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12. W.K.Woods
13. P.F.Gast
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DECEMBER 12, 1946

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GRAPHITE EXPANSION COMMITTEE
MEETING OF DECEMBER 8, 1946

The twelfth meeting of this committee was held on December 8, 1946. Present were Messrs. Myron Davis (substituting for J. H. Warren), H. A. Fowler, G. W. Hay, E. Hilgeman, W. R. Lewis, R. A. Rohrbacher, and W. K. Woods.

Summary

Recent laboratory studies suggest that the rate of graphite expansion decreases with exposure when the samples are exposed in an air atmosphere at ambient pile temperature, though the relative effects of atmosphere and temperature are not known. These observations are in qualitative agreement with the decreased rate of vertical expansion of the piles.

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The neoprene seal strips at the top of the near and far sides of the F Pile were removed during November. The cork seal in back of the Third Safety Tanks at the F Pile was also removed.

Current estimates predict the general rupture of Van Stone flanges after 300,000 - 350,000 MD of pile operation if the rate of expansion is uniform.

The working model of the split gun-barrel has been completed but is being modified to provide a key to prevent the gun-barrel flange from rotating.

The proposal to replace a few tubes in operating piles, as discussed last month, has been modified in favor of more extensive work at the B Pile before moving to the D or F Piles.

Discussion

Laboratory Studies

Fowler compared expansion rates for test hole samples exposed under various conditions. X-ray studies on samples exposed in air-filled water-cooled (35-75° C.) test holes showed that the a_3 lattice spacing increased at a linear rate from a value of 6.70 Å initially to a value of 7.00 Å after an exposure of 820 MD/CT. However, the a_3 value for graphite exposed in an air-filled test hole at ambient pile temperature increased to 6.78 Å after an exposure of 300 MD/CT and to only 6.80 after 700 MD/CT. The temperature increased progressively from about 100 to 145°C. These data indicate a very pronounced decrease in rate of expansion at moderately high pile ambient temperatures. Extrapolation of the data to 1000 MD/CT indicates that crystal expansion at ambient pile temperature is only about one-third as great as that shown by samples from a cooled test hole. These data were reported by the Metallurgical Laboratory.

Similar results are shown by measurements of bulk graphite expansion. For samples in cooled tubes, the expansion was linear at an average rate of 0.60% per 1000 MD/CT when the test hole was air-filled (B Hole of D Pile) and 0.85% per 1000 MD/CT when helium filled (B Hole of F Pile). Expansion of samples exposed at ambient pile temperature was determined from annealing data at 1000°C. Samples from the D Hole of D Pile (air-filled, temperature increasing from 100 to 170°C.) showed only 0.17% after 921 MD/CT, and samples from No. 9 Thimble of D Pile (CO₂- and air-filled, temperature increasing from 100 to 150°C.) showed only 0.28% after 1054 MD/CT. The relative effectiveness of temperature and atmosphere on reducing the expansion is not known.

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These data are not absolutely conclusive, but they are in qualitative agreement with data on the vertical expansion of the D Pile. Eye level readings formerly indicated a rate of rise of the roof of about 0.10 in./mo. Since at least June 1946 the rate of rise of the top central tube has been about 0.06 in./mo.

It should be noted that samples from air-filled test holes at ambient pile temperature also showed abnormally low stored energy and change in thermal conductivity.

In the ninth meeting of this committee data were presented which indicated that annealing rates in an air atmosphere were considerably greater than those in a carbon dioxide atmosphere. Confirming data on the accelerating effect of an oxygen atmosphere have now been obtained using graphite from the No. 9 Thimble of the D Pile. When samples were annealed for 5.5 hours at 650°C. the percentage recovery of the expansion was only 69% in a pure helium atmosphere, but was 88% when the helium atmosphere contained 1.78% oxygen. Additional samples were oven-dried for several hours at 200°C., and were then annealed at 590-600°C. for 5.5 hours. In a pure helium atmosphere the expansion recovery was 53% and no weight change was noted. In the helium atmosphere with 1.78% oxygen the recovery was 60%, accompanied by a weight loss of 0.8%.

All the preceding data suggest that graphite expansion may be inhibited by use of an oxygen atmosphere in the pile. It is recognized that the possible loss of reactivity as a result of loss of graphite by oxidation is disadvantageous. It is planned to expose graphite samples in a dry process tube through which oxygen is passed. The committee stressed the necessity for obtaining precise data on any changes in mechanical strength of the graphite samples during this test. Concern was also expressed over the possibility of spalling of surface layers when large graphite blocks rather than small graphite samples are exposed to oxidizing atmospheres.

Bowing of Vertical Thimbles

Production Test No. 105-82-P provides for a bowing traverse of Tube 4454-D. The test work is scheduled for December 31, 1946. Based on the relative activity of tubes in the 24 and 44 rows, it is expected that the outward bowing of Tube 4454-D is only about 0.60 inches, as compared to 1.50 inches for Tube 2496-D. If the outward bowing of Tube 4404-D is significantly greater than 0.60 inches real concern will be felt over the possibility of bending or shearing of vertical thimbles at a point just below the cast iron blocks.

Trouble has been encountered with sticking of vertical safety rods. In particular, a rod which tests properly when the pile is

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cold may not drop when the pile is hot. The fact that the sticking occurs when the rod is clear out and hence when the tip of the rod is up inside of the rod guide, indicates that the trouble is not caused by thimble shearing from graphite expansion but is more probably the result of decreased clearance between the guide and the thermally hot rod tip.

Neoprene Seal Strips

The neoprene seal strips on both the near and far side of the F Pile were replaced during the extended shut down which started on November 4. The cork layer and the top row of cement blocks in back of the Third Safety Tanks were removed and the opening was covered with a strip of canvas cemented and clamped to the adjacent concrete roof and the side of the wall which faces the inner rod room. The only neoprene seal strip at the top of the side shields which has not yet been replaced is the seal at the top of the near side of the B Pile.

Various restrictions on access to the roof of the piles were inaugurated at the request of this committee because of hazards associated with possible rupture of taut neoprene seal strips on the far side of the piles. Now that the hazardous condition has been corrected the committee has no interest in a continuation of these restrictions.

Abnormal gas leaks were detected at the F Pile following the extended shutdown. These leaks originated between the steel base plate of the side shield on the near side and the underlying concrete. In spite of the coincidence, it is believed that removal of the cork from the top of the near side was not responsible for these leaks, for the micrometer brackets on the near side indicate that no abnormal motion of side shield was encountered. It is conceivable that tilting of the side shield could rupture the welded joint around the stud bolts in the base plate and cause gas leakage out between the base plate and the concrete, but measurements of the outward bowing of Tube 2451 and 2456 indicate that the far side of the D and F Piles and the near side of the D Pile are all in a condition more aggravated than the near side of the F Pile.

However, removal of the cork did cause a re-setting of the roof of the F Pile such that the near side of the top shield rose about 0.2 inches and apparently slipped about 0.04 inches toward the far side. Comparable changes of the roof of the D Pile were observed, the near side rising 0.1 inches and the apparent horizontal displacement toward the far side being 0.06 inches. It is reported that an additional 0.1 inch rise of the near side of the D Pile occurred during November only part of which is attributed to continued graphite expansion.

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Endwise Expansion of Pile Graphite

Tube 2174-F and 2284-F were replaced during the extended shut-down of the F Pile. Measurements of the length of the graphite layer exposed when the tubes were removed showed an endwise expansion of 28/32 and 23/32, respectively, as compared with an expansion of 20/32 inch observed for Tube 3671-B.

Difficulty with replacement of Tube 2284-F and anomalous results obtained from jacking tests at the B Pile caused reconsideration of the proposal to replace tubes in the D Pile, in favor of preliminary studies at the B Pile, as discussed below.

Lewis presented results of predictions of tube life as affected by endwise graphite expansion. Two different hypotheses are used for estimating purposes. By hypothesis A it is assumed that endwise expansion is caused by expansion of the crosswise graphite blocks between the process tubes, that the expansion occurs at a rate of 0.009 inches/1000 MD of pile operation as predicted from vertical expansion of pile, and that the abnormally low observed endwise expansion may be attributed to slippage between graphite layers. By hypothesis B it is assumed that no slippage occurs between layers and that the present apparent expansion rate since startup will continue indefinitely at a value of 0.006 in./1000 MD. The validity of these hypotheses should be revealed soon after duplicate jacking tests have been performed on tubes in the operating D Pile.

	<u>Hypothesis A</u>	<u>Hypothesis B</u>
Zero run-clearance in cold pile	255,000 MD	175,000 MD
Combined displacement of end shields	5/16-inch	
Rupture of Van Stone joints	340,000 MD	300,000 MD
Combined displacement of end shields	17/16-inch	

Details of these estimates will be presented in a forthcoming Interim Report for Production Test No. 105-52-P.

Gun-Barrel Binding

A working model of a split gun-barrel similar to that shown in Drawing No. H-1-435 attached to the minutes of the eighth meeting of this committee has been prepared. The model demonstrated that no key had been provided to prevent the gun-barrel flange from rotating and hence twisting the tube. This defect is to be corrected in a subsequent model.

Check readings on Van Stone flanges in the D Pile were made during November. The checks were not very satisfactory, possibly be-

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cause of using different equipment and a slightly different method than was used to obtain initial readings. These recent readings will now be taken as initial readings for future use.

A program of further study of tubes which had indicated binding in previous tests at B Pile was discussed by the committee. It is agreed that it is desirable to study the occurrence of binding at jacking forces high enough to endanger the Van Stone flanges. It is also agreed that rupture tests of process tubes after exposure in the unit would be necessary before stress-strain data obtained from new aluminum tubes and Van Stone flanges could be applied. It was brought out by Mr. Davis that if the split gun-barrel were used it is possible that galling or binding would occur between the gun-barrel and aluminum tube. Tests were therefore incorporated in the program whereby the aluminum tubes would be moved with respect to the gun-barrels and inspected for galling as they were removed. The advisability of studying the ability to replace tubes located high in the pile has been previously agreed upon, and the committee endorses initiating this study at the B Pile. The program as modified and indorsed by the committee is to be submitted as Supplement F of Production Test 105-52-P.

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