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January 7, 1947

100 AREAS TECHNICAL ACTIVITIES REPORT - PHYSICSDECEMBER, 1946D File - E. B. MontgomerySummary

A coefficient test was performed on December 27. This test was made with a low level of ten hours' duration for the purpose of calibrating the control rods used during the test.

The pile operated at 250 MW except for two scheduled shutdowns, one unscheduled shutdown of about 35 minutes and the coefficient test. Seven special request tubes were recharged. The high tanks were not tested this month. A solids purge of 100 ppm was made on 12-17-46 after a sudden rise in pressure drop following the 12-3-46 shutdown. The orifices of five tubes were increased to decrease the temperature rise following startups. The remaining 17 VSR thimbles were pneumatically tested and found to be satisfactory. No. 37 VSR continues to bind in the out position. It was re-buffed, but this did not remedy the trouble.

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Details

Special Requests

The following tabulation lists the changes made in the Special Request materials in the D File during December:

<u>Date</u>	<u>Tube</u>	<u>S.R.Out</u>	<u>No</u> <u>Pcs.</u>	<u>S.R.</u> <u>In</u>	<u>No.</u> <u>Pcs.</u>	<u>ih</u> <u>nom.</u>	<u>d ih</u>
12-17-46	1474-D	15-7	18	15-10	27	40	+10
12-17-46	3274-D	15-9	12	15-10	27	40	+17
12-17-46	1569-D	15-6	26	15-10	26	39	0
12-17-46	1579-D	15-8	23	15-10	23	36	0
12-17-46	2082-D	15-6	24	15-10	24	37	0
12-17-46	2066-D	15-8	27	15-10	27	40	0
12-17-46	3179-D	15-7	32	15-10	32	44	0
							+27 ih nom.

This increase raises the inhours held in the special requests to a total of 435 inhours nominal or 320 ih effective.

Reactivity Status

The reactivity status at the beginning and at the end of the month is given below.

	<u>11-30-46</u>	<u>12-31-46</u>
Amount in rods	64 ih	64 ih
Xenon	497	492
Special requests	302	320
Bismuth tubes	34	34
Lead dummy	2	2
	<u>899</u>	<u>912</u>
ih due to C_0 of 0.37 ih/MW	-92	-92
Total cold, clean reactivity	<u>807 ih</u>	<u>820 ih</u>

Reactivity Coefficient Test

On December 27, 1946 at 9:00 AM the level of the D File was lowered to start a coefficient test. The level was dropped from 250.0 MW to 203.7 MW. The lower level was held for ten hours after which the level was raised to 250.6 MW. The operation of this test was very good. The changes in level were performed as quickly as the rod controls would allow and at the same time the operation was smooth. This test should provide as reliable data as we are able to get with the present instruments and controls.

The values obtained are tabulated below.

<u>Coefficient</u>	<u>Drop</u>	<u>Rise</u>	<u>Average</u>
Metal C_m	-0.32 ih/MW	-0.31 ih/MW	-0.32 ih/MW
Graphite C_g	0.70 "	0.69 "	0.70 "
Overall C_0	0.38 "	0.38 "	0.38 "
Relaxation Period	62 min.	57	60 min.

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After the rise, as the graphite temperatures came to equilibrium, the reactivity curve and the calculated xenon curve came to coincidence within the scale of the graph used.

* As the two curves came to coincidence after the graphite transient had died out the overall coefficient for the last half of the test was assumed to be the same as for the first part. The total coefficient was obtained using this value.

Foil Test

A foil was irradiated at the B Pile in Tube 1363 on 12-17-46. Two foils were irradiated but one of the irradiations gave such dubious results that it was discarded. The other foil gave an mv of 105.2 n/cm²/sec. This is equivalent to 1.5 k below critical. The gas purity was 98.9% which is 0.2% lower than at the last irradiation. This accounts for most of the small difference in reactivity.

Orifice Changes

The orifices of Tubes 3788-D, 3887-D, 3986-D, 4084-D and 4180-D were changed from 0.175" to 0.200" to reduce the exit water temperature during the first few hours after startup.

F Pile - A. B. Carson and H. A. Gauper, Jr.

Summary

During the month of December the F Pile was shutdown three times as scheduled and two Production Tests (Power Coefficient Tests) were run. The regular power coefficient test of 5 hours at reduced power on December 3 was followed by a ten-hour run at reduced power on the 18th in order to run a rod calibration. There were no scrams during the month.

Number 2 Horizontal Rod was not used in the startup of December 26 as it was found to have a water leak. This rod will remain out, pending repair or replacement.

Special request material and a graphite sample were charged in "B" Experimental Hole during the shutdown on the 4th.

The pile lost a total of 10 inhours of cold, clean reactivity during the month, with most of the loss occurring after the December 4th shutdown.

Details

Power Coefficient Tests

A Production Test was performed on 12-3-46 to determine the reactivity power coefficients of the F Pile. The test consisted of lowering the level

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from 200 MW to 175 MW for 5 hours and then raising it to 204 MW where it was held until the shutdown of 12-4-46. Interpretation of the data in terms of the current A rod calibration curve was difficult in view of the fact that the observed and calculated reactivity curves were displaced by about 6 inhours for operation at 204 MW following the 5 hours' operation at 175 MW. A "flattened" A rod calibration curve was also employed, corrected in the region from 0 to 100 inches by the same ratio as was necessary in analyzing the data from the xenon-free coefficient test of 11-7-46. This correction gave much better results but appeared to be slightly flatter than it needed to be to give ideal results.

Coefficient values obtained;

Normal "A" Rod calibration

Drop; C_0	= 0.36 ih/MW	Rise;	0.40 ih/MW
C_m	= -0.25		-0.30
C_G	= 0.61		0.70
t	= 58 min.		109 min.

Flattened "A" Rod calibration

Drop; C_0	= 0.32 ih/MW	Rise;	0.27 ih/MW
C_m	= -0.20		-0.22
C_G	= 0.52		0.49
t	= 66 min.		54 min.

In order to check the rod calibration, a second test was performed on 12-18-46. This time the level change was held for 10 hours so that the xenon transient introduced would be large enough to use for a rod calibration.

Coefficients;

Normal "A" Rod calibration

Drop; C_0	= 0.40 ih/MW	Rise;	0.39 ih/MW
C_m	= -0.26		-0.27
C_G	= 0.66		0.66
t	= 65 min.		70 min.

Flattened "A" Rod calibration

Drop; C_0	= 0.40 ih/MW		0.39 ih/MW
C_m	= -0.24		-0.25
C_G	= 0.64		0.65
t	= 65 min.		68 min.

($-\Delta$ ih, xenon) and (Δ ih, observed) were plotted against time, and the two curves compared. The results were similar to those of the test of 12-3-46. For the period immediately following the rise to 201 MW, the observed reactivity change rises to a value higher than the xenon curve and approaches it again from above when the normal rod calibration curve is used. When the flattened curve is used, the observed reactivity change rises steadily to a value about 1/4 ih below the xenon curve. This can be taken to be coincidence in view of inaccuracies involved.

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It was also found that when "A" Rod was calibrated from the data obtained from this power change, the result was in better agreement with the flattened than with the normal "A" Rod calibration curve. Data from the rise in power gives a smooth curve from 45" to 125" which agrees with the flattened calibration curve exactly. Data from the drop in power gives values for the strength of "A" Rod from 170" to 190" where the normal and flattened curves are the same.

Rod Calibration

In addition to the revised calibration of A Rod obtained from the power coefficient test of 12-18-46, a check of the calibration of the horizontal rod system has been made. This check consisted of comparing rod positions during operation following the shutdowns of 11-27, 12-4, and 12-11, with xenon variations calculated for these same time intervals. These calibration curves are consistently lower than the set of curves now in use. The curves now being used in connection with critical rod position prediction charts for pile startups are based on an average of calibration curves calculated in each of the 3 areas about 10 months ago, using the same technique described above. These curves are included in Document No. 7-3687. The best average of the three new sets of curves range progressively from about 5 to 30 inhours lower than the curves currently in use in the region from A and 9 rods to A, 9, 2, 7, 6, 4 and part of 5 in. These differences may be due to an incorrect allowance for the effect of the change in pile poisoning of the xenon equations. The value of 350 ih used for the effective flattening of the pile seems to be acceptable for present conditions however, since the average temperature rise of tubes in the central flattened zone agrees with that predicted for this flattening at 200 MW by the graphs of Document No. 3-2267, "Procedure for Flattening: Output Charts", J. A. Wheeler to W. E. Jordan, 4-27-45.

Other possible sources for these differences are being investigated before the new curves are incorporated into the prediction charts.

Effectiveness of Poison Columns

A more elaborate study of the dependence of poison column effectiveness upon local flux is being carried out. The inhours which will be absorbed by a poison column should be given by the following equation:

$$ih = \frac{\sum_{\text{pile}} (nv)_1^2 B}{\sum_{\text{pile}} (nv)^2} = \frac{(\Delta T)_1^2 \text{ flattened } B}{\sum_{\text{pile}} (\Delta T)^2 \text{ flattened}}$$

where;

$(nv)_1$ is the neutron flux at the position where the poison column is to be placed.

$\sum_{\text{pile}} (nv)^2$ is the sum of the $(nv)^2$ over the whole pile.

B is a constant dependent upon the total cross-section of the column.

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For a full P column in the center of an unflattened pile this equation becomes;

$$68 = \frac{(nv)_0^2}{\sum_{pile} (nv)^2} \cdot B = \frac{(\Delta T)_0^2 \text{ unflattened}}{\sum_{pile} (\Delta T)^2 \text{ unflattened}} \cdot B$$

Solving for the inhours absorbed at some position i, in a flattened pile, one gets

$$ih = \frac{(\Delta T)_{i \text{ flattened}}^2 \times 68 \times \left[\frac{\sum_{pile} (\Delta T)^2 \text{ unflattened}}{\sum_{pile} (\Delta T)^2 \text{ flattened}} \right]}{(\Delta T)_{\text{unflattened}}^2}$$

The bracketed expression was first evaluated for the temperature distribution curve used by U. M. Staehler in determining the value of 48° C. as ΔT for a central column in an unflattened pile operating at 250 MW. This assumed that the temperature distribution was symmetrical cylindrically, and an average of the vertical and horizontal traverses was used as the distribution along the radius. This gave a value for the bracketed expression of 1.13. When applied to the experimental data available, agreement was unimproved over that obtained when this expression was assumed to be unity.

A similar evaluation was made from a temperature map of F Pile operating at 200 MW, at about the time the experimental data was taken. This gave a higher value of ΔT for a central column in an unflattened pile, but again gave a value for the bracketed expression of 1.13. Use of these values in the formula improves the agreement with experimental data somewhat. Solving for the exponent of the ΔT gives values of about 2.4 instead of 2.0 as used in the equations above.

Another evaluation was made from the more uniform temperature distribution obtained with a more recent poison pattern and a control rod configuration of No. 9 at 145" and "A" at 135". This gave a still higher value for ΔT in an unflattened pile, and gave a ratio of 1.22. In this case the ΔT of each individual tube was squared and the summation was compared with an unflattened cylindrical pile of equivalent volume. Use of these values gives still better agreement with the experimental data. Solving for the exponent gives values from 2.0 to 2.4. Of course the flattening of the pile was considerably different at the time the experimental data was taken and at the time the temperature distribution used here was obtained.

If the dependence of column effectiveness on $(\Delta T)^2$ is taken as correct, the reduction in observed ih absorbed might possibly be due to shadowing by other columns. For a typical case, the observed value of ih absorbed is 25.1 while that calculated by ΔT considerations is 29.6. This would give a shadowing effect of about 0.85, which does not seem unreasonable.

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Special Request Material

The charging and discharging of special request material and poison during the month is summarized in the following table:

Date	Tube	<u>Discharged</u>			<u>Charged</u>		
		S.R. No.	Material	Nom.ih	S.R. No.	Material	Nom.ih
12-4-46	2271-F	20	--	7	--	HM	0
	1579-F	15-8-7	LiF	48	15-9-10	LiF	36
12-26-46	2068-F	--	4L-1P	23	15-10	LiF	34
	3179-F	15-7	LiF	46	15-10	LiF	36

Special request material No. 28 and graphite samples were charged in "B" Experimental Hole on the 4th of December.

Tubes No. 2071-F, 2077-F, 2671-F and 2677-F were newly charged with bismuth during the shutdown of December 4, 1946. Tubes No. 2085-F and 1274-F were recharged with bismuth at the same time. This brings the bismuth pattern very close to its final form.

Reactivity

A comparison of expected and observed reactivity changes during December shutdowns is shown in the following table:

Date	ρ_3	$\Delta 1h$ nom.	$\Delta 1h$ eff.	$\Delta 1h$ metal	$\Delta 1h$ l.t.	$\Delta 1h$ total	Obs.
12-4-46	0	+9	+6	0	+3	+8	+1
12-11-46	4.6%	0	0	-4	+3	-1	-1
12-26-46	6.3%	+2	+2	+6	+3	-1	+3

Reactivity Balance

The reactivity of the F Pile at the end of December is compared to the reactivity at the last time of equilibrium in November in the following table:

	11-27-46	12-31-46
Amount held in rods	47	51
Amount held in xenon	427	427
Amount held in poison	17	0
Amount held in special request in poison pattern	281	267
outside poison pattern	16	11
Amount held in Bi	41	62
Amount held in dummy tubes	2	2
Overall power coefficient	-76	-76
Total cold, clean reactivity	754	744

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General Physics - H. A. Fowler

Production Test 105-1-P

Three capsule columns, Tubes 3171, 3172, and 3277, were loaded in the P Pile on December 11. These were new columns and were loaded with 6 capsule pieces per column. All previous loadings were 3 pieces per column.

Transverse cut pieces machined from the graphite removed from the No. 9 Thimble of the D Pile after 1054 MD/CT exposure at ambient pile temperatures were annealed at 600° C. in helium and helium plus 1.78% oxygen atmospheres to determine if the displaced atoms could be removed by oxidation. The results obtained are given in the following table:

<u>Temp. ° C.</u>	<u>Atmosphere</u>	<u>Annealing Time Hrs.</u>	<u>Length Change % Recovery</u>	<u>c/c₀</u>	<u>% Loss in Wt.</u>
590-600	He	5½	55.	1.43	0
590-600	He + O ₂	5½	56.	1.41	0.80
590-600	He	10	55.	1.26	0
590-600	He + O ₂	10	56.	1.24	1.28

Transverse cut graphite samples removed from the "B" Test Hole of the D Pile were measured for dimensional changes and the results obtained are given in the following table:

<u>Exposure MD/CT</u>	<u>Place Exposed</u>	<u>Dimensional Changes %</u>
263	T.H. 105-B & 105-D	0.22
289	T.H. 105-D	0.19
1110	T.H. 105-B & 105-D	0.65
1169	T.H. 105-D	0.64*

- * This result is the average of 3 values, one of which is abnormally low. The average of the other 2 values would be 0.68% which is more in line with previous results.

General Physics - J. M. West

Billet Egg Testing

The special stringer which is to be used for testing billet eggs has been calibrated for weight and purity variations. The reactivity of the pile was found to be independent of the weight of test samples in the range 1850 to 1950 grams per cell. The relation found to hold between pile reactivity and sample purity is:

$$\Delta k = 0.52 \Delta h$$

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Six lots of billet eggs which were tested previously at Argonne have been retested in the test pile. Results of all tests thus far are as follows:

Lot No.	$\Delta K\%$ at H.E.W.		$\Delta K\%$ at Argonne
	First Test	Second Test	
1331*	-0.02*	-0.02*	-0.02
1328	-0.01	-0.02	-0.03
1329	0.00	-	-0.02
1332	0.00	-	-0.02
1336	-0.09	-	-0.05
1337	-0.10	-0.09	-0.08

* Lot 1331 was arbitrarily chosen as a standard at H.E.W. The values obtained at Argonne are tentatively assumed to be correct for this lot.

An investigation is under way to determine and if possible correct the causes for very erratic results obtained in metal tests during recent months. The following items have already been checked or changed:

- (1) The rod thimbles and test stringer holes have been cleaned out by means of a vacuum cleaner. The test stringer and platform were also cleaned thoroughly.
- (2) Iron filings which had accumulated in the horizontal safety rod guide as a result of wear on the cable were removed.
- (3) All cables in the ionisation chamber circuits were replaced with shielded cable.
- (4) The ionisation chambers were checked individually for sensitivity and stability by means of a 1 gram Ra-Be source.
- (5) The Selsyn position indicator for the control rod was checked against index marks on the rod.
- (6) The aneroid and mercury barometers were checked against each other.
- (7) All batteries and instruments in the ionisation chamber circuit were checked. Faulty batteries were replaced.

As a result of the above, some improvement in reproducibility of results is believed to have been obtained. Unexplained discrepancies remain however, and further checks aimed at their elimination are planned for the immediate future.

The test pile is now ready for testing billet eggs on a routine basis. A letter has already been written, requesting that all test material be

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shipped to H.E.W. after being tested at Argonne.

Request No. 26

A 50 mg. pellet of antimony was loaded in "B" Test Hole No. 5 of the F Pile. during the shutdown of December 4, 1946. Exposure will continue for a period of about two months.

December 17 Shipment of Special Request Material

The following material was shipped December 17. All casks were satisfactory from the radiation standpoint.

<u>Request No.</u>	<u>No. Slugs</u>
15-4	14
15-5	197
15-6	50
15-7	2
20	1
3-1	43
B material	120

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