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FROM: W. K. WOODS

May 21, 1947

This Document consists of
11 Parts No. 1 of
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100 AREAS TECHNICAL ACTIVITIES REPORT - ENGINEERING

APRIL 1947

COPY 1 OF 1

This is the first of a series of monthly reports covering details of the work of the Engineering Group of the Pile Technology Section of the Technical Department. The monthly Slug Inspection Report is being discontinued as a separate document and is being incorporated in this group report.

CORROSION AND BLISTERING - W. K. Alexander, C. P. Cabell, R. A. Rohrbacher

SUMMARY

The only unusual cases of blistering during the month of April were stuck pieces in Tubes 3396-D and 1252-F. No unusual blistering was found in any of seven tubes containing slugs of borderline quality.

The rear Van Stone flange of Tube 3396-D contained pits which extended about one third of the way through the aluminum wall.

The flow of cooling water through the B Pile was interrupted for about 92 hours but no sign of heat evolution was detected.

Work is proceeding on problems associated with (1) a proposed flow laboratory using irradiated water for the study of corrosion of outlet Van Stone flanges, (2) the discharge of slugs which are more badly warped than any encountered to date, and (3) the phenomenon of chattering of slugs in tubes.

Details

The only unusual cases of blistering in the month of April were stuck pieces in Tubes 3396-D and 1252-F. Inspection of the pieces from 3396-D showed one piece which was extensively blistered with large swollen areas which had caused it to be bent near the middle until it bound in the tube. There were two other pieces in this tube which showed some overall warp. One of these could possibly have caused some binding. One piece was found in the charge from 1252-F which was only moderately blistered on the surface but which had a uniform warp over its entire length. This piece was severely scratched.

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There were seven borderline tubes pushed during the month. There were no indications of any unusual blister formation in any of these tubes.

Tabulated below are the results of the exposed metal examinations:

Tube #	Type	Prod. Test No.	MD Power	Exposure Days	Blistered				Penit. Rate	
					O.K.	Sl.	Mod.	Ext.	Ave.	Max.
2084-D	Corrosion	9	27.2	164	5	27	0	0	0.03	0.04
3396-D	Reg. Push*	73	28.0	841	30	29	1	1	—	—
1252-F	Reg. Push**	73	28.0	770	5	25	0	1	—	—
1072-F	Low Reactivity Regular Metal	69	25.9	210	3	24	0	0	—	—
					0	5	0	0		
1076-F	Low Reactivity Regular Metal	69	25.9	210	2	25	0	0	—	—
					0	5	0	0		
1761-F	Low Reactivity Regular Metal	69	25.0	207	0	5	0	0	—	—
					17	10	0	0		
1786-F	Low Reactivity Regular Metal	69	25.0	207	2	3	0	0	—	—
					7	20	0	0		
3061-F	Low Reactivity Regular Metal	69	25.0	207	1	4	0	0	—	—
					8	19	0	0		
3086-F	High Density Regular Metal	69	25.0	207	2	3	0	0	—	—
					7	20	0	0		
3262-F	High Density Regular Metal	69	25.0	207	1	4	0	0	—	—
					12	15	0	0		

* One piece missing

** 3 pieces missing

Borescoping

The two tubes which contained stuck pieces were borescoped to determine where in the tube these slugs had been and how much damage had been done to the tube when they were discharged. In tube 3396-D it was found to have been the 22nd piece from the upstream end which was stuck. The tube was quite severely scratched. It was found to have been the 19th slug from the upstream end of Tube 1252-F which had been stuck. It was of special interest to note that this piece had been in contact with the top of the tube at two points. As mentioned above, the piece which stuck was uniformly warped and from the appearance of the tube the two ends were against the top of the tube. Both of these tubes are being replaced.

Tube Traverses

Tubes 4674-D and 4674-F were traversed to measure the vertical bowing. The maximum difference in elevation found was 2 25/32 and 2 1/2 inches, respectively.

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Van Stone Flange Inspections

Both Van Stone flanges of Tube 3396-D were inspected before the tube was replaced. The front flange was found to be moderately pitted with large flat pits. The rear flange was more severely pitted. The maximum depth appeared to be about 1/3 of the total thickness of the flange. The rear flange was removed and saved for further study.

Calorimetric Test of 100-B

Under Production Test 105-99-P an attempt was made to determine the amount of heat being generated by fission product decay in the B Pile. The test proposed to reduce the water flow from the usual 4000 GPM to 40 GPM in four steps, and note if there was any temperature rise at each intermediate flow. At 40 GPM it was predicted that the temperature rise should be about 7°C. The flow was then to be shut off entirely, and the rate of temperature rise in the graphite noted. It was expected to amount to about 20°C/24 hrs. No temperature increase was noted in the steps between 4000 and 40 GPM. At 40 GPM the water was being cooled in the unit due to the inlet water warming up in the pipe lines before it reached the unit. If there was any heat being given off it was not enough to warm the unit up to inlet water temperature. The water flow was reduced to zero and allowed to remain there for about 92 hours and there was no noticeable temperature rise in the graphite as measured by the graphite thermocouples and by a special thermocouple in an empty process tube channel. The only explanation for this apparently is that the theoretical predictions were based on insufficient data.

Hot Flow Lab

It is proposed to build a hot flow laboratory in the "X" sample room of 105-D to study corrosion of Van Stone flanges under various temperature conditions. Irradiated water from the back face of the unit will be used. Estimates have been made as to the flow available through present openings in the shielding walls surrounding the "X" sample room (a number of spare 1" lines are available, in addition to an opening in the wall which will take about a 2" pipe). Flow tests are scheduled for early in May, and upon completion of these tests final designs will be drawn up.

It is desired to build a system which will operate entirely by gravity flow to eliminate maintenance problems which would be expected with pumps. Preliminary calculations indicate that this will be practical.

The Stuck Slug Problem

It is estimated that a force of about 4000 lbs. was required to discharge Tube 1252-F on April 6. This force is approaching the load limit both of the Van Stone flanges in tension and of the jacketed lead slugs in compression. Considerable study has been given to this problem and a program of study is being proposed. Experimental work at this time has been confined to measuring the maximum load (4500 lbs.) which can be exerted on a standard lead piece without mushrooming, when the load is transmitted through the smaller diameter of a double-diameter stainless steel piece.

Chattering Studies

1. Production Test 105-89 - During a shutdown on the F Pile in late February orifices were changed on 18 process tubes which had been loaded with solid

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aluminum dummies at start-up in 1945 and run with 0.140" orifices ever since. The orifices on six tubes were changed to 0.240", on six to .200" and on six to 0.175". The first six tubes to be discharged were inspected in late April after two months' operation at the higher flow rates. Two of the tubes had 0.240" orifices, two had 0.200" orifices, and two had 0.175" orifices. The tubes were borescoped over the dummy zone. The examination was made of the upstream zone only, because of lack of time. None of the tubes showed any signs of chattering.

The other tubes are still operating, and the next six tubes will be inspected in June.

2. Flow Lab Tests on Slugs to be Used between Uranium Pieces - These tests are being run to determine the density and diameter (and length) required in a special request slug to be used between uranium pieces. It is desired to find the correct combination of these variables to prevent both chattering and cocking. The problem is complicated by the fact that it is possible for gaps to form between uranium pieces. In late March we found that eight-inch 1.46" O.D. slugs of specific gravity 4.00 would cock, but similar pieces of 1.43" diameter would not. Test pieces of lower specific gravity would cock or chatter.

Fortunately, the cans used for special request samples are 1.422" O.D. This month we placed a Production Test with the 300 area for the purpose of checking our conclusions with slugs suitably weighted and fabricated in the normal manner. These slugs were delivered in late April and will be tested in May.

3. Flow Lab Tests on Slugs to be Used in Tubes without Uranium Pieces - The purpose of these tests is to find the limiting dimensions for special request slugs which are used in tubes without uranium pieces. No gaps will be present in these tubes, and steady cocking of the pieces during the run will be tolerated.

Tests were made using the special window equipment. A column of four to six special slugs was held between lead dummies at each end, and tests were run with each end of the column in front of the window. The following sizes of aluminum dummies were tested: Eight inch -- 1.460", 1.450", 1.440", 1.430", 1.420", 1.410", 1.400", 1.390", 1.340" and 1.290". Four inch -- 1.340".

No chatter or cocking was observed on the group except for the 1.410" and the 1.420" slugs. Both cocked, and on one test the 1.420" slug chattered, but the chattering was not repeated. This chattering took place on the downstream end of the column.

It was thought that perhaps variations in the frequency of amplitude of the vibrations in the water might be associated with chattering. However, when an oscilloscope was hooked to a vibration pick-up it was not found possible to "stop" the water vibration on the screen for measurement, since it consists of a constantly varying vibration of about 30 cps frequency.

Because of the irreproducibility of chattering in the window apparatus, a 40-ft. tube in the flow laboratory is being loaded with various combinations of special dummy slugs for extended tests at various water rates. The initial test was started on April 17 and is still in operation.

Tentative conclusions are that all test pieces studied to date are acceptable for use in tubes containing no active slugs if the water rates are no greater than 14 g.p.m.

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Hydraulic Leak Tester for Process Tubes

At the request of the P Department, the hydraulic leak tester was examined, repaired, and tested. (The actual work involved was done according to our recommendations by the P Department). After repair, it was found that the leak tester is in good condition and can be used satisfactorily at 200 pounds header pressure.

. We calculated that, based on present graphite conditions, the leak tester would pick up any hydraulic leak over 0.1 pounds per hour. Smaller leaks would be masked by expansion of the water, if the test were run on the hottest tube.

GRAPHITE EXPANSION - W. R. Lewis, J. T. Carleton

SUMMARY

The use of a hone to smooth the inner end of the inlet gun-barrel of Tube 4385-B decreased the galling between the tube and the gun barrel by an amount insufficient to offer a practical solution to the problem of replacing badly bowed tubes.

Design has been completed for a one-tube mock-up to be used for study of some effects which may result from increased graphite expansion.

No significant stretch of either inlet or exit Van Stone flanges in 12 selected tubes of the D File has been observed.

Experimental studies indicate that rupture of an inlet Van Stone flange may result in detectable leakage between the inlet nozzle and the gun barrel in about half of the cases.

The gas thermometer in the F File has been overhauled but results have not been ascertained at the present writing. .

Details

Tube Replacement

Work was continued on the problem of replacing Tube #4385-B. Previous attempts to replace this tube had proved unsuccessful because the inner ends of the gun barrels scored the process tubes inserted. It was found that the scoring was caused at a point on the gun barrel $3\frac{1}{4}$ inches from the inner end where the tapering of the gun barrel begins.

During April an attempt was made to smooth the rough spot on the gun barrel by honing it with a hone of the type used for hydraulic brake cylinders. It was found at first that honing of the gun barrel decreased the scoring of the aluminum process tube. However, after several feet of tubing had been inserted past the inner end of the gun barrel, the aluminum tube became galled by particles of aluminum picked up on the gun barrel. The galling increased progressively as the tube was rotated and moved in and out. It may be concluded that honing of the gun barrel will decrease galling of the tube but will not eliminate it.

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One Tube Mock-up

Design has been completed for a one tube mock-up for observing the behavior of some of the components of the pile as the graphite expands progressively. The mock-up will include the gun barrel, the first graphite block, a length of process tube, the cast iron blocks and donuts and the various components of the pile which exert force on the gun barrel and first graphite block. Adjustable clamps are provided on the mock-up to deflect the graphite block and gun barrel in order to simulate their relative alignment in the pile and to set up stresses caused by deflecting them.

At the present time it is intended to make the following tests on the mock-up:

1. Increase the slope of the first graphite block until either the block or the gun barrel ruptures.

(a) With the graphite block allowed to bend as its slope is increased.

(b) With the graphite block prevented from bending as its slope is increased.

It is hoped to evaluate the significance of the probe tests on freedom of discharge of process tubes during this study.

2. Attempt to replace a process tube when the first graphite block is deflected upward as much as the worst tube in the pile.

3. Determine the advisability of reaming the gun barrel to a larger inside diameter to facilitate tube replacement.

The relative availability of bored 4-foot graphite blocks will determine the scope of the tests to be run.

Van Stone Flange Measurements

The measurement of the change in distance between the outer end of the process tube nozzle and the beginning of the ribs in the process tube has been used as a measurement of the stretching of the Van Stone flange. It is assumed that the nozzle is not affected by the stretching of the process tube. The results of the Van Stone flange measurements are as follows (an increase in reading indicates stretch):

100-D Front Face:

Dial Readings in Inches

<u>Tube No.</u>	<u>4/29/47</u>	<u>3/15/47</u>	<u>12/3/46</u>
0769	.223	.221	.224
1482	.274	.273	.275
1769	.194	.191	.191
1966	.184	.184	.184
2373	.248	.247	.242
2474	.256	.255	.259
2979	.181	.178	.173
3070	.260	.259	.259
3424	.241	.240	.234
4082	.095	.094	.094
4088	.263	.262	.263
4574	.278	.278	.275

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100-2 Rear Face:

<u>Tube No.</u>	<u>4/29/47</u>	<u>3/15/47</u>	<u>12/3/46</u>
0769	.293	.292	.294
1482	.378	.376	.376
1769	.336	.334	.334
1966	.353	.351	.350
2373	.379	.378	.380
2474	.304	.303	.300
2979	.344	.343	.342
3070	.292	.287	.285
3474	.288	.286	.285
4082	.326	.325	.323
4088	.370	.367	.367
4574	.346	.346	.343

Unit Motion Measurements

The devices for measuring unit motion were inspected during April at B, D, and F Piles. It was found that improvements could be made in some of the devices. Present unit motion data are adequate for determining a general trend of movement over a period of several months, but are not precise enough to indicate the month-to-month movement of the pile. Some examples of possible improvements are:

1. The tight wires are held in place by eyes bolted to brackets welded to the shielding. These eyes are easily bent when subjected to blows from falling objects. Holes drilled in the brackets would provide better anchorage for the tight wires.
2. The scales clamped in place to read the tight wires on the front and rear faces are inaccessible. Relocation of these would give more precise readings.

A detailed report of the improvements to be effected in the unit motion devices will be written in collaboration with the Instrument Department.

Flow of Water into the Pile from a Ruptured Tube

It is assumed that the process tubes will eventually be ruptured at the Van Stone flanges by the face-to-face expansion of the graphite. A rupture of the front flange would be more serious because the water pressure is higher at the inlet end of the tube.

A process tube was stretched in a mock-up until it ruptured at the Van Stone flange in the "front" gun barrel. The downstream end of the tube was plugged and water at various pressures was supplied to the inlet end of the tube. The amount of water leaking between the process tube and the gun barrel was measured. The results are as follows:

<u>Pressure (PSI)</u>	<u>Flow (gal/min)</u>
330	2.16
300	2.07
280	1.94
200	1.64
150	1.29
100	.84
50	.32

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- These tests show that maximum flow is encountered at rates below about 1.6 gpm.

It was noted that water leaked between the nozzle and the gun barrel because of disruption of the Van Stone flange. The detection of leakage around the nozzles in the pile may be used to locate some broken tubes. About one half of a dozen process tubes previously broken in a mock-up had the flanges distorted enough that leakage of water between the nozzle and the gun barrel would be probable.

Gas Thermometer

- The gas thermometer at F Pile has been overhauled. The work done consisted of:

1. Purging the gas bulb when the pile was hot in order to drive off any impurities which might condense at low temperatures.
2. Recalibration of the pressure gage.
3. Determination of the volume of the bulb and correction for the volume of the gage and connecting pipe.

The results of the overhaul have not been ascertained as yet. If the gas thermometer is found to be reading correctly, the procedure outlined above will be used to check the gas thermometer at D Pile.

Horizontal Thimble Effects

A light was inserted 25 feet into the No. 6 horizontal rod thimble at F Pile on April 6 and inspection of the graphite track was made with a telescope. No irregularities sufficient to cause rod binding were noted in the track. After adjustment of the rod guide and gate no further binding was noted.

IRRADIATION STUDIES - E. S. Jones - J. C. Chatten

SUMMARY

A second assembly for measuring the temperature of an operating slug was charged into tube 2679-F on April 6. Results obtained are in good agreement with results obtained from the assembly in tube 1367-F.

Preliminary measurements using the thermal wave principle indicate that there is no difference between the thermal conductivity of uranium rod in directions parallel and transverse to the direction of extrusion.

Work is progressing on methods of calibrating thermocouples after irradiation.

The combined compressive and tensile testing unit for the underwater laboratory has been designed and some detail drawings prepared. Certain work has been requested from the General Engineering and Consulting Laboratory at Schenectady.

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Installation of Thermocouples

A second thermocouple slug was charged into Tube 2679-F in order to confirm the surprising result obtained in the case of the thermocouple slug charged in Tube 1367-F. This was done during the shut-down of April 6.

The thermocouple lead wires and the gas tubing, running from the A sample room over to the discharge nozzle of Tube 2679-F, were installed during the shut-down of March 23rd, to allow the gas system to be checked and permit more time for actual loading of the tube with the special assembly.

The assembly charged into the tube was similar to that charged into Tube 1367-F, but two significant changes were made:

1. The extra thermocouple was seated 3" out from the bottom of the hole, which means that it is 1" from the end of the metal.
2. The 5th and 14th perforated aluminum slugs, numbering from the uranium slug, were replaced with solid aluminum dummies containing a 1/4" diameter hole for the thermocouple tubing. This was done to eliminate the chattering of the small tubing in the long length of perforates.

Other minor changes were made in various fittings and a selector switch was installed at the L & N recorder to facilitate reading the different couples and calibrating the recorder.

Slug Axial Temperature

The couples at the center of the two slugs which are in the center of Tubes 1367-F and 2679-F differ at equilibrium conditions by 6° C. The following table shows the temperature ratios for the two slugs under pile conditions at equilibrium.

Table I - Slug Axial Temperature

Tube No.	1367	2679	1367	2679
Date	4/11	4/11	4/29	4/29
Test duration - weeks	13.1	0.7	15.7	3.3
Slug Temp., °C.	103	100	107	100
Inlet Water Temp., °C.	7.2	7.2	10.3	10.3
Local Water Temp., °C.				
From adjacent tubes	19.6	20.2	22.5	22.6
From test tube	22.8	23.3	26.7	26.3
Slug ΔT	83 - 30	80 - 77	84 - 80	77 - 74
Water Rise	12.4 - 15.6	13.0-16.1	12.2-16.4	12.3-16.0
ΔT /Rise	6.7-5.1	6.2-4.8	6.9-4.9	6.3-4.6

In the above table the local water temperature from adjacent tubes is taken as inlet water temperature plus half the average rise in the eight adjacent tubes, adjusted for the somewhat higher flow rate (see below) in the test tubes. It is not known which measure of local water temperature is the more accurate. However, in either case, the performances of the two thermocouples are in agreement within 10%. The corresponding value of ΔT /rise for Tube 1367-F on January 13, 1947, at the time of the first equilibrium reading was 6.5 - 5.0, based on local water temperatures estimated from outlet temperatures of adjacent tubes and test tube, respectively.

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Three uranium slugs have been machined down to pieces 4" long by 0.300" diameter for shock determinations of thermal conductivity parallel to the axis of the slug.

Brushes are being made for the D.C. generator used for a current source in the thermal conductivity test to improve the stability of the source and therefore the accuracy of the test. ●

Because of the short length of the uranium samples cut perpendicular to the ring axis it was not possible to determine the thermal conductivity directly with the apparatus at hand. By means of the thermal wavy method, however, a comparison was made of the conductivity in the longitudinal and radial directions. No difference in conductivity between longitudinal and radial samples could be detected. The accuracy of the method was checked at a later date by comparing the apparent diffusivities of cadmium and brass. The experimental results of this experiment checked well with literature values, but comparison between the uranium and the brass on the cadmium indicated that the conductivity of the uranium was about twice as great as expected. Although this result is in the direction indicated by results of the thermocouple test in the operating pile the result is viewed with suspicion. Further work is planned.

Thermocouple Irradiation

Two approaches are being made to the problem of re-calibrating thermocouples after irradiation. In one design thermocouples are exposed in the pile and withdrawn into a can for calibration, whereas in another design an electric heater is provided in the pile to enable the thermocouple to be calibrated in place during pile shutdown.

The first design is intended for use in a 1/2-inch test hole. Six thermocouple assemblies were fabricated but attempts to calibrate in a simulated cask showed that the cold junction was receiving undesirably large amounts of heat from the heating source, so design modifications are being studied.

The second design is proposed for use in a dry process tube. The water will be used to melt a eutectic solder of known freezing point. One preliminary assembly was fabricated from a copper rod and heated inside of a ribbed aluminum tube which was externally cooled with water. The data are currently being analyzed to distinguish between radiation, gas conduction, and rib conduction effects. Temperatures as high as 230° C. above water temperature were obtained with a power input of 270 watts in an assembly six inches long.

Part Four Graphs

It is predicted by theory that about 8% of the heat generation in the pile originates in the graphite. An experimental measure of this quantity would aid in interpretation of graphite and slug temperature readings. An estimate of the quantity could be obtained by reducing the flow in an inactive tube to the point where the outlet temperature was equal to the outlet temperature of the adjacent active tubes. For this purpose a special pigtail assembly containing a pressure regulator was calibrated in the flow laboratory so that any desired flow from 0 to 6 g.p.m. may be obtained.

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The unusual loading on the tubes equipped with thermocouple slugs complicates the prediction of probable flow rate in these tubes. Experimental data have been obtained in the flow laboratory for these loadings but the results have not been analyzed. The office calibrations obtained at that time indicate that the flow in tubes 1367-F and 2674-F under current operating conditions should be 23.8 and 21.3 g.p.m., respectively, as compared to 19.6 g.p.m. in normal tubes.

Underwater Laboratory

Considerable progress has been realized during the month on design of equipment for underwater physical measurements of properties of irradiated materials.

One machine, a combination compressive and tensile testing unit, has been designed and detailed drawings have been prepared. Certain work connected with the stress and strain gages for this machine has been requested from the General Engineering and Consulting Laboratory at Schenectady. Certain parts not likely to require revision as a result of Schenectady strain gage design will be fabricated in the near future.

Drawings and specifications of the Wilson Universal Testing Unit (Rockwell Hardness) have been received and fabrication of the U.T.U. for underwater determinations is proceeding.

W. K. Woods

W. K. Woods, Chief Supervisor
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