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TECHNICAL ACTIVITIES REPORT

HEAT, WATER, AND MECHANICAL STUDIES

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by

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Pile Engineering Branch
Pile Technology Unit

October 4, 1951

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HEAT STUDIES - M. W. Carbon

FRONT AND REAR FACE REFLECTOR SHIELDS AT C-PILE - H. Greenfield

Calculations were made to determine the necessity for using reflector shields between the front and rear thermal and biological shields in C-Pile.

The calculated masonite temperatures in the sub-block and at the inner tie strap, with and without the use of a reflector shield, appear in Table I. Values were calculated for two assumed conditions: (1) An increase in heat generation in the thermal and biological shields by a factor of 18 over that encountered in the H Pile at present, and (2) a similar heat generation increase but only by a factor of 6.

Estimated values for heat generation in the H Pile shields were obtained from R. L. Dickman. The factor of 18 was arrived at by assuming a pile power level of twice the present value of H Pile with an additional nine-fold increase due to front-to-rear enrichment. The factor of 6 was arrived at by assuming only a threefold increase due to enrichment. If enriched metal were used to replace the first slug in the train, the factor of 18 would probably be the most realistic. However, J. A. Horning has postulated that, in order to make the most effective use of the enriched material, said material would probably be located about four lattice units into the active metal zone. In that case, the factor of 6 would be most realistic. The latter factor appears more realistic from a shield-life viewpoint also. The neutron flux in the masonite would increase approximately in direct proportion to the heat generation. Thus, for the factor of 6, it would be assumed that the life of the masonite shield would be only 1/6 of that anticipated for the H Pile shields under present operating conditions. For the factor of 18, the life of the shield would be further decreased.

From the table, the conclusion may be drawn that the shields should be installed if the most extreme operating conditions are assumed. This statement is based upon the assumption that the masonite should be kept below 100°C. If the more moderate conditions are assumed, the shield would not be required in front. However, it would be required in the rear.

If it is assumed that front-to-rear enrichment will never be used, both shields may be omitted.

A document presenting the calculations will be issued.

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TABLE I

CALCULATED "C" PILE FRONT AND REAR SHIELD TEMPERATURES

18 x Heat Generation at H

	<u>Thermal Cast Iron Shield Temp. °C</u>	<u>Maximum Masonite Temperature in Sub-Block of Biological Shield, °C</u>	<u>Maximum Masonite Temp. Near Inner Tie Strap, °C</u>	<u>Local Water Temp. °C</u>
<u>Front Shield</u>				
Without Reflector	180	145	90	20
With Reflector	180	140	30	20
<u>Rear Shield</u>				
Without Reflector	250	230	165	90
With Reflector	250	108	100	90

6 x Heat Generation at H

<u>Front Shield</u>				
Without Reflector	75	55	40	20
<u>Rear Shield</u>				
Without Reflector	145	135	110	90
With Reflector	145	98	95	90

PROCESS TUBE CHANNEL THERMOCOUPLES - K. G. Toyoda, H. H. Greenfield

It has been proposed, in Document HW-21832, to install thermocouples in empty process tube channels in the piles to ascertain the following information:

1. Relative front-to-rear graphite temperature distribution.
2. Relative front-to-rear graphite conductivity distribution.
3. Correlation of lattice conductance data with rod configuration.
4. Comparative temperature data between process tube channel thermocouples and adjacent VSR thimble thermocouples and C-Hole thermocouples.
5. Desirability of this type of thermocouple installation to monitor graphite temperatures after removal of the vertical thimbles with the attached thimble thermocouples.

Calculations are being made in support of this work to determine the change in the temperature of the filler block caused by removing one of the adjacent process tubes.

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REVISION OF WATER TEMPERATURE LIMIT FOR HORIZONTAL RODS - H. H. Greenfield

A recommendation for revision of an Operating Procedure specification concerning shutdown emergency due to high outlet water temperature from the horizontal rods was made to the Production Unit, HY-22264. The recommended revision alters the limit from a 35°C maximum outlet water temperature to a limit on the temperature rise of the cooling water of 20°C for the rod. The change does not involve any relaxation in the heat generation limits. In fact, it imposes a greater limitation during the low inlet water temperature months by reducing the allowable temperature rise from about 30° - 33°C to 20°C. It allows a higher outlet water temperature during the summer months, but the allowable heat flux in the horizontal rod is the same as for winter operation. No excessive horizontal rod temperatures are foreseen due to this recommended operating limit change. The change in the operating specifications will prevent reduction of power levels with subsequent reduction of operating efficiency during the summer months.

SLUG TEMPERATURE AND THERMAL CONDUCTIVITY CALCULATIONS - H. H. Greenfield

A report, HY-22189, was issued concerning slug temperatures and the thermal conductivity of uranium.

At 550 MW, with 1300 effective tubes, the maximum slug axial temperature was calculated to be between 230 and 325°C. The thermal conductivity of the uranium probably lies between 15 and 17.8 Chu/hr/sq ft/°C/ft.

At 650 MW, with 1300 effective tubes, the maximum slug axial temperature was calculated to be between 325 and 370°C. The thermal conductivity of the uranium probably lies between 15.6 and 18.2 Chu/hr/sq ft/°C/ft.

These values are based on the conductivity of unirradiated uranium.

MAXIMUM SLUG-END CAP TEMPERATURE - H. H. Greenfield

The maximum slug-end cap temperature for a slug in a pile operating at a power level of 550 MW was calculated to be 127°C or less. The following conditions were assumed:

1. 0.240 orifice
2. Water flow = 22 gpm
3. Inlet water temperature = 17°C
4. Outlet water temperature = 35°C
5. Riser pressure = 400 lb/sq. inch

The saturation temperature of the water at the corresponding position in the tube of maximum slug-end cap temperature was 174°C. Thus, the maximum slug-end cap temperature is 47°C below the saturation temperature.

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BOILING CONSIDERATION STUDIES - R. G. Vanderwater

An investigation is being made of the practical possibility of reducing the so-called "boiling disease safety factor." It is believed that the factor could be somewhat reduced if the Panellit indicator system could be made to scram the pile automatically. Many unnecessary scrams have resulted from automatic systems in the past. Consequently, present efforts are being directed toward obtaining an automatic system with a time-delay relay. Theoretically, such a relay could reset itself in case of a momentary pressure fluctuation and yet activate a scram switch in case of a permanent pressure fluctuation. Some progress has been made toward procuring such a relay.

SCRAM TIME LIMIT FOR PANELLIT ALARM - R. G. Vanderwater

A partial review has been made of the delay time which may be permitted between a Panellit alarm and the shutdown of the pile. The limit set on the delay is intended to prevent melting of the aluminum can and Al-Si bonding in case of a water flow reduction or stoppage. The 20 second limit that is in use was established on the basis of a power level of 305 MW.

For sudden and complete stoppage until three seconds after the control rods have gone in, the limits would be 13, 10, and 8 seconds at powers of 500 MW, 600 MW, and 700 MW respectively. For a partial stoppage, a somewhat longer delay could be tolerated. However, for a complete stoppage of water in the maximum tube of a 700 MW pile without resumption of flow after the pile is shutdown, it is likely that melting of the Al-Si bonding would occur even in spite of an immediate shutdown. In this case, heat flow to the graphite probably would be insufficient to prevent melting.

The delay time of 13, 10 and 8 seconds were based on the following assumptions: (1) heat flux that of the maximum slug in a pile with 1300 effective tubes and a ratio of $\frac{\text{tube maximum flux}}{\text{tube average flux}} = 1.45$, (2) No heat flow to graphite (valid for at least 15 to 20 seconds), (3) 1000 inhours of control are effective 3.7 seconds after scram is initiated, (4) Only five percent of the water in the tube is vaporized, (5) Three seconds after rods are effective, sufficient water is flowing to begin cooling the slug again, and (6) The slug temperatures should not exceed 550°C.

After the calculations have been placed on a more firm basis, a document discussing the subject will be issued.

ASSISTANCE TO METALLURGY - G. L. Locke

A request was received from A. C. Callen of the Metallurgy Branch for an estimate of the severity of a proposed heating-quenching cycle for the slugs before they are placed in the pile.

The results of a rough analysis of the problem are summarized in a letter to A. C. Callen, dated September 20, 1951. It was found that temperature gradients within the slug would be greater in the pile than in the autoclave in which quenching took place. Conditions in the autoclave, therefore, would not be as severe as in the pile.

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HEAT TRANSFER TEST - G. L. Locke, H. Harty

The operation of the heat transfer test equipment has been delayed by alterations to the 189-D Test Laboratory. Upon completion of the alterations, circumferential temperature distribution tests will be made on a C-Pile process tube configuration. This configuration is obtained with a ribless process tube and a uniform walled heater tube upon which plastic ribs have been cemented.

Design of the new variable wall aluminum heater tube is complete. Fabrication will commence upon final checking of the drawings.

ASSISTANCE TO THE REACTOR UNIT - G. L. Locke

Work was completed on recommendations for the initial flow rate and inlet pressure to be used in C-Pile. These recommendations are summarized in HDC-2327. They involve three alternative recommendations depending on the anticipated length of time before high power levels are reached and before high enrichment is used.

SLUG STRESSES - D. E. Amos

In view of the seriousness of the slug rupture problem, calculations are being made to investigate slug stresses. Emphasis is being placed on those stresses resulting from temperature gradients within the slug. No reportable results have been obtained as yet.

THERMAL INSULATION OF BOTTOM TUBE ROW AT C-PILE - M. Altman

The problem of preventing heat loss from the lowest tube row and reflector graphite was examined in detail. Keeping the temperature of this region up is important from the point of view of graphite damage.

In general, there are two ways of accomplishing this end. One is to put a resistance to heat flow between the bottom cast iron shield and the graphite. The other one consists of raising the temperature of the cast iron, thus decreasing the temperature difference between tube block and cast iron shield. The steel webbing, which was proposed originally, would have accomplished the former, and flowing hot water through the cooling tubes in the cast-iron shield would be an example of the latter.

The coolest portion of the tube blocks will occur near the inlet end of the pile. Both of the above means were examined under conditions representative of those which might be expected in this region. The results of these calculations are summarized in Table I.

TABLE I

Probable Conditions at Lowest Tube Row at Horizontal Center of C-Pile, Two Feet Downstream from Inlet End of Active Zone, Power Level of Approximately 855 MW.

Condition	Tube Block Temp. °C		Area Average Temp. °C.	Estimated ¹ Expansion in/1000 F/D	Percent Reduction from Maximum Expansion Rate
	Coldest	Hottest			
No Web and Cold Water	40	51	47	0.11	0

1. R. K. Andersen, "Correlation of Apparent Graphite Expansion With Radiation Exposure and Lattice Unit Temperature," HDC-1287, 1-19-51.

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TABLE I
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Condition	Tube Block Temp. °C		Area Average Temp. °C.	Estimated ¹ Expansion in/1000 M-D	Per Cent Reduction from Maximum Expansion Rate
	Coldest	Hottest			
Web and Cold Water	51	70	64	0.08	27
Hot Water with no Web	61	119	101	0.044	60

These calculations indicate that the use of hot water is preferable to the installation of a thermal insulator. A detailed report was presented to the C-Pile Working Committee, and is summarized in document HW-22216.

This document also includes a suggestion as to how such hot water heating could be obtained.

PRESENT PILE ENRICHMENT - M. Altman

The heat transfer problems involved in front-to-rear and radial enrichment are being examined in detail. No results have as yet been obtained.

HEAT GENERATION DATA - M. Altman

The Physics Group of the Pile Technology Unit computed the following heat generation rates in the shield of a pile being operated at 400 MW.

Thermal Shield — 0.45 watts/cm²

Biological Shield — 0.001 watts/cm²

The heat generation rate for the thermal shield of H Pile was computed from experimental data, and found to be 1,797 BTU/hr-sq. ft. at 550 MW. Correcting the value of the Physics Group to the corresponding power level results in a value of 1960 BTU/hr-sq. ft. Since that value was presented as probably being about 30 percent too high, it is felt that an excellent check on the calculated heat generation data has been obtained.

FLOW TESTS - L. E. Foster

Installation of the new pressure drop tube at 100-F Flow Lab. has been completed.

Tests have been made to determine pressure drop differences through 10 o'clock and 4 o'clock nozzle and pigtail assemblies. These tests included both inlet and outlet ends. The physical difference in the assemblies is in their orientation only. Data do not show a difference in pressure losses between the inlet 10 o'clock and the inlet 4 o'clock nor between the outlet 10 o'clock and the outlet 4 o'clock arrangements.

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The pigtails that have been fitted with pressure taps at approximately two inches from the inlet and outlet ends were compared to standard pigtails. Again the difference, if any, was experimentally undetectable with present equipment. In view of above tests, the pressure tap fitted pigtails are being used and no regard is being given to nozzle and pigtail orientation.

At present, data are being gathered on an equivalent B, D, and F mockup. This mock-up differs from H in inlet nozzle and outlet crossheader fitting. It differs from DR in inlet nozzle only. Inlet nozzles at H and DR are galvanized stainless steel. B, D, and F have aluminum inlet nozzles. The outlet crossheader fittings at H are welded to L shaped 3/4 inch pipes. The 3/4 inch pipes are welded to the crossheaders. On all other piles, the rear crossheader fitting is welded directly to the crossheader. The parameter in these first tests is orifice size.

Some preliminary curves of pressure drops through various components of the complete mock-up have been drawn. They indicate a good degree of consistency is being obtained with the present equipment.

The test equipment has been fitted, to assist a member of the Production Unit, to test a one-inch pigtail and crossheader fitting. This test will require only one day.

ELECTRIC ANALOG - L. E. Foster

A preliminary design for a three dimensional electrical analog has been completed. This design would facilitate the study of steady state heat transfer problems and would be readily adaptable to the more complex transient problems. Present design would make a 10 x 10 x 3, 8 x 8 x 4, 7 x 7 x 5, or 6 x 6 x 6 temperature point study possible. These point arrays refer to the number of locations in each dimension of a medium that a temperature could be determined. This analog could be used for a 32 x 20 point two-dimension study.

Improvements over the present analog would include:

1. Rapid assembly of resistance pattern.
2. Faster method of feeding in known currents to node points.
3. The facilities to study three-dimension problems.

A preliminary survey of costs involved in this design has been completed.

This study is being carried out to determine what type of analog is suited to the largest number of heat transmission problems. As the design becomes more definite, minimum cost to secure such an analog will be considered. The possible sources would be from a manufacturer of analogs; from our own shops; or from an off-the-project shop.

MEASUREMENT OF THERMAL CONTACT RESISTANCE - R. Weidner and G. L. Locke

In the calculation of the temperature gradients in the thermal and biological shields at C-Pilo, it is necessary to estimate the contact resistance between the shield and the lead which surrounds the cooling tubes. Lack of experimental data makes this estimation rough at best. Therefore, it was decided to build a simple apparatus to obtain the needed information.

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Such an experimental set-up was designed and built and at present is ready for use. It consists of three concentric tubes 42 inches long which form one inner flow tube and two annuli. Steam is passed through the inner tube while water at a given flow rate is passed through the outer annulus. The inner annulus is filled with lead.

The overall thermal resistance between steam and water can be calculated from the steam temperature, temperature rise in the water, and flow rate. The contact resistance between lead and tube walls can then be separated from the overall resistance. This is accomplished with the aid of existing equations for the film resistances and for the resistance of the lead and tube wall material.

Preliminary tests have been made on the equipment. However, the results have not been completely analyzed as yet and will not be reported at this time.

M. W. Carbon
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WATER STUDIES - R. M. Fryar

100-D FLOW LABORATORY - J. M. Atwood

Construction of 100-D Flow Laboratory was stopped during the month because of over-expenditure of funds. Procedures are being followed to obtain additional funds for completing the project. A revised project proposal is being readied for approval by the Appropriations and Budgets Committee. During the month nearly all of the critical material needed for completion of the project has been delivered. It is estimated that approximately three weeks will be required to complete construction after approval for additional funds are received.

Tests using process water and raw water have been operating since the latter part of August. Two 16-foot mock-up process tubes were loaded with weighed aluminum dummies and a perforated aluminum pear dummy pattern. Daily measurements of flow rates and tube pressure drops were made. A plot of ΔP divided by the square of the flow rate was found to give a good indication of the rate of film build-up in the tubes and to minimize fluctuations due to normal variation of pressure. During 25 days of operation at approximately 20°C, $\Delta P/Q^2$ increased 13 percent in the raw water tube. The flow rate was maintained at 20 GPM.

Raw water with no purging:

<u>Slug Number</u>	<u>Weight of Film*, mg</u>	<u>Corrosion Loss, mg</u>
1	95	0
2	111	4
3	94	1
4	104	2
5	89	2
6	109	2

* As removed by a three minute immersion in 2 percent chromic-five percent phosphoric acid at 85°C, followed by water, acetone, and water rinses.

A statistical analysis showed that the experimental error of weighing in this weight range is 2.1 mg. The above data and visual examination indicate that no corrosion from raw water at temperatures of 20°C.

The preliminary information gained in the tests mentioned above shows that reliable data concerning both film formation and corrosion effects can be obtained with the flow laboratory equipment.

PT-105-473-P - ALUMINUM SULFATE FOR 100 AREAS' PROCESS WATER COAGULATION -

W. C. A. Woods

The above document specified the starting date of the test as soon after September 6, as alum was available on the plant. Sufficient quantities of alum arrived on the plant September 19, and the test was scheduled to begin September 24. The unscheduled outage of F-Pile of September 23 has delayed the initiation of the test approximately one week, since it was felt that the test should not start until equilibrium conditions in the pile were established.

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Prior to the starting date, all preliminary work has been completed. This work included the removal of approximately 46,000 pounds of ferric sulfate from two storage bins and chemical feeder hoppers in the 133-F Head House. These two feeders are now filled with alum in preparation for the beginning of the test. In addition, the installation of a small water softener in the Head House has been completed. This was believed necessary because of the possibility of plugging the lime addition lines with deposits of scale. This difficulty is already present under present operations and would be aggravated by the much longer lines and small flow rates required in the test. The use of softened water should eliminate this problem.

It is planned to check the operation of the softener and lime addition equipment prior to the substitution of alum for ferric sulfate. The use of alum requires a lower coagulation pH than ferric sulfate, and consequently, lime must be added in the effluent flume from the filters in order to adjust the pH to the current specification of 7.6. In order to test the proper operation of the lime equipment, the coagulation pH will be lowered to 7.2, and the pH of the clearwell effluent will be tested to determine if the lime is channeling through the clearwell. It is expected that a pH of 7.2 will be required in the filter effluent to maintain a residual aluminum concentration of less than 0.05 ppm.

When satisfactory operation under the above conditions is obtained, the ferric sulfate feed will be stopped and the addition of alum sufficient to maintain the proper aluminum residual as determined by analysis will begin. As soon as operation has been stabilized and satisfactory filter operation established, the optimum operating conditions for alum will be determined and operation continued on this basis.

At the end of 30 days continuous operation with alum, process tube pressure drop data, Pamelli pressure data, effluent water activity, and filter operation data will be compared with similar data now being accumulated with ferric sulfate addition. This comparison should establish the effects of alum on pile operation and will furnish the basis for a decision to continue the use of alum.

FUNDAMENTAL STUDIES ON FILM FORMATION - R. V. Andrews

Because of the importance of film formation in the operation of the Hanford Piles, a fundamental study of the factors influencing this film formation is of the greatest importance. Apparatus is being designed to allow the determination of the effect of various variables such as Reynold's Number, surface temperature, pH, and water composition and treatment on the formation of this film. In addition, an experimental procedure for the most efficient use of this apparatus is being detailed to determine the significance of these variables in the minimum of time.

SODIUM SILICATE ADDITION AS AN AID TO FERRIC SULFATE TREATMENT OF WATER - R. V. Andrews

A study of the possible use of activated silica prepared from sodium silicate to be used with ferric sulfate treatment of raw water is being made. The primary purpose of this study will be to determine the possible advantages of such an addition for increasing the capacity of the 100 Areas filters. Since the final pH value to be used for process water has not yet been determined, systems most effective in both acidic and basic waters should be investigated. In basic waters, ferric sulfate has advantages, while in acid waters, alum has

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advantages. The use of activated silica in conjunction with ferric sulfate is reported to increase the size and toughness of the floc produced, thereby allowing an increase in the capacity of the filters. A report is being prepared and will be issued discussing the possible use of activated silica, together with ferric sulfate.

COATINGS ON TIP-OFFS - N. R. Miller

Water repellent coatings were applied to tip-offs in hope that this action would ease the job of their decontamination. It was found that coated tip-offs were no more easily decontaminated than were the uncoated ones. It is probable that the slugs abraded the coatings off as they were discharged and thus no advantages are obtained from this process.

CAN DIFFERENCE TEST - N. R. Miller

The Can Difference Test is being continued using one tube in the 100-F Flow Laboratory. The flow rate is being maintained at 20 gpm and the outlet temperature is being held at 80°C.

A promised shipping date of October 5, 1951, has been received on the gage ordered for the measuring of film thicknesses. When this gage arrives, the slugs being used in this study will be discharged from the tube and the test ended.

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

The study of slug jacket abrasion at flow rates of 26, 30, and 34 gpm is being continued using three tubes in the 100-F Flow Laboratory. It is planned to discharge the slugs used in this study on September 26, 1951, to determine the amount of abrasion which occurred during the second month of exposure.

PT-105-450-P - N. R. Miller

PT-105-450-P, "The Effect of In-Pile Conditions on Dri-Film Coatings Applied to Slug Surfaces," has now been underway for slightly more than three months. Data taken thus far still do not indicate that Dri-Film coatings on slug surfaces have a beneficial action in reducing the rate of film build-up or in increasing purge efficiency.

SLUG COATING INVESTIGATIONS - N. R. Miller

A study of the effects of two water repellent coatings on slug surfaces is being continued using one tube in the 100-F Flow Laboratory. The investigation is being conducted using process water at a flow rate of 20 gpm and an inlet temperature of approximately 19°C. The water is heated by three steam jackets in series on the process tubes in steps to 50°, 75°, and 90°C.

It is planned to discharge the slugs being studied from the tube, weigh these slugs to determine the amount of film deposition on slugs coated with each of the two types of coating and uncoated slugs, and then recharge the slugs for an additional period of time.

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HIGH TEMPERATURE CORROSION - S. Goldsmith and M. Lewis

Expansion of the high temperature corrosion facility in the 100-2 Flow Laboratory has been partially completed. Eight tubes are now available for studying corrosion at temperatures higher than are currently encountered in the pile. A study of slug corrosion rates at outlet water temperatures of 118°C and 150°C are now under way. The remaining tubes will be charged during the month.

FRONT TUBE DUMMY SLUGS - M. Lewis and S. Goldsmith

The test to study the effectiveness of various dummy slugs for eliminating front tube corrosion is scheduled to get underway during the coming month. The relative efficiency of 2S aluminum, 72S aluminum, and magnesium dummies is to be determined by loading weighed two foot sections of process tubing with the dummies, and passing water through the tubes at various velocities. Weight loss measurements and "before and after" visual inspections of the tubes will determine which dummies offer the best protection.

POTENTIAL MEASUREMENTS - M. Lewis and S. Goldsmith

Solution potentials of 72S versus 2S aluminum in 20°C water were measured with a Brown recording potentiometer. The water was passed over the 72S and 2S aluminum electrodes at a rate of 150 ml/minute. Initially, the 72S was anodic to 2S by 20 millivolts. The potential difference between the two electrodes gradually decreased until after seven days the potential reversed and the 2S aluminum became approximately 2.6 millivolts anodic to the 72S. Solution potential measurements of the two metals will be continued with the electrodes at different temperatures.

CORROSIVE EFFECTS OF HEAVY METALS IN WATER - G. S. Fujioaka

A test has been started to determine the effects of trace amounts of heavy metals in the process water on corrosion of aluminum. Test strips of 2S and 72S aluminum are to be exposed in waters containing trace amounts of copper, lead, tin, and silver. Weight loss measurements and "before and after" visual inspections are to be made to determine corrosive effects of the trace elements in the water.

METALLOGRAPHIC EXAMINATION OF TUBES FROM H-PILE - M. Lewis and S. Goldsmith

The metallographic examination of tubes 2276 and 2376 from H-Pile has been completed. These tubes were in use from the time of H-Pile start-up until their removal on July 20, 1951. They never contained a front dummy pattern and only galvanized nozzles were used on these tubes. Almost no evidence of corrosion was observed. The corrosion noted was in the form of a few isolated shallow pits. A more detailed report is being prepared.

PT-105-407-P - M. Lewis and S. Goldsmith

Borescoping of three magnesium-loaded tubes at H and three at B was carried out according to PT-105-407-P. No corrosion was noted at H and a comparison with adjacent tubes showed the only difference to be in the film. Magnesium-loaded tubes had a grey appearance, no film being visible, whereas adjacent tubes contained a light brown film. A similar phenomenon was noted at B. Corroded areas were noted in the B Area tubes, with corrosion products in evidence even in the magnesium-loaded zone.

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A visual examination of three process slugs that had been in physical contact with magnesium slugs showed no significant difference from other process slugs examined simultaneously.

FIFTY-TUBE MOCK-UP - J. D. Fogelquist

The Front Tube Corrosion Mock-Up, Project C-469, has been fully approved and a directive from the AEC has been received which authorizes construction. All materials and equipment required for construction have been located. To expedite construction, all materials are scheduled to be purchased and accumulated in the next two weeks. Initial construction is scheduled to begin October 8, 1951, and the estimated completion date of this mock-up is November 1, 1951.

INDUCTION HEATING FACILITY - J. D. Fogelquist

An informal project has been submitted to obtain approval for installing in the Corrosion Laboratory in the 185-189-D Buildings an induction heating unit for experimental purposes. The induction heating coil will be built around an already existing mock-up process tube and by the use of steel-filled aluminum-jacketed slugs, it will be possible to simulate very closely in-pile conditions for corrosion experiments. Calculations show that heat rates and heat distributions closely resembling those of central zone tubes can be obtained. Thus, it will be possible to duplicate all the variables of corrosion, with the exception of radiation, that occur within the pile.

SODIUM DICHROMATE ELIMINATION TESTS - R. H. Purcell

Pigtail strainers were added to the test system during the shutdown of August 29 and 30, 1951. After start-up, it was observed that the pressure drop across the pigtailed was excessive. While part of this loss may have been recovered by using larger mesh screen in the strainers, it was felt that the pressure drop would still be prohibitive, especially if it ever became necessary to furnish process water to the tubes after charging with regular metal.

The system was briefly shifted to process water to obtain the Panellit pressure readings. The lowest reading was 212 lbs/sq. in. Approximately 10 lbs/sq. in. must be subtracted to allow for the heating of the water when the tubes are charged with regular metal. The resulting value of 202 lbs/sq. in. is below the Panellit trip point for scrambling the pile.

It was agreed with members of the Production Unit that these strainers would be removed from the test system. The system would then contain three 50-mesh strainers in series for filtered water and two 50-mesh strainers for process water.

The pigtail strainers were removed from the system on September 28, 1951. It is planned to recharge the tube with regular metal at the time of the poison push. Continuous monitoring will be supplied during the first week of operation.

OPERATIONAL PROCEDURES AND STANDARDS - W. C. A. Woods

The document, "Emergency Requirement Considerations for the Process Water Pumping System," HW-21356, W. C. A. Woods and R. H. Purcell, which is being published, proposes the operation of the process pump steam turbines without

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the present accelerational feature. Consideration was given to various types of emergency conditions under the proposed operation, and safe operating limits were established for these conditions. It was found that it would be possible to continue operation without scrambling if one pumping unit failed, but that the pile should be scrambled if two units failed. The minimum header pressure requirements following an electrical power outage would be exceeded without the accelerational feature even if one pumping unit failed immediately following the power outage. Since the proposed operating change will require modification of the present instrumentation of the 190-Building steam turbines, specifications were proposed for the required changes. It was found that setting the turbine speed governor 25 RPM above the normal operating speed under minimum film conditions would be sufficient. The elimination of the speed-up feature should reduce operating costs in the 100 Areas for two reasons. First, it will permit operation of the turbines at their most efficient speed by the use of suitable speed reduction units, thereby reducing the normal steam load of the 190 Building. In addition, the emergency steam demand will be reduced, since the greater steam demand of the turbines during the operation of the accelerational feature will be eliminated. The combination of these effects should reduce the emergency steam demand in all of the 100 Areas sufficiently to allow the operation of one fewer boilers. This will allow the operation of the remaining boilers at higher capacities and thus at higher efficiencies.

VERTICAL SAFETY ROD DROPPING TIME TESTS - W. C. R. Woods

The minimum header pressure requirements proposed in HW-21065 were based on the assumption of a maximum dropping time of the VSR's of 3.7 seconds. Because of the greater distortion of the graphite in the B, D, and F Piles, it was believed necessary to measure the dropping times in these piles. This work has been completed and the data will be published in an appendix to HW-21356. It was found the 3.7 second dropping times was exceeded by only one VSR in the D-Pile. This rod was an experimental flexible rod. It is recommended that the minimum header pressure requirements following an electrical power failure proposed in HW-21065 be accepted.

RECIRCULATION - R. H. Furcell

Studies are underway to determine the feasibility of using the recirculation method for graphite pile cooling. The advantages of such a system appear to be in (a) lowering operating costs, (b) reducing the radioactive waste water disposal problem, (c) lowering cooling water requirements, and (d) increasing the possibilities of power recovery from the piles. Certain problems are anticipated, and it will be the purpose of these studies to define these problems and to outline a logical experimental program to solve these problems.

POWER RECOVERY - R. M. Fryar

The survey on various possible methods of utilizing the heat from the pile nuclear reaction process is being continued. It is anticipated that a comprehensive survey of all the various methods which might be utilized will take about six months to accomplish. The purpose of the survey will be determined the most feasible method or methods of power generation both for present piles and for future piles. Such a survey is a necessity if a logical development program is to be initiated.

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PILE RESEARCH DIVISION

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MECHANICAL DEVELOPMENT STUDIES - H. J. White

EFFECT OF SPHINCTER SEAL AND LUBRICANT ON VSR DROP TIME - H. Harty - P. M. Jackson

Drop-out times for VSR No. 20, D Pile, were measured for each of several conditions. The mean and standard deviation is given for each series of runs. The times represent the elapsed period between the start of rod movement and 90 percent of rod travel.

1. Neoprene seal (lubricant on rod two months)

$$\bar{x} = 3.055 \text{ seconds; } s = 0.063 \text{ seconds}$$

2. Dust seal (for simulated free fall)

$$\bar{x} = 2.237 \text{ seconds; } s = 0.018 \text{ seconds}$$

3. Silicone seal (new lubricant)

$$\bar{x} = 2.500 \text{ seconds; } s = 0.004 \text{ seconds}$$

4. Neoprene seal (new lubricant)

$$\bar{x} = 2.694 \text{ seconds; } s = 0.030 \text{ seconds}$$

The theoretical drop time for free fall through a similar distance is approximately 1.4 seconds.

The difference in drop times between Runs 1 and 4 is due to the thickening of the lubricant. It is not known whether this is caused by the effects of heat, foreign material, radiation, or a combination of these. Further tests will be made to determine the most satisfactory lubricant.

The difference in drop times between Runs 3 and 4 is probably due to the fact that the silicone seal had not been contaminated with the old lubricant - at least not to any great extent - whereas the neoprene seal was the same one used in Run 1.

Plans have been made to investigate "Molykote" and Dixon's graphite (dry lubricants) for application to the VSR seal. A few simple tests will be made to determine (a) sealing effectiveness, (b) temperature resistance, and (c) durability of these two commercial products. An in-pile application test at VSR #20 at 100-D will follow, if preliminary results are promising.

SLUG DAMAGE DUE TO CHARGING - L. A. Nelson

The test was divided into two sections of 1000 slugs each. The collecting, marking, and inspection of slugs for both sections have been completed.

The Flow Lab at 105-F was made a Danger Zone and the charging machine was installed. The first section of slugs was charged through the tube and was caught by hand at the rear end. After the charging was completed, the charging machine was removed and the lab cleaned. The slugs were returned to 300 Area and partially re-inspected by Technical. The re-inspection by the Production Unit (first test and final autoclave) has as yet been completed.

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The damage due to charging of the slugs was investigated by Technical. No obvious damage has been observed although inspection is as yet incomplete. The second 1000 slugs will be charged to confirm the results. They will be charged early in October and the test should be completed by mid-October.

IN-PILE SLUG DAMAGE DURING CHARGING - C. H. Goldthorpe

The required number of slugs have been gathered and made ready for the in-pile tests. Four tests have been completed in the D Area and one test has been completed in the F Area. The slugs which have been charged through the pile are now being inspected for damage.

SLUG BUBBLE TESTER - C. H. Goldthorpe

A test slug was made which contained a small pin hole through the cap weld. This slug was used to make a "dry run" on the equipment and to more fully acquaint those who will be using the equipment with the procedure. The equipment was found to operate satisfactorily and it has now been used to test canned radium slugs.

P-13 REMOVAL - R. C. Lovington

The Proposal Memorandum for the P-13 Pressure Assembly Removal has been written and is being circulated for comments and suggestions. The proposed method consists of withdrawing the pressure assembly, including step-shield and attached aluminum thimble, as a single unit into a steel container. This container will then be pulled through a steel tube extending in a straight line from the X-1 level to the burial site.

CHEMICAL SLUG STRIPPER - R. C. Lovington

A chemical stripping apparatus for process slugs has been designed for the Canning Development Group of the Metallurgy Branch. Five slugs, either 4, 8, or 10 inches long, can be suspended vertically in a chemical solution and rotated at a speed of 250 RPM about their axes. The driving motor is mounted directly on a movable platten and drives the slugs through a shaft, miter gear, and flexible coupling arrangement. The movable platten is capable of both vertical and horizontal displacement to allow the slugs to be dipped into any one of three different solutions. The weight of the platten, drive unit, and slugs is counterbalanced by adjustable lead weights, and a clamping device is included to hold the platten in the lowered position.

The design and detailed drawings are almost complete and purchase requisitions have been issued.

REAR FACE MONITORING BY TELEVISION - H. Harty

The project proposal covering the closed circuit television system for pile rear face monitoring is being prepared. Concurrently the preliminary installation design and equipment requirements are being studied. Tentative plans indicate that a mock-up will be built in the 189-D Lab to test the design and equipment.

From preliminary considerations it appears desirable to locate one control monitor (camera controls and viewer) on the C elevator and one in the control room. Two cameras will be used, both located on the D elevator. One camera will be placed below the elevator; the other above the elevator. Both cameras will be controlled from either control monitor.

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EFFECT OF PROCESS TUBE RIB SPACING AND WIDTH - J. C. Wood

No work was done on this problem during September, owing to pressure of more urgent work.

INK FACILITY INSTALLATION - W. K. Alexander

A Formal Project Proposal has been prepared to provide funds for installation of a one tube Ink facility in DR File. It is estimated that this project will require expenditure of approximately \$30,000. The Project proposal will be presented to the A & B Committee for their October meeting.

TEST LABORATORY - E. G. Dosskey

The new aluminum heater heads for the heat transfer test have been completed and installed on the generator bus.

The construction crew has removed the remaining three refrigeration units from 189-D, and the floor will be replaced by the last of September. Owing to use of the Whiting Crane by the construction crew, the installation of the crane travel motor has been delayed until the middle of October.

A new engineering assistant was added to the laboratory custodian staff and will help to even the work load in the building.

PRESSURIZED "C" AND "D" MACHINES: TEST #29 - J. C. Wood

Tests showed that the pressurized "C" and "D" Machines can charge and discharge a process tube during conditions of full flow in the tube. The "D" Machine has repeatedly attached itself to the nozzle, discharged slugs, closed the tube, and removed itself from the nozzle successfully.

After sufficient testing using lead dummies, uranium rejects were used in the machine. The rejects washed out of the process tube by using a pressure drop across the slug column of approximately 200 psi.

When charging oil was used in the process tube, the slugs washed out easily and the scratches on the slugs from the tube were not as severe as with water alone. No difficulty of the dummies' gouging the process tube ribs has been experienced in the process of backseating the dummy patterns.

After charging six tubes full of slugs through the process tube, the tube was sectioned lengthwise for examination. It was found that the slugs had scratched the top of the tube along the last two-thirds of its length. It is suspected that this is due to the impact of the slugs against one another as they are charged and discharged.

Additional testing will consist of repetitive runs of the above nature to determine the frequency of "reluctant" slugs which may require more forceful discharge methods than washing by water. Both water alone and oil-water will be investigated.

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UNPRESSURIZED CHARGING MACHINE: TEST #39 - W. J. Morris

Final assembly of the equipment used in Test #39 has been completed. This included lining the discharge tank with rubber, strengthening the discharge tank supports, installing, leveling and aligning the gun barrels, installing the process tube, drilling and tapping the flapper nozzle for a pressure gage, and altering the loading tray of the charging machine.

Several corrective measures were taken to rectify defective parts and components of the machine. The machine was first operated using lead dummy slugs. Twenty lead dummy slugs were charged successfully, but the 21st slug jammed in the throat of the machine and could not be forced through with the ram. Any increased force on the ram tended to jam the slug tighter because of the softness of the lead. After the throat was disassembled from the machine and the jammed slug was forced out, four unused lead slugs were picked at random and placed in the throat. At a point approximately one-half inch from the welded end of the cans, all four slugs were stopped. While the can diameters measured very close to 1.440, the bulges one-half inch from the welds measured .007 to .011 inches oversize on the diameter. Since a) the diameter of the throat is 1.455 \pm .005 inch, b) the can bulges are badly oversize, and c) the lead is soft; reject uranium slugs were used in the next test run.

The charging machine was loaded with 64 reject uranium slugs, 12 rows containing 5 to a row, row 13 containing 3 slugs with one slug in the charging chamber. Row 14 was occupied by the ramming bar. The header pressure was 375 psi and the inlet nozzle pressure 200 psi. Because of a defective valve which operates the door of the discharge tank, considerable leakage occurred and an accurate measure of the flow rate could not be made but it was estimated to be 25 gpm. The stop plungers in the discharge assembly (slug arrestors) have not been adjusted as yet, therefore, the slugs were not slowed up as they were washed down the tube. In discharging, the first slugs began to move down the tube when 300 psi was applied to the inlet nozzle.

The machine satisfactorily charged the 64 uranium slugs. The ramming bar, which is used to push the last slugs into the process tube and then remains in the Collins type seal until the machine is disconnected from the flapper nozzle, was found to be longer than necessary. This rammer, when pushed to the forward-most position, extended through the throat and into the process tube, and since the small clearance of the throat would not allow the rammer to move, any misalignment caused the rammer to gouge into the process tube ribs. The original rammer length was 20-9/16 inches. By shortening this length to 14-1/16 inches, the rammer did not gouge the tube ribs but was still long enough to push out the last slugs and remain in the seal.

Tests are continuing to improve the operation of the charging machine and to "debug" the discharge mechanism which is currently being used in conjunction with this apparatus.

ZIRCONIUM PROCESS TUBE CREEP: TEST #46 - C. D. Emmons

On test #46 there is still practically no change in the readings of circumference for this month. A slight gas leak slowly bleeds the nitrogen in the 600# system, so cylinders were reversed in order to use as much as possible of the gas in each cylinder.

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FLAPPER NOZZLE ASSEMBLY: TEST #50 - R. E. Schilson

No tests were made on the flapper nozzle during the past month. It has been installed in the 189-D Building to be used in conjunction with Test #39 (Unpressurized Charging Machine). While thus installed, pressure drop measurements across the inlet orifice will be made.

DEFLECTION TESTS OF SINGLE GUN BARREL ASSEMBLY: TEST #51 - R. E. Schilson

All test data have been summarized and all deflection curves drawn. The final report is now being written.

PIGTAIL FLEXURE: TEST #54 - R. E. Schilson

The testing assembly for the flexible connector (pigtail) has been completed, and tests are now underway on the Atlantic Hose connector. Tests will be made on other connector designs after the above tests are completed.

FABRICATION OF ENLARGED, REPLACEMENT PIGTAILS - R. E. Schilson

One inch 2S aluminum tubing has been obtained and the pigtail is now being fabricated with the aid of "Bendalloy," a low melting point metal. A flexure test of this pigtail will be made using the flexible connector testing assembly for Test #54.

HORIZONTAL ROD GLAND SEAL: TEST #64 - R. E. Johnson

Previous to cycling, the gas chamber was pressure tested to determine the effect of barometric pressure and temperature upon the helium pressure. The chamber pressure proved to be very sensitive to these variables.

The following cycling runs have been completed:

<u>Run No.</u>	<u>Seal Make-Up</u>	<u>Effect on Rod</u>
1	Wipers plus original chrome glands	Scratching developing into galling at very few cycles.
2	⊙ Wipers plus chamfered chrome glands	Scratching developing into galling at very few cycles.
3	Wipers plus no glands	No galling - very fine scratches on periphery - 500 cycles.
4	No wipers plus O-ring adapter glands of tobin bronze	Scratches up to 200 cycles - galling begins.

After Run #2, the rod driving apparatus was altered for increased stability and better alignment. A dial indicator check showed the rod to vary from 2 to 4 mils out of alignment during a stroke length. This appears very satisfactory, as considerable sanding and polishing has been done on the rod.

Chamfering the gland edges for Run #2 slightly increased the number of cycles before excessive galling began. Run #3 showed that the wipers were innocent of any galling, but could be responsible for producing the particles that start

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galling within the gland proper. The O-ring gland adapter of Run #4 produced a few medium depth scratches until excessive galling began to occur at 250 cycles. There was no noticeable gas leakage during the four runs, but some water leakage was present during excessive galling stages.

The following investigations will be made in the near future:

- a. Light spindle oil will be used with the O-ring adapters.
- b. Molykote, (a dry, anti-gall lubricant), will be used on the rod with the O-ring adapter glands.
- c. Graphite glands will be tried with water, oil, and Molykote lubrication.
- d. An anodized rod will be tested with the best glands and lubricants.

The 61S aluminum rod for part "d" is nearing completion in the shop.

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

G. A. Fluke was assigned as representative of Project Engineering Division for the project. The securing of funds was delayed approximately one week for lack of AEC Project Proposal signatures which pended Appropriations Act approval in Washington.

The electrical drawings have been completed and approved. Considerable difficulty was encountered in securing bids on the electrical control system because G. E. (Schenectady), the only possible vendor, was apparently overloaded with high priority work. This problem, however, was eliminated when approval was received to remove and use the H-rod experimental test system of 100-B Area. This test system will supply all major drive and electrical equipment pieces, other than a DC voltage supply. A motor-generator or a rectifier transformer will be purchased as a DC source.

The simulated graphite portion of the test is nearing structural completion. The graphite has been machined and delivered, and the packing support is approximately 70 percent fabricated in the shop. Some alterations to the design have been made to fit available material.

FUNCTIONAL TEST OF "C" PIPE - VS RODS AND BALL 3-X SYSTEM: TEST #67 -

C. H. Goldthorpe and C. D. Emmons

The exit pipe tests have been completed in 189-D Lab. It was found that the average flow rate of balls through the exit pipe was 300 cubic feet per hour. Different sizes and types of orifices were inserted in the system to determine the correct size needed to restrict the flow to the limits of the ball flight conveyor: 100 cubic feet per hour. It was found that, to restrict the flow of 3/8 inch diameter commercial steel ball bearings to this amount, a 2-7/32 inch diameter straight orifice is required, and for 3/8 inch diameter nickel plated boron steel balls (high polish), a 1-15/16 inch diameter straight orifice is required. With a 45° beveled orifice, a 2 inch inside diameter orifice is required for the commercial balls and a 1-15/16 inch inside diameter orifice is required for the nickel plated balls. A 1-7/8 inch diameter straight orifice or a 45° beveled orifice will restrict the ball flow to 80 cubic feet per hour for both types of balls. Bridging of the balls across the orifice did not occur.

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MECHANICAL DEVELOPMENT TEST ASSIGNMENT SUMMARY

MONTHLY PROGRESS AS OF SEPTEMBER 25, 1951

Name of Test	Proj. Responsible No.	Engineer	Date Work Started	Portion of Over-All Project										Final Report Approved	Disassembly and Storage of Equipment	Tests	Erection and Assembly of Apparatus	Fabrication and Procurement	Test Design Complete	Wrote, Approved Memorandum	Data for Test Memorandum	Project Completion Date (Test Report)	Estimated Per Cent Complete (Over-All)	Project Completion Date (Test Report)	Estimated Per Cent Complete (Over-All)	
				Cumulative % Completed																						
				10	15	20	25	30	35	40	45	50	55													60
Creep Tests - Aluminum Process Tubes	8	CD Emmons	May, 1949	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-1-51	93	11-1-51	93
D Machine Locating Pressurized C & D Machines	29	JC Wood	April, 1950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12-31-51	54	12-31-51	60
Concrete Pour Test C & D Machines, Unpressurized	34	CD Emmons	May, 1950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-1-51	97	11-1-51	97
Creep Test - Zirconium Process Tubes	39	WJ Morris	June, 1950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1-1-51	49	1-1-51	51
Flapper Nozzle Assy. Deflection Test of Single Gun Barrel Assembly	46	CD Emmons	Oct., 1950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12-31-51	70	12-31-51	73
Flapper Nozzle Assy. Deflection Test of Single Gun Barrel Assembly	50	RE Schilson	Mar., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	9-10-51	84	10-20-51	87
Gun Barrel Assembly	51	EG Dosakay	Jan., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	9-10-51	86	10-8-51	93
Gun Barrel Assembly	51	RE Schilson	Mar., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-1-51	37	10-20-51	50
Pigtail Flexure Intermediate Test Ball XI and VSR Systems	54	RE Schilson	Mar., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	9-10-51	93	10-1-51	95
Horizontal Rod Island-Seal	63	CH Goldthorpe	Feb., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	9-15-51	70	10-15-51	72
Horizontal Rod Mock-Up	64	RE Johnson	Mar., 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-15-51	32	12-15-51	37
Horizontal Rod Mock-Up	65	RE Johnson	April, 1951	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12-1-51	72	12-1-51	72
Ball XI - Present Piles		H Hart	June, 1949	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-1-51	53	11-1-51	53
Process Tube Replacement		LA Nelson	Aug., 1950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	10-1-51	53	11-1-51	53

Slug Bubble Tester	CH Goldthorpe	Nov., 1950	X	X	X	X	X	X	X	X	8-31-51	95	8-31-51	100
Final Test Ball XI and CSR Systems	CH Goldthorpe CD Emmons	May, 1951	X	X	1/3						3-15-52	10	3-15-52	25
Deformed Tube in Cored Graphite (9-Tube Mock-Up)	GE Wade	May, 1951	X	X	X	X	X	X	X	6/7	9-15-51	98	10-15-51	99
Fabrication of Enlarged, Replacement Pigtail	RE Schilson	May, 1951	—	—	X	1/2					Uncertain	16	Uncertain	20
Strainerap and Strength Determination	PM Jackson	June, 1951	X	X	X	1/5					Uncertain	13	11-1-51	32
Effect of Process Tube Sub Spacing and Width	JC Wood	July, 1951	X	X							11-15-51	15	11-15-51	15
Slug Damage-Charging (Flow Lab)	LA Nelson	Aug., 1951	X	X	X	X	3/8				10-1-51	41	10-20-51	41
F-13 Removal	RC Lovington	Aug., 1951	X	4/5	2/3						Uncertain	15	Uncertain	24
Cast Iron Modifications for Easier Gun Barrel Replacement	GE Wade	Aug., 1951	X	X	4/5	3/5	3/5	1/2			Uncertain	9	10-20-51	59
Effect of Sphincter Seal and Lubric. on VSR Drop Time	H Harty PM Jackson	Aug., 1951	X	X	X	3/5	3/5	1/4			9-30-51	40	11-15-51	52
Rear Face Monitoring by Television	H Harty	Aug., 1951	X	4/5	1/5						Uncertain	13	1-1-52	17
Chemical Slug Stripper (Assistance to Metallurgy)	RC Lovington JM Roberts	Sept., 1951	X	X	4/5	1/5					—	—	Uncertain	29

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