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February 19, 1947

GRAPHITE EXPANSION COMMITTEE
MEETING OF FEBRUARY 7, 1947

The fourteenth meeting of this committee was held on February 7, 1947. Present were Messrs. M. G. Barnard, H. A. Fowler, P. F. Gast, C. W. Hay, E. Hilgeman, W. R. Lewis, R. A. Rohrbacher, J. E. Warren, V. W. Wood, and W. K. Woods.

Summary

Laboratory studies indicate that either the graphite thermocouples are reading low or that annealing effects at elevated temperatures within the pile are much greater than those encountered in the laboratory.

Current difficulties with operation of some of the horizontal and vertical control rods seem to be attributable to graphite expansion,

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though no complete understanding of the phenomena has been obtained and one is unable to predict the time required for similar difficulties to develop in other rods. Sticking of vertical rods is associated with inclination of the rod guides as a result of the buckling of the roof; the use of new rod guides with an inclined bore is a promising remedy. Binding of horizontal rods is associated with an abrupt change in slope of the graphite track in the thimble as the thimble enters the graphite portion of the pile. Modification of the present rods to provide greater clearance and greater flexibility appears to be a practical remedy. Mock-up studies of horizontal thimble and rod assemblies are recommended as a means of anticipating future difficulties.

Changes in clearance between process tubes and pile graphite in the D Pile during the last six months have been erratic in nature but have averaged much less than had been anticipated. The negligible decrease in clearance for central tubes indicates that the expanding cross-wise graphite layers are slipping with respect to the graphite layers which contain process tubes.

Difficulty with replacement of process tubes in the B Pile forebodes extreme difficulty with replacement of tubes in piles with greater exposures. This phenomenon is considered very serious, for it suggests that the effective life of the pile may be reached when endwise expansion results in rupture of process tubes.

Discussion

Laboratory Studies

Exposure of graphite samples in dry process tubes in carbon dioxide, oxygen, and helium atmospheres is scheduled to start in the D Pile on February 11, 1947.

Graphite samples exposed in the B test hole of the D Pile for 1162 MD/CT while cooled and then for 13 MD/CT at ambient pile temperature showed values of stored energy and thermal conductivity equivalent to values which would be expected after annealing in the laboratory at temperatures around 220° C., though the maximum pile graphite temperature as indicated by pile thermocouples is only 180° C. These samples had been cut parallel to the direction of extrusion so no expansion effects were measured. It is possible that the pile thermocouples have changed their calibration under service conditions in a direction such that they are reading low, or it may be that greater annealing effects are encountered under pile operating conditions than are encountered in the laboratory at the same temperature.

In the tenth meeting of this committee it was reported that attempts were to be made to determine changes in void volume of irradiated graphite. Experimental difficulties were encountered and shortage of manpower has caused a postponement of this study. It is, of course, necessary to have data on void volume both before and after exposure, so no significant information on this subject will be obtainable in the immediate future.

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Bowing of Process Tubes

The maximum vertical bowing of Tube 4674-F on January 29 was 2-3/8 inches. This corresponds to a rise of 9/16 inches in less than five months, a rate about twice as great as the current rate of rise at the D Pile. However, the total rise is only 1/8 inch greater than the rise at the D Pile after a comparable exposure.

Short probes (4.35-inch long) have been used in conjunction with long probes (8.7-inch) to verify the assumption that binding of process slugs will be reduced by use of short slugs. For Tube 4674-F a long probe 1.485-inch diameter would not pass through the tube, but a short probe 1.490-inch diameter would pass. This result is encouraging, for it indicates that flattening or squashing of the tube is not a dominant cause for the apparent decrease in clearance between the slugs and the tube.

Vertical Rods

The Maintenance Department has made measurements of the slope of the rod guides at both the D and F Piles, by measuring the slope of the rod as it protrudes from the guide after being pulled part way out of the pile. The numerical results are shown in the attached Figures 1 and 2. In general, the rod guides are inclined toward the front or rear of the pile in a manner attributable to the buckling of the roof by expansion of the graphite.

Trouble has been encountered with Rod No. 37 in the D Pile and Rods No. 35 and 36 in the F Pile. When one of these rods is lowered under power while the pile is down it may hang up in the out position, or if jarred loose it may then slip part way in and stick again. This phenomenon is evidently associated with the tilting of the rod guides, although there are many trouble-free rods in the D Pile for which the rod guides are out of line by amounts greater than for the troublesome rods.

This difficulty was not foreseen by the committee, and plans for correcting the trouble have been proposed outside of the committee. These plans include provision for polished bearings at the upper end of the rod guide, lubrication of the rods, and possibly relocation of the rod winches. In addition, three new rod guides have been ordered. The hole in these guides is inclined at an angle which deviates from the axis of the guide by 1/16-inch per foot, and the guides are to be chrome-plated both inside and out. Delivery is expected about March 1.

It is still considered imperative to determine whether any of the present trouble is caused by slippage of the top layers of graphite relative to the cast iron blocks and the rod guides, or to anticipate the possible development of such trouble in the future. A special probe for measuring eccentricity between the rod guide and the thimble a short distance below the guide is being developed by the Instrument Department and is to be used in Vertical Thimbles No. 27 and 37 at the D Pile on February 11.

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Horizontal Rods

Trouble is developing in the operation of some of the horizontal rods. The rods in question are Rods No. 2 in the D Pile and Rods No. 2 and 6 in the F Pile. This trouble is evidenced by scratches on the exterior of the rod and by a slightly erratic, non-uniform motion of the rods as shown by the Selsyn position indicators. As with the vertical rods this operating difficulty was unanticipated by the Graphite Expansion Committee.

The No. 2 Rod Thimble at each pile has been borescoped and traversed for vertical bowing of the track. Results of the traverse of the No. 2 Rod Thimbles in the D and F Piles are given in Table I. The maximum bowing of the track is quite directly proportional to the accumulated megawatt days of pile operation, varying from a bowing of 0.85 inches at the B Pile after 100,000 MD, to a bowing of 1.5 inches at the D Pile after 175,000 MD. (These data, incidentally, indicate that the rate of graphite expansion has not decreased significantly after prolonged exposure.) The track is substantially horizontal within the shield structure, and then changes slope abruptly and rises at a rate of about 0.15 in./ft. in both the D and F Piles. Borescopic examination shows marked signs of wear at the inner end of the kick plate and some scratches on the thimble beyond the point where the track levels off in an elevated position. No examination has been made of No. 6 Rod Thimble.

The above data indicate that the curvature imposed on the thimble by graphite expansion is causing the horizontal rods to bind as they attempt to maneuver around the curves. However, the trouble does not seem to be determined solely by vertical expansion of the graphite, for Thimble No. 5 in the D Pile is undoubtedly bowed considerably more than Thimble No. 6 in the F Pile, etc. It may be that comparable binding of Rods A and B may be present but undetected because of difference between electric and hydraulic drive. Observation of Thimble No. 6 in the F Pile is scheduled for February 12.

The present No. 2 Rod in the F Pile is a new rod which has not been used inside of an operating pile and which is therefore radioactive only at the tip end. Efforts to improve the operability of this rod by filing on the kick plate or by adjusting the elevation of the rolls outside the pile have been unsuccessful. The rod has long scratches starting about four feet from the tip and running almost the entire length. It has been proposed to plane down the upper surface of the scratched portion of this rod about 1/8 -inch, thereby increasing both the rod flexibility and the clearance between the rod and the thimble. Mock-up studies are contemplated in connection with the procedure.

Other methods of attack which have been considered but temporarily rejected include (1) planing the pile graphite after removal of the thimble, (2) modification of the existing track inside the thimble, (3) reducing the thickness of the lower block of the present rod design, (4) shortening the kick plate, and (5) new rod design aiming at reduced rod thickness and increased rod flexibility.

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The committee assumes that the trouble with the No. 2 Rods in the D and F Piles is associated with the pile expansion and that the operating difficulty will become progressively worse. It is recommended that mock-up studies be used to study the ability of proposed changes to correct conditions as they will probably exist after a considerable increase in the amount of pile expansion. Hay and Wood will prepare designs for such a mock-up installation.

Endwise Expansion

Push-pull tests on fourteen tubes in the D Pile were repeated after an interval of five to six months. The data reported in Table III show an average reduction in clearance of only 3/32-inch, with larger decreases occurring in the upper tubes and negligible decreases occurring in the central tubes. Since the vertical bowing of Tube 4674-D increased about 5/16-inch during this period an increase of about 5/16 inch in length of graphite between end faces was expected. No general explanation of the data has been formulated, but the negligible changes in clearance for central tubes suggests that slippage is occurring between process tube graphite layers and the expanding cross-wise layers of graphite. Such slippage might be expected to continue until the crosswise layers begin to push directly against the thermal blocks. Measurements indicate no change in length of process tubes during this period.

Difficulty in moving Tube 4385-B within the gun barrels was reported last month. It was found that this tube had been annealed far enough back from the Van Stone joint that the expanding mandrel used to grasp the tube was expanding the tube proper, causing binding. During rupture tests on Tube 4385-D failure occurred at the front Van Stone flange with a tensile force of about 4300 lbs. The associated tube stretch was 7/8-inch just before rupture; 5/16-inch of this stretch was permanent strain.

The gun barrels of both Tubes 4082-B and 4385-B were honed with emery cloth near the inner end before replacing the tubes. The new Tube 4385-B was subsequently withdrawn part way for inspection and was found to be scratched to an extent that made questionable its use in the pile.

During discussion the following program was outlined. The laboratory studies should include measurement of hardness of irradiated graphite by means of scratch tests. Tube 4385-B should be rotated in place in order to identify points of binding by means of the resulting circumferential scratches, paying particular attention to any signs of scratching within the graphite. Improved technique for honing the inside of the gun barrels of Tube 4385-B should be developed. A hydrostatic rupture test should be made on the present Tube 4385 to determine how seriously the observed scratches have weakened the tube. No work involving tube replacement in the D Pile should be started before the work at the B Pile has been completed, but it was emphasized that the committee considers this difficulty in replacing process tubes to be an extremely serious problem in its effect on the life of the piles.

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The clearance between the gun barrels and the process tubes was made very small in order to insure adequate cooling of the thermal blocks at the ends of the pile. The heat load on the thermal blocks is so much lower than the liberal design estimates that it should be quite feasible to enlarge the bore of the gun barrels by reaming if this becomes necessary.

General

The next meeting of the committee is scheduled for March 7, 1947.

W. K. Woods

W. K. Woods,
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TABLE I

ELEVATION OF TRACK IN NO. 2 HORIZONTAL ROD THIMBLE

Note: Measurements made in D File on February 4, 1947.
Measurements made in F File on January 29, 1947.

<u>Distance from outer surface of near side shield, ft.**</u>	<u>Elevation about 1st graphite block, inches.</u>	
	<u>D File</u>	<u>F File</u>
-1/4	0.000	(0 ± 0.005, assumed)
0	-0.080	-0.094
1		-0.044, -0.035*
2		-0.069
3	-0.060	-0.062, -0.079*
4	+0.035	+0.006
5	0.115	0.036
5-1/2		0.212*
6	0.245	0.241
6-1/2		0.306
7		0.381
8	0.545	0.556
8-1/2		0.749*
9		0.726, 0.731*
10		0.854
12	1.220	1.066
13		1.139*
14		1.156
16	1.520	1.181
18		1.164
20	1.517	1.134
22		1.130
24	1.510	1.147
25		1.150

* Values obtained during withdrawal from thimble.

** Measured to near side of boat which carried traverse equipment.

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TABLE II

ARRANGEMENT OF TRACK IN HORIZONTAL ROD THIMBLES

(Reference: Drawings W-71811 and W-72457)

-2-1/2"	Start of first #508 block
- 1/2"	End of first #508 block
0	Outer surface of near shield
1' 1-1/4"	End of first cast iron spacer
1' 3-1/4"	End of second #508 block
2' 5"	End of second cast iron spacer
2' 7"	End of third #508 block
3' 8-3/4"	End of third cast iron spacer
3' 10-3/4"	End of fourth #508 block
4' 2-5/8"	End of fourth cast iron spacer
4' 4-1/2"	Start of thermal block
5' 0-5/8"	Start of pile graphite and end of #510 block
9' 0-5/8"	End of first #501 block
13' 0-5/8"	End of second #501 block
17' 0-5/8"	End of third #501 block
21' 0-5/8"	End of fourth #501 block
22' 10-1/8"	End of #509 block
25' 11-7/8"	End of #507 block
29' 11-7/8"	End of fifth #501 block
33' 11-7/8"	End of sixth #501 block

Thickness of graphite block = $0.875" + 0, - .005$
Thickness of cast iron spacer = $0.781, + 0, - .005$
Differential thickness = $0.094" \pm 0.005$

Footnote: Tabular values refer to distance from outer face of near side of the pile.

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TABLE III

CHANGE IN CLEARANCE BETWEEN PROCESS TUBE
ASSEMBLIES AND GRAPHITE IN THE D PILE

Tube No.	Original Measurement		Second Measurement		Change in Sum- Clearance
	Date	Sum-Clearance	Date	Sum-Clearance	
0274	8-6-46	27/32	1-21-47	25/32	-2/32
0859	8-6-46	22/32	1-21-47	17/32	-5/32
0888	8-6-46	19/32	1-21-47	16/32	-4/32
1474	7-23-46	18/32	1-21-47	19/32	+1/32
2362	7-30-46	23/32	1-21-47	20/32	-3/32
2362	7-23-46	17/32	1-21-47	14/32	-3/32
2386	7-23-46	19/32	1-21-47	16/32	-4/32
2396	7-30-46	21/32	1-21-47	19/32	-2/32
3574	8-13-46	19/32	1-21-47	14/32	-5/32
3969	7-23-46	14/32	1-21-47	12/32	-2/32
4188	8-13-46	16/32	1-21-47	12/32	-4/32
4474	8-13-46	11/32	1-21-47	7/32	-4/32
2373	7-30-46	16/32	1-7-47	16/32	-1/32
2474	7-30-46	19/32	1-7-47	18/32	-1/32

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FIGURE 1
SLOPE OF VERTICAL
ROD GUIDES
Note - Arrow points to low point
Values are inches per foot, deviation from vertical.

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AREA 100 F

DATE 1/15/47

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FIGURE 2
SLOPE OF VERTICAL
ROD GUIDES

FRONT

After Arrow points to line point
the rod is in the line point

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