1. A rod alone will compensate for 51 inhours of excess reactivity.
2. The presence of No. 9 Rod in a midway position decreases the slope of the A Rod calibration in the intermediate positions, but increases the slope near the in position. The net result is an increase of two or three inhours in the overall strength of A Rod.
3. The value of "F", (perfect flattening), used in the xenon equations is not critical in obtaining rod calibrations. The difference between $F = 350$ ih and $F = 250$ ih amounts to a change of about eight inhours on No. 5 Rod, but less than

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7-6801

0.1 inhour on A and 9 rods for the withdrawal order now in use.

4. Checks on the rod calibration under similar conditions are good to only plus or minus 5 inhours with about 6 rods in the pile and plus or minus one inhour on A Rod alone. These variations are due principally to fluctuations in the power level and to uncertainties in the constants for the xenon equations.

Critical Power, Grade Y

There have been four occasions at 100-F in which a grade Y critical power condition has been declared. Present practice dictates that the pile be shut down on each such occasion. The nature of reactivity changes in connection with such a shutdown has made it necessary to remain down at least eight hours in each case, in spite of the fact that the critical power condition was over in considerably less time. Consideration has been given to a revision of this practice to allow operation at a reduced level during the critical power condition. The advantage to be offered by such a policy is that the return to normal power could be made at any time regardless of the duration of the actual grade Y conditions. Results of this study as they apply to the F Pile which normally operates at 200 MW are summarized below.

1. If the operating level is to be reduced to 100 MW, it would be necessary to maintain about 60 inhours excess in the control rods for normal equilibrium operation in order to be sure of being able to return to normal power at any time.
2. If the operating level is to be reduced to 120 MW, it would be necessary to maintain about 50 inhours excess in the control rods for normal equilibrium operation in order to be sure of being able to return to normal power at any time.
3. If a scram should occur near the point of minimum reactivity at the reduced level, the unit would probably be forced to remain down for a period of about eight and one-half hours.

Special Request Material

The following table summarizes the charging and discharging of material under the special request program.

Date	Tube	S.R.No.	Discharged		S.R.No.	Charged	
			Material	Nom.ih		Material	Nom.ih
1-15-47	3169-F	15-7-8	LiF	34	15-10	LiF	36
1-16-47	2374-F	15-8	LiF	48	15-10	LiF	40
1-22-47	2970-F	--	H.M.	0	14-1	Al - U	7
1-22-47	2074-F	--	H.M.	0	14-2	Al - U	7
1-22-47	2977-F	--	H.M.	0	14-3	Al - U	7

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2-12-47

7-5801

In addition to the special charges listed above, a uranium piece fitted with two thermocouples was charged into Tube 1367-F during the shutdown of January 8. Only the front half of this tube is now charged with uranium pieces.

Reactivity Balance

The reactivity balance for the F Pile at the beginning and the end of this report period is given in the table below.

	<u>12-31-46</u>	<u>1-29-47</u>
Amount held in rods	51 inhours	47 inhours
Amount held in xenon	427 "	427 "
Amount held in special requests		
in poison pattern	267 "	262 "
outside poison pattern. . . .	11 "	26 "
Amount held in bismuth	62 "	61 "
Amount held in dummy tubes	2 "	5 "
Due to overall power coefficient .	-76 "	-78 "
Total cold, clean reactivity . . .	744 "	750 "

Note that the value of the overall power coefficient has been taken as 0.39 inhours per MW in the tabulation for January 29, which was the last point of equilibrium operation for the month. This value is in accordance with results of the coefficient test of December 18, 1946.

The above comparison shows a net increase of six inhours in the cold, clean reactivity of the F Pile during the month.

General Physics - H. A. Fowler

Production Test 105-1-P - Graphite Monitoring

Capsule columns 2074-D and 2369-D were pushed on January 2 and reloaded with 6 capsule pieces per tube. The graphite in the capsules from Tube 2369-D had received 1266 MD/CT exposure. There were two types of graphite in Tube 2074-D, graphite which had been exposed 836 MD/CT in the "B" Test Hole of the D Pile plus 595 MD/CT in the capsule; and graphite, transverse cut, which received only 595 MD/CT exposure in the capsule.

Length change measurements were made on transverse cut graphite removed from the "B" Test Hole of the F Pile after 446 MD/CT exposure. This graphite was at ambient pile temperatures during the first 67 MD/CT exposure then under cooled conditions during the remainder of the exposure. The per cent change in length, 0.31%, is slightly lower than for graphite in this test hole under cooled conditions only.

Samples exposed 1196 MD/CT in the "B" Test Hole of the D Pile were measured for stored energy and thermal conductivity. These samples were

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7-5801

2-12-47

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exposed in a cooled test hole for the first 1182 MD/CT, then at ambient pile temperatures for the remaining 13 MD/CT exposure. The stored energy was 23.3 cal/gm. and E_0/A : 35.6. On the basis of laboratory annealing data, the estimated sample temperature from the stored energy curve is 215-225° C. and from the thermal conductivity data, 215-220° C. The maximum pile graphite temperature varies from 165-180° C. The test hole is upstream and would be in a lower temperature zone. This indicates greater annealing effects under pile conditions than under laboratory conditions for the same temperature.

Production Test 106-86-P - Exposure of Expanded Graphite

The equipment and test pieces for this test have been prepared and are scheduled to be put in the D Pile on February 11. Grooved steel plugs to be used as a biological shield were prepared according to specifications and were found to fit a new tube perfectly. A test run was made on Tube 4574 in the B Pile and it was found that these plugs would not fit. It was necessary to reduce the diameter of the plugs 0.010" and to increase the size of the grooves before the plugs could be put into the pile.

General Physics - J. M. West

Test Pile Investigation

The major cause of the erratic results which have been obtained in reactivity comparison tests with the 306 Pile during recent months has been traced to an arithmetical error in a document (No. 3-7028, July 18, 1945) reporting the results of a new calibration of the control rod. A chart giving inhour values as a function of control rod position was prepared from a table in this document, and the arithmetical error from the table was incorporated into the chart. A new chart has been prepared and put into use which does not contain the aforementioned error. This chart has been shown to give much more reproducible results.

Even with the corrected chart, significant day to day differences in test pile results still remain. An extensive search for ways to improve the accuracy has been under way during the past month. One of the most likely causes of poor reproducibility seemed to be the possibility of the existence of local irregularities (ripples) in the sensitivity of the control rod. All charts for control rod calibrations have assumed a smooth cosine distribution of neutron flux along the control rod channel. The control rod sensitivity could be expected to magnify any small departure from the assumed smooth curve since the sensitivity of the rod at any point is proportional to the square of the local flux density. A series of pile period measurements were made for various positions of the control rod. Many measurements were made within the range of rod settings normally used for testing purposes, together with enough measurements at other positions to permit a more precise calibration curve to be drawn than had hitherto been possible. Results of the overall calibration

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7-5801

2-12-47

showed that the inhour values reported in the original calibration (Document No. 3-458, July 5, 1944) should be increased by the factor 1.06. The degree of precision with which inhour values could be measured from relatively long periods (representing very small movements of the control rod) was not good enough to definitely establish or refute the existence of ripples.

The search for local irregularities in control rod sensitivity was continued in another way. A series of measurements was made to determine the amount of control rod movement required to compensate for the addition of a piece of iron wire to the metal test stringer. The critical position of the rod prior to addition of the wire was adjusted at will by means of the skim rod and other iron wire, prior to addition of the standard wire. In this way, it was found that the sensitivity of the rod varied by about 20 per cent over the range 114 to 124 inches. The change in sensitivity seemed to have a definite periodicity, each ripple having a length of about $2\frac{1}{2}$ inches.

A trial calibration chart was prepared in which the ripple effects were included. When applied to past data, improvement in reproducibility resulted. Small day to day differences still remain. This is not surprising, since the measured variations in sensitivity represented averages over one-inch intervals, and the point-to-point differences are undoubtedly much greater. It is now planned to thoroughly explore the portion of the rod normally used for testing purposes, probably measuring the sensitivity over intervals as small as 0.2 inch.

Other conclusions reached during the month in regard to test pile performance include the following:

1. Changes in humidity probably do not affect the accuracy of reactivity comparisons. An increase from 32 to 55 per cent in the relative humidity of the ventilating air in the 305 Bldg. had produced no measurable change in reactivity after one hour. Tests made to determine the amount of water which will be absorbed from the air by graphite indicated an increase in weight by about 0.0007 per cent when 100 gm. samples, which had been in a room at 40% humidity, were placed in a container at 80% humidity for 18 hours or longer. This percentage of water in all the graphite of the test pile would reduce the reactivity by only about 1 inhour. A uniform distribution of water throughout the pile would not affect the results of reactivity comparisons with a standard sample, even if the effect on the pile as a whole were much larger than 1 inhour.
2. The accidental failure to remove one or two boron-steel balls from the vertical shot thimble prior to beginning a day's testing program could not cause erratic results in comparison tests. Ten balls in the thimble were found to reduce the pile reactivity by about 0.46 inhours. This amount of local

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disturbance at a point several feet from the samples being tested and even further from the control rod should not influence the test results obtained. It is not mechanically possible to drop any balls in the hole containing the shot thimble.

3. The extreme sensitivity of the power level indicating galvanometers to static electricity in their neighborhood was traced to a faulty ground connection in the galvanometer circuit.

Egg Testing Program

Seventeen lots of billet samples ("eggs") which had previously been tested at Argonne, were tested in the Test Pile, January 29. Results obtained at H.E.W. check those at Argonne very well, as will be noted in the following tabulation:

Lot Number	ΔK Per Cent		H.E.W. Minus Argonne $\Delta K\%$
	H.E.W.	Argonne	
1440	-0.03	-0.04	+0.01
1441	-0.03	-0.03	0.00
1442	-0.05	-0.06	0.00
1443	-0.03	-0.03	0.00
1444	-0.02	-0.03	+0.01
1445	-0.03	-0.03	0.00
1446	-0.03	-0.02	-0.01
1447	-0.02	-0.03	+0.01
1448	-0.10	-0.08	-0.02
1449	-0.04	-0.04	0.00
1450	-0.11	-0.08	-0.03
1451	-0.10	-0.11	+0.01
1452	-0.11	-0.11	0.00
1453	-0.09	-0.10	+0.01
1454	-0.09	-0.08	-0.01
1455	-0.09	-0.08	-0.01
1456	-0.11	-0.10	-0.01

Shipment of Special Request Material

The following special request material was shipped January 22, 1947. All casks were satisfactory from the radiation standpoint.

<u>Request No.</u>	<u>No. of Slugs</u>
15-6	50
15-7	86
15-8	50
15-9	100
15-10	13

Paul F. J.
P. F. Gast,
100 Technical

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