HW-19955

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100 AREAS TECHNICAL ACTIVITIES REPORT

ENGINEERS, DECEMBER, 1950

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SUMMARY

Small increases were made in the maximum power levels attained in the B, DR and H Piles, however the B, D and F Piles could not consistently maintain previously attained average levels. The following table lists the average and maximum power levels which were achieved during the months of November and December:

Area	November Power Level		December Power Level	
	Average	Maximum	Average	Maximum
B	356	365	342	375
D	321	335	313	330
DR	401	430	430	445
F	301	325	286	315
H	415	470	452	480

The maximum levels can be maintained only when uniform heat generation is achieved and requires an optimum poison pattern and rod configuration. The average power generation was materially reduced during several operating periods when the required rod configuration varied from the predicted configuration resulting in local hot spots which limited the power levels.

Production Test 105-391-P, "Graphite Burnout In Pile Experiment" is now in progress in the F Pile. Weighed graphite samples will be exposed to pile atmosphere, CO_2, O_2, CO, and a mixture of 95% CO_2 and 5% CO at pile ambient temperatures. The samples will be removed and weighed periodically. It is planned to raise graphite temperatures after each series of weighings in order to obtain data on graphite burnout rates.

A rutpured slug occurred in the H Pile. The slug had swelled excessively and could not be discharged from the tube. The tube was distorted at the point of slug rupture requiring removal of the rear gun barrel.

A program is in effect to make all possible changes, short of a system redesign, which will improve the sensitivity of the effluent water activity monitoring system.

A test exposure of untransformed uranium slugs which were rolled at different temperatures indicates that the uranium rolling history has a pronounced effect on the exposure behavior of this metal.

Horizontal tube traverses taken in the D Pile have revealed that there is lateral graphite recovery in pile packing. Graphite on the near and far sides has moved 0.4 in. and 0.3 in. respectively towards the center of the pile.

Vertical tube traverses of fringe tubes in the B Pile have revealed that there is more vertical expansion of the top half of the pile than in the bottom half, probably due to bridging or cantilever action of the blocks in the upper more distorted portion of the pile.

B PILE MONTHLY REPORT FOR DECEMBER - H. L. Mars - H. G. Spencer

Power Level. The B Pile operated at 365 to 370 MW from 12-1-50 until shortly before the 12-13-50 shutdown when the power was reduced 25 MW for a coefficient test. During this shutdown a 40 piece P-10 column in tube 2338 was discharged and a 23 piece P-10 column was charged in tube 1569. This change was made to increase flattening and to raise the graphite temperature around the controlling graphite thermocouple 13G.

The poison changes caused an excessive increase in temperature in the graphite near 13G thermocouple, and while the ΔT_W limit was raised 2°C, the pile power level had to be decreased due to the non-uniform heat generation. Between 12-16-50 and 12-21-50 the power varied between 300 and 360 MW. Several rod changes were recommended and tried but none were very helpful in controlling the far side hot spot during this period. From 12-22-50 to 12-27-50, 340 to 345 MW was maintained. The following data is for the periods mentioned. Tabulated data is on the following page.

The last change in ΔT_W limits on 12-21-50 was made somewhat conservatively because little data were available at equilibrium conditions. Using the data after 12-21-50, a .240 zone ΔT_W of 53°C for the hottest tube would be allowable. The apparent thermal conductivity around 13 G has increased almost 9% with the change of average 13 G temperature from 318 to 356°C.

Flattening was adjusted during the 12-27 shutdown to decrease the far side temperature moment with a minimum lowering of 13 G temperatures.

Pile Motion and Graphite Expansion. No unusual trends were shown by standard monitoring instruments.

Vertical tube traverses of tubes 2451 and 2496 were made on 12-13-50, as provided in PT 105-372-P. Maximum elevation of tube 2451 was .45 inch at 18 feet from the front tube flange. Tube 2496 had a maximum elevation of .58 inch at 17 feet. The doubled maximum elevations of 2451 and 2496 are 0.96 and 1.17 inches respectively as compared to an elevation of 1.88 inches in tube 4574 at 14 feet from the tube flange and maximum elevations of 1.50 and 1.58 inches in tubes 4354 and 4393.

B Test Hole. On the shutdown of 12-13-50 during a charging operation it was not possible to remove the shielding plug in hole No. 3. After several attempts to remove the plug, a large leak was developed in two sample tubes. Graphite samples in the other holes were removed and stored in caves on the X level. The samples in No. 3 tube could not be removed so presumably they will be of no future value. The B Hole was drained and the water supply disconnected. This facility will be repaired or replaced and it is anticipated that improvements will be made in the methods of retrieving samples and shield plugs to prevent a reoccurrence of such leaks. Loss of 20 in-hours of water in the B Hole had some harmful effect on the flattening of the pile and the mishap also delayed the start-up a short while.

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PILE DATA

Dates (inclusive) and Equilibrium	Ave., Max., or Limit	Graphite Temperature 13 G	Cal. Max.	q/ T_g at 13 G	Maximum T_w's Hottest,4 .240	Hottest .240	Hottest .200	Maximum .200	Outlet Water Temps. .175	.140
12-1-50 12-11-50 Equilibrium	Average	317.7	378.3	5.673	48.7	47.8	53.3	62.4	66.6	66.6
12-1-50 12-11-50 Equilibrium	Maximum	322	386	5.750	49.1	48.6	54.5	63.6	68.8	67.8
12-1-50 12-11-50	Limit	380	380		49.0		60	69*	78*	80
12-12-50 Coefficient Test Non-equilibrium		302	394	5.505	48.9	48.1	53.7	63.0	68.5	66.5
12-16-50 12-21-50 Non-equilibrium	Maximum	352	376	6.054	49.8	49.5	51.1	59.9	67.8	69.7
12-22-50 12-26-50 Equilibrium	Average	356.2	365	6.172	50.4	50	50.7	59.6	65.6	66.7
12-22-50 12-26-50 Equilibrium	Maximum	366	368	6.236	51.0	50.7	52.0	60.9	68.7	70.8
12-22-50 12-26-50	Limit	380	380		51.0		62	71*	80	80

* 9°C Inlet Water Temp.

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C Test Hole. The C test hole has been prepared for the installation of a number of graphite temperature monitoring thermocouples. During the shutdown of 12-13-50 the short aluminum thimble with its shielding plugs and the majority of the tubing to the gas thermometer bulb were removed. The inner steel stop plug could not be removed with the existing removal equipment. New equipment was obtained for the 12-27-50 shutdown and the plug was removed at that time. All graphite pieces were recovered and stored in a cave. The gas thermometer bulb could not be removed so it was pushed to the rear end of the hole. Little trouble is anticipated in the installation of the thermocouple assembly.

Exit Water Monitoring System. During the shutdown of 12-13-50 the shimstock ion chambers were cleaned with oxalic acid. The flows were improved to some extent. In the new type chambers, which are constructed with 5/16 O.D. saran tubing in place of the approximately 1/8 x 2 in. shimstock annulus, it was noted that the flow is greatly restricted. This information was given to the Instrument Division for their consideration. The activity read by the ion chambers in the A, B, and C sample rooms was decreased from about 2.2, 2.9, and 2.3 x 10^{-11} to about .4, .8 and 1.2 x 10^{-11} by the cleaning, indicating a very high previous background activity. It is anticipated that a careful selection of chambers (as to brass shimstock, steel shimstock, and saran tubing types) will help in balancing flows.

On December 4, 1950, the cycle time for all of water sample rooms was changed from about 45 seconds to 80 seconds per header. This has materially reduced the mixing and dilution of high activity samples with previous and subsequent samples.

D PILE MONTHLY REPORT FOR DECEMBER - J. F. Sullivan - J. M. Atwood

Power Level. The D Pile operated during the month of December at 100% CO_2 and the power ranged from 305 to 335 MW averaging 314 MW. The table below lists the observed graphite temperatures, apparent thermal conductivity values at the graphite thermocouples, and the ΔT_w limits in effect during the month:

	Graphite Temps.			Apparent Thermal Cond.		T Limits			
	130	140	Calc. Max.	130 $q/\Delta T_{gh}$	140 $q/\Delta T_{gh}$	.240	.200	.175	.140
Max.	348	356	395°C	5.91	5.72	47.5	56.0	75.0	75.0
Ave.	326	335	375°C	5.40	5.42				
Min.	292	314	341°C	5.13	5.20				

q = Heat generation in the Average of four tubes surrounding the graphite thermocouple.

ΔT_{gh} = Temperature difference between the graphite and the local water in the four tubes adjacent to the thermocouple.

Efforts to locate the limiting graphite temperatures in the region of the 130 and 140 thermocouples to determine whether the present method of calculating maximum graphite temperatures is conservative have not been successful to date because of the pile poison column arrangement. During the December 20 shutdown, the pile poison columns were adjusted to improve the flattening of the pile from top to bottom.

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On December 28 it was necessary to cut the pile power level from 330 MW to 325 MW because of measured V S.R. thimble thermocouples exceeding 380°C. This is the first instance at D Pile where the power level was limited by a measured temperature in excess of 380°C.

VSR Thimble Thermocouple Installation. The #25 VSR thimble was replaced with a thermocouple thimble containing six chromel-alumel thermocouples. The couples were installed on the thimbles so they will be opposite graphite layers 24, 36, 48, 60, 68, and 84. All thermocouples are operating except the thermocouple opposite layer 48. An attempt will be made to repair this thermocouple on the next shutdown.

Unit Motion. Four traverses were made at D Pile during the month. Vertical bowing measurements were made in tube 2451 and in tube 4674, which was traversed both from the front and from the rear. Horizontal bowing measurements were taken in tubes 2451 and 2496, on the near and far sides.

Vertical bowing data on the top center tube indicate continued recovery of graphite damage in the center of the pile. The elevation of the midpoint of the tube has dropped 0.8 inch since March, 1950; total recovery from the highest elevation, which occurred in 1948-49, is over 1 inch. Correlation of bowing measurements from front and rear shows the outlet end of the tube is about 0.1 inch lower than the inlet.

Tube 2451 was traversed vertically in accordance with PT 105-372-P, which provides for monitoring graphite expansion in the cooler portions of the pile by periodic traverses of fringe zone tubes. Maximum vertical elevation of the tube was 0.80 inch. The tube will be traversed again in approximately nine months.

Horizontal bowing measurements of tubes 2451 and 2496 indicate lateral recovery at the center of the tube of 0.4 inch on the near side and about 0.3 inch on the far side. Tight-wire readings at the center of the far side since the latter part of 1949 also indicate an inward movement of this face. Maximum horizontal bowing on the near and far sides is 1.0 and 2.5 inches respectively. Removal of the near side cork seal does not appear to be necessary in view of the indicated recovery of outward bowing.

Measurement of Flux Distribution. Thirty-four numbered aluminum dummies were installed this month in tube 1365 as spacers for graphite samples. After scheduled discharge of the tube in May the aluminum pieces will be weaseled and the activities plotted against position to obtain further information concerning front to rear neutron flux distribution in D Pile.

Exit Water Monitoring. The exit water monitoring system was inspected to determine its present suitability for the early detection of a ruptured slug. The monitoring apparatus in A and X sample rooms at D Pile is equipped with two solenoid valves in the tap lines from each header. Modifications in the other sampling systems (B, C, Y, Z) have enabled their operation with one solenoid valve per line. Malfunction of those valves occurs several times each month. The trip limits and flow rates through each line must be reset until equilibrium conditions are attained. These inadequacies give rise to a well-justified mistrust of the monitoring system by the pile operators.

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It was found that from one-fourth to one-half of the total flow through the top lines passed through the ionization chamber and that time for fresh water to first appear through the chamber was 1 1/2 minutes with a flow time through the apparatus varying from 1 1/2 minutes to 10 minutes.

The modification of the B, C, Y, & Z Sample rooms has enabled visual examinations of flow, but results in considerable mixing of water from difference headers and delays passage of water through the chamber.

On the next shutdown it is planned to encase the exit water from the chamber in a manifold to reduce air contamination in the A and X rooms and in the other locations when time is available. The ionization chambers will be lowered to increase the flow of water. This change is expected to enable considerably better operation of the monitoring system.

F PILE MONTHLY REPORT FOR DECEMBER - M. W. Carbon - W. D. Gilbert

Power Level and Graphite Temperatures. The F Pile operated at a nominal 305 MW power level during the month. However, during the early part of the month the equilibrium level varied from 310 MW to 325 MW, but at the end of the month difficulty was encountered in maintaining a level of 305 MW. At the time this report was written, the level had been temporarily cut to 290 MW.

The power level during the month was governed by the maximum calculated graphite temperature. Early in the month the calculated apparent thermal conductivity of the graphite and CO_2 around 13 G was high, and consequently relatively low maximum graphite temperatures were computed. Near the end of the month the apparent conductivity fell off sharply and the calculated maximum graphite temperatures rose. The reason for the changes in conductivity are unknown, but the fact that there are changes was somewhat substantiated by similar caluclated changes around thermocouple 14G. Plots of apparent conductivity versus graphite temperature and CO_2 concentration yielded little information as to the cause. A plot of conductivity versus time from August, 1950 to the present indicated a fluctuation in conductivity which was somewhat periodic, but no definite cycle was apparent. About the only firm point which can be stated is that the apparent conductivity decreased sharply after the shutdown on December 21, 1950.

CO_2 Concentration. The F Pile is being operated at a nominal CO_2 concentration of 100%. However, during most of the month the concentration actually varied from 90% to 93%. Three shutdowns occurred during the month, and a tube and a thimble were removed; consequently, the concentration tended to remain low.

Thimble Installation. A vertical thimble with three attached thermocouples was installed in #27 VSR hole on December 21. Unfortunately, two of the thermocouples were broken during installation, but the remaining couple is located at the center of the pile, and preliminary readings indicate that the thimble temperature is well below the temperature at 13G. Confidence exists that high rate of thermocouple breakage will not be present when the additional thimbles and thermocouples are installed.

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Slug Corrosion Rates at Elevated Temperatures - PT 105-103-P. An average slug corrosion rate of 0.18 mils/mo, and a maximum of 0.45 mils/mo. were observed from tube 2275 discharged from F Area on December 21, 1950 at an enrichment level of 400 MWD/T and an average outlet temperature of 75.5°C. An average rate of 0.33 mils/mo. was observed for the four slugs having the highest rate in the tube. The slugs were charged for a total of 260 days. Following is the percentage of time the slugs were exposed at elevated temperatures, exclusive of shutdowns:

Temperature Range - °C	% of Time in Range
up to 59	14.3
60 - 69	14.3
70 - 79	32.5
80 - 90	38.9

In order to obtain slug corrosion data at higher average outlet water temperatures, authorization has been requested, in Supplement C of PT 105-103-P, to permit outlet water temperatures up to 95°C. Under this test, regulation of the pigtail valves would be permitted in order to maintain the highest practical outlet water temperatures.

Graphite Burnout Test - PT 105-391-P. Tubes 2682 and 2777 were selected for installation of graphite burnout samples at 100-F Area. Process tube 2682 was removed on December 5, 1950, and weighed graphite samples were placed in the bare channel and are being exposed to the pile atmosphere. Three groups of samples, together with thermocouples were placed in the channel at the following distances from the front face - 22 feet, 28 feet, and 33 feet. Graphite temperatures of 315°C, 280°C, and 85°C, respectively, were observed at a power level of 305 MW.

Two groups of weighed samples, contained in small aluminum tubes, were placed in process tube 2777 on December 21, 1950. Samples in the center of the pile, 22 feet from the front face, are being exposed to gas atmospheres of oxygen, carbon dioxide, carbon monoxide, and a mixture of 95% carbon dioxide and 5% carbon monoxide. The samples in the rear of the pile 30 feet from the front face are being exposed to a gas atmosphere of carbon monoxide. Temperatures of 325°C and 75°C, respectively, were observed for these graphite samples at a power level of 305 MW.

Slug Weighing Apparatus. The apparatus for weighing corrosion test slugs in air is being set up for testing in the receiver pit at 189-F building. A platform has been erected to give the height necessary to test the apparatus and to give test conditions which simulate those encountered in the transfer basin. A water eductor for the removal of water in the apparatus was ordered and has been received. Testing is scheduled to start the first week in January.

Tube Bowing. Results of the traverse of tube 4674 made on December 5, 1950, shows that the maximum point of vertical displacement is continuing downward. The maximum vertical displacement, 3.1 inches occurs at a point between 13 and 14 feet from the front Van Stone.

~~PT-105-347-P - Water Flow Stoppage In Cross Header after Shutdown.~~ Supplement A to Production Test 105-347-P has been written. The purpose of this supplement is to determine the maximum time the flow in a cross-header can be shut-off at various time intervals after shutdown at F Pile. The supplement is now being circulated for approval.

Unit Motion. There have been no significant changes observed during this month.

Traverse of No. 2 Horizontal Thimble. A traverse of the No. 2 horizontal thimble was made during the shutdown of December 14, 1950. The results of this traverse show that the maximum vertical displacement, 1.65 inches, occurs between 9 and 10 feet from the edge of the near side. Between 4 and 9 feet in from the near side, vertical rise of the thimble is approximately 0.3 inch per foot.

H PILE MONTHLY REPORT FOR DECEMBER - E. C. Wood - R. B. Hamilton

Power Level and Limits. A disturbance in the heat distribution of the pile which appeared after the shutdown of November 28 caused the pile to run at reduced power during a part of the month. The effect was aggravated by an apparent change in the calibration of the Brown tube temperature recording system which, although H-10 tube limits could be raised in accordance with the instrument change, caused the heavy metal tubes in the H-10 zone to run over limits at 470 level. The instrument condition is now fairly well understood, but its inadequacy for operation in this manner is evident.

After the 470 level was reached, it appeared that the pile had come out at equilibrium with more than the optimum excess reactivity in the rods. As a result, the former even temperature distribution was disturbed. Rod manipulations were ineffective in reducing the hot spot. It was observed at this time that the Brown temperature recorders did not give consistent readings either between the two instruments or among any of the three systems of monitoring used with a single instrument. This effect had been noted before when only the H-10 tubes were limiting; but, since the H-10 limit is determined using the Brown instrument, the absolute accuracy of the instrument is unimportant as long as the same set-up is used for monitoring as was used for determining the limit. However, if any tubes are running at the boiling disease limit, the accuracy of the instrument is of considerable importance. At the time, two of the regular metal tubes in the H-10 zone appeared to be over limits, and a careful check was therefore made on the accuracy of the Brown. This was done by unsoldering the thermocouple leads from the connection board and reading the thermocouple with a precision potentiometer using an ice bath cold junction. As a result of such checking, the Brown instrument was recalibrated and was found to read about 1° higher than before. After checking as described above, the power level was reduced until the maximum temperature rise in the hottest regular metal tubes was 58°. The reduction eventually brought the pile power level to 440 MW.

As was anticipated, it was found that the cut necessary to bring the tubes within limits was greater than would have been expected from the amount of excess above limits. Most of the factors which work in favor of an increase also oppose a decrease in the power level. At the lower level more excess must be carried in the rods and the temperature balance suffers from the crowding of the hot tubes in a smaller space. In this case the loss in power level was 30% more than the excess over limits after recalibration.

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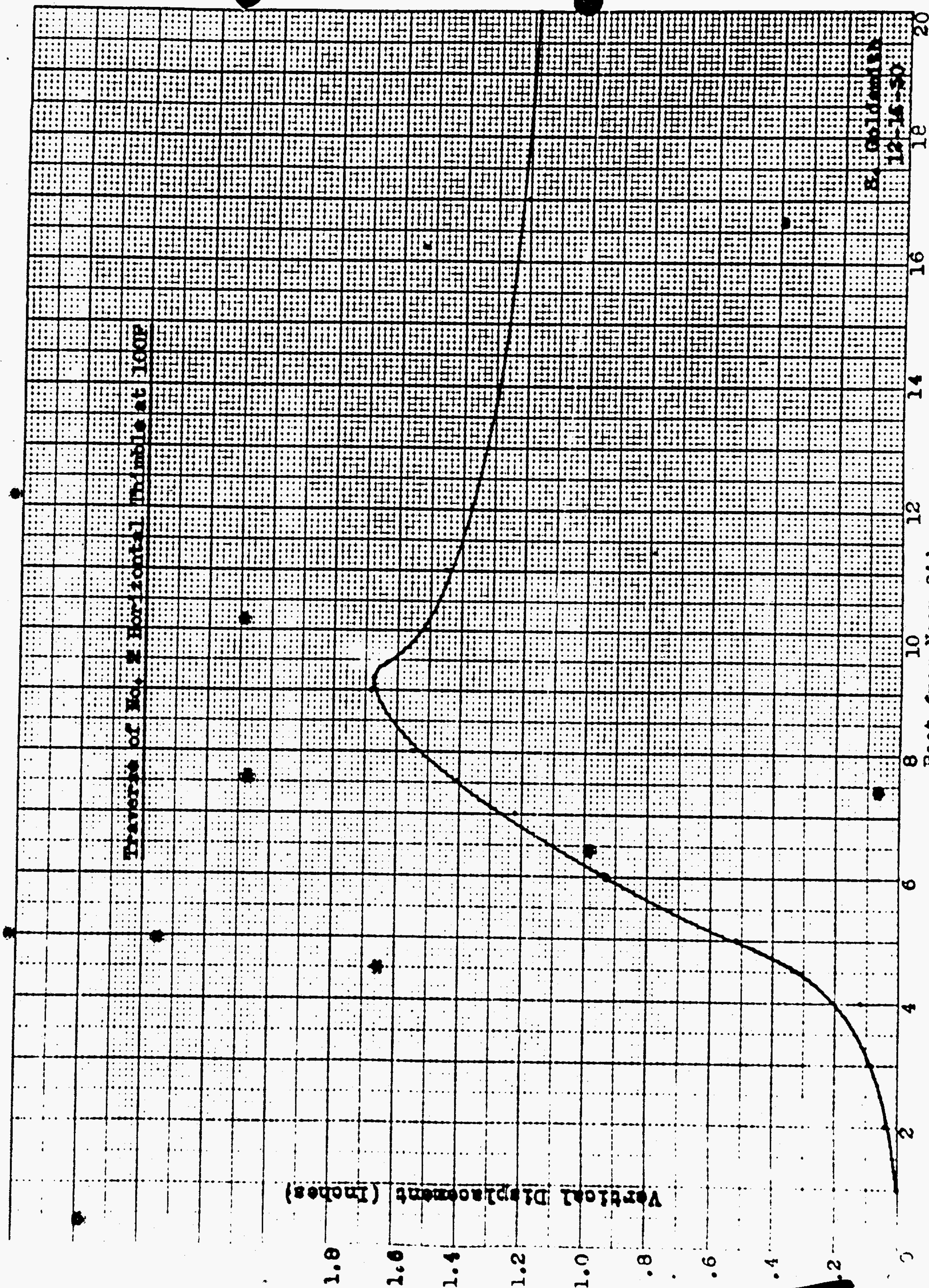

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The distrubance in the heat distribution was corrected by the area physicist on the shutdown of December 19. This was done by replacing heavy metal tube in the center of the pile with a light poison tube, and the result, together with a slight change in the rod configuration which was made, was effective enough that a rise to 480 MW was made on December 29. There are three facts which were made evident by this experience and which deserve further emphasis. First, the temperature distribution of the H Pile is critical and delicate. Small changes, made in the course of routine loading changes, can upset it out of proportion to the size of the change. All of these cannot be foreseen or their effect exactly predicted. Therefore, it is to be expected that the power level will be reduced from time to time in spite of every effort to avoid it. Second, in order to have sufficient flexibility to compensate for changing conditions, it would be desirable to discharge some of the heavy metal tubes in the H-10 zone from time to time at low concentrations and replace them with loadings specified by the area physicist. Some of these tubes are now limiting and should be replaced with shortened columns in any case if it is desired to operate the pile at the maximum attainable power level. Third, the reliability of the present temperature monitoring system for this type of operation is in question, and efforts should be, and will be, made to improve it. It is doubtful if the - if the auxiliary system as currently used can be relied upon with ± 2%.

As of December 28 the limits are set at 58° temperature rise in the heavy metal tubes, and 55° in the H-10 tubes. The 2.5° increase in the H-10 delta T limit is largely due to the varying calibration of the Brown.

Front to Rear Flux Distribution. The accompanying figure presents the data obtained from four recent flux traverses. Work was begun on this when post discharge activity readings of the pieces from H-10 tube 2772, discharged under PT 105-316-P Supplement B, showed an unexpected peak at the downstream end of the H-10 load. It appears that the maximum flux occurs about at the edge of the H-10 load and midway between the plane containing the central thermocouples (which are used for control of the graphite temperature) and the plane containing those next downstream. The flux, and therefore the local heat generation, is higher at the peak than at the central thermocouple location by about 8%. If the transition to regular metal at this point is ignored, it is calculated that the temperature at the peak may be slightly in excess of 400°C. However nothing is known about the length of the transition zone between the H-10 loading and the regular metal loading; and the portion of the total heat generation which appears in the graphite in the H-10 loading is believed to be about 1.5 times that in the regular metal loading. Therefore, depending on the length of the transition zone, the temperature at the peak may be considerably lower than a simple calculation would indicate. It is planned to evaluate this effect by running a temperature traverse of the empty tube position at 2577. The skewing of the flux distribution curve is apparently the result of a departure from symmetry in the construction and loading of the pile. At present the center line of the rod system is located 14 1/2" upstream of the centerline of the pile. The loading is centered about 1 inch downstream. This is shown on the figure. Some help might be provided by moving the loading forward to make the configuration more nearly symmetrical, and a program for testing this is being studied.

Ruptured Slug. The major incident of the month was the outage for clearing a ruptured slug from tube 3288. The first indication was a rise in the sample reading from header 31 at about 3:00 AM on December 4. This was accompanied by an almost simultaneous increase in the far side riser sample. A decay curve run on the sample from 31 header showed no evidence of fission products. Operation during the day proceeded normally with close monitoring of the sample rooms and the panellit gauges on header 31. The pile was scrammed at 6:56 PM when the panellit reading on 3288 showed a total increase of eight psi from normal readings.

When attempts to move the charge had failed, the flow from the tube was diverted into a hose and the effluent run into a special crib which had been prepared near the 105 building. Removal of the metal from the tube was accomplished by the same procedures as were used in the DR incident. It was necessary to remove the gunbarrel from the rear face to pass the section of tube containing the ruptured slug. The ruptured slug was the 34th from the upstream end. After replacement of the gunbarrel, and tube, and recharging, operation was resumed on December 7.

Unit Motion. There were no unusual thermal motions of the pile structure this month. The present trend is for the top shield to move diagonally toward the far rear corner during operation and to return to normal when cold. The results of the manometer traverse of tube 4674-H taken on 11-28 were reported in Document HW-19646. A review of the data indicates that a net deflection of 0.06 inches has occurred at a point 10 feet from the front Van Stone flange since 6-7-50. This is small but signficant. The overall expansion of 0.308 inches is about one-third of that noted for the older piles at an equivalent exposure.

Gas Analysis and Consumption

No. Shutdowns in period	Low pressure Gas loss Std. Cu. Ft.	Average Percent CO_2	CO
3	18,000	89.8	4.8

Metal Exposure - PT. A test exposure of depleted 238 Uranium slugs in alpha rolled lead dipped Uranium slugs has been partially completed. The test slugs were all untransformed and the natural uranium slugs were made from rods representing 3 rolling temperatures. The following table summarizes the results to date of slugs discharged at 100 MWD/T.

Type of Slugs	No. of Slugs	Average length change	Average diameter change	Average warp change
Depleted U^{238}	10	+ 0.018	negligible	none
alpha rolled at high temp.	5	+ 0.008	none	+0.004
alpha rolled at medium temp.	5	+ 0.035	-0.004	+0.002
alpha rolled at low temp.	5	+ 0.171	+0.005	+0.012
Group V control slugs	11	- 0.002	-0.002	none

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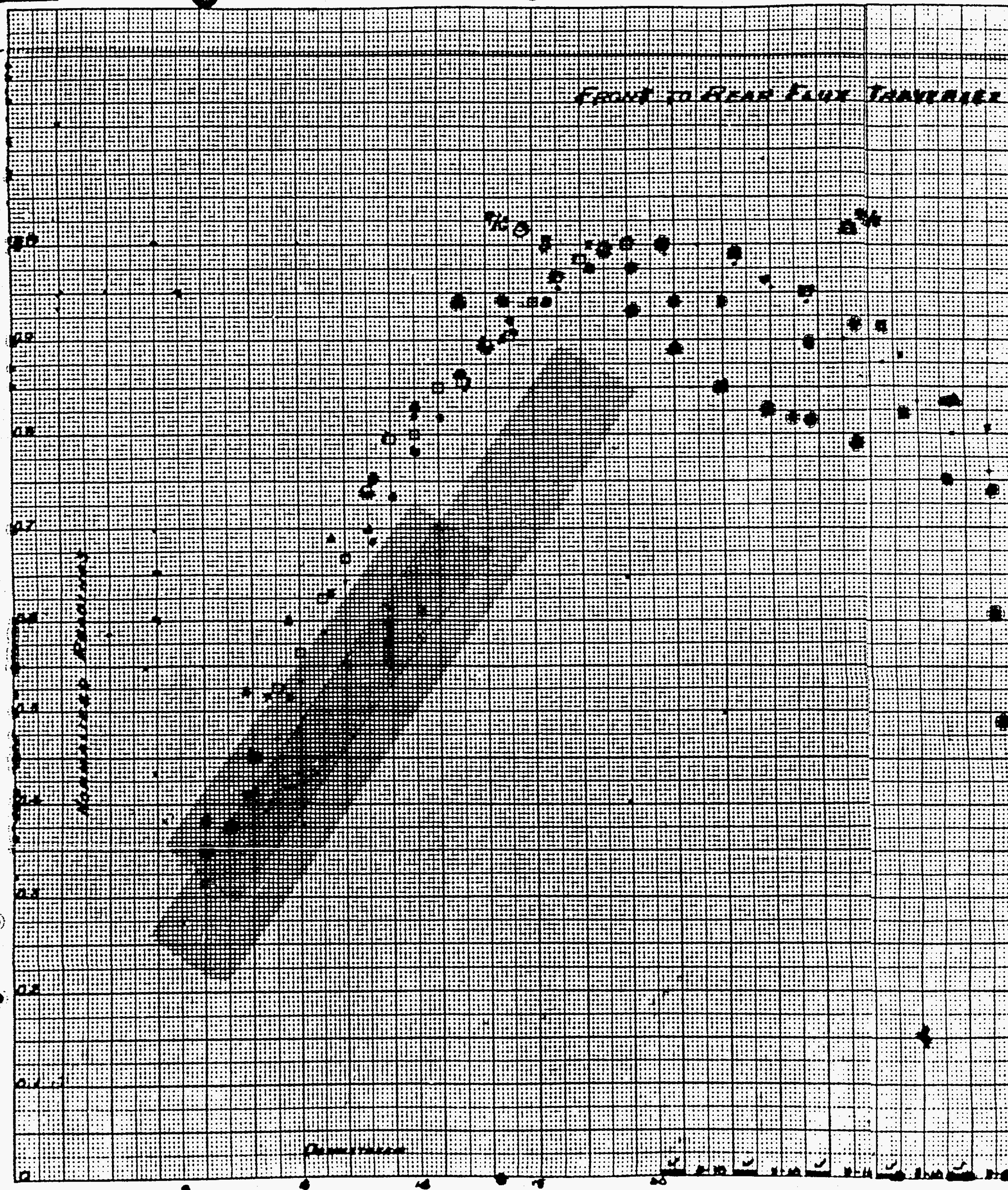

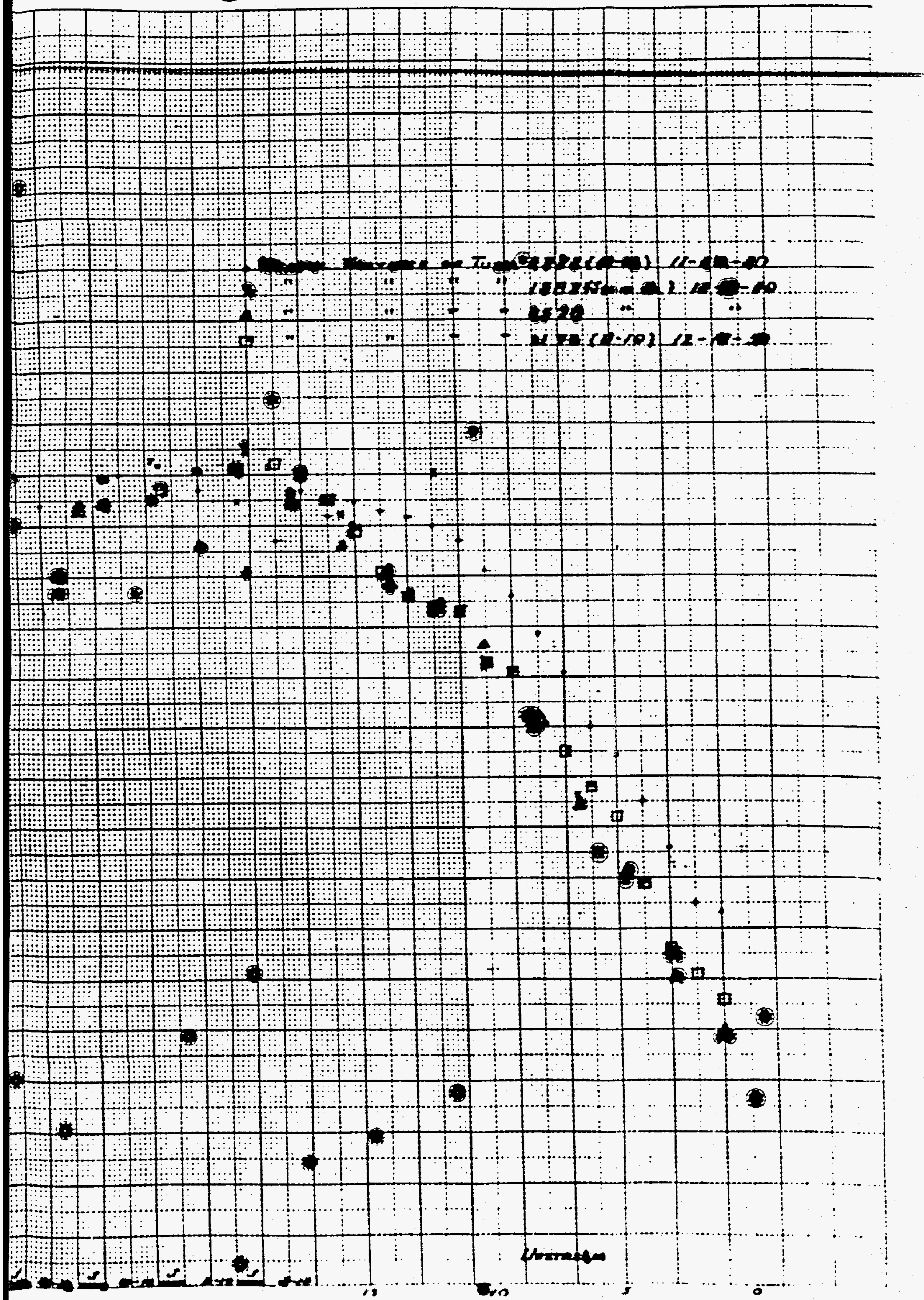

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DR PILE MONTHLY REPORT FOR DECEMBER - P. A. Johnson - C. W. Wheelock

Pile Performance. The DR Pile operated at a power level of 425 MW to 445 MW during the month except for four days of operation at 415 to 425 MW because of high temperature rises in individual tubes. The only outages were three instrumentation failure scrams from which quick returns were made to nominal level. The power level has continued to be limited by the maximum heat generation per tube based on boiling requirements; however, a rise in power level was attained during the month from improved rod flattening possible because of reactivity gains. Increased water flow resulting from a partial purge during unit operation also allowed a power level increase. Within the next month power level increases should be possible due to the increased flattening associated with the anticipated continued reactivity gains or from increased water flows resulting from effective tube purging.

As the power level was raised, the maximum recorded graphite temperature increased to 273°C on thermocouple 14G while the maximum claculated temperature increased to 280°C. The percentage average of the Orsat analyses for the past month was: CO_2, 97.7; CO, 0.4; O_2, 0.4. The continued high gas losses, averaging 2860 standard cubic feet per day, would tend to prevent any build-up of carbon monoxide.

The following table indicates the general operation characteristics of the past month. The dates listed are those on which the power level was changed to the value shown, and the maximum temperature values are typical for the indicated power levels.

Date	Power Level	Maximum Measured Graphite Temperature	Maximum Calculated Graphite Temperature	Maximum Water Temperature Rise Central Tube	Maximum Outlet Water Temperature
11-14	430 MW	250°C	256°C	68°C	80°C
12-8	425 MW	253°C	254°C	68°C	77°C
12-17	435 MW	261°C	273°C	68°C	77°C
12-19	445 MW	272°C	280°C	68°C	77°C
12-30	430 MW	273°C	282°C	68°C	76°C

Film Build-up. Since the actual operating limitation for boiling in the tubes is based on an allowable temperature rise across the tube, the power level at the DR Pile is quite sensitive to the reduced water flow resulting from the build-up of film in the tubes. In the 45 days of operation after the November 3 purge, the total water flow had dropped 1500 GPM and the flow in typical central tubes had dropped approximately 0.7 GPM. This three to four percent drop in flow effectively lowered the maximum power level by a like percentage, approximately 15 MW. The accidental iron rust purge of December 18 increased the flow 500 GPM and allowed a power level rise of approximately 5 MW, but after the purge the film build-up continued at approximately the same rate as before.

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Lack of available reactivity makes the possibility of successfully purging on a scram shutdown and quickly returning to nominal level doubtful, at the present but continued gains should make this possible in the near future. In view of this type of situation, which will probably repeat itself at DR rather frequently in the future, the best manner in which to reduce the film with a minimum production loss appears to be a purge during unit operation. Based on a spectroscopic analysis of the diatomaceous earth used as a purge material, calculations were made which indicated that with a two second irradiation at a neutron flux of 1×10^{13} nv, the activity induced in diatomaceous earth would be 400 μc per pound. The principal activity would result from the $_{14}Si^{30}$ which has a half-life of 170 minutes. A 100 ppm concentration of the above material in water would result in a suspension with an activity of 0.09 μc/liter compared to the current activity of 1.3 μc/liter in the normal effluent from the 107 DR basin. No allowance was made for any hold-up in the pile of any of the components in the purging material, although there is some evidence that this phenomenon does occur. The indicated activity is low enough, however, that under a controlled test no difficulty would occur even if the actual activity were many-fold that calculated. The effect on pile reactivity of 100 ppm of diatomaceous earth should be much less than one MW. There should be little danger of plugging any screens in the water system, as the purge material would be added in the same manner as during a normal shutdown purge. Operation at a reduced level during the purge should also reduce the potential hazard from a plugged screen. Flow through the sample rooms would have to be stopped during such a purge but for the relatively short time involved this should not be too serious a problem. if operating at a reduced power level.

It is porposed to conduct a trial purge on a production test basis by reducing the power level at DR Pile to 150 MW and purging for 30 minutes with 100 ppm of diatomaceous earth. The water will be run into a separate basin during the purge so samples can be obtained to determine the actual amount of activity added to the water by the purging medium and the removed film. At the conclusion of the purge the power level will be immediately raised back to nominal level and the water flow diverted to the other basin. If this method of purging would prove to be workable, a considerable saving of production could result in any pile operating on boiling disease limitations.

Iron Rust Purge. The pile was inadvertently purged with iron rust on December 18 when clear well Number four at 190 DR was returned to the water system. This clear well had not been in use for approximately a month when system leaks were being repaired. After repairs were completed it had been flushed, but apparently some rust particles were not removed. Soon after the valve to the main suction line in 190 DR was partially opened, a sixty percent increase in effluent water activity and a slight loss of reactivity were noted at DR Pile. The effluent activity returned to normal in twenty minutes and the total water flow increased slightly because of the purging action. Several hours later the valve to the suction line was completely opened and a twenty percent increase in water activity resulted. This dropped back to normal in approximately three hours. As a result of this purge the water flow was increased by 500 GPM, the panellit pressures were lowered by 2 to 13 psi., and the pressure drop across the tubes in which this drop is routinely measured decreased 8 psi. It was noted that the screen in the Number 4 inlet line to the risers was partially plugged, so flow was cut from both this line and the Number 4 clear well.

The screens in both Number 3 and Number 4 inlet lines were later removed and the lines between 190 DR and DR Pile flushed. Examination of particles caught in the screens showed that they apparently were fine iron rust, the bulk of which would pass a fifty mesh screen.

No ill effects were noted from this purge; in fact a five MW rise in power level can be attributed to the increased water flow. Apparently most of the solid matter settled in the 107 basin as no rise in activity on the effluent side of the basin was noted. It is tentatively planned to inspect the near cross-header screens on the first available shutdown, as the bulk of the rust would have passed into Number 3 and Number 4 inlet lines which feed primarily into the near riser.

Unit Motion. No significant changes in thermal motion of the pile structure were noted during the month. Trends previously noted continued as expected at the higher temperatures resulting from the increased power levels.

Test Hole Facilities. The water heater to be installed on the B test hole was received from H Pile, and plans for its installation at DR Pile are being drawn up at the 101 Shops. As the low reactivity condition which made the removal of the water from the B and D test holes desirable has improved considerably, it will be recommended that the water be returned to these test holes at the next shutdown.

Effects of Ruptured Slug. Preliminary investigation by the Metallurgical Group of the section of tube 1476 DR, containing the ruptured metal piece, verified the presence of a hole in the tube section. The amount of water that leaked into the pile from this hole was apparently small, because the average amount of water removed daily from pile during the month was 44 pints while the average for the first week after the tube ruptured was only 52 pints. What appeared to be uranium oxide was visible in the hole in the tube section, so it is likely that some fission products were transferred to the graphite channel. Analytical results are not yet available from the solid material vacuumed from the channel. There has not been any evidence of fission products in the pile gas.

Sample Room Water Monitoring System. A preliminary survey of the operation of the sample room monitoring system has revealed several shortcomings. In order to balance the radioactivity of the cross-headers which are opposed on the bucking circuit of the Beckman, considerable variation in sample flow for the various headers is necessary. This results in an indeterminate lag between the time of sampling and the time the sample passes through the ionization chamber. Tests on random headers indicated the time for a sample to pass through the system varied from 47 to 130 seconds, while the actual sample cycle was 40 seconds. Apparently at times the lag is even longer, as the radioactivity from the ruptured piece in 1476 appeared six cycles after cross-header 13 1/2 was sampled. Tests also indicate that of the time necessary for the sample to pass through the system, occasionally nearly half is consumed before the sample enters the chamber itself. This delay results from the rotometer and piping upstream of the chamber. The significance of the lag in passage of water through the sample system is that considerable dilution of the sample takes place.

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Several relatively simple alterations should improve the operation of the system. Putting the rotometer on the downstream side of the ion chamber and simplifying the piping on the upstream side should eliminate considerable time lag. Changing the manner in which the cross-header radioactivities are compared on the bucking circuit should also improve the operation. Currently the activities on adjacent headers are compared, but the near side of one is compared to the far side of the other. This makes the system quite sensitive to rod changes and poison distribution and occasionally necessitates large flow adjustments. The construction of the sample rooms at the DR Pile would allow the comparison of the activity of adjacent cross-headers on the same side of the pile with a minimum of repiping and only small changes in the Beckman circuits. This change would also facilitate making flow adjustments as all changes on any one bucking circuit could then be made in the same sample room.

Increased Pump Pressure at 190-DR. The advice of the Ingersoll-Rand Company has been asked on the feasibility and safety of operating the 190-DR pumps at discharge pressures in excess of the currently allowed 425 psig. This latter limit is 25 psi in excess of the original design value, but was judged safe by the test section of Ingersoll-Rand. It is unlikely that the manufacturer will authorize the use of the pumps at higher pressures unless the castings are replaced with an alloy steel. Since an increase in header pressure of 20 to 25 psi at the DR Pile should allow an increase in power level of 20 to 25 MW when the pile operation is limited by the heat generation per tube based on boiling, the possibility of operating at higher pump pressures should be fully considered. The water supply system from the pump discharge has been pressure tested at 900 psi.

As the pumps are not subject to shock loads it would seem to follow that a practice of operating at a pressure of two-thirds the amount for which the pumps have been hydrostatically tested would be safe. Since the pumps have been tested at a hydrostatic pressure of only 650 psig, consideration should be given to the feasibility of testing them on the plant at a higher pressure equal to one and one-half times that which might be desired as a working limit. The receipt of requested information from the manufacturer should provide a firmer basis for any recommendation on this problem.

Graphite Conductivity. It appears that the overall thermal conductivity of the graphite moderator of DR Pile has decreased somewhat since initial start-up. Data gathered between October 12 and December 29, 1950, representing total pile exposures between approximately 1370 and 29,700 megawatt days, have been used to calculate a thermal conductivity factor, kilowatts per tube-foot-degree centigrade which is shown plotted against total exposure of the moderator at the respective thermocouple location. This exposure has been calculated in terms of megawatt days per tube-foot, based upon water flow and temperature rise in the four process tubes surrounding the particular couple under consideration. A cosine power generation distribution from front to rear, symmetrical to the graphite center-line, was assumed.

The curves for 10G, 14G, and 19G are plotted on the accompanying chart and indicate the general trends to date. These three couples are surrounded by the same four process tubes, 2573-74 and 2673-74; 14G is located 10.46 inches downstream from the pile center and 10G and 19G are 7 feet, 1.84 inches up and downstream respectively from the graphite centerline. The curves for the other ten central graphite couples, which have similar front to rear locations, indicated the same general trends to date.

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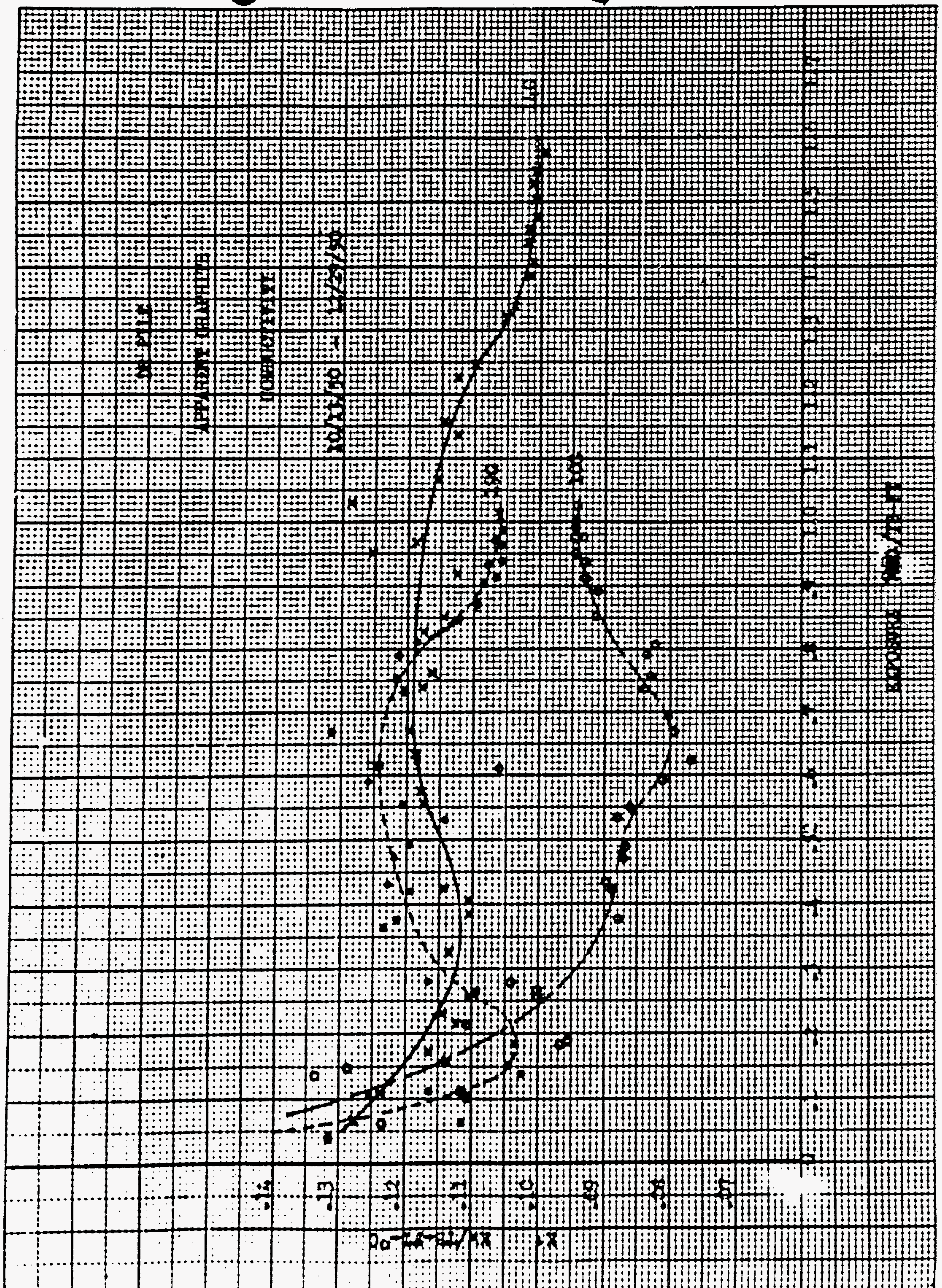

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In general, the results did not show the continuity hoped for, but did indicate a conductivity decrease at all couples over the period considered. In all cases the greatest conductivity loss was at the upstream couples, while the central and downstream points showed no consistant relative variations. The conductivity at the downstream couples now appears to be better than that at the center for the same tube locations, but the values do show some decrease in moving from the center toward the sides of the pile. The conductivity at most of the couples seemed to drop off during the first part of the period, but showed an apparent increase later on. This trend for the central and downstream couples again appeared to reverse itself during the last two or three weeks and it is now indicated that the conductivity at the central and downstream couples is decreasing while that at the upstream couples is increasing.

The study so far has not been particularly conclusive, but is not complete. Furthere work may aid in predicting changes before decreased conductivity would result in high graphite temperatures that would limit pile operation. It is hoped that data taken for power rises during start-up, and available from recorder charts for selected couples since, will provide another method of finding relative graphite conductivity through graphite period calculations. Some work has been done along this line, and its completion should provide information for the first 1370 megawatt days of operation as well as a check of the material herein reported.

C W Botsford
PILE TECHNOLOGY DIVISION

CW Botsford/wjk

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ENGINEERING DEVELOPMENT GROUP

BALL 3-X PROGRAM - D. J. Foley - T. P. Hockman

Ball 3-X Drop Test. On December 6, 1950, under Production Test 105-338-P, Supplement A, a ball 3-X drop test was made in No. 20-D VSR hole. This hole is equipped with a special fluted Ball 3-X stop plug with thimble removed.

The test was considered a successful demonstration of the feasibility of using this type of third safety.

Preliminary to the test the smooth 3/8 inch steel balls to be used were counted by a special electronic counter developed by Instrument Division. Also prior to the drop a special vacuum line was installed from the top of the unit to two 7 1/2 HP Spencer industrial vacuum cleaners on the roof outside X-Level, special hoppers were installed on the stop plug, and the VSR hole was vacuumed to remove any loose particles.

After filling the hoppers with approximately equal numbers of balls and sealing the top of one hopper with a transparent Lucite cover, the drop was made. Flow times of 13 and 18 sec. were measured for the open and sealed hoppers, respectively. This difference was felt to be entirely too great to be wholly attributed to the back flow of gas into the sealed hopper.

The bulk of the balls were removed from the hole after the drop by means of the special vacuum line. This removal consumed about two hours time with no difficulty encountered.

After vacuuming a special air jet apparatus was used to remove balls from the cracks between the vertical hole liner blocks. The bottom of the hole was re-vacuumed after the blowing and a number of balls were removed.

The hole was inspected with a borescope and two balls were observed in the crack in the thermal shield and six balls in the graphite. Four of the balls in the graphite were wedged in a narrow liner block crack and would have been impossible to remove by an air jet alone. A similar number of poison 3-X balls in each of the 29 holes in a pile would result in a reactivity loss of less than 5 inhours.

The balls as yet have not been recounted nor have the filter boxes used been examined to determine the approximate amount of graphite removed from the hole by the ball drop.

Gas Seal Operations. During the month of October, 1950 a new type of gas seal and a new jointed VSR were installed in the No. 20-D position, from which the thimble had been removed.

The Kanne chamber which monitors the gas drawn from about the top of the gas seal has indicated a leak since the time the new seal and new rod were installed. During the shutdown of D Pile on December 20, 1950, both the new seal and the new rod were inspected by means of a leak detecting liquid, "C-Leak", with the pile gas pressure at 5 in. of water. This inspection revealed a small continuous leak through the rod which had been plugged, but did not show any leak through the seal.

An expanding silicon rubber plug will be made for inserting inside the jointed rod to stop this leak.

SPECIAL PILE INSTRUMENTS - J. B. Cole

Test Hole Measuring Equipment. Fabrication of this equipment has been completed. This equipment is designed to take visual measurements of graphite block widths in the pile test holes. Mock-up tests of the equipment were conducted in the 101 Shops. The testing seemed to indicate that visual measurements tend to be about ten-thousandths greater than when taken with a micrometer. This error was consistent and may be optically induced.

A graphite block having a width of 4.185 in., as measured by a micrometer, was measured five times with the subject equipment. The width measurements were as follows: 4.193, 4.194, 4.195, 4.192 and 4.193. This variation is less than .005 in. which should be satisfactory in detecting graphite growth, which present data indicate is in the magnitude of .030 in. to .120 in. for the graphite blocks. This equipment is being scheduled for use at H Pile.

Graphite Core Borer. The handle and controls for the core borer are undergoing fabrication at the 101 Shops. This equipment has tentatively been scheduled for use at D Pile on the first shutdown subsequent to January 1, 1951.

Bore Gage. The design of the bore gage has been modified by mounting a smaller differential transformer vertically in the gage. In this way the measuring contacts will be fastened directly to the ends of the transformer, eliminating the linkage that was necessary to transmit motion to the transformer when it was mounted horizontally. This should result in increased accuracy, and reliability of the gage.

PILE FLUX DENSITY MEASUREMENTS - R. A. Horton

Equipment is complete for removing and handling irradiated aluminum wire from a loaded process tube. The equipment consists of two manually operated reels, each mounted in a lead-sheilded cask. One cask has an indicator for determining the point being measured along the wire. After a period of irradiation the wire will be wound into one cask and then into the second cask passing by a monitoring instrument for a reactivity traverse of the irradiated length. Several other applications for this equipment have been suggested and are being studied.

MAGNESIUM INLET DUMMIES - C. H. Goldthorpe

Magnesium dummy slugs are to be installed in the upstream end of the process tubes of each pile. This is being done to reduce the amount of corrosion taking place in the first eight feet of each process tube. Working drawings of the inlet dummy slugs are being made in the 101 Technical Shops. The first shipment of magnesium to be received consists of 1.30 in. diameter rods 24" long. These rods will be upset, cut to proper length, and then placed in 10 tubes at both the B and D Piles. The rest of the magnesium slugs are to be made off site and will be placed in the piles at a later date.

ASSISTANCE TO PILE PHYSICS GROUP - C H. Goldthorpe

Irradiated Slug Bubble Tester. The original drawings of the irradiated slug bubble tester have been corrected and returned to 101 Technical Shops where this drafting work will be completed.

Underwater Monitoring Equipment. Drafting work on underwater monitoring equip- is being done in 101 Technical Shops.

The gamma monitoring chamber has been designed and a drawing has been prepared by the instrument design group to be used with this equipment.

WATER SURVEY PROGRAM - R. M. Fryar

The literature survey of the water quality study has been completed and the results have been documented (HW-19709). An experimental program consisting of a correlated series of flow laboratory and inpile experiments is being planned. An informal Technical committee with representatives from Power, Analytical, H.I., and Metallurgy has been established to furnish assistance on the experimental program. The experimental work will take place in 100 D flow laboratory and pile and it is anticipated that tests will begin as soon as the necessary construction work is completed.

BOILING STUDIES - J. T. Carleton

Pressure drop measurements of water boiling in an electrically heated tube were found to be in good agreement with values predicted by the methods currently used to determine pile process tube heat load limits. The hydraulic radius of the heated tube was the same as that of the pile process tube water annulus, and the enthalpies used ranged up to 35% in excess of those which might be encountered under pile operating conditions.

SLUG TEMPERATURE MEASUREMENTS - H. H. Greenfield and S. S. Jones

A production test has been written to determine the effects of the pressure drop film and shutdown heat generation on the uranium slug temperatures. The equipment necessary for this test has been procured.

The tube will be charged with a thermocouple slug similar to the one used in PT 105-80-P, 7-5367. It is planned to purge the tube after a sufficient film build up while the pile is operating. The rate of temperature rise in the center of the charge at various periods after shutdown and for various water flow conditions will be determined.