HW-152 95

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December 5, 1949

100 AREAS TECHNICAL ACTIVITIES REPORT - ENGINEERING

COPY 1 OF [redacted]

OCTOBER 1949

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PILE ENGINEERING - GROUP I

Corrosion Laboratory Testing Details - J. F. Sullivan

Corrosion rate measurements were started this month on a number of different aluminum alloys. These tests include both galvanic corrosion cups (coupled dissimilar metals) and individual immersion weight loss samples. These tests, which will continue over a six month period, are as follows:

GALVANIC CORROSION CUPS

Couple			No.	Temp. Range
2S-H14	r	3S-H14	5	17°-90°C
"	"	52S-H34	5	"
"	"	53S-T6	5	"
"	"	56S-H36	5	"
"	"	61S-T6	5	"
"	"	63S-T6	5	"
72S-H	"	2S-H14	5	"
"	"	3S-H14	5	"
"	"	52S-H34	5	"
"	"	53S-T6	5	"
"	"	56S-H36	5	"
"	"	61S-T6	5	"
"	"	63S-T6	5	"

WEIGHT LOSS CUPS (Individual Immersion)

Alloy	No. of Samples	Temp. Range
2S-H14	25	17°-90°C
3S-H14	25	"
52S-H34	25	"
53S-T6	25	"
56S-H36	25	"
61S-T6	25	"
63S-T6	25	"
72S-H	25	"

Pile Borescopic Inspections - J. F. Sullivan

During the October 10th shutdown the first 8 foot section of tube 3867-D, which is a 2S aluminum tube, was borescoped to ascertain the severity of corrosion on nonclad tubing under operating conditions. This tube in the pile since September 16, 1947 was found to be in fair shape, the corrosion appearing to be no more serious than in alclad tubes. At the present time there are approximately 30-2S aluminum tubes in the piles and plans are under way to borescope a representative number of them.

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Slug Deformation Details - E. A. Eschbach

P. T. 105-224-P - High Nickel Uranium

The final tube of this production test has been discharged at 400 MD/T. The slug measurements are in progress.

P. T. 105-235-P - Effect of Transformation

Measurements were made on four tubes of this metal which were discharged at 344 MD/T. The dimensional instability of some of this metal necessitated that the remainder of the tubes be discharged at an exposure level of 340 MD/T.

P. T. 105-238-P - Exposure of Slugs Fabricated from Forged Uranium

A tube was pushed at 250 MWD/T but measurements could not be completed due to an instrument breakdown. Initial observations indicate that this metal will reach the same as alpha rolled metal.

P. T. 105-241-P - Exposure of Quenched Slugs

Cursory observation of a tube pushed at 209 MWD/Ton indicate that this metal will be essentially the same as group V metal.

P. T. 105-277-P - Exposure of Induction Heated Metal

This test has been charged and the first tube is scheduled to come out at 100 MWD/T for orientation checking.

Van Stone Flange Corrosion Details - J. F. Sullivan

Van Stone Inspection on H Pile

Inspections of 52 van stone flanges (24 front and 28 rear) on the H-pile were made this month by the Pile Technology Division for corrosion reference. A series of sixteen thickness measurements were recorded for each flange. This will enable Technical to ascertain the van stone corrosion rate under the new type nozzles.

Inspections on P. T. 105-114-P

Magnesium Gaskets

Four rear face and one front face van stone falnges with magnesium gaskets on them since October 22, 1948 were inspected during this past month. In all cases the gasket had corroded nearly away but the van stone was perfectly protected. This form of van stone flange protection is not satisfactory because the gaskets corrode away and causes water leaks.

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Aluminum Gasket

The rear van stone flange on tube 1352-F under test with an aluminum gasket since November 17, 1947 was inspected at F Pile. The inspection indicates that the aluminum gaskets do not protect the van stone flanges. More aluminum gasket inspections are planned.

Aluminum Dummy Pattern in Stainless Steel Nozzle.

The aluminum dummy patterns (1 double diameter piece and one solid piece) in five rear face stainless steel nozzles were inspected to determine the severity of aluminum corrosion under these conditions. Both aluminum pieces were found to be badly pitted with the exception of about two inches on the double diameter piece at the flange where the water velocity was very high; here no pits or corrosion products were found. These pieces have been exposed since May 26, 1948.

Galvanizing Baths Specifications

When the front face nozzles on the H Pile were galvanized, Technical set a maximum of 1% lead in the galvanzing bath. During, the galvanizing operation it was found that the lead bath analyzed more than one percent during one days operation during which time approximately one hundred nozzles were dipped. Tests are in progress to test the effect of more than 1% of lead in reducing the life of the galvanized coatings on the inlet nozzles.

DR Rear Face Inspections -

In an effort to determine whether the pits on the rear van stone flanges of the DR pile, caused by stagnant water, are increasing in depth Technical has been monitoring the thickness of a representative number of flanges for the past two months. Twenty-three van stones flanges have been "miked" and the results indicate no noticeable increase in pit depth. Further inspections are planned around the first of the year.

P. T. 105-103-F (Supplement A) Corrosion Rate at Elevated Temperature

H.H. Greenfield

This production test has been approved and is now well under way. All the orifices have been changed and all but one of the rear van stone flanges have been inspected. The corrosion tubes are being charged as their dates come up. Charging will be completed by the first of the year.

Corrosion Tubes for H Pile Startup

Eight tubes have been charged for corrosion studies at H Pile under P. T. 105-9-P Four of the tubes are in the 0.285 orifice zone and the rest distributed over the other orifice zones.

Corrosion Rate of Slugs Discharged Under P. T. 105-9-P

The average and maximum corrosion rate of slugs discharged at the three pile areas during the month are shown in the following table. These corrosion rates

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are of the same order of magnitude as those for the four and eight inch slugs measured to date under P. T. 195-9-P.

Tube	Area	Exposure (MWD)	Slug Size (inches)	Corrosion Rate (mils/mo) Average	Maximum
1374	B	48.2	4	0.10	0.17
1478	B	48.2	4	0.09	0.18
1681	F	52.3	4	0.07	0.13
0554	D	26.5	3	0.02	0.03

Corrosion Studies on Aluminum and Magnesium Tubes

The test on the effect of hot unirradiated process water (90°C) saturated with CO_2 in contact with a magnesium tube and a graphite tube block showed extensive deep pitting and etching as well as deposition of white corrosion products over the entire surface of the tube. The test on the effect of dry CO_2 and graphite in contact with a magnesium tube that was heated to 90°C by hot unirradiated process water flowing through it showed no evidence of corrosion by pitting or etching of the surface of the metal in contact with the graphite and dry CO_2 atmosphere. The inside of the tube in contact with the hot unirradiated process water was pitted and etched by the water. The test results on a magnesium tube after two weeks of being partially immersed in cold stagnant unirradiated process water, saturated with CO_2 and in contact with a graphite tube block were about the same as that for hot unirradiated process water saturated with CO_2. Little change in the amount of pitting and etching as well as deposition of corrosion products from one week exposure (September Monthly Report) was observed after two weeks exposure. The pH of the stagnant water used was 7.4. The result of the test on an aluminum tube after two weeks of being partially immersed in cold stagnant unirradiated process water, saturated with CO_2 and in contact with a graphite tube block showed general pitting where it was in direct contact with the water and graphite. Little change in the amount of pitting and etching as well as deposition of corrosion products from one week exposure was observed after two weeks exposure. The pH of the stagnant water used was 5.3. Photographs of the tubes and equipment used are contained in document GEH-15,618.

Added Control Ink Facility - WK Alexander - EC Wood

Work during the month on this project consisted largely of developing a method of measuring the concentration of the Potassium tetra borate solution. Work is being done toward developing a colormetric method. Potassium dichromate will be used as the coloring agent. It will be mixed with the dry borate. The light absorption will be measured with a #929 Photo tube and recorded with a standard pH recorder which will be calibrated directly in in values. It has been determined that with approximately 0.05% chromate in the solution light

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of 3700 Å is absorbed very effectively.

Light of this wave length is obtained by using an incandescent light and two filters, one pyrex glass and the other deep violet.

Tests with boric acid indicated it would be satisfactory if the temperature were kept above the crystalization point. It was found that when cooled down the boric would crystalize out and plug the tubes.

Tests were run in the 305 pile to determine the poisoning strength of Borate solution. The table below shows the observed absorption values for various solutions.

70 $K_2B_4O_7$ 5_{H2O}	% Black	Nominal iH per tube	actual ih per tube (calc)
1	30.8	20.9	7.67
2	45.0	30.6	11.4
3	55.5	37.7	1.39
4	62.5	42.4	15.6
5	68.0	46.2	17.0
6	72.8	49.4	18.1
7	76.5	52.0	19.0
8	80.0	54.4	20.0
9	83.0	56.3	20.7
10	85.6	58.2	21.4

It is planned to use 10 tubes which should give over 200 ih additional control.

Thimble Replacement

A document has been prepared which presents a preliminary survey of the problems. It is pointed out that it will not be possible to replace the thimbles with ones made from some other metal since no such metals with suitable properties are available. It, therefore, seems advisable to work on removing the thimbles entirely. This will necessitate developing a replacement 3-X. It has not been determined just what type of 3-X will be best and it appears that the use of some type of balls will be most easily developed and most practical.

Borescope Equipment and Repair - L. W. Lang

All borescope equipment was inspected, and those parts not in good working order were sent to the 300 Area Optical Shop for Repair. An inventory of each piece, its location and condition was started. More adequate storage facilities have been arranged in the 105 Building in the 100-D Area. In the future the borescope will be stored at the O-level near, eliminating the necessity of wrapping to remove from the work area and storing inconveniently in Filter Cell No. 1. Better facilities have been made, also, at O-level near for assembling and minor repair.

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New transformers are being made to take the place of the present inadequate ones which in the past have been responsible for burning out several of the viewers bulbs. It is planned to have a tool kit, a transformer, and one complete borescope in each area, and with the "P" Division's approval to store at 0-level near in all areas.

Water Recirculation Cooling Test - D. F. Snoeberger

The analytical program for the test (Doc. HW-14064) was discussed and minor changes made at a meeting of Technical, H. I., and Design personneal ("Minutes of Meeting Held October 4, 1949"). Further details are to be worked out with Mr. D. H. Elderkin.

Dry steam from the 100 Area power plants condensed in a surface condenser to avoid solution of all of the CO_2 with the steam is considered a satisfactory feed water for the test system. This and the low CO_2 content of the atmosphere at Hanford (0.07% measured October 1949, equivalent to about 2 ppm CO_2 in pure water at equilibrium) and tests on samples of condensate containing total CO_2 in the steam, which have dropped from 36 ppm CO_2 (pH 5.0) to 10 ppm CO_2 (pH 6.0) on standing in partly filled bottles, indicate that it will not be necessary to redistill or degas as part of the water treatment.

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PILE ENGINEERING - GROUP II

Pile Expansion - H. L. Mars

B Pile

Since reaching 60% CO_2 atmosphere on August 15, 1949, the center of the Top has gone down .04 to .06 inches as shown by Wye levels and confirmed by dial gauges A80V & A81V. The middle of the top edge of the Far Side has moved in about .1 inches. Ames dial gauge A80H was installed at the center of the upper edge of the Near Side in May 1949. It showed an outward motion of .07 inches during June of 1949, but no outward movement since then.

D Pile

One set of Wye level data indicates an .04 inch upward motion of the center of the Top during the last month. This is not confirmed by dial gauges and it will be necessary to examine subsequent data to ascertain movement if any. The Near Side dial gauge A80H was installed in April 1949. Since that time it shows an outward movement of .02". The Far Side gauge at top center of Far Side shows an outward movement of .06" in the last two months.

F Pile

Wye level data of the center of the Top is questionable and is not confirmed by gauges M25V and A80V. Measurements of bowing of Tube 4674 taken in October indicate a drop of 1/4" at the maximum elevation since May 1949. This confirms Wye level measurements which show a similar 1/4" decrease since 60% CO_2 was reached at the end of May. Ames A80H was installed at the center of the upper edge of the Near Side in May 1949 and since that time shows an inward motion of .04 inch. Readings on mike bracket M25H at the top center of the Far Side show no net outward motion during the last month but readings are erratic and additional data is necessary.

H Pile

Base readings were taken at H Pile prior to startup. Motion data will be included in subsequent reports. H Pile unit motion instrument description, equations for motion, and base readings were entered in Notebook HW-2968-T. Graphs following H Pile unit motion are being plotted.

Pile Motion Instruments

Plumb bob P-1 for B, D, & F Piles is being fabricated and will be installed as shutdown time is available. Pieces to extend range of Brown unit motion instruments at D Pile are being fabricated and will be installed when shutdown time is available. Document HW-14912 containing recommendations for DR Pile unit motion instrument changes was issued.

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Carbon Dioxide Experiment - S. S. Jones

The carbon dioxide in the D Pile atmosphere was increased from 40 to 43% on October 31st as the first step in a planned increase to 60%.

The H Pile was started up with 100% CO_2. At 100 MW power level the central graphite temperature was 54°C. The graphite temperature at the B Pile when first attaining 90 MW was about 32°C. This amounts to an increase in the graphite temperature elevation above local water of from 7 to 35°C.

Special Instruments for Graphite Expansion Measurements - WM Haussler-PA Johnson

The mercury level manometer was tried out in the nine tube mock up. Several defects were found. The instrument has been returned for redesign of the "head" which is inserted in the tube.

A new tape and probes were obtained for measuring endwise expansion of the graphite. Small modifications were made to the 16" and 32" curvature gages so that they could be used in process tubes. They were recalibrated and are ready for use.

Graphite Core Sample - T. P. Beckman

During the shutdown of October 12, 1949 the distance in the "A" test hole of the D Pile from the far side of the shield to the far side of tube bearing block 2282 was measured in accordance with P. T. 105-276-P. During the shutdown of October 26, 1949 the core cutter was inserted and a solid core 7/16" dia. was cut and removed from tube bearing block 2282.

Vertical Thimble Temperature

A chromel-alumel thermocouple was installed in No. 26 vertical thimble of F Pile according to P. T. 105-272-P during the shutdown of October 6, 1949. Temperatures of this thermocouple, and of thermocouple #13 G were recorded continuously, and later imposed onto the same graph.

The maximum temperature of both thermocouples was reached approximately ten hours after the poison push startup of October 7, 1949, and were as follows: #26 thimble - 296°C, #13 graphite - 285°C. After three days of steady operation at 275 MW the two thermocouples steadied at the following approximate temperatures: #26 - 270°C, #13 - 255°C. The thermocouple was removed from #26 thimble, and the rod restored to normal operation during the shutdown of October 18, 1949. Details are reported in "Final Report Production Test 105-272-P".

The 100-F Maintenance Shop reworked 6 foot sample section of vertical thimble to demonstrate a method of attaching permanent thermocouples to a thimble.

The sample appeared to be satisfactory, and a full thimble with thermocouples installed is planned for the future.

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H Pile Dry Coefficient Test - S. S. Jones

Three 8 inch uranium slugs were successfully drilled and canned to obtain thermocouple slugs for measuring changes in the temperature of the heavy metal slugs in the center of a dry Hanford pile charged to dry critical. A total of ten 4 inch uranium slugs were successfully drilled and canned. These were used to shield the thermocouple slug from the Wilkins heating effect.

Two of these special thermocouple slug assemblies were charged into the center of tubes 2674-H and 2680-H after completion of charging to dry critical. This assembly was then used to measure the temperature coefficient of the metal in the dry pile. Then by holding the metal temperature constant as measured by these assemblies, it was possible to determine the graphite coefficient of the dry pile. This was found to be negative in agreement with other known gas cooled graphite moderated units. The details of the coefficient effects will be reported by U. M. Staebler while the heat transfer analysis will be reported by M. W. Carbon.

Five days after charging the two thermocouple slug assemblies were discharged and collected in a metal storage box for possible future use. There is now on hand the following special equipment for temperature measurement:

1. Two thermocouple slug assemblies containing copper constantan aluminum sheathed thermocouple wires.
2. One 8' inch thermocouple slug.
3. Three 4 inch canned uranium slugs with 3/16" Dia. holes extending axially through their center.

H Pile Heat Transfer Analysis - M. W. Carbon

A heat transfer analysis of data from the dry coefficient test has been reported in Doc. HW-15009. Calculations of the graphite temperature and heat transfer coefficients at the H Pile were reported in HW-15028.

Beta Experiment - J. B. Lambert - W, H. Welch

E-5 was charged into process Tube 1071 F on October 6, 1949 and discharged on October 18, 1949. Total irradiation time at 275 MW was 10.6 days.

E-4 was charged into Tube 1071 F on October 18.

E-2 is irradiating in Tube 0865-F. Special inlet and outlet nozzles were installed on the third tube (1077-F) assigned for beta experiments. Nine slugs containing spring units have been received from Schenectady. These are to be irradiated at pile temperature to determine the effect if any of irradiation on the properties of springs.

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PHYSICAL CHEMISTRY GROUP

X-Ray Diffraction Studies - D. H. Curtiss - E. P. Warekois

Graphite Core Sample

A solid core of graphite about 7/16 inches in diameter and 0.9 inches long was cut from tube block 2282-D over the A test hole by T. P. Heckman et al under P. T. 105-276-P, This tube block contained a metal tube since startup and had an accumulated exposure of approximately 3300 MD/CT.

X-ray measurements of the Co-spacing were made along the length of this sample and on a sample mined from the bore of the same tube block with the following results which are presented below and in graphical form.

Distance from bore (inches)	Co-spacing (Å)	X-ray Expansion (%)	Equivalent physical Expansion (%)
0	7.67	14.5	1.87
0.35	7.43	10.9	1.34
0.8	7.26	8.35	1.00
1.2*	7.12	6.26	0.85

*Surface of tube block

The equivalent physical expansion was calculated from the relationship between X-ray and physical expansion previously obtained from test hole and capsule samples. About 50% of the difference in expansion from the bore to the surface could be caused by the difference in effective damaging flux at the two points. The remainder must be attributed to the temperature difference at the two points.

The graphite at the bore has expanded in 3300 MD/CT an amount equivalent to capsule samples after about 1400 MD/CT although the flux is about the same. The difference must be attributed to the temperature difference between the two locations, and illustrates the importance of higher temperatures in reducing the rate of damage. Similarly the graphite at the surface of the block expanded in 3300 MD/CT an amount equivalent to test hole samples after 1000 MD/CT. The test hole samples are exposed at a slightly lower flux and at a much lower temperature.

A sample mined from 3469-D with an exposure of about 1500 MD/CT as a metal column and 1800 MD/CT as an empty position (gas tube) gave a Co-spacing of 7.14 ± .01 Å which is equivalent in damage to the graphite from the surface of the tube block (end of core sample), although the mined sample received a large portion of its exposure at a relatively low temperature and high flux. The long exposure as a

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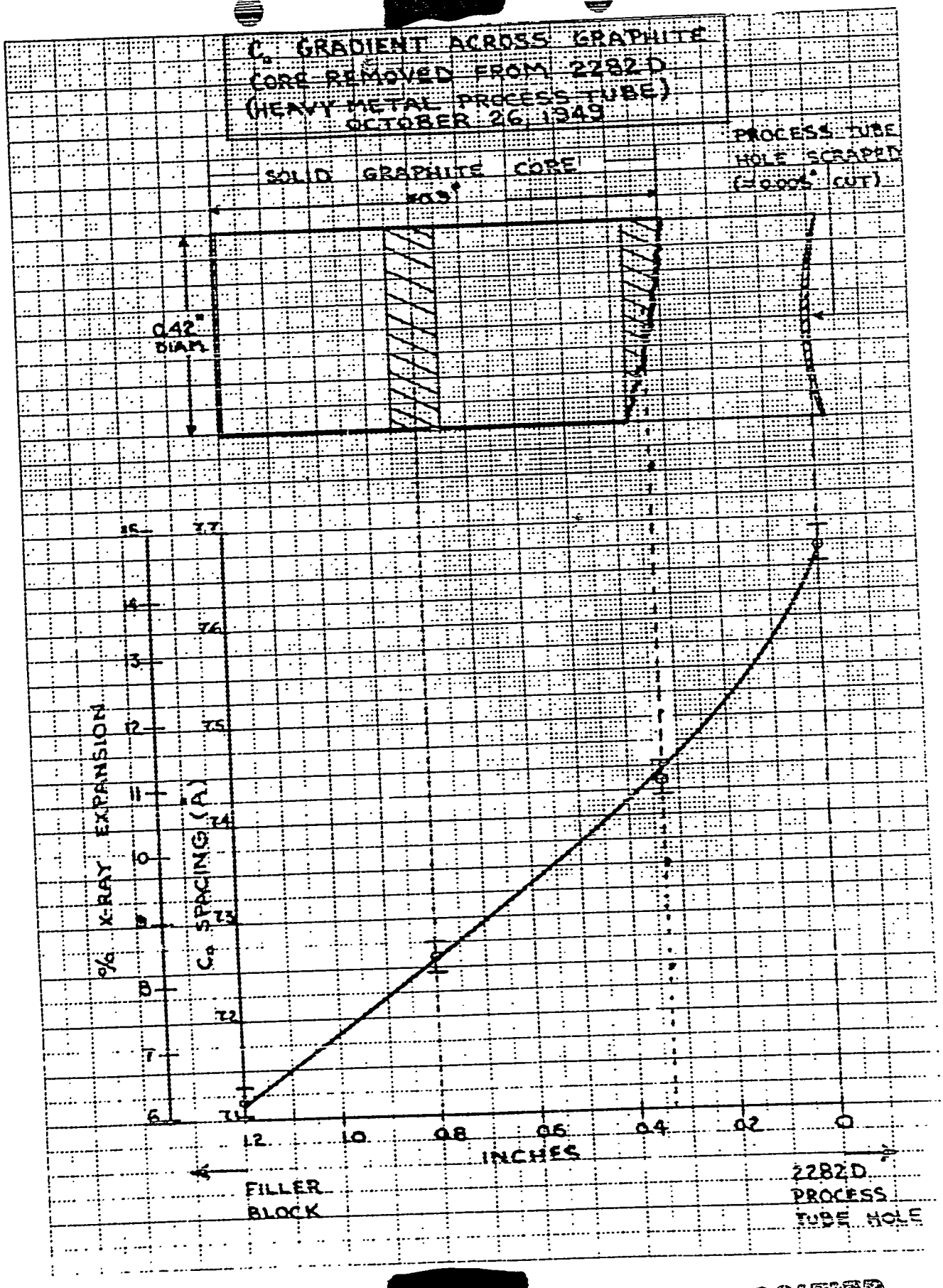
C_o GRADIENT ACROSS GRAPHITE CORE REMOVED FROM 2282 D (HEAVY METAL PROCESS TUBE) OCTOBER 26, 1949



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gas tube, at temperatures of 200°C to 275°C, apparently results in considerable annealing, although more controlled exposures are necessary before quantitative results can be obtained. An apparent contraction in the Co-spacing was detected on this sample of graphite, and was estimated as 0.65%. With a Co-spacing expansion of 6.1%, a net increase in the volume of the unit cell can be calculated to be about 5%.

WSF Expansion

From a plot of per cent physical expansion vs. degree of particle orientation, a value of 0.4% expansion/1000 MD/CT in a transverse direction is predicted for WSF graphite. This is less than the experimentally determined values of 0.85%/1000 MD/CT for KC and 0.6%/1000 MD/CT for CSF graphite.

Thermal Annealing - H. H. Burton - H. A. Baskin

Final results for the thermal annealing of an irradiated KC parallel-cut sample of graphite are tabulated below. The specimen had received an exposure of 700 MD/CT at a maximum temperature of 150°C and 1666 MD/CT at 30°C. The experiment was a "dry run" to determine the minimum amount of time required for nearly complete thermal annealing at 275°C a large group of samples with varied exposures.

Total time at 275°C Hours	Per Cent Recovery			
	Electrical Resistivity Ratio	Thermal Conductivity Ratio	Physical Expansion	X-ray Expansion
1	12.5	9.6	11.4	----
17	13.6	11.0	12.9	----
82	14.3	11.0	13.7	----
242	14.5	14.1	14.5	26

From a plot of the above data, 120 hours is adequate for a virtually complete thermal anneal at 275°C for samples with an exposure of 2366 MD/CT or less.

Seven groups of samples with an exposure gradient from 2366 MD/CT to virgin material have been selected and the initial values of resistivity, thermal conductivity, Co-spacing, and length have been determined. The samples will be thermally annealed at 375°C for 5 days, remeasured, and exposed for periods of one, two and three months in the ambient pile temperature B test-hole facility at F Pile. Recovery following the thermal treatment and continued exposure should then be attributable to nuclear annealing. Present B test-hole temperatures of 332-334°C allow a safety margin of 30°.

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Empty Process Tube Temperatures - H. H. Burton

On October 12, a thermocouple mounted in a standard graphite sample was placed in uncooled empty process tube 1582-D for temperature measurements. After 13 hours of operation the couple failed, but sufficient data was obtained to show that at 250 megawatts a maximum temperature of 286°C was reached 11 hours after startup and that equilibrium at this power level might have been established at about 235°C.

Oxidation

A rough determination was made of the effect of progressive oxidation on the electrical resistivity and thermal conductivity of CSF graphite. Three transverse samples cut from the same bar were oxidized earlier to 5.55, 9.20, and 11.35% of total. Values for R and K are listed below. Virgin values are averages for adjacent samples.

Per Cent Oxidized	Electrical Resistivity (ohm-cm)	Thermal Conductivity cal/deg cm sec
Virgin	11.40×10^{-4}	0.278
5.55	14.2×10^{-4}	0.196
9.20	14.12×10^{-4}	0.1957
11.35	19.20×10^{-4}	0.1176

Apparatus is being assembled to measure continually the resistivity of a sample during oxidation.

Length Changes During Thermal Annealing - G. P. Kerr

Interferometric measurements were completed on a transverse sample of KC graphite exposed 1215 MD/CT in a cooled test hole at about 25°C. Contraction on annealing began at about 170°C; the fractional contraction gradually increased from 8.5×10^{-6} per deg C at 200°C to 18.5×10^{-6} per deg C at 600°C. The total contraction at 600°C was 4.95×10^{-3} which represents about 45% recovery in expansion in agreement with X-ray annealing data on the same sample taken before and after annealing. An expansion of 2.0×10^{-3} was reported for parallel cut KC on thermal annealing to 600°C after an exposure of 1215 MD/CT in a cooled test hole and 910 MD/CT in a capsule. Plots of the fractional dimensional change / °C are widely different in character for these two samples; X-ray annealing data over the same temperature range are necessary to explain the dimensional changes on annealing.

Thermal expansion coefficients (α and β) obtained from these runs on exposed KC graphite are given to fit the equation $L = L_0 (1 + \alpha t + \beta t^2)$ over the temperature range 25°C to 600°C.

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	$\alpha \times 10^6$	$\beta \times 10^9$
Parallel KC	1.20	2.5
Transverse KC	5.14	2.0

[redacted]lues for α are approximately in the same ratio as the particle orienta-[redacted]or KC graphite.

P H Reinker

C. C. Johnson

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