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14. H.A. Fowler
15. S.F. Schure - C.W. Hay
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October 7, 1946 21A

GRAPHITE EXPANSION COMMITTEE
MEETING OF OCTOBER 4, 1946

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The tenth meeting of this committee was held on October 4, 1946. There has been an almost complete turnover of personnel since the previous meeting on August 2, 1946. The committee now consists of the following men:

H. A. Fowler 1956

P. F. Gast

C. W. Hay

E. Hilgeman

J. H. Warren

W. K. Woods, Chairman

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The tenth meeting of the committee was attended by all the above members and by Messrs. S. S. Jones, W. R. Lewis, and R. A. Rohrbaucher.

Summary

Recent data show that test hole samples out from the center of a bar show greater expansion rates than do samples out from the edge of a bar. The previously noticed irregularities in expansion of test hole samples are attributed to this phenomenon. For unexplained reasons, the

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expansion of the graphite piles is in close agreement with the smaller expansion rates shown by test hole samples rather than with the larger rates.

It is recommended that the neoprene seal on the far side of the F pile be replaced before the end of the year.

It is recommended that the neoprene seal on the near side of the D Pile be replaced after replacement neoprene is on hand. It is recommended that the compressed cork and about 4 inches of the cement block wall in back of the Third Safety Tanks at the D Pile be removed at the time of replacement of the neoprene seal, and that the resulting gap be covered with a flexible air-impermeable membrane such as rubberized canvas.

Actual measurement of the length of graphite between the gun barrels of Tube 3671-B confirms the predicted end-wise expansion of the graphite as deduced from jacking tests on this tube assembly. This technique, which involves tube removal, is viewed with favor as a superior way to determine end-wise expansion in cases where the jacking tests indicate anomalous expansion.

Initial tests on the plug device used for monitoring Van Stone flanges have demonstrated that the equipment has satisfactory speed and precision. Lock-up studies on a few Van Stone flanges indicate that a flange can be stretched as much as 0.05 inches before rupture occurs. Further tests are in progress.

Discussion

Laboratory Studies

A test-hole sample which had been cut transversely from the center of a graphite bar showed an expansion of 0.18% after an exposure of 188 MW-days /central ton (MD/CT) of metal. Another sample which had been cut transversely from the edge of a graphite bar showed an expansion of only 0.14% after the same exposure. These results indicate that there is a variation in the extent of crystal orientation in various portions of the extruded graphite bar. This phenomenon would tend to produce cracks even in blocks which do not carry process tubes.

As noted in the minutes of the ninth meeting of the committee, duplicate samples have shown 0.60% expansion in one case and 0.77% expansion in the other case, after an exposure of 1007 MD/CT. It is now believed that the first sample had probably been cut from the outer portion of a bar while the second sample had probably been cut from the central part of a bar.

The samples which had been exposed for 1007 MD/CT would have ex-

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panded only 0.11% and 0.14%, respectively, after an exposure of 188 MD/CT if the expansion were proportional to the exposure. The fact that these values are somewhat lower than the observed expansion after the short exposure, suggests some small tendency toward decreased expansion rates after long exposures.

In the Interim Report No. 1 on Production Test No. 105-48-P (Doc. 7-3747) it was noted that there was close agreement between the observed vertical bowing (1.69 inches) of Tube 4574-B on March 7, 1946, and the predicted vertical bowing (1.67 inches). However, the predicted bowing was based on test hole results of 0.52% after 836 MD/CT, equivalent to 0.63% after 1007 MD/CT. Now that the reported value of 0.77% after 1007 MD/CT is viewed with less suspicion, one would have predicted a vertical bowing of 2.05 inches, a value which agrees less satisfactorily with the observed expansion of the pile graphite.

The laboratory studies for the following month are to be concentrated primarily on the annealing of exposed graphite samples at various temperatures in a helium atmosphere containing various amounts of oxygen. Crushing strengths will be determined for the annealed samples. These data are needed before any attempt is made to anneal a pile, for it is known that in an air atmosphere at high temperature the graphite is weakened to such an extent that it crumbles when lifted with forceps. The data will also be of value as an indication of the possibility of selective oxidation of displaced carbon atoms, and hence of the possibility of inhibiting expansion by use of an oxygen-containing atmosphere in an operating pile. The latter application of the data will be of more immediate interest to this committee.

Since the expansion of graphite crystals, as indicated by X-ray measurements, is considerably greater than the bulk expansion of extruded graphite it is concluded that exposure in the pile probably results in a decrease in the void space in the bar. The fact that both expansions have been approximately linear with exposure appears fortuitous. Further study of this phenomenon is to be made by actual determination of the void volume.

It was suggested that confirming data regarding the variation in crystal orientation within a bar might be obtained from annealing tests on graphite samples cut from the track of the replaced No. 9 Thimble of the D Pile.

Bowing of Vertical Thimble

The outward expansion of the graphite produces bowing of the vertical thimbles but this bowing is not considered serious. However, it is conceivable that graphite at the top of the pile might be dragged outward by expansion of the underlying graphite and that the thimbles might shear at a point just below the thermal blocks. This problem was considered previously during the seventh meeting of the committee. It is now

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proposed that No. 27 Thimble at D be borescoped during the extended shut-down in October, 1946, in an attempt to detect any sign of thimble shearing.

As a suitable tube, such as Tube 4491, in the upper far corner of the pile comes up for normal discharge it would be of interest to traverse the tube for horizontal bowing. This test would be of value either as an indication of whether thimble examination was required or as a follow-up on observed thimble deformation.

Neoprene Seal Strips

The neoprene seal on the far side of both the E and D Piles has already been replaced. The neoprene seal on the far side at F has now become taut and it is recommended that this seal be replaced before the end of this year. Replacement neoprene is on hand.

The neoprene seal on the near side of the D Pile has been pulled taut and early replacement is indicated. Replacement neoprene for this seal is on order and should arrive before the extended shut-down scheduled for D Area during the middle of October. Although the near seal at D seems more taut than the far seal at F, it is felt that the single strip of neoprene now on hand should be reserved for F, for the rate of stretching is probably greater at F. The seal on the near side at F will presumably need replacement eventually; detailed inspection will be made after the near seal at D has been replaced.

The intended replacement of the near seal at D forces consideration of the advisability of removing the cork from between the near side of the top of the E Pile and the concrete shelf in back of the Third Safety Tanks. This problem was considered during the eighth meeting of the committee without reaching a decision. We have not been able to prove that leaving the cork in place will definitely be detrimental. However, we do believe that removal of the cork at the time of replacement of the near seal at D can not do any harm and may forestall future unforeseen trouble. Since the cork no longer provides a flexible joint, removal of the cork will permit a return to the original design condition.

The cork is now only about 3/4 inch thick at the center of the side, compared to about 2 inches thick at the ends. Removal of the cork may result in a swinging of the roof to a balanced position, further decreasing the clearance. Hence, it is recommended that in addition to the cork about 4 inches of the underlying cement block wall should be removed, and that the gas seal between the top of the pile and the inner rod room be retained by cementing a strip of rubberized canvas across the gap. C. W. Hay will study the practicability of such a seal, using test strips.

Consideration was given to the advisability of installing additional instrumentation for measuring the outward displacement of the top of the

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near side shield. It was decided that this information was not sufficiently important to justify installing permanent scaffolding for reading micrometer brackets nor to warrant installation of remotely indicating devices.

Endwise Expansion of Pile Graphite - Jacking Tests

The relationship between observed gun barrel clearance and endwise graphite expansion is not well established. The clearances for the top tubes are a little smaller than those for the central tubes; this suggests that the top graphite has been dragged outward a little farther than the expansion of the underlying graphite. The clearances for the bottom tubes are only slightly greater than for the central tubes; this suggests that the bottom graphite has expanded 40%-50% as much as the central graphite. Neither of these suggestions is reasonable.

Jacking tests on Tube 3671-B showed a sum-clearance of $5/8$ inch, which indicates a graphite expansion of $5/8$ inch by difference from the original design clearance of $10/8$ inch. This value of the apparent graphite expansion is based on assumptions that (a) the actual length of the gun barrels is equal to the nominal length, although some gun barrels were refaced, (b) the actual length of the aluminum tube was so long that it would shrink to nominal length at a temperature of 6°C ., although the tube temperature at the time of installation is not known, and (c) the tube length at a given temperature has not changed with extended service. Recently, however, Tube 3671-B was removed and an accurate measurement was made of the length of the graphite between the ends of the gun barrels. The observed length was $5/8$ inch greater than that shown by instruction records, confirming the estimate obtained from jacking tests.

The committee would be interested in removing a few process tubes and measuring the length of the graphite in order to evaluate more extensively the relation between sum clearance and graphite expansion. In particular, it is proposed to replace Tubes 0174-D and 4674-D (currently filled with dummy slugs) and to replace one of the more active process tubes in the center of the D Pile as it comes up for normal discharge. J. H. Warren will investigate the feasibility of such proposals from the standpoint of the P Department.

Resumption of the push-pull program at the B Pile to investigate further the frequency and location of gun barrel binding is scheduled for the coming month.

Endwise Expansion - Monitoring of Van Stone Flanges

Because of the slow expansion of the graphite it seems possible that one might detect incipient tube failure before actual rupture occurred. Because of the ample sum-clearances for most of the tubes as shown by jacking tests, the only tubes which might fail in the next six months would be those containing two stuck gun barrels. Hence, initial measurements have been made on both Van Stone joints of twelve process tubes at

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the D Pile, including all known tubes which had limited observed motion during recharging or which had evidenced gun barrel binding during jacking tests.

It is then necessary to obtain data from mock-up assemblies which can be used to specify the frequency with which tubes should be monitored and the permissible distortion of the Van Stone flanges before taking corrective action. Two alternative measuring devices are used; the optical device measures the distance from a scratch mark in the tube to a reference location in the nozzle, the plug device measures the distance from the ends of the ribs to the end of the nozzle. The plug device has proven more accurate and much more rapid to use. Recent tests involving 28 readings on 10 tubes at B by 3 different men showed an average deviation of 0.003 inches between successive readings with a maximum deviation of 0.008 inches. If the spring-loaded plug gage is not removed between successive readings, as is usually the case during mock-up tests, measurements are reproducible to within 0.001 inches.

Tests now in progress show that an annealed Van Stone joint undergoes a permanent stretch of 0.003" after being subjected to a load of 2500 lbs. for 24 hrs., and a total permanent stretch of 0.010" under a load of 3000 lbs. for an additional 24 hr. period. Previous tests involving loads applied for brief time intervals had indicated that Van Stone joints would stretch as much as 0.050" before rupturing.

Auxiliary studies could involve the use of resistance wire strain gages to follow compression stresses in gun barrels caused by tensile stresses in tubes. Preliminary studies had indicated that temperature effects would mask the compression effects in the discharge gun barrels during pile transients. There is renewed interest in this study and Hilgeman was advised of the availability of personnel in Schenectady as experts on strain gage technique.

In the event of the development of danger signals, corrective measures as now contemplated would involve splitting one of the gun barrels and affixing a slip joint as shown in the print attached to the minutes of the eighth meeting of the committee. C. W. Hay was asked to prepare a working model of a split gun barrel for use in mechanical studies of its operability.

General

The next meeting of the committee is scheduled for November 1, 1946.

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W. K. Woods

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