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TECHNICAL ACTIVITIES REPORT

WATER STUDIES

BY

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Pile Engineering Sub-Unit
Pile Technology Unit

March 3, 1952

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WATER STUDIES - QUALITY - J. M. Atwood

105-L FLOW LABORATORY

Tube Discharge - J. B. Kendall

Twelve slugs were discharged from each of four tubes on February 15, 1952. The tubes had been operating for approximately six weeks using raw water and process water at 65°C and 95°C.

Six slugs from each tube were dried in air and weighed before film removal. Film from the remaining slugs was scraped off for analysis. All forty-eight slugs were then cleaned by dipping a 2 per cent chromic - 5 per cent phosphoric acid solution at 85°C, dried and weighed.

Corrosion loss is obtained by subtracting the cleaned weight from the charging weight. Film weight is the difference between cleaned and uncleaned weights. Since some film is removed during discharge, film weight is only a rough indication of the film forming properties of the water in each tube.

Below is a summary of the data:

TABLE I

FLOW LABORATORY SLAG WEIGHT LOSS

TUBE	WATER	TEMP	HOURS	Corrosion Loss in Grams			Film Formed in Grams		
				HIGH	AVG	LOW	HIGH	AVG	LOW
1	Raw	95°C	980	0.170	0.127	0.083	0.221	0.202	0.195
3	Process	95°C	905	0.449	0.412	0.343	0.330	0.289	0.267
12	Raw	65°C	980	0.036	0.017	0.002	0.113	0.103	0.098
10	Process	65°C	905	0.022	0.010	0.002	0.144	0.059	0.034

Preliminary Results of Film Formation Tests - B. O. Reese

The initial twenty-four days of controlled temperature, flow, and pH operation have been completed in the sixteen mock-up process tubes and preliminary results have been obtained. A factor k , defined as pressure drop divided by flow rate squared, is plotted against time in Figures 1 and 2.

The film growth factor k makes a good variable, since, as is shown below, when temperature and flow length are constant, it depends only on friction factor and

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Figures 1 & 2

Fig 1. Film Growth in 95°C Mock-up Process Tubes

Fig 2. Film Growth Variation with Temperature
Tube Pairs with Same Supply Water

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hydraulic radius, and is entirely independent of flow rate. The points plotted are computed from daily averages of data, in order to smooth out the effect of transient pressure fluctuations.

The k factor may be related to friction factor and hydraulic radius as follows:

By definition, $k = \frac{\text{pressure drop}}{Q^2}$

$$\text{Head Loss, } h = \frac{fLv^2}{2gd} = \frac{fLQ^2}{d^5}$$

Pressure drop is directly related to head loss by a temperature and dimensional factor,

$$h = T\Delta P$$

$$\text{Equating and solving, } k = \frac{h}{TQ^2} = \frac{C}{T} \frac{fLQ}{d^5 Q^2} = \frac{C}{T} \frac{fL}{d^5}$$

Nomenclature:

- f = Fanning friction factor
- L = flow length in tube
- d = hydraulic radius
- C = dimensional constant
- T = temperature factor (Cameron, Hydraulic Data, p. 25)

Two conclusions may be noted from the data shown on the figures, first that the film growth increases with hydrogen ion concentration, and second that higher temperature produces more film than a lower one. Tubes 7, 9, 11, and 13, operated with filtered water under pH control, show a rapid build-up during the first ten days followed by a sharp change to approximately linear behavior. The slope of the upper portion of the curve will remain somewhat indeterminate until further data are obtained. Tube 3, operated with pile process water, shows a more gradual build-up and leveling off. Tube 1, using raw water, shows the most favorable results with regard to friction head loss across the tube. Figure 2, showing one pair of tubes operated with filtered water and one pair with process water, suggests a parallel growth between the lower and higher control temperatures.

An experimental aberration in flow rate measurement will increase the slope of all the curves slightly. Film formation in the rotameter tubes led to a progressive decrease in flow rate, since operation was held at an apparent constant of 20 gpm by rotameter reading. A calibration study is now underway to arrive at a precise correction for this error.

Iron Pickup - R. J. Jaffe

Iron concentrations are now about 0.1 ppm for most Flow Laboratory water, except for process water with 0.04 ppm and filtered water of pH 6.2 with 0.6 ppm.

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It is believed that the samples analyzed do not reflect the true iron content of the water. This is because whenever a Hoke valve which feeds a sample bottle has a setting changed, rusty water is noticed. After a few minutes the rust disappears. In addition, an analysis of water taken from the film formation tubes has shown an iron content of 0.14 ppm compared with the sample content of 1.6 ppm for that day. From the physical layout, there is no reason for this difference, except in the sampling system itself.

In order to remedy the situation the sample drip is discontinued for five minutes when changing the Hoke valve setting. This technique has reduced the analyzed iron in the pH 6.2 system from about 1.6 to 0.6 ppm. Another method of reducing the amount of rust entering the sample is to adjust sample flow with a pinch clamp on the sample tube, rather than by resetting the Hoke valve. Analysis of samples from various points will be continued.

Because the 8 per cent sulfuric acid used to adjust pH picks up a large amount of iron in the present system, some iron is introduced to the waters in which pH is adjusted. Thus the stream of pH 6.2 contains about 0.025 ppm from the acid. Other streams have 0.0068 and 0.0042 ppm introduced by the acid. When the new pH adjusting system is installed, this pickup should cease.

Development of New pH System - J. M. Atwood

The final design of the new acid addition system has been completed. The primary design criteria for the system were dependability of operation and the elimination of stainless steel from the system to minimize iron pick-up.

Delivery has been obtained on the Hastelloy pump and the pyrex rotameters and manifold. A special teflon fitting is now being machined. Installation of the equipment will be made as soon as possible.

PHASE II - PROJECT C-424 - J. M. Atwood

No progress was made on the construction of the in-pile phase of the water quality experimental facilities during the month. However, material for the project is beginning to arrive on the plant. Several critical items of material were expedited to insure delivery before May 1, 1952. Five central zone process tubes with discharge dates around the end of June, 1952, were chosen as the experimental tubes for the project.

Discussions were held with representatives of the Radiological Sciences Department concerning the experiments to be conducted with the in-pile facilities. The experimental setup is adaptable to a wide variety of tests for obtaining information about film formation and effluent activity. A preliminary outline of the in-pile tests is being prepared.

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FILM TEST APPARATUS - R. V. Andrews

The film test apparatus has been operating for approximately 800 hours using two 24S aluminum plates and an outlet water temperature of 60°C. A flow rate of approximately five gallons/minute has been employed giving a linear velocity of the water of some thirty feet/second. Two methods of obtaining data have been available; one, to maintain a constant flow rate and measure the pressure drop through the apparatus, or two, to hold a constant pressure drop through the apparatus and measure flow rates. The latter method of operation was chosen since it allows very accurate flow rates to be determined by collecting and weighing the apparatus effluent for a definite period of time and it is also independent of any possible clogging of the valves or changes in the pressure drop through the valves for any other reason. Under these conditions of operation, the rate of film formation is extremely slow. This run is being brought to a conclusion, and the data obtained will be analyzed carefully.

Because of the slow rate of film formation found in the first run, a higher outlet water temperature will be used for the second run. In addition, a wider flow channel will be used to give a lower linear velocity of the water passing through the apparatus while maintaining approximately the same Reynold's Number for flow. Present information indicates that the linear velocity of the water may be an important factor in influencing the rate of film formation. If this contention is substantiated by the results obtained in run two, the original latin square arrangement for obtaining information will be modified by including linear velocity as one of the variables and omitting the variation in Reynold's Number.

Several changes have been made in the apparatus for run two. A new set of aluminum plates consisting of one 2S and one 72S clad 2S aluminum plate has been fabricated. Two pressure taps to the face of the aluminum plates forming the water flow channel have been added as well as several additional thermocouples. A movable thermocouple has also been added in a stainless steel tube which will be placed in the water flow channel in an attempt to measure the actual water temperature at various points along the length of the flow channel. These changes have been worked out with the cooperation of Mr. H. H. Greenfield, of the Heat Transfer group in order that heat transfer data as well as film formation data may be obtained from this apparatus. The changes involved are nearly complete, and it is estimated that a new run will be started sometime during the first week in March.

WATER QUALITY TEST - 100-H AREA - W. C. A. Woods

In order to evaluate more fully the relationship between film formation rates, effluent activity, and process water quality, a test was initiated in the 100-H Area February 20, 1952. The residual iron and turbidity concentrations in the process water will be maintained as low as possible by increasing the ferric sulfate coagulant feed rate and by closer control of filter backwash schedules. Since water of a similar quality, with low iron and turbidity, is being produced in 100-F Area using alum, it is hoped that a better understanding of the effects of the aluminum residual in process water can be obtained.

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Film formation rates will be determined by panellit pressure data and process tube pressure drops. The effluent activity will be determined routinely by continuous monitoring. The test has been in effect for too short a time to obtain any data.

ACTIVATED SILICA ADDITION EQUIPMENT - W. C. A. Woods

Minor Construction forces have completed the items which were listed as exceptions when this project was accepted December 22, 1951. The completion of these items resulted in the final acceptance of the project on February 26, 1952. These exceptions were of a minor nature and were not necessary for operation of the equipment. Their completion, however, will result in more satisfactory and safer operation.

The actual operation of this facility has been by the Power and Maintenance Unit, Reactor Section. Since start-up of the equipment, several suggestions for improvements from an operational or safety view-point have been received from operating personnel. Consequently, an area safety committee inspected the facility and submitted a report itemizing several modifications. A number of these were accomplished by Minor Construction; the remainder will be accomplished by plant forces.

During the past two months, the operation of this facility has been quite satisfactory. The maximum rate at which activated silica can be fed is limited by the size of the feed tanks. It has been found possible, however, to increase the strength of the final solution by 50 per cent, from 1.0 per cent SiO_2 to 1.5 per cent of SiO_2 . The capacity of the system was thereby increased by the same factor. If necessary, the strength can be increased to 2.0 per cent SiO_2 , effecting an additional increase in capacity.

PRODUCTION TEST NO. 105-503-E - ACTIVATED SILICA AND ALUM TEST - W. C. A. Woods

Filter Plant Operation

Operation of the 183-F Filter Plant was characterized by normal operation throughout most of the month. Severe breakthrough difficulties were encountered, however, for a period of two days, February 2 and 3, 1952. During this period the concentration of iron in the process water increased to 0.045 ppm, the aluminum to 0.05 ppm, and turbidity to 3 ppm for a period of approximately twenty-four hours. Lack of operating experience with alum and activated silica at high filter rates and high turbidity prevented the production of process water meeting process water specifications during this period. Previous to this date, as reported last month, the filter rate at F-Area was 4.45 gpm/sq.ft. As a result of the breakthrough, it was decided to reduce the filter rate to 3.95 gpm/sq.ft. This was done on February 5, 1952.

On February 14, it was decided to produce the highest quality of water possible, with a minimum of iron, aluminum, and turbidity residuals, in order to test the effect of this water on film formation rates in the pile. It has been possible to produce process water with the impurities shown in Table II since that time.

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TABLE II

100-F PROCESS WATER IMPURITIES

<u>IMPURITY</u>	<u>MAXIMUM</u>	<u>AVERAGE</u>	<u>MINIMUM</u>
Iron, ppm	0.007	0.005	0.003
Aluminum, ppm	0.05	0.04	0.03
Turbidity, ppm	0.2	0.1	0.0

During this same period, the operation of the filter plants in the other 100 Areas has been limited by breakthrough difficulties caused by the extremely cold river water temperature. Filter runs have been reduced from 40 - 50 hours to 16 - 24 hours, and it has proven very difficult to produce water meeting the above specifications with the standard ferric sulfate type coagulant. No difficulty has been encountered, however, at 100-F Area. Filter rates have averaged 3.95 gpm/sq. ft., which is 50 per cent higher than the other 100 Areas. Filter runs are sixteen hours, limited by excessive head loss after this time.

Pile Operation

Film formation rates in the F-Pile varied considerably throughout the month. During the filter breakthrough reported above, panellit pressures decreased very sharply, indicating the removal of film from the process tubes and slugs. Apparently the large amounts of turbidity in the process water resulted in an effective purge in the pile. As a result of this experience, a supplement to the production test, HW-23469, Production Test No. 105-503-E, Supplement A, The Use of Activated Silica as a Coagulation Aid for Aluminum Sulfate, W. C. A. Woods to Files, February 8, 1952, was issued, which authorizes the production of process water containing a maximum of 0.05 ppm iron, 0.4 ppm aluminum, and 3 ppm turbidity for a period of twenty-four hours. For one hour during this period concentrations of these impurities may reach a maximum of 0.10 ppm iron, 0.4 ppm aluminum and 5 ppm turbidity. Recent experience at the F-Pile has shown that no harmful effects to the pile will result if process water containing these higher concentrations is supplied for a short period of time.

For a period of five days, no film formation increases were encountered, but on February 9 and 10, 1952, marked increases were found. Since the only significant change in the water quality was found to be high iron concentrations, a test was initiated to determine the effects of low iron residuals on film formation. Since this test started February 14, 1952, no further difficulty has developed from film formation. The variation in panellit pressures and iron concentration is shown in Figure 3.

This test will be continued in order to determine what variation in iron, aluminum, and turbidity residual concentration is allowable without film formation. In

FIGURE III

106-P PANELLIT PRESSURES & PROCESS WATER IRON

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order to assist with this work, a very sensitive turbidimeter, with a sensitivity of ± 0.1 ppm in the range 0 - 10 ppm, is being constructed by the Instrument Sub-Unit. The use of this instrument will result in more precise control of process water quality.

Recent measurements of Rear Face activity during discharge operations by Radiation Monitoring personnel at F-Area have shown that the activity due to the rear nozzles and attachments is approximately 10 per cent of that encountered with ferrifloc operation. It has been estimated that this reduction should result in a considerably longer personnel exposure limit during discharge operations, thereby reducing shutdown costs. Contamination from ruptured slugs now represents the greatest radiation hazard on the Rear Face. This decrease is attributed to the absence of film and purge material accumulations in the rear nozzles.

ACTIVATED SILICA ADDITION EQUIPMENT FOR 100-C AREA - R. M. Fryar

On the basis of experimental information now being obtained from the F Area alum and activated silica test, it appears that the C-Pile start-up in September should be with process water treated with these materials.

This information has been communicated to the Water Plant Working Committee for Project C-431-B along with the Technical recommendation that immediate steps be taken to design and install activated silica addition equipment. This equipment should be ready for operation not later than December 15, 1952.

WATER PLANT DESIGN FOR X-PROGRAM - R. M. Fryar

In order to make the most significant gains possible in the design and construction of the water plant of the proposed future pile, it was decided to base pre-design studies upon data now being obtained in the Water Studies Program. Although it is recognized that the present data are incomplete and the proposed design basis is primarily the opinion of the technical personnel of the Water Studies Program, the potential gains are of such magnitude as to make a small calculated risk worthwhile.

The probable water treatment standards and procedures for the pre-design study were given as follows:

1. River water to be chlorinated for slime and algae control.
2. River water to be coagulated with aluminum sulfate as the coagulant and activated silica as the coagulation aid.
3. No lime addition to the water.
4. No sodium dichromate addition to the water.

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5. The pH of the process water to be 7.2 to 7.4 due to the natural lowering by the coagulation process if the present iron and aluminum piping system is used.
6. The pH of the process water to be as low as 6.5 by acid adjustment if a complete aluminum piping system is possible. This piping system would require aluminum clad steel transfer lines and special metal 190 process pumps.

PRODUCTION TEST NO. 105-453-P - SODIUM DICHROMATE ELIMINATION TESTS - R. H. Purcell

A supplement to the production test was issued during this month as "Production Test No. 105-453-P, Supplement A, Sodium Dichromate Elimination Tests," R. H. Purcell to Files, February 4, 1952, HM-23436. This supplement authorizes the premature discharge of the four experimental tubes at the March outage of H Pile in order that the final analysis of the results of this production test may be immediately available.

At the time of the discharge all four tubes will be replaced and will be subjected to a metallographic examination. Arrangements are being made to remove the tubes and the discharged dummies from the storage basin within two days. The regular metal from the four tubes will be shipped to DR for air weighing.

Due to an increased resistance in the special pigtails on the filtered water tubes, a special boiling limitation has been placed on these tubes. The new Δt is 62°C while the tubes are being furnished filtered water, and 60°C when the tubes are furnished emergency process water.

Some difficulty was experienced during the two purges due to the plugging of a 50 mesh strainer with purge material. This condition was corrected by flushing the strainer.

The system tripped to process water on February 17, 1952, due to a blown fuse in an instrument used for the weekly checks of the trip circuit. This fuse was replaced and the new fuse immediately failed. The trip circuit contacts in this instrument were jumpered and the test system returned to filtered water. For the remainder of the test it will be necessary to trip the system to process water for the weekly checks since it is now impossible to trip the circuit without turning off a pump. The installation of the three-second time limit on panel light resetting and the automatic shutdown mechanism make any trips precarious. All future tests of the trip circuits will be made only when the pile is shut down.

PRODUCTION TEST NO. 105-450-P - THE EFFECTS OF IN-PILE CONDITIONS ON DRI-FILM COATINGS APPLIED TO SLUG SURFACES - N. R. Miller

No significant changes have been shown by the data taken on this production test during the past month. The test is now scheduled for discharge in March, 1952, instead of February, 1952, as previously reported.

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FILM FORMATION AND CORROSION STUDIES IN ALUM COAGULATED WATER - N. R. Miller

The test began on January 21, 1952, using one tube in the 105-F Flow Laboratory to study film formation and corrosion of 2S aluminum in alum-coagulated water has continued during the past month. Thus far, a total of 470 hours of effective operation has been obtained. Effective operation is defined as operation with the effluent water temperature being above 80°C.

During the past month, the effluent water temperature has been held at 90°C and the water flow rate at 9 gpm.

Pressure drop data taken since the beginning of the test indicate that there has been little or no film build-up on the aluminum dummies.

It is planned to continue the test until a total of 1100 or 1200 hours of effective exposure has been obtained. At the end of the test, the tube will be discharged and corrosion and more film formation data collected.

SLUG JACKET ABRASION AT HIGH FLOW RATES - N. R. Miller

The tube operating at a 35 gpm flow rate was discharged on February 14, 1952, after a total of sixty-five days of operation since the last date of discharge.

The slugs were washed in water and weighed dry. The data show that the amount of abrasion during this period was negligible.

A summary of the weight loss from the slugs during their 105 days of exposure to alum coagulated water is given below.

<u>No. of Slugs</u>	<u>Wt. Loss in Grams</u>
1	-0.004
2	0.001
5	0.002
7	0.003
7	0.004
5	0.005
2	0.006
1	0.007
1	0.026

The weight losses shown above correspond to overall abrasion of about 0.001 mils/month, and, therefore, are negligible.

It is planned to recharge the tube during the week of February 25, 1952, for another period of operation.

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WATER STUDIES - CHEMICAL EFFECTS - M. Lewis

FIFTY TUBE MOCK-UP - S. Goldsmith

The acceptance test performed on the fifty tube mock-up facility showed that the present design of the facility would not give the required flow rates. The two filtered water pumps were to deliver a total of 250 gpm at 90 psi. These pumps delivered a total of 144 gpm. The process water pump was to deliver 100 gpm, but delivered only 35 gpm. In an attempt to obtain the required flow rates, resistance to flow in the piping was reduced by removing the 5/8 inch Saran nozzle connectors that were on the rows of tubes having the highest flow rates. These nozzle connectors were eliminated by threading the aluminum nozzles and connecting 1 1/2 inch pipe directly to the front of the nozzle. This change brought the flow rates within approximately 10 per cent of that required. More such changes are to be made in an attempt to get the required flows.

HIGH TEMPERATURE CORROSION - S. Goldsmith

The high temperature corrosion apparatus has been placed back in operation this month. The boiler scale on the heat exchangers has been removed and the heat exchangers are operating at their designed capacity.

A summary of the data obtained from the high temperature corrosion apparatus is presented in Table III.

Plots of the data are presented in Figures 4, 5, and 6. The plots show that there is an initial high rate of corrosion after which the rate of corrosion tends to remain constant.

The corrosion rates reported at 80°C in the table are lower by approximately a factor of ten than those previously reported by N. R. Miller in HW-23102, "The Effects of Process Water on Three Types of 2S Aluminum Jackets." Essentially, the only difference between the two tests is the method of heating the water. In the test conducted by N. R. Miller, the water was heated to the desired temperature by means of a steam jacket placed on the process tube. This heated the water as it passed over the slugs. In the high temperature facility the water was heated in a heat exchanger to 150°C and then cold water added to give the 80°C water temperature. The heat exchanger that had been used for this purpose had a heavy deposit of calcium carbonate on the inside of the water tubes. To what extent the precipitation of the calcium carbonate changed the water quality has not been fully determined. However, a test has been made to determine how the pH is changed when process water is heated to 150°C. In this test process water was heated to 150°C under 400 psi pressure in the test bomb described in HW-23361, "Technical Activities Report - Water Studies, January, 1952," rapidly cooled, and pH measured. It was found that the pH of the process water had been lowered 0.28 of a pH unit, from 7.68 to 7.40.

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TABLE III
WEIGHT LOSS AND CORROSION RATES OF 2S ALUMINUM

Temperature - 80°C				
Time Days	Minimum	Average	Maximum	Aver. Corr. Rate Mils/Mo.
Weight Loss Grams				
6	.005	.007	.009	.033
8	.004	.006	.009	.022
16	.006	.011	.015	.022
26	.007	.016	.027	.018
34	.017	.020	.024	.018
Temperature - 118°C				
2	.034	.053	.071	.78
4	.034	.092	.070	.69
6	.097	.119	.141	.59
8	.095	.152	.200	.56
21	.386	.462	.632	.66
Temperature - 135°C				
4	.447	.481	.514	3.59
7	.467	.467		2.00
9	.432	.496	.525	1.64
11	.435	.561	.799	1.53
16	.476	.617	.721	1.15
27	.592	.855	1.097	0.902
36	.642	.842	1.044	0.682

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Figure 4

Figure 5

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Figure 6

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CORROSION OF 2-3 ALUMINUM JACKETS

Temperature 135°C

Flow Rate: 10 rpm

CORR. RATE, mils/mo.

WEIGHT LOSS, grams

Rate curve

Wt. loss curve

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In a plot of pH versus corrosion shown in CT-3027, "The Corrosion of Aluminum in Dilute Solutions - Laboratory Studies," page 24, the corrosion rate at pH 7.40 is lower than at pH 7.68 by a factor of 3 to 4. From this curve it appears that we are operating in a critical pH range. This may be one of the factors that cause the difference in the corrosion rates presented in the above table and the corrosion rates reported in HW-23102. Studies are being continued to determine any other factors which may cause such a difference.

Continued operation of the high temperature facility will yield data for longer exposure time and also supply checks on the data already obtained. It is also planned to obtain corrosion rate versus time and weight loss versus time data for temperatures of 60 and 95°C.

GRAPHITE ALUMINUM TEST - S. Goldsmith

Preliminary data have been obtained from a test to determine the rate and type of aluminum corrosion encountered when 2S aluminum and graphite are coupled together and exposed to process water at various temperatures.

The test samples were 2S aluminum rods, 3 inches long and $\frac{1}{2}$ inch in diameter, placed in a graphite block 1 by 1 by $2\frac{1}{2}$ inches. These graphite-aluminum assemblies were exposed to process water at 7°C, 65°C, 75°C, and 85°C.

Pitting attack was very bad at 7°C, and severity of pitting decreased with increasing temperature. Overall corrosion also followed this trend. Overall corrosion rate was approximately 50 per cent more at 7°C than at 65°C and was approximately 125 per cent more at 7°C than at 85°C.

The following table is a summary of the results obtained.

TABLE IV

CORROSION OF 2S ALUMINUM COUPLED WITH GRAPHITE

<u>Temperature, °C</u>	<u>Corrosion Rate, Mils/Month</u>
7°C	1.015
65°C	0.721
75°C	0.672
85°C	0.455

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INDUCTION HEATER - C. D. Wilson

The induction heating facility was started on a test run on January 30. Three weighed aluminum dummies and one thermocouple dummy were loaded in the slotted process tube. Two of the weighed slugs are being exposed to the flux of the coil, and the other weighed slug is upstream of the coil. Slug surface temperature data are being taken with the thermocouple slug to assure constant temperature difference between slug surface and cooling water. The unit has been maintained at a constant power input to the coil of thirty kilowatts. This power level with a constant water flow rate of five gallons per minute gives a temperature difference of 25° to 30°C between slug surface and cooling water. Data are also being taken on the pressure drop across the tube to determine the rate of film formation. Slug weight loss data will be available after March 15, 1952, the scheduled completion date of the test.

Two new safety devices were installed on the unit during the past month. A relay switch, which operates on the motor-generator cooling water mercooid switches, was installed in the M-G stop-start circuit. This relay will drop the power to the motor if the cooling water line pressure drops below a certain value. The other safety device installed is a thermostat control on the coil cooling water exit side. This control will drop the load to the coil if the temperature of the cooling water approaches the boiling point.

CORROSIVE EFFECTS OF HEAVY METAL IONS ON ALUMINUM - G. S. Fujioka

The three months' studies dealing with the effect of silver, copper, lead, tin, and chromium ions on 2S and 72S samples in synthetic process water have been concluded. The corrosive effect of each of the metal ions at concentrations ranging from 0.001 ppm to 0.2 ppm have been evaluated in terms of area of attack per coupon, which measures 2 inch by 3/4 inch. Photographs are being made to permanently record the surface appearance and also to serve as a basis for comparison with the same samples before exposure to the heavy metal ions.

Synthetic process water was prepared using specially purified distilled water and carefully weighed amounts of salts normally found in process water exclusive of the heavy metal ions. The synthetic process water still had a residual copper ion concentration of 0.005 ppm, so all heavy metal ion solutions made from it have this copper concentration superimposed upon them. The samples were placed in a shaker and agitated for three months. The solution was renewed at the end of each month. The temperature at which the studies were made averaged 30°C.

A table showing the area of attack found on samples immersed in the solutions of metal ions at several concentrations is given in Table V. The table indicates that the 2S samples are attacked uniformly regardless of the type of ion and its concentration. Attack of the aluminum surface in the heavy metal ion solution is only slightly greater than for the samples containing no heavy metal ions. Copper ions give a slight accelerating effect on corrosion except at 0.050 ppm where no attack was visible.

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TABLE V

CORROSION OF ALUMINUM BY HEAVY METAL IONS

<u>WATER SAMPLE</u>	<u>HEAVY METAL ION ADDED</u>	<u>CONC. OF ADDED IONS (ppm)</u>	<u>AREA OF ATTACK (Mils²) PER COUPON (2.1" x 0.75")</u>	
			<u>2S ALUMINUM</u>	<u>72S ALUMINUM</u>
Process #1	None	—	900	45
Process #2	None	—	160	0
Process #3	None	—	—	0
Synthetic #1	None	—	75	800
Synthetic #2	None	—	84	330
Synthetic Process	Ag ⁺	0.001	250	72
"	"	0.005	150	30
"	Cr ⁺⁺⁺	0.001	550	30
"	"	0.005	18	234
"	"	0.025	75	0
"	"	0.050	120	300
"	"	0.100	100	240
"	Cu ⁺	0.005	650	0
"	"	0.025	570	2600
"	"	0.050	0	1200
"	"	0.100	225	3400
"	"	0.200	3600	29,000
"	Pb ⁺⁺	0.001	15	60
"	"	0.005	110	160
"	"	0.025	31	90
"	"	0.050	330	125
"	"	0.100	160	0
"	Sn ⁺⁺	0.001	100	185
"	"	0.005	225	25
"	"	0.025	0	4
"	"	0.050	48	350
"	"	0.100	0	75

The 72S samples were attacked less uniformly than the 2S samples; some showed greater resistance to attack while others showed greater susceptibility, notably with copper ions. No apparent trend is distinguishable between amount of attack and concentration in either type of aluminum except in the case of the 72S samples immersed in solutions containing copper ions.

The depth of the corrosion area was very difficult to determine but all appeared to be less than 5 mils with 2 or 3 mils the average depth.

A more detailed report will be made on all phases of the study at an early date.

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ELECTROGRAPHIC DETECTION OF CORROSION FOCAL POINTS - G. S. Fujioka

The study of end cap contamination by foreign metals other than aluminum was concluded in early February. An electrographic technique was employed in which a very thin surface of the end cap was electrically oxidized to ions which were then absorbed by a suitable electrolyte-dampened filter paper. The filter paper was then "developed" by a spot test reagent specific for only one metal ion.

The results showed that on 30 process slugs tested, no detectable deposits of copper or tin were present. The detection limits for copper and tin as given by F. Feigl, "Qualitative Analysis by Spot Test" were 0.006 micrograms for copper and 2 micrograms for tin.

To determine if either copper or tin deposits could be found below the surface of the end cap, six process slugs were machined to various depths, the maximum down to 65 mils. The tests on these machined surfaces were negative.

A final report on the electrographic studies will be made next month.

STUDIES ON FILM FORMATION BY COLLOIDAL PARTICLES - G. S. Fujioka

A preliminary program for studying mechanism of film formation by colloidal particles is being formulated. By the use of an electron microscope and an ultramicroscope it is hoped to determine particle size, shape, charge, distribution of size and mobility of colloids in Columbia River water at various stages of water treatment.

Coagulation of these colloidal particles under thermal, radiation, and aging influences will be studied as well as surface effects of aluminum on colloidal particles.

WATER COMPOSITION - FILM FORMATION - EFFLUENT ACTIVITY RELATIONSHIPS - D. H. Dills

A reinvestigation of the factors affecting film formation and effluent activity is being undertaken. Data are still being accumulated. In this study (a) the effect of age of metal and orifice size on panellit pressure change, and (b) the river water manganese - process water manganese - effluent water manganese activity interrelations are being considered.

Film Formation

The ways of estimating film formation are (a) change of gross flow, (b) pressure drop change (measured for eight central tubes), (c) panellit pressure change. The limitation of panellit pressure change as an indication of film formation is

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illustrated in Table VI, showing pressure change at 100-H during the period September 1 to September 24, 1951.

TABLE VI

PANELLIT PRESSURE CHANGE (psi) FOR 12 TUBES AT 100-H

September 1, to September 24, 1951

		<u>New Tube</u> <u>New Metal</u>	<u>Old Tube</u> <u>New Metal</u>	<u>Old Tube</u> <u>Old Metal</u>
Solid Al	1 st. Orifice Zone	7	7	3
	2nd. Orifice Zone	11	Not obtained	12
Regular Metal	1 st. Orifice Zone	10	10 8	10 9
	2nd. Orifice Zone	Not obtained	Not obtained	14 15

These may be broken into complete two factor and incomplete three factor analyses. The features brought out are (a) the panellit pressure is insensitive to the age of metal and tube, (b) the difference between regular metal and solid aluminum slugs is not great, (c) the pressure change is greater in the fringe zones where the pressure and velocity are lower.

Effluent Activity

The periodic samplings of water entering the 107 Basins taken by Radiological Sciences Department and subjected to radiochemical analysis (HW-21844) are taken as a "best measure" of effluent activity. Many elements (eg. Fe, Si, Mn, Na) are present in the river water largely in colloidal form, and it appears that they are present in an amount directly proportional to the turbidity.

Preliminary results from data taken over the first six months of 1951 show no correlation between river sodium and effluent sodium activity. It would be desirable to initiate regular measurements of process water sodium concentration, which are not at present taken, for the purpose of future comparison.

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These data from the first six months of 1951 show linear correlation between treated water Mn concentration and effluent Mn activity. There is no linear correlation between river water Mn and process water Mn. Thus the water treatment is varying for Mn and to reduce the Mn in treated water may be to reduce the effluent Mn activity. Further work will be done to determine the degree of reliability of the correlation.

CHEMICAL REMOVAL OF FILM - M. Lewis

The test of versene at 0.2 ppm as an agent for preventing and removing film has been operating in the 100-H sample room since January 18, 1952. No noticeable change in flow rate had occurred after five weeks operation either with or without versene present. Because of the low flow rate through the sample line and the large hold-up chamber, the temperature of the water in the capillaries was only 36 - 38°C. The rate of film formation at this temperature was apparently too low for the purposes of this test. Arrangements are being made to transfer the equipment to a line without holdup in order to increase the rate of film formation.

WEIGHED TUBE APPARATUS - M. Lewis

Film is apparently forming in the tubes of the weighed tube apparatus. Flow rates have decreased approximately 3 per cent during the past month. The test will be allowed to run until the flow decrease becomes excessive. At that time it will be dismantled and the condition of the tubes noted.

SHORT COURSE ON CORROSION - M. Lewis

A short course on corrosion sponsored by the National Association of Corrosion Engineers was attended on the University of California Campus at Los Angeles, February 4 through 8, 1952. Lectures on the theory and practical aspects of corrosion were presented by national authorities in their respective fields. A trip report on the meeting is being published.

"PROBOLOG" - TUBE TESTING DEVICE - M. Lewis

Interest has been shown by several Hanford Works personnel in the "Probolog," an instrument manufactured by the Shell Development Company for the purpose of detecting corrosion or defects in non-magnetic heat exchanger tubing. A demonstration of the instrument on sections of ordinary tubing showed that it has a possible application in the examination of Hanford process tubing. As a result, an order has been placed to procure a "Probolog" for testing.

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WATER STUDIES - RECIRCULATION - R. H. Purcell

FLOW LABORATORY RECIRCULATION STUDIES - N. R. Miller

Flushing of the laboratory recirculation system and the production of approximately 700 gallons of steam condensate was completed on January 31, 1952. On February 1, 1952, the first recirculation test was begun with a 16 GPM flow rate, a 25°C tube inlet, and a 80°C tube outlet water temperature. An analysis of the condensate at the beginning of the test showed zero ppm of SO_4 , Cl, Mg, and Cr_2O_7 ; 0.015 ppm of Fe; and 1.2 ppm of Ca. The specific resistance was found to be 230,000 ohms/cm³. The initial pH of 5.0 was increased by aeration which eliminated CO_2 from the water.

During the first eight days of operation, 24-hour coverage was maintained. During this period, a water leak developed through one of the pump gaskets and the gasket was replaced; otherwise, operation was normal. While the test was shutdown for the gasket replacement, an additional 100 gallons of condensate were produced to compensate for that lost through leaks.

The test was shut down from February 8 to February 12, 1952, while an air operated valve was located and installed to replace a similar valve which became inoperative. The air operated valve serves to shut off steam to the jacket on the tube whenever pile process water pressure drops to 350 psi or lower, or when the recirculation tube inlet pressure becomes 75 psi or lower. With the valve in good working order, overheating of the condensate is avoided when either the condensate or the cooling (pile-process) water flow rates are reduced. Operation without the valve in good working condition was deemed to be unsafe.

Work is now progressing on the installation of a new steam line and a PRV on the cooling water line. With these two additions, considerable more flexibility in the equipment will be realized.

As of February 25, 1952, the test has run a total of 343 hours. The tube will be discharged after 700 hours of operation and film formation and corrosion data taken. More analyses of the water will be made to check on an iron and aluminum pick-up by the condensate.

100-H IN-PILE RECIRCULATION EXPERIMENT - R. H. Purcell

The rough draft of the production test has been prepared and is being circulated to those concerned for comment. It is believed that the production test will be circulated for approval during March.

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It is now planned to start the experiment in May, 1952, and operate with the tube charged with dummy slugs for a period of approximately two months. During this time, the test system will be thoroughly tested. After the equipment has been proven satisfactory for regular operation, the tube will be charged with regular metal.

The request for an appropriation for demineralization equipment to be used with the flow laboratory experiment and with the in-pile experiment has not yet been approved by the Appropriations and Budget Committee. This request is being considered at the February meeting of the committee.

H. M. Arvan

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