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TECHNICAL ACTIVITIES REPORT

MECHANICAL DEVELOPMENT STUDIES

by

W. K. Alexander
Pile Engineering Sub-Unit
Pile Technology Unit

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CG-PR-2, 4-9-92
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May 1, 1952

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I. PILE CONTROLA. HORIZONTAL ROD GLAND SEAL; TEST #64 - R. E. Johnson

A rough draft of the final report on this test has been completed and is being circulated for approvals. Sketches to accompany the report are being drafted.

The corrosive effect of the aluminum-graphite electrolytic couple set up in the C-File Horizontal Rod gland seal, is shown in Figure 1. The total accumulative exposure time through several months of intermittent operation is estimated as one month.

B. HORIZONTAL ROD MOCK-UP; TEST #65 - R. E. Johnson

The past month has been spent carrying out Acceptance Test No. 1137. The following alterations and additions have been made to the mock-up:

1. The step plug had to be reset to give a proper vertical clearance.
2. Graphite tip shield inserts had to be fabricated.
3. An inlet water pressure gauge had to be installed.
4. The rod guides had to be reset to give clearance for rod thermal expansion.
5. Graphite seal glands obtained from 100-C stock had to be shortened and enlarged to fit seal and rod respectively.
6. A selsyn transmitter for the small indicator hand had to be set and wired.
7. A variable resistor acting as a thyrite substitute had to be adjusted to completely absorb the discharge from the amplidyne circuit to prevent amplidyne current fluctuation being transferred to the selsyn circuit. This transfer of surge current to the selsyn circuit is possible because of a single transformer supply to both circuits. This is a test condition and is not possible in 100-C electrical circuits.

The following observations were made during the completed Acceptance Test procedure:

1. The rod when unpressurized has approximately a .040 inch horizontal bend in the first ten feet of the tip end.
2. The end cap of the rod was loose enough to cause leakage at 60# inlet pressure.
3. Several scratches have occurred on the rod. They have probably been caused by the presence of foreign particles in the close fits of the seal and step plug.

For protection against contamination the adjacent laboratory area will be thoroughly cleaned and a protective cover for the rod will be constructed. A guard rope will be placed the length of the rod and drive to protect both the rod and personnel.

The Acceptance Test is complete except for speed and limit switch checks and several trial runs. Painting will be completed afterward. The motor-generator set will be installed on arrival in June.

A functional test with 105-C startup conditions will be performed first. The requested electrical data with the aid of Electrical Maintenance will be obtained secondly. The tests under conditions of graphite growth will then be performed.

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FIGURE 1

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In case an in-pile test of the C rod control strength should become necessary, a rough draft of a proposed production test¹ has been issued.

C. HORIZONTAL ROD GAS SEALS - R. E. Johnson

The teflon chevron rings were received and were tested immediately. After several hundred cycles of operation considerable frictional heat was generated indicating insufficient lubrication. Shortly thereafter, severe galling occurred. It appears that either an added lubricant or a greater bearing hardness differential will have to be utilized to effectively use teflon as a seal. A gas seal was not made but this undoubtedly could be corrected by adjusting the spring pressure upon the rings and by running the rod until the seal seated properly.

A study has been initiated to determine whether or not a seal can be developed for a rectangular rod. Recommendations are being sought from the United States Gasket Company and the United States Graphite Company.

D. HORIZONTAL ROD CONVERSION - PRESENT PILES - J. M. Roberts

As originally planned the design has a two-fold purpose. First, the removal of the thimbles which absorb reactivity and present a serious maintenance problem in the older piles because of frequent ruptures. Second, the development of a more flexible, stronger neutron absorbing rod, which would be more operable in the distorted graphite channels.

Tentative designs call for the replacement of the present thimble with an external thimble placed between the pile face and the barricade wall with a seal at the latter. The seal operates with an oil lubricant on the inactive rear section of the rod which is made of steel.

This approach to the thimble removal complicates the rack drive mechanism which must now be run on separate elevated guides above the rod guides. In the inner rod room the rack passes above and is guided along the top of the external thimble. Some considerations to simplify the drive mechanism have consisted of screw drives, conveyor belt drives, and friction drives. However, each system has one or a multitude of faults which rule out its use. The friction drive similar to the one proposed for the Vertical Control Rod (See test reports for Process Design Engineering Projects 41 and 42) seems most promising. This drive has a range from 0.01 ft/sec to 1.0 ft/sec which provides the proper speeds for all conditions except scram. In the vertical rod installation the rod weight caused the rod to inch through the mechanism. This difficulty would be removed on the horizontal installation. Two problems remain to be answered, however. These are:

1. Can a scram be incorporated in the design?
2. Will the oil on the rod from the oil lubricated seal make the friction rollers slip before 760 pounds of thrust is produced?

1. "Secret Rough Draft of Production Test #105-512-A" by R. E. Johnson, HW-23828, April 9, 1952.

These questions will be investigated further.

The reasons for making the rod more flexible by dovetailing two segments together and by designing a flexible step-plug have been given a critical review during the past month. Since the graphite growth is additive throughout the height of the pile, the upper three rod holes—A, 2 and B—should have much more distortion than the middle three or the lower three. If the graphite distortion is jamming the rods, then the trouble should be frequent at the upper levels, and in turn, the lower rods should run trouble free. The fact is that rods stick at all levels, quite indiscriminately. Some of the first occurrences were in the upper levels and the blame was placed on graphite growth at that time. It was found however, that by replacing the graphite tracks satisfactory service was restored, even at the upper levels, and in spite of the growth. In replacing the track considerable dirt and graphite was removed. This was used as an explanation for the sudden improved performance. It hardly seems possible that a 1 1/2 inch deflection at 8 feet (worst condition) could generate a 750 pound friction force on a rod as limber as the present ones. In light of these facts it appears that the graphite track itself is the main trouble-maker. Traverses of the track before removal have usually shown hills and hollows with abrupt crests (Document # 7-3987). One explanation was given that the blocks expanded longitudinally against fixed ends. Another is that dirt and graphite dust collects under the blocks and raises them. Still another contributing factor may be the thermal curling induced when a cool rod lies on the top of the heated track. The end result seems to be that the rod is forced against the top of the thimble (one quarter inch clearance) causing the rod to jam. By removing the thimble and the track, not only will the principle cause of jamming be removed, but a large portion of the total graphite growth under the rod will be negated. The thimble and track raise the rod roughly an inch above the bottom of the hole. This represents a relief in all holes of one inch. Future tests on the horizontal rod mock-up will answer the question of how flexible a rod must be under graphite distortion. In the meantime work will proceed on a design for a less expensive one piece rod with more boron and a fair degree of flexibility.

A question also arose as to the condition of the thin spacer blocks in the bottom of the rod track under the thimble. They may be broken and chipped from surrounding graphite pressure. Two unsuccessful attempts were made to boroscope the number 8 hole in D-Pile after the old thimble was removed. Other attempts will be made as the opportunity arises.

An effective seal which would work at the pile face would simplify the conversion enormously. One idea for a seal was to use a light fitting rubber washer with a slightly undersize hole which would have slight value as a seal but would separate the pile gas from the atmosphere. This is illustrated in Figure 2. If the pressures on both sides of the washer were then equalized, a seal would be effected. This could be done by feeding compressed air through a diaphragm equalizer to the outer side of the washer. The air would leak out through a graphite bearing into the inner rod room. The pile gas pressure would operate the equalizer. The objection has been raised that fluctuations in the air line might force air past the seal into the pile if the equalizer were not operating properly. It is expected that the pressure could be balanced to within one quarter inch of water but the valve might jam open and load the pile with air. More thought will be given to this problem.

FIGURE 2

E. BALL 3X - PRESENT PILES - P. M. Jackson

The months work on the Ball 3X sphincter seals is described in detail under Section I - G, titled Sphincter Seal and Lubrication on V.S.R. Drop Time; Test No. 72.

The Ball 3X vertical rod hole seam filler device was completed and tests were started. A graphite stack was set up with several simulated seams and after several minor changes in the seam filler the cracks were able to be located very accurately with this device.

Difficulties have been encountered with the equipment however in that the compound of sodium silicate (water glass) and graphite powder would not pass through the

check valve (Drawing # H-1-3359). Changes are being made in order to increase the flow area so that the mixture will pass into the piston and then out into the seams.

A floating piston may have to be added to the top of the cylinder holding the filler mixture so that the sodium silicate will not be forced from the mixture by the air pressure.

Testing and modifications are continuing in the 189-D laboratory with the assistance of Project Engineering.

F. FUNCTIONAL TEST OF C PILE V.S. RODS AND BALL 3X SYSTEM; TEST #67 - C. D. Emmons

The preliminary shock strut tests have been completed at the White Bluffs Test Tower. Tests were being performed to determine the correct size orifice required to allow the shock absorbers to effectively stop a free falling C-Pile rod in 6 inches of deceleration travel. A weighted DR rod equivalent to that of C-Pile was used in these tests.

A variable type orifice is required which is obtained by using a constant area hole and a metering pin. As the bumper block is forced down, the cross-sectional area of the hole is decreased by allowing a rigidly fixed tapered pin to cut off the available opening through which the hydraulic oil passes. The dimensions of the orifice and the metering pin are shown in Figure 3. A deceleration displacement curve is shown in Figure 4. The tests will again be repeated to verify these results obtained upon receiving a C-Rod.

A new air valve (Schrader No. AN-6287-1) for the shock absorbers has been obtained, and it was found to operate very satisfactorily.

The graphite stack in the test tower has been re-stacked and aligned preparatory for future C-Pile Ball 3X and V.S. Rod Drop Tests.

G. EFFECT OF SPHINCTER SEAL AND LUBRICATION ON V.S.R. DROP TIME; TEST #72 -
P. M. Jackson

During the last shutdown of D-Pile (April 8, 1952) a molded "C" type sphincter seal and new housing were installed. These seals were a special order for test purposes and were equal to the C-DR-H type seals (Drawing # P-8358) with the exception that they have all diametral dimensions decreased three-fourths of an inch in order to fit the 2 1/4 diameter B, D, and F Vertical Safety Rods. The housing was made similar to the C type housings with provisions to fit No. 20-D step-plug.

The seal was installed and several drops were made. The times were not secured because the timing apparatus did not function properly. During the drops the seal seemed to function quite well and no rod binding was evident. The seal was left pressurized with three feet of water.

After pile startup an excessive gas leakage was found to exist either through the seal or the seal housing. During the poison push permatex was applied to the threads holding the housing to the step-plug and also to the under side of the gas tight weld. This did not seal the gas leak so preparations were made to pour parafin around the inside of the seal housing where the leak was believed

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C PILE SHOCK ABSORBER
METERING PIN
FOR VARIABLE AREA ORIFICE

FIGURE 3

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C PILE SHOCK ABSORBER
TIME DISPLACEMENT CURVE
USING METERING PIN FOR
VARIABLE AREA ORIFICE

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FIGURE 7

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to be. After two applications of parafin the leakage decreased to a reasonable amount which proved the housing and not the seal had been leaking. The water pressure on the seal was increased to 6 feet.

On April 16, a R.M.U. check on the top of the unit showed the presence of fast neutrons in the vicinity of V.S.R. 20-D. Several possibilities for this neutron beam exist and a thorough study is being made to determine the cause. There is the possibility of having a short rod which would give insufficient shielding. All cases will be investigated during the next shutdown (May 5) at D Unit.

A "C" type seal bound up and prevented the rod from dropping after 12 successful drops. Inspection of the seal after its binding showed that the lubricant (Molykote) seemed to have been carried away thus leaving portions of the seal unlubricated. An "O" ring lubricator was added to the top of the housing used at the tower. This consisted of two "O" rings with a groove filled with Molykote between. As the rod moved up or down the lubricant was wiped on the rod. Twenty-five consecutive free drops were made without any binding of the rod and the drop times averaged the same as a free drop without a seal attached (1.36 sec). The seal was examined and found to be in very good condition. Several notches had been made in the "O" rings; however they were not damaged sufficiently to impair their use as wipers. The rod at the test tower is in very poor condition after the numerous free drops made for shock strut testing so even better results should be obtained from a new rod.

Another type lubricator was added to a new sealing boot at the test tower. This lubricator was a piece of carpeting which had a small quantity of Molykote rubbed into the nap. As the rod moved through the wiper, a small amount of lubricant was added to the rod. Fifty power drops through the seal were made and examination showed that the seal was in very good condition and was very well lubricated. There was considerable lubricant left in the nap of the carpeting after these drops indicating that many more drops could be possible without experiencing trouble. A wiper ring of this type is currently being designed by Project Engineering for use on the present piles.

Pressure testing was run on the BDF seal in 189-D and results showed that no leakage will take place in either the seal or the housing. This seal will be installed along with the fabric wiper mentioned above during the next shutdown at D.

A "C" type sphincter seal housing has just arrived. It will be used in testing the three sizes of sealing boots ordered by Process Engineering as soon as the new "C" V.S.R. is installed at the test tower where this testing will be conducted. A wiper ring is undergoing investigation by the Process Engineering Unit for installation with the C-Pile sphincter seals.

H. INK FACILITY - J. M. Roberts

A one tube ink facility of the type outlined in HW-19420 is to be installed in tube # 2388 in DR-Pile. It was decided that since the Pile Physics group will be running the functional test they should prepare the Production Test. The Mechanical Development group will check the mechanical operation of the equipment and follow the installation.

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L. E. Bishop of Project Engineering Unit called an initial meeting on April 11, of all parties directly concerned with the installation of the test facility. Represented were Power and Maintenance Unit, Project Engineering Unit and Pile Technology Unit. It was pointed out that the actual installation, which was to be accomplished during the extended ball third safety system installation shutdown, may not be able to muster sufficient manpower at that time. Consequently, it may be necessary to do this work in a piecemeal manner.

There will be a 20 week delay on the instruments from the Foxboro Instrument Company which will probably move the completion date to October or November. There seems to be no apparent way of expediting the order to give a more favorable delivery date.

Radiation Monitoring Unit has requested that the solution from the ink facility be tanked after use instead of running it into the retention basin with the pile effluent water. This tank will very likely be a permanent fixture unless it is found during operation that the decay is such that it can be dumped in the effluent. It is estimated that two 500 gallon tanks are sufficient for one year of operation, after which one of the tanks will have decayed enough to empty.

The instrument panel was moved to a position opposite from the control console at the request of the Operations Unit. This will make the controls more accessible to the operator and free the previous space for thermocouple instruments.

J. HIGH PRESSURE GAS SEAL - R. C. Lovington

In conjunction with a contemplated investigation of the possibility of pile control utilizing a variable pressure gas system, a study is being made of the design of a high pressure gas seal. Considerable operating difficulty has been encountered with the present neoprene expansion joint seals as a result of pile movement, and it is hoped that a new design will eliminate some of the problems.

K. CONTROL STUDY - J. M. Roberts

Several systems are being investigated as possible replacements for the horizontal rod type control. They are as follows:

1. Ink Facility - Movable Pistons

This system proposes to use solution concentration for shim control and opposed movable pistons for regulating control. At the same time, considerable flattening control is available since the poison column is held symmetrically in the center of the pile. Unfortunately graphite growth and corrosion would probably restrict the pistons in time, making this system somewhat unreliable.

2. Ink Facility - Water Dilution

This system uses full strength ink which is introduced from each side of the pile through small tubes with ends located at the center of the pie. Surrounding this is a larger tube which holds the full ink column and provides a mixing chamber for the dilution water. The dilution water is introduced through five orifices in another small tube surrounding the concentrated ink tube. Regulating control is maintained by varying the

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dilution water pressure. Shim control is established by changing the concentration of the incoming concentrated ink. The orifice holes are located along the water annulus in such a fashion that the concentration is weak at each end and strong in the middle for longitudinal type flattening in each control rod. Graphite distortion will not effect this system since there are no moving parts, but the control at its weakest strength is still a full column of water which is a disadvantage over system number 1 above. This type system is illustrated in Figure 5.

FIGURE 5

3. Ink Facility - Gas Dilution

If CO₂ gas is substituted for water in system number 2 above then zero strength would be a column of CO₂ gas. Some doubt exists as to the reliability of such a system since the bubbles might form in an erratic manner causing locally fluctuating control in the pile.

4. BF₃ Gas System

It is estimated that at 400 psi BF₃ in a process tube would give the same boron concentration as the presently planned 10% potassium tetraborate solution. By using enriched B¹⁰ the pressure could be reduced to about 75 psi. Both shim and regulating control would be handled by varying the pressures. The system would consist of a pressure tank regulating valve, control tube, and an evacuation pump for the tube. Thus instead of pressurizing for control the tube will be evacuated for control. In this way failure of the pump would result in an automatic scram. The tube could be built with varying diameters, large in the center, small at the ends, for longitudinal flattening.

Two difficulties with this system are the possibility of corrosion of BF₃ on aluminum, and the possibility of losing BF₃ through a sudden rupture. However, if each tube was a separate pressure unit the loss of one could be compensated with the others. The corrosion problem is unknown except when water is present in the system, and this condition is not permissible. The BF₃ must be introduced absolutely dry and must be maintained dry. The hydrides of boron were investigated as an alternative gas for the system but were abandoned because they are unstable chemically. The BF₃ system is very promising. It would be free of graphite growth problems and would have a full range of control without distortion of the flux distribution. Also, it would lend itself readily to automatic control since the only variable would be the pressure in each control tube.

5. Pile Gas - Pressurized

No work has been done on this system as yet. The idea is to use the pile gas itself as a control by pressurizing the entire pile. This becomes a combination sealing and structural problem which will likely rule out its use. However, the idea is sound and will be given some consideration.

It might be pointed out that the solution type controls have an advantage over the gas type controls since they can be used for manufacturing by-product by using selected absorbers.

L. BALL 3X GRAPHITE SLOT EROSION - C. D. Emmons

The C-Pile vertical stack mock-up was disassembled and photographs were taken to show the amount of graphite erosion that had taken place after a full charge of steel balls had been dropped through the stack 100 times. The depth of the most severe damage observed of 13/64 inches (Figure 6) was located in layers 96 and 97. This erosion took place on the wall opposite the inclined opening through which the balls enter the stack.

The location of this damage on the C-Pile design would be outside the process tube region. If the vertical safety rods were eliminated from future pile designs, then this damage would not exist for the balls would very likely be dropped directly into the graphite slots.

The rate of graphite erosion is increased when the blocks have beveled edges or when they are next to undercut blocks as seen in Figure 7. The ball flow has dented the graphite surface as noted from the vertical lines along the corners

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FIGURE 6

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FIGURE 7

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of the graphite slot. Figure 8 indicates the results of scribe markings on a graphite surface when subjected to the ball flow. The result is an increased rate of damage. Note that not much damage occurred between these blocks since the beveled edge was not present.

The amount of graphite worn away due to the chamfered and undercut blocks, amounted to 5/6 of the total volume of graphite lost. Approximately 14 grams of graphite was lost per ball drop in the graphite stack C-Pile mock-up.

II. SHIELDING

A. BROOKHAVEN CONCRETE WATER RETENTION TEST - R. C. Lovington

The special samples for testing the water retention characteristics of Brookhaven concrete completed the 28-day curing period the early part of this month and were placed in the oven for testing. A testing temperature of 125°C. was prescribed for the tests by the Shielding group, but some difficulty was encountered in initially stabilizing at this temperature. The variation was due to faulty and inadequate equipment, which has since been adjusted for optimum performance. In regard to this, two automatically controlled furnaces of much higher capacity have been obtained from the P-10 Project, and will be installed for use on a more extensive concrete water-retention program.

The initial results from the present samples, show that of an added water content of 4.82 percent by weight, approximately 4.00 percent has already been driven off. These figures do not include the water which was in combination with the limonite when the batch was mixed. A determination as to the amount of water which was added in this way is being made.

B. X-LEVEL SHIELD FACILITY - G. E. Wade

The purpose of this project is to devise a method of charging and discharging samples from the "B" and "D" test holes that will overcome present difficulties encountered in using the gatling gun.

The primary disadvantage of the gatling gun is that it is extremely difficult to align with the test sample tube. A slight misalignment can cause galling of the aluminum samples with resultant damage to the test sample tube and seals. The gatling gun must be entirely realigned whenever it is removed for maintenance of the test hole facility.

Radiation leaks between the present gatling gun and the test facility is a disadvantage requiring additional shielding to be placed around the gun. This shielding must be partially removed for operation of the gatling gun, thus entailing much extra work.

Another difficult task with present equipment is the transferring of all samples from the gatling gun to a shipping cask. With samples that are very "hot" this requires that the cask be aligned with the gatling gun. None of this transferring operation or the charging or discharging samples, can be observed. This means lost time when "something goes wrong", as it frequently does.

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FIGURE 8

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The idea of a movable shield has been investigated but found impractical. The weight of the shield and space requirements for its storage when not in use are factors against its use. A shield similar to the present gatling gun, employing a lead glass window for observation purposes and requiring less critical alignment is now under consideration. However, this type of shield is still in the "talking stage".

C. AGGREGATE SURVEY - R. C. Lovington

Various experiment stations, universities, government agencies, and mining companies throughout the United States were contacted regarding materials in their particular area which might be used as heavy aggregates for concrete shielding. Replies to these requests for information at first produced several promising leads, but further investigation revealed the materials to be inferior in abundance, availability, and specific weight as compared to magnetite and limonite. The minerals pyrrhotite and marcasite are discarded in the tailings from several mines and appeared to offer good possibility as aggregates, until it was determined that they oxidize readily and thus prevent good bond formation. The aggregate survey will continue as additional sources of information are uncovered.

III. PROCESS TUBE ASSEMBLY

A. CREEP TESTS - ALUMINUM PROCESS TUBES; TEST NO. 8⁴ - C. D. Emmons

A final report on the 400 pound aluminum process tube creep test¹ has been prepared and issued. It was found that a very minor amount of circumferential creep took place, on the order of 2 mils over a 10,200 hour period.

B. CREEP TESTS - ZIRCONIUM TUBES; TEST NO. 46 - C. D. Emmons

The zirconium creep test is nearing completion. The internally applied pressures of 400 and 600 psi were gradually reduced to zero and the changes in circumference were recorded. This caused only a slight change in the gauge readings which averaged approximately 0.0005 inches. The temperature of the system will be brought from 100°C to room temperature and then a final report will be written.

C. PIGTAIL FLEXURE TEST; TEST NO. 54 - R. E. Schilson

Because of the extensive number of pigtail designs for several development programs, tests in the future will be classified according to the programs in which they originate. The sub-divisions are: 1. Pigtails tested in the past for the C-File program. 2. Pigtails to be tested for the RDA-DC-3 program. 3. DR and H replacement pigtails. A final report will be issued for each of these sub-divisions. No tests were conducted during April because the hydraulic jack was employed for the "Process Tube Assembly Distortion Tests - Present Piles" at the 305-A Building.

1. "Radial Creep Test On Aluminum Process Tubing; Test No. 8" by C. D. Emmons, HW-24236, April 25, 1952.

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Two double loop inlet stainless steel pigtails, one of 3/4 inch diameter and the other 7/8 inch diameter, (Drawing # SK-1-20032) for the RDA-DC-3 program were obtained during the month. These pigtails, as well as the 1-inch pigtail obtained earlier, will be tested when the testing machine is again available. An order has been placed off site by Project Engineering for DR and H replacement pigtails of 3/4, 7/8 and 1 inch 2S aluminum. Drafting of necessary modifications to the testing machine is now underway. The replacement pigtails will be tested as soon as they are received and the testing machine is available.

D. EFFECT OF PROCESS TUBE RIB SPACING AND WIDTH - R. V. Dulin

Drawings of the proposed test set-up have been completed and issued. (SK-1-968, H-5-625). Construction work will start as soon as the 305-A Building Process Tube Distortion Tests are completed.

E. TAPER BORE GUNBARREL DEFLECTION TEST: TEST NO. 73 - R. E. Schilson

All errors in fabrication of the taper bore test assembly have been corrected. Assembly of the test equipment is now underway, and, upon completion, the test will begin on the taper bore gunbarrels.

Tests will be conducted to determine deflection curves of the gunbarrels when the graphite entry block is sloped approximately 1/4, 1/2, 3/4 and 1 inch per foot and is positioned 0.100 inches above, 0.100 below, and in-line with the B block hole. A restraining load of approximately 870 pounds (Row 58 load) will be applied with a dynamometer on the thermal shield side of the graphite block. A dial indicator assembly (Drawing SK-1-20024) will be used to measure the gunbarrel deflection at 2 inch intervals. In addition, the following information will be obtained:

1. The maximum diameter of a 4 inch probe that can pass through the process tube.
2. The force on the tube block due to the thermal blocks and gunbarrel.
3. The vertical rise of the graphite on the thermal shield side.

F. PROCESS TUBE DISTORTION TESTS - PRESENT PILES - G. E. Wade - R. V. Dulin

During April all necessary test equipment arrived in the 300 Area. After checking the equipment, testing started as outlined in the Test Memorandum.¹

Briefly the purpose of the test is to study the limits of graphite growth and the resultant gunbarrel and process tube distortions that will prevent the charging and discharging of slugs. The possible limiting effects of graphite growth to be investigated are:

1. Bending of the process tube at the male-female junction between two graphite tube blocks.
2. Bending of the process tube at the junction of a fracture in a graphite tube block.
3. Bending of the process tube in the gunbarrel.
4. Fracture of the graphite entry blocks near the end of the gunbarrel.
5. Bending or crimping of the process tubes at the end of the gunbarrel after fracture of the entry block by the gunbarrel.

1. "Proposed Study of Process Tube Distortion Limits for B, D, and F Piles" by G. E. Wade, HW-23458, February 21, 1952.

6. Elastic failure of the gunbarrels due to excessive deflection.
7. Inability to remove or replace gunbarrels.
8. Inability to remove or replace process tubes.

All of the limits mentioned above are, of course, interrelated and their accurate prediction is impossible. Besides, graphite growth affects the graphite bore thus changing many values. This is especially evident in data regarding process tube removal and replacement (limit 8). In data taken to date on conditions similar to those in present operating piles forces to 1500 pounds have been used to remove and replace the tubes. Much higher forces are often experienced in the piles. The difference is attributed to changes in the graphite bores. This change has been measured in some cases and may be due to creep or corrosion products.

A new method of tube replacement has been used in these tests. The tubes have been pulled into the pile with a winch and mandrel. The mandrel is shown on SK-1-775. This method of replacement has been quite satisfactory even at extreme growth conditions tested.

Removal and replacement of gunbarrels (limit 7) has been carried on without much difficulty at lower slopes of the inlet blocks. Removal of the gunbarrels has required up to 1000# forces. Replacement has required up to 1300 # force. All moving of the gunbarrel has been done with a 3 ton tube jack as shown on drawings H-1-426, as adopted for pulling and pushing gunbarrels.

All gunbarrel replacement has been done with a special gunbarrel replacement bullet nose as shown on H-1-3383. So far this bullet nose has performed adequately up to the severest conditions of graphite growth tested.

Elastic failure of the gunbarrels (limit 6) is determined by checking their straightness after removal. That failure does occur, has been established at the higher distortions. However, a gunbarrel can be replaced under such conditions. Elastic failure of the gunbarrel is important only because it makes its removal through the thermal shield on the donuts difficult. This difficulty is due to the small clearances that exist in these parts.

Limits #4-5 have not been encountered in the tests yet. So far the inlet or outlet blocks have failed to fracture with vertical rises of .85 inches and slopes of 0.6 inches per foot. Higher slopes and rises will be tried until the limit is determined. Rise as used herein refers to the amount of vertical growth at the edge of the graphite.

Bending of the process tube in the gunbarrel has limited the passage of a probe 1.495 inches in diameter and 8" long. However at larger slopes we can expect a point to be reached where a 1.440 inch probe 8 inches long will no longer pass. Of course at this point we also have elastic failure of the gunbarrel.

The bending of the process tube is checked with steel probes 4 and 8 inches long. The diameter of these vary from 1.495 inches down to a slug diameter of 1.440 inches. From the maximum probe diameter that will pass through a tube the radius of curvature has been, in the past, predicted. However, from the information gained in this test this determination of curvature seems incorrect. Constrictions in the tube that occur at block junctions or fractures seriously affect the probe size that will pass.

These constrictions in the tube diameter and their length are measured with a Schaevitz inside diameter gage. This is a linear differential transformer coupled with a Brown Recorder. The accuracy of this device is 0.001 inches. A comparison of the data taken with the Schaevitz as to the size and location of the constriction with data as gathered with the probes shows the latter to be questionable for use to determine curvature.

Another test was run on process tube curvature. A tube was supported and loaded so a theoretically perfect circle of curvature existed. From these tests it was determined that 0.006 inches flattening of the tube results as the curvature is increased from zero to a 300 inch radius. However, the probe data taken on this test and that taken on the mock-up show no comparison.

Bending or crimping of the process tube at a fracture (limit 2) is a severe limitation on slug passage. Crimping of the tube has been pronounced in several of the tests run so far.

Limit one is not being investigated presently, but this work will be carried out as soon as the other limits are determined. This condition exists because of a limitation of the number of limits that can be tried simultaneously on the Nine Tube Mock-Up.

The tests will be extended farther during the next month to higher inlet block slopes. It is expected that several more severe limitations will occur. Efforts will then have to be directed at overcoming the limits as they occur.

G. CREEP TESTS - IRRADIATED PROCESS TUBES - R. C. Schilson

Design of the test set-up and electric furnace has been completed. All necessary equipment has been ordered or received, and construction of the electric furnace and other test equipment has begun.

Six pieces of aluminum process tubing 18 inches long, which will be used in the test, have been obtained from the DR-Pile and have been decontaminated.

When all the necessary components are received, assembly of the test set-up will begin. However, some difficulties will be encountered in applying the strain gages to the process tubing because of the high radiation level that exists. This will be done in a radiation danger zone prior to setting up the equipment in the 189-D Building. A 4-inch lead shield shall be constructed around the test assembly.

IV. PILE OPERATING EQUIPMENT

A. PRESSURIZED "C" AND "D" MACHINES: TEST NO. 29 - J. P. Cooke

An interim report was issued on the "C" and "D" machine work done prior to April.¹

1. "Interim Report No. 2, Test No. 29, "C" and "D" Machines Functional and Life Tests", by J. C. Wood HW-23955, April 24, 1952.

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Two further runs were made during the month of April which showed cocked slugs in tubes charged as tight slug columns at 25 gpm and 30 gpm respectively (See Figure 12 at end of this report). These pictures were taken from the side of the tube and the fact that the slugs were charged in groups of five apparently bears some relationship to the cocking pattern which also is accented on every 5th slug in most cases. Since the column was tight beyond the point where the new slugs were introduced, this would indicate that the action of the jet of water at this inlet nozzle is partly responsible for these cocked slugs. Both the nozzle spool piece and the flapper nozzle have since been worked over to provide better support of the slugs at the point where they enter the tube.

The sphincter seal performed very satisfactorily as a discharge device - 100 psi around the seal held the slugs even against the full charging force of the "C" machine ram rod and the force of the water pressure. Fifty pounds of sealing pressure let the slugs be pushed through by the charging machine, yet held them nicely against discharge water pressure.

Arrangements are being made for lease of an X-Ray machine from Industrial X-Ray Engineers of Seattle, and the machine should be ready for use about May 5 if not sooner, depending somewhat on how much more time is required for the formal signing of the lease contract which was delivered to the vendor on April 26th. In anticipation of our needs, however, the vendor has ordered some of the special X-Ray tubes required to convert certain of his units to narrow beam fields, and expects to be able to ship the machine within about 3 days of receipt of notice to proceed.

Satisfactory darkroom facilities have been provided next to the washroom in 189-D, and necessary film and chemicals are being procured.

B. UNPRESSURIZED "C" AND "D" MACHINES: TEST NO. 39 - W. J. Morris

Development of the front seal slug holding mechanism has now assumed the proportions of a double acting piston operating from the hydraulic system of the machine. This holding device is used to hold the fifth slug of each charge in the machine seal thus sealing off the process tube from the machine. It was found that the single acting spring loaded piston released too slowly to be timed with the charging ram. The necessary valves to operate this system arrived this month and have been installed. The cam which controls the timing of the holding device by closing a limit switch which in turn operates a solenoid valve, is yet to be developed.

Two tests will be run with the present equipment:

1. A standard slug pattern and a flow rate of 10 gpm shall be used. This test will use the "Postem" system as originally outlined in Test No. 39. The tube will be charged, discharged, and reloaded, and then X-rayed to determine the position of the slugs.
2. This test will be repeated at a flow rate of 30 gpm.

At the conclusion of these tests a final report will be published as this will complete Test No. 39.

Following the issuance of the final report a new phase will be started toward developing the original Test No. 39 system to a continuous charge and discharge system. This will necessitate the development of the following:

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1. A method for charging perfs. The design of the machine is such that it can not charge a presently designed perf.
2. A satisfactory discharge method. The present design is wholly inadequate as slugs jam as they wash out of the tube.

C. WATER COOLED TEST HOLE - G. E. Wade

This project has been completed during the month. A letter to L. P. Bupp dated April 17, 1952, titled "Water Cooled Test Hole Facility" was written recommending equipment for the improvement of the facility as per his requirements. Drawing SK-1-938, Sheets 1 through 5, show the test facility as revised, as well as gatling gun modifications. The drawings were turned over to H.L. Henry of Pile Services group for further action as required.

D. PROCESS TUBE REPLACEMENT - P. M. Jackson

A one third horsepower motor was installed on the process tube puller before it was taken to the 305-A Building for use with the nine tube mock-up. Several successful pulls have been made with pulling forces up to 1500 pounds. The machine and mandrel are proving to be useful, but the pulling rate is very slow. A similar type puller with greater pulling capacity and speed is currently under investigation. This puller will be designed to have a pulling speed of about fifty feet per minute.

E. REAR FACE MONITORING BY TELEVISION - W. J. Morris

The television equipment arrived this month and is presently operating in the 189-D Test laboratory. The RCA Industrial TV Equipment consists of a miniature camera and a control monitor, photographs of which are shown as Figures 9 and 10. Figure ~~8~~ 9 also shows the Vidicon pick-up tube. The picture is transmitted from the camera to the monitor by means of a connecting cable. The monitor may be located up to 500 feet from the camera, although greater distances can be covered by use of slave monitors or booster amplifiers. All controls are operated from the viewing position at the control monitor.

Present plans are to mock-up the upper camera. The mock-up structure to simulate the rear face and rear elevator is complete. The upper camera carriage design has been completed subject to approvals. All parts necessary for its construction have arrived with the exception of the small electric motors. In order to determine accurately the correct size motors to be used, a test will be run with the camera. These tests will consist of torque measurements required to move the camera. Preliminary testing is underway to determine the necessary illumination.

F. IN-PILE PROCESS TUBE PRESSURE TESTER

No work has been done on this project during the past month.

G. PROCESS TUBE O.D. GAGE

No work has been done on this project during the past month.

H. CASK STANDARDIZATION - R. E. Johnson

Because of higher priority work, no further progress has been accomplished on this design.

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FIGURE 2

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FIGURE 10

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N. HIGH SPEED FLUX MONITORING - R. E. Schilson

It is desirable to know the front to rear flux curve in the piles for various reasons. In order to do this accurately and rapidly, it is proposed to develop a high-speed method of measuring the radiation level of individual uranium slugs as they are discharged from the pile, automatically and without interfering with the discharging operations. In tests to date a zero level HM Chamber was used to make these measurements, but the readings obtained were too flat to be reasonable. The reason for this was that the HM Chamber measured the average radiation of several slugs on or in the tip-off, in the rear nozzle, in the outlet end of the process tube, and in the process tube near the rear edge of the biological shield.¹ One method being considered to overcome these shortcomings is the use of an automatic monitor using photographic film. In this system, a photographic record would be made of the radiation level of each slug as it was discharged. From the film data, the flux distribution could be determined.

V. POWER RECOVERYA. FUEL CONFIGURATION - G. E. Wade

The calculations of the stresses in a split hollow slug have been completed and an optimum size selected. The outside diameter has been fixed at 1.720 inches. This size was selected after considering the coating which will be required on the outer surface of the slug, but leaving clearance in the nominal 1.744 inch inside diameter of the graphite bore. The present process tubes have a nominal outside diameter of 1.729 inches. Although 1.720 inches is not the most desirable outside diameter, this value was settled on in the hope that the split slugs could be inserted in the present Hanford Reactors for testing. However, the best approach would undoubtedly be to design the slug lattice spacing and graphite simultaneously.

The inside diameter of the cooling tube was selected rather arbitrarily. A value of five-eighths of an inch was decided upon, considering cooling water flow, uranium volume, water volume, and other factors. The outside diameter of the cooling tube or the inside diameter of the slug is then the one variable.

All calculations are based on document CP-2098 which was written when the original work on split slugs started in 1944. Of course, the calculations depend on the high temperature properties of uranium which are not very well known yet.

The slug configuration mentioned above reduces the water per tube thirteen percent and increases the uranium twenty two percent. These factors contribute to the favorability of this slug from the reactivity standpoint.

Last month it was mentioned that extremely high stresses in this design are a result of large thermal gradients across the cooling tube and the slug. The temperature drop across a one-sixteenth inch wall cooling tube with a slug power output of 25 KW per foot is on the order of 150°F. The resulting stress in a tangential direction on the outer or inner fibers of the cooling tube is over 140,000 psi. This stress

1. "Proposal For Determining Front-To-Rear Graphite Flux", letter from L. H. McEwen to E.C. Wood, dated February 13, 1952.

is rather fictitious, considering the temperature of the tube wall and the modulus of elasticity of the stainless steel. Rather the value indicates the cooling tube will be overstressed and we will expect some type of creep failure.

Looking at the stresses at the inner surface of the slug we find equally high values. In fact a stress of 250,000 psi in tension is calculated. Such a value could never exist, of course, and we would expect a yielding of the slug. This yielding of the slug may not be serious, for upon reheating, it will again tend to grip the cooling tube. However, a physical test of the slug is desirable to determine if recycling of the slug will have any ill effects. The calculated stresses indicated here would disallow the use of a split slug (at 25 KW per foot anyway). There are numerous methods of overcoming these stresses - by waffling the surface, by making the liner flexible, by changing the dimensions, by use of materials, etc. As a consequence, stresses are not felt to be the limiting factor.

A program has been agreed upon for these tests and the design of the necessary equipment will start immediately. The first slugs to be tested will be made of stainless steels that have properties similar to those of uranium at the temperatures in question. These tests will bracket the necessary uranium properties and give a more general approach to the type of slug required.

B. CREEP TEST - IN PILE - J. M. Roberts - R. E. Schilson

The preliminary prints are out and extensive checking turned up several revisions. One major difficulty was the use of stainless steel instead of aluminum for several of the parts. This was required in order to fasten the bellows more effectively. This in turn makes the disposal of the apparatus more difficult after the in-pile test. All four test cells are attached together which makes the most active section four feet long. By proper manipulation this can be trimmed of all connectors and pushed into the basin from the front face.

VI. PILE PIPING

A. STRAINER PRESSURE DROP AND SCREEN STRENGTH DETERMINATION: TEST NO. 69 -
P. M. Jackson

The data obtained from the crossheader screens secured from DR unit has been tabulated and compared with that of clean DR-H baskets. It was found that only a negligible difference in pressure drop occurred between the new and the used baskets. This difference did not exceed that which would be found between various new baskets. A graph, Figure No. 11, is included which shows the difference between these strainer baskets.

The final report will be prepared during the coming month.

B. PIPING STUDY - G. E. Wade

No work was done on this project during the month because of the requirements of high priority work.

J. SLUG AIR WEIGHER - R. C. Lovington

The detailed designs for the improved slug air weighing system have been completed and checked. The tracings are being corrected and changed to incorporate several minor improvements in the design. It is anticipated that the cost estimate will be made and construction started in the next few weeks.

K. P-13 REMOVAL - R. C. Lovington

Project Engineering has made numerous revisions during the past month to the project proposal for the P-13 pressure assembly removal. The cost estimate has been altered several times to show more clearly how the required funds are to be distributed. The proposal itself has been changed to comply with recent revisions in the Organization and Policy Guide. The final rough draft is almost complete and is to be circulated for approval in the near future. It is hoped that approvals will be obtained, and the proposal in its final form in time to be presented to the A and B Committee meeting scheduled for May.

L. RECIRCULATION TEST ASSISTANCE - R. W. Vivian

The Reactor Section of the Manufacturing Department has requested assistance from the Pile Technology Unit in testing the hot water recirculation system for 105-H. This system will, during shutdown, recirculate through the pile 2000 gpm of steam heated water. The purpose of this recirculation is to hasten the drying of pile graphite after it has become wet due to water leaks into the pile. At present all component parts of the system are being checked for operability. An operating procedure will be written before the test is run. It is expected that the system will be tested at the next regular shutdown.

M. SLUG IDENTIFIER - R. C. Lovington

At the request of the Process Control and Analysis group, Mechanical Development is investigating various methods which might be used to determine the exact location of the slugs in the process tubes. At the present time, little, if anything, is known regarding the orientation of the slugs in a particular tube. The batch-type system of discharge, especially in the case of a rupture, does not allow the Analysis group to properly correlate data which may help explain the reasons for the slug failure.

Some of the ramifications of this problem which are being investigated are:

1. The determination of a marking or orienting method which will not increase the present charging time or add elaborate book-keeping procedures.
2. The feasibility of re-designing the ram on the present charging machines to mark each slug as it is charged into the piles.
3. The development of a new slug numbering system for the 300 Area so that each slug will have a separate number rather than as many as 100 slugs having the same number as is presently the case. Initial investigation into this aspect of the problem indicates that an individual numbering system would result in several advantages as far as the canning operation is concerned.
4. The workability of a method of marking the slugs as they are discharged from the pile. It is believed that this could be done with some degree of reliability in the case of a normal discharge, but serious problems are apt to arise during a rupture removal.
5. The possibility of cartridge-type loading for the charging machines rather than hand feeding as at present.

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COMPARISON OF NEW AND USED *
CROSSHEADER STRAINER BASKETS

*(18 MONTHS USE IN DR UNIT)

ALL BASKETS 30X8X30 DR&H STYLE

FIGURE 11

— FLOW GALLONS PER MINUTE —

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VII. TEST LABORATORY

A. TEST FACILITIES - E. G. Dosskey

Ovens and other equipment are on site for the Brookhaven Concrete Water Retention Test. The equipment will be installed in the near future.

Available floor space in the 189-D Laboratory is at a premium at present. In order to accommodate pending tests, it may be necessary to establish another laboratory. A survey of possible facilities is being made.

B. MODIFICATION TO THE 189-D TEST LABORATORY - W. J. Morris

Project Engineering reports that this project will be handled as an informal request. The request has been written and will be released shortly. The project will provide office space, a lunch room and adequate rest room facilities.

IN-CHARGE, MECHANICAL DEVELOPMENT
PILE TECHNOLOGY UNIT
ENGINEERING DEPARTMENT

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