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STANDARD FORM NO. 64

HAN-74591-DEL

Office Memorandum • UNITED STATES GOVERNMENT

TO : PE&M Files **DATE:** January 12, 1961

FROM : R. L. Plum, Chief
Reactor Branch

HAN--74591-Del.

SUBJECT: MONTHLY REPORT - DECEMBER, 1960

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OR:GTO:GRG

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OPERATING EXPERIENCE

Production

Record reactor production of Pu exceeded the November maximum by 3.3%. Forecast was exceeded by 9.5%; 12.9% at the six old reactors and 4.7% at the K's.

Efficiency

Over-all time operated efficiency was 84.9% (82% forecast); 86.3% at the six old reactors and 80.6% at the K's.

Power Level

The combined reactor instantaneous power level was increased 205 megawatts (18,580 to 18,785). The individual reactor record power levels were increased 90 megawatts at KW (3910 to 4000), 70 at B (1175 to 1245), 25 at D (1785 to 1810), 20 at C (2070 to 2090), 10 at H (1890 to 1900), and 10 at F (1825 to 1835). Input production records were achieved at D, DR, F, H and KW reactors during December.

Power Level Limit

The limit to the power levels of six of the eight reactors during this report has been rupture control considerations. However, H and KW reactors were limited for a portion of this period by the administrative safety limit.

Fuel Ruptures

Thirteen ruptures, six I&E regular metal, five I&E enriched, one solid regular, and one KER were removed from the reactors. Three of the I&E regular ruptures were at KE and one each at B, F, and H. Two of the enriched ruptures were at KW, two at C and one at KE. The solid rupture was at DR.

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Maintenance and Equipment Experience

1. Ten process tubes were installed; eight at B and two at DR.

2. Four tube leaks and one Van Stone leak were corrected. Two tube leaks were at B and one each at DR and H. The Van Stone leak was at F.

3. The No. 5 river pump at 181-D was removed from service because of excessive vibration. Inspection showed a crack in the lower column section of the pump, which was corrected by welding.

4. The transformer supplying the 4.16 KV bus "A" at 165-KW failed December 5, 1960, but reactor operation was not affected.

The failure of a rear-face Parker fitting on tube 3776 in D Reactor was investigated. The fitting cracked in the thread-relief area. A peculiar type of pitting completely through the fitting near the flare area was observed. The fitting is undergoing metallographic testing and examination in Hanford Laboratories Operation. This is the second failure of this type, the first fitting crack being observed at F reactor in early 1960.

The KER front face lateral and inlet connectors have been removed from loops number one and three for destructive examination. The rear-face lateral from loop number one was removed because of a leak in a flared fitting. Sections of the tubing will be tested to determine the effects of service environment. In particular, the rusting of carbon steel (from loop 1) and the potential for stress corrosion cracking of stainless steel (from loop 3) will be monitored to determine the cumulative effects of water leaks on the front face.

Three horizontal control rods at KE Reactor continue to be only partially insertable due to the lodging of 3X balls in the rod channels. Current operation is only slightly affected by the partial loss of these rods.

The design for an inlet-nozzle reinforcing sleeve to convert present inlet nozzles for use with bumper fuel elements has been completed. The sleeve replaces existing nozzle lug rings with integral lugs, which transfers the charging machine and end cap loads from the snap ring groove, which has been weakened from enlarging the nozzle barrel, to the heavy section of the nozzle barrel. Ten sleeves have been fabricated for testings.

Reactor Outages

Outages for the month of December are as follows:

B REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/30	12/3	65.3	Removal of an I&E regular metal rupture from tube 3566 and miscellaneous maintenance.
12/18	12/19	35.9	Removal of an I&E regular metal rupture from tube 1559.
12/21	12/23	44.1	Leak testing and replacement of tubes 1276 and 2379.

C REACTOR

12/4	12/8	89.4	Scheduled charge-discharge and maintenance. Two channels were successfully overbored.
12/14	12/15	33.7	Removal of an I&E E metal rupture from tube 0957.
12/25	12/27	41.8	Removal of an I&E E metal rupture from tube 2276.
12/29	12/29	0.4	Leaking front pigtail.
12/30	12/30	0.3	An unexplained Beckman trip.

D REACTOR

12/12	12/15	55.2	Scheduled charge-discharge.

DR REACTOR

12/11	12/13	41.8	Removal of a solid regular metal rupture from tube 4090 and charge-discharge.
12/22	12/23	36.9	Leaking tube 3275 was replaced.

[redacted]

F REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/30	12/2	47.4	Removal of an I&E regular metal rupture from tube 1677 and charge-discharge.
12/3	12/3	1.5	Open gamma monitor sample line.
12/3	12/4	21.9	Water leak - a gasket leak on tube 0854 was corrected and a new Van Stone was formed on tube 0964.
12/17	12/19	54.6	Removal of an I&E regular metal rupture from tube 2861 and charge-discharge and maintenance.

H REACTOR

Date Down	Date Up	Outage Hours	Remarks
12/26	12/29	55.8	Removal of a stuck I&E regular metal rupture in tube 1472 and charge-discharge.
12/29	12/29	0.3	Unexplained Panellit trip.

KE REACTOR

Date Down	Date Up	Outage Hours	Remarks
12/7	12/8	42.8	Removal of an I&E E metal rupture from tube 5369. Installed two single pass tubes for 1706 system.
12/8	12/9	3.0	Replaced venturis in two tubes.
12/9	12/9	6.2	Tripped due to a rupture in loop 3. (PT-IP-309A).
12/10	12/12	36.4	Removal of an I&E regular metal rupture from tube 3476.
12/15	12/17	34.7	Removal of an I&E regular metal rupture from tube 4351, charge-discharge and miscellaneous maintenance.
12/18	12/18	0.5	Tripped due to a ruptured spline cap seal on tube 4588.

[redacted]

[redacted]

KE REACTOR cont.

Date Down	Date UP	Outage Hours	Remarks
12/18	12/19	31.6	Miscellaneous maintenance following a high pressure Panellit trip.
12/20	12/20	0.4	Adjusted shielding in two vertical rod channels.
12/21	12/22	31.0	Removal of an I&E regular metal rupture from tube 5055.

KW REACTOR

Date Down	Date UP	Outage Hours	Remarks
12/4	12/5	41.1	Removal of an I&E E metal rupture from tube 5359. Charge-discharge.
12/21	12/23	60.6	Removal of an I&E E metal rupture from tube 5261.

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RESEARCH AND DEVELOPMENT - EXISTING REACTORS

Self-Supported Fuel Development

Thirty columns of CIVMS fuel were discharged from C Reactor at an average exposure of 918 MWD/T during the outage of December 4, 1960. One tube (3672-C, 878 MWD/T) failed to move under full force of the charge machine, and it was classified as the first stuck charge experienced in a self-supported fuel geometry. The tube was finally discharged with charging machine forces after undergoing a series of oil flushes between pushes.

The modified prototype charging machine for self-supported fuel elements was demonstrated successfully at C Reactor during the December 4 outage. Some further slight modifications to the machine will be required.

Bumper Fuel Development

Twelve tubes of bumper fuel elements (4-rail) were successfully machine charged at D Reactor during the December 12 outage, bringing the total number of bumper charges in D Reactor to 36.

Post-irradiation examinations of bumper elements to determine the associated hot-spot frequency reduction have been completed. The data are being prepared for machine analysis.

Hot-spots were observed on some bumper fuel elements fitted with collapsible bridge rail bumpers. The data have not been fully analyzed as yet, and the full significance of the observations is not yet apparent.

Three bumper fuel elements that exhibited high weight losses will be sent to Radiometallurgy for residual can-wall determination. One control piece that exhibited a post-irradiation ellipticity measurement of 69 mills will also be sent to Radiometallurgy.

E-N Calculations

The E-N K_∞ calculations previously done were repeated using the corrected P_3 and "Idiot" program results. The relative length ratio was 18.45 E to 1 N when the K_∞'s were matched for the hot, clean, wet case. This E-N ratio may be too high, since the same axial flux distribution was assumed for both hot and cold cases. The above results were based on the assumption that the measured E-N ratio of 14.95 to 1 matched the natural uranium reactivity for the cold, dry case.

[redacted]

Rear Face Connectors

Pending the availability of improved rear face connectors being developed by the Materials Development Operation, an acute need for replacement units has arisen, particularly at H Reactor. To minimize a possible emergency due to lack of replacement components, the design, specifications, drawings and purchase requisitions were provided for an interim connector of the helical (du Pont) configuration, with Inconel as the tubing material. Satisfactory bids for 31,000' of tubing have been received, and order for this quantity has been issued to International Nickel Company. Ten to eleven thousand connectors can be made from this amount of tubing.

Remote Rear Face Equipment

Thirty-five additional flapper cap seals were installed on KE Reactor, making a total of 88 flapper caps and six ball caps under test. Upon startup, 33 of these cap seals leaked and were removed pending replacement with a newly designed seal. On December 22, most of the flapper cap seals were rearranged in three horizontal rows, 51, 52, and 53, for operating convenience, and additional caps were installed. At present there are 73 flapper seals and six ball seals on the reactor.

Vertical Safety Rods

Preliminary designs are being prepared for replacement of vertical safety rods at 105-C Reactor. Graphite distortion has rendered two vertical safety rods inoperable and caused binding in three additional rods.

Graphite Distortion

An engineering study for restoration of the K Reactor graphite stack has continued, and the following study items have been completed:

(1) Shield bracing and motion monitoring

(2) Evaluation of materials for horizontal control rod sleeves

(3) Determination of rod deflection and pushing forces with saddle blocks, ahd

(4) Evaluation of ceramic sleeves for the horizontal control rods.

The study indicates that graphite sleeves for the horizontal control rod channels are feasible, and it recommends their installation.

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Mattress Plates

An improved mattress plate material for the reactor discharge basins has been formulated and tested for resistance to water, radiation, and impact. The material, Hycar Buna N #1002, was specified for replacement mattress plates at the DR Reactor.

MISCELLANEOUS PROGRAMS

Reduction of Reactor Effluent Radioactivity

The test at 100-B measuring the effects on effluent activity of adding 18 ppm aluminum sulfate in the water treatment process (about four times the normal concentration) was terminated December 8, because reduction of radiosotopes concentrations had apparently leveled off. The following reductions were reported: P_{32}-60%, Cu 64 -33%, As 76 - 75%, Zn 65 - 33%, Cr 51 - 25%, and Np 239 - 57%.

The test at 100-H measuring the effect of adding 20 ppm aluminum nitrate in the water treatment process is continuing in order to study corrosion effects. The following reductions were reported: P_{32} - 70%, Cu 64-33%, As 76 - 75%, Zn 65 - 25%, Cr 51 - 25%, and Np 239 - 65%.

Experimental Water Filtration Facility

At the request of Coolant Testing Operation, and with assistance from Construction Engineering and Utilities, work was started on an engineering study of a model filtration plant to be used in conjunction with the single pass 1706 KE facilities in a research program on reactor effluent activity. The merits of modifying one of the existing 1706 filters, as compared to building a new filter bed, is being evaluated as part of the program of investigation.

Nitrogen Test

The initial replacement of CO_2 as a pile gas by N_2 under PT-IP-358-AC occurred without incident in KE Reactor. A gas composition of about 75% He and 25% N_2 was attained. The purpose of the test is to evaluate this method of reducing graphite burnout via the C-CO_2 reactions.

[redacted]

Columbia River Flow

On December 21, all Priest Rapids turbines relayed out, shutting off all river flow at the dam except turbine flow (about 10,000 to 12,000 cfs) for about twelve minutes. It was reported that the barges below the dam holding dredges settled to the river bed. Emergency power to operate the gates came from the contractor's temporary line.

The cofferdams below the gates were washed out when the gates were opened and river flow was restored. The river gage station one mile below the dam showed that the flow there held above 36,000 cfs.

REACTOR MODIFICATION PROGRAM

Oversize C Reactor Tubing

As reported last month, Zircaloy tubing for the 20-tube overbored facility has been ordered. The 12 tubes ordered from Allegheny Ludlum Steel Company have been extruded and tube reduced. After final sizing and inspection they will be shipped during the week of January 9. Other Zr and Al tubes on order are expected to be delivered about February 1, 1961.

Zr-Tube Fabrication

The Wah Chang Company scrap recovery process appears to yield reactor-grade sponge. It may be desirable to perform further out-of-reactor and in-reactor tests on the material at Hanford.

Reactor Hardware

During an unscheduled C-Reactor outage December 26-27, overbored channel 1464 was counterbored for the large-size gunbarrels. Installation of oversized hardware was completed and the tube was pressure tested, charged, and is operative. A standard sized process tube was used in the absence of oversized tubes, and a sleeve was installed to fill the annular space in the oversized gunbarrel which would ordinarily be filled by the oversized tube.

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Downcomer Capacity

Preliminary results of a study to determine the adequacy of the C Reactor downcomers for proposed flow increases to 115,000 gpm indicated that the downcomer trays should be perforated and the individual tray vents eliminated. The remainder of the system, downcomer approach section, and effluent lines appear to be adequate.

Control Strength Studies

A study is being made to determine the strength of the ball 3X system in the overbored flooded C-pile. The present methods used are not adequate to describe the real physical systems and it has been necessary to investigate more detailed methods. This involves a multi-region and possibly a two-group calculation.

NEW PRODUCTION REACTOR

Fuel Testing

KER-1: Ten NIH-1 elements were charged on December 8, 1960, under PT-IP-378-A, to evaluate the effect of different heat treatments on fuel distortion during high temperature irradiation.

KER-2 and KER-4: The charges of KSE-3 elements with brazed end closures have reached an exposure of about 540 MWD/T.

KER-3: A failure occurred on December 9, 1960, in the KSN-1 elements being irradiated under PT-IP-309-A and PT-IP-309-A, Supplement A, at an exposure of about 1730 MWD/T. The fuel element jacket was circumferentially split just below the weld bead. The mechanism of the failure has not been established. This was the first test of unbonded, flush-seated cap, welded end closures. Loop 3 was recharged on December 15, 1960, with four KSE-3 elements, PT-IP-363-A, to evaluate the behavior of large diameter tubular elements with brazed end closures.

Graphite Procurement

Top and bottom Reflector: Shipment of final bars from Great Lakes Carbon Corporation plant in Morgantown, N. C., was made December 15, 1960.

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Active Core: All of the required 6" x 6" solid bars have been received from the National Carbon Company plant in Clarksburg, W. Va. This represents about one-third of the number of bars and one-half of the total tonnage of bars ordered for the active core. All material in general appears to be of satisfactory quality.

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OUTAGES (Year) (1960)

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	25.5	72.8	27.8	37.1	30.2	16.5	16.8	49.5	276.2
Maintenance	46.8	25.9	10.4	16.9	52.4	18.6	10.8	14.6	196.4
Rupture Removal	11.5	29.5		9.9	10.8	18.7	73.9	26.8	181.1
Leak Testing	23.1			14.8	19.0				56.9
Tube Replacement	17.8		12.7		4.9	2.0			37.4
Project Work	4.0	4.0			3.0			5.5	16.5
Production Tests	3.7	33.0	4.3		1.5		53.5	3.8	99.8
Instrument & Circuitry		0.3				0.3			.6
Rupture Suspects									
Miscellaneous					1.5		31.6	1.5	34.6
Total	132.4	165.5	55.2	78.7	123.3	56.1	186.6	101.7	899.5
Scheduled Outages	95.9	128.3	54.9	43.9	66.0	31.3	62.0	63.6	546.4
Unscheduled Outages	36.5	37.2	0.3	34.8	57.3	24.3	124.6	38.1	353.1

RUPTURED SLUG TABULATION FOR December 1960

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations	
5359 KW	[illegible]	12-4-60	1589	619	892	.23	I&E E	Hot Spot
5369 KE	10-4-60	12-6-60	1461	603	745	.21	I&E E	Hole Failure
3476 KE	10-4-60	12-10-60	1397	495	513	.13	I&E Reg.	Hole Failure
4090 DR	6-17-60	12-11-60	762	793	1116	.63	Solid Reg.	Split
0957 C	10-9-60	12-14-60	1189	590	344	.17	I&E E	Hole Failure
4351 KE	10-4-60	12-15-60	1342	530	[illegible]	.13	I&E Reg	Hole Failure
2861 F	10-1-60	12-17-60	1230	499	595	.33	I&E Reg.	Unknown
1559 B	9-18-60	12-18-60	1207	603	639	.34	I&E Reg.	Side Other
5055 KE	10-4-60	12-21-60	1336	585	1104	.29	I&E Reg	Hot Spot
5261 KW	11-11-60	12-21-60	1705	426	698	.17	I&E E	Hot Spot
2276 C	11-6-60	12-25-60	1278	514	559	.27	I&E E	Hot Spot
1472 H	10-10-60	12-26-60	985	524	834	.15	I&E Reg.	Hot Spot
3565								
KER-3	[illegible]	12-9-60	640	2173	745	.21	Tubular element	Unclassified
							Single tube, zircally-clad natural uranium fuel element.	

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TO : PE&M Files

DATE: December 9, 1960

FROM : R. L. Plum Chief
Reactor Branch

HAN-74591-DEL
Rpt. No. 11

SUBJECT: MONTHLY REPORT - NOVEMBER, 1960

OR:GTO:GRG

This document consists of 12 pages
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OPERATING EXPERIENCE

Production

Reactor production established a new record, exceeding the previous maximum (May, 1960) by 0.3 percent. Forecast production was exceeded by 9.1 percent, 5.9 percent at the six old reactors and 13.7 percent at the K's.

Efficiency

Over-all time operated efficiency was 85.3 percent (82 percent forecast); 84.7 percent at the six old reactors and 87.0 at the K's. Efficiency was high due to the effective utilization of unscheduled outage time to minimize scheduled outage time.

Power Level

The record for combined reactor instantaneous power level was increased 325 megawatts (18,255 to 18,580) on November 27. The individual reactor power level records were increased 70 megawatts at KW (3840 to 3910), 55 at KE (3800 to 3855), 45 at B (1730 to 1775) and 20 at D (1765 to 1785).

Power Level Limit

The primary limit to reactor levels during this report period has been rupture control considerations. D, DR, and H Reactors were restricted for a portion of the month by bulk outlet water temperature limits.

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Fuel Ruptures

Eleven ruptures, eight I&E regular, two solid regular and one I&E enriched were removed from the reactors. Three of the I&E regular ruptures were at B, two at KE and one each at C, D, and F. The two solid ruptures were at DR and the I&E enriched at KW.

Maintenance

Eighteen process tubes were installed; 7 at D, 4 at F, 3 at C, and 2 each at DR and H.

Six tube and six Van Stone water leaks were corrected. D and F had two tube leaks and DR and H had one each. Four of the Van Stone leaks were at H and one each at D and F.

A new 700 H.P. motor (No. 10-C) installed in August under Project CGI-845, "Increased Pumping Capacity - 181-C", failed and was returned to the manufacturer (Lewis-Allen) at Portland, Oregon. A fault in design of the lubrication system was corrected and the motor returned to service. A sister motor (No. 1-C) was similarly modified.

Vibration of the crossheaders and thermally induced stress at the crossheader riser joints are two major rear face piping problems at the old reactors. It has been proposed to eliminate these problems by installing flexible joints at the ends of the crossheaders and appropriate guides and supports along the length of the crossheaders. Design for a prototype installation at H reactor is complete.

Reactor Outages

Outages for the month of November are as follows:

B REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/6	11/8	46.3	Charge-discharge and rupture removal.
11/8	11/8	3.2	Panellit trip due to plugging of cone screen in tube 3992.
11/14	11/16	36.6	I&E regular metal rupture in Tube 11[illegible].
11/30	Still down		An I&E regular metal rupture in tube 3566.

C REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/6	11/10	88.3	Charge-discharge and rupture removal. Two channels were successfully over-bored 0.550" from the front flange to the graphite.
11/11	11/11	0.4	Panellit trip due to a faulty gauge.

D REACTOR

Date Down	Date Up	Outage Hours	Remarks
[illegible]m 10/31-11/1	11/2	53.5	Charge-discharge and leak testing.
11/12	11/15	60.0	Charge-discharge and rupture removal.

DR REACTOR

Date Down	Date Up	Outage Hours	Remarks
[illegible]m 10/24-11/1	11/3	236.9	Scheduled ball 3X revisions and chute liner and mattress plate replacement.
11/17	11/18	35.3	Leak testing.
11/18	11/18	1.0	Change venturi on tube 0757.
11/18	11/18	1.6	Panellit trip due to heat shift.
11/20	11/21	36.2	Solid regular metal rupture in tube 1192.
11/21	11/22	1.9	Manual trip due to insufficient rods for control.
11/22	11/22	1.1	Solid regular metal rupture in tube 2455.

F REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/13	11/16	70.1	Rupture removal and charge-discharge.
11/16	11/16	1.0	Adjustment of shielding on air channel 2083.
11/19	11/21	3[illegible].1	Leak Testing.
11/[illegible]	Still down		I&E regular metal rupture in tube [illegible]77.

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H REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/7	11/8	34.5	Charge-discharge following a Panellit trip.
11/8	11/8	0.5	Unexplained Panellit trip.
11/8	11/8	0.2	Unexplained Panellit trip on row #45.
11/9	11/9	0.2	Unexplained Panellit trip on row #20.
11/9	11/9	0.2	" " " " " "
11/10	11/11	32.1	Leak testing following a Panellit trip.
11/19	11/19	0.2	Unexplained Panellit trip.
11/19	11/30	32.3	Miscellaneous maintenance following a Panellit trip.
11/27	11/27	0.2	Unexplained Panellit trip on Gauge 3956.
11/28	11/29	33.1	Leak testing.

KE REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/11	11/12	46.6	Charge-discharge and rupture removal.
11/27	11/30	71.6	Rupture removal. A rewound motor was installed on #2 low lift pump and three 1706 single-pass tubes were installed.

KW REACTOR

Date Down	Date Up	Outage Hours	Remarks
11/11	11/14	68.8	Charge-discharge following rupture removal.
11/14	11/14	0.6	Open two Gamma monitor sample lines.

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Files [redacted] December 9, 1960

RESEARCH AND DEVELOPMENT - EXISTING REACTORS

Projection Fuel Testing

No unusual irradiation experience was noted during the month in the 69 tubes of self-supported fuel elements in C Reactor and the 11 tubes in D Reactor. Thirty-two tubes of these elements were discharged from C Reactor during the November 6 outage without difficulty. The average exposure of the fuel elements discharged was 782 MWD/T.

Thirty-three tubes of test elements irradiated under PT-IP-262-H in D Reactor are being examined for hot-spot frequency at the 105-C Metal Examination Facility. Sixteen of these tubes were charged with bumpered fuel elements, seventeen with normal elements. The exposures ranged from 1100 to 1200 MWD/T. As reported last month, the irradiation performance indicated a 38-fold improvement in rupture resistance at a 95% confidence level or a 15-fold improvement at a 99% confidence level for the bumpered fuel elements.

Bumper Fuel Charging Machine

The prototype of the charging machine for bumper fuel elements failed to perform satisfactorily during the November 12 outage at D Reactor, and further modifications are necessary.

E-N Conversion Ratio Test

E-metal from three additional columns of the E-N conversion ratio test was shipped to Redox on November 7. This material has been dissolved, and sample taken for analysis. The results of the analysis will give additional conversion ratio data on the striped and fringe part of the E-N load. The results from the single column of the earlier dissolutions have been received, and they indicate higher Pu-239 conversion ratio and U-235 burnout than previously assumed. Final reporting of the E-N conversion ratios will await the receipt of the results now being developed by CPD.

Process Tube Outlet Fittings

The following combinations of outlet sizes have been determined to be compatible with requirements for process tube flow protection by the panellit gauge system.

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Flow Increases Possible with Enlarged
Outlet Fittings

Ref. No.	Header Parker Fitting ID	Pigtail Type and Size	Nozzle Parker Fitting ID	Type Nozzle	Flow Increase Percent
1	.469"	du Pont 5/8"	.469"	BDF	0
2	.469"	J 3/4"	.650"	BDF	4.3
3	.610"	J-2 5/8"	.610"	BDF	[illegible].0
4	.610"	J 3/4"	.650"	BDF	10.2
5	.650"	J 1"	.870"	K	15.0
6	.870"	J 1"	.870"	K	15.2

Study drawings of proposed inlet and outlet process tube assemblies for modifying C Reactor for use of self-supported fuel elements have been made. This concept provides that the rear assembly be fixed rigidly to the rear tie straps, with process tube expansion allowed at the inlet end only. Seals, both gas and water, are fabricated from materials other than elastomers.

Remote Rear-Face Equipment

Additional nozzle caps were installed on the rear-face of the KW Reactor, bringing the present total to 50, of which 46 are flapper caps and four are ball caps. The newly designed seals of both the ball and flapper types appear to be functioning satisfactorily.

A prototype nozzle was designed and built for use with the balanced hydraulic charging machine. It is sized for K-Reactor bumper slugs and it incorporates the flapper cap and tube inlet sampling valve that the charging machine requires.

[redacted]

[redacted]

MISCELLANEOUS PROGRAMS

Export Water System Studies

Design studies to further define the modifications required for improvement of the export water system were continued. The following items were accomplished:

1. Preliminary design was completed providing delayed automatic start of the 182 Building steam driven pumps.

2. Recommended settings were developed for the surge suppressors by Mr. G. R. Rich, Consulting Engineer.

3. The contract was extended with Mr. Rich to engage his services during the design and testing of proposed export water system modifications.

Reduction of Reactor Effluent Activity

On the basis of data obtained to date from the increased alum feed rate test at B Reactor, a 50% reduction in output of P^{32} and a 70% reduction in output of As^{76} can be realized. These gains are contingent upon increasing the aluminum sulfate feed rate in water treatment to 11 ppm and using .011 ppm filter aid.

The test at H Reactor involving the substitution of aluminum nitrate in place of aluminum sulfate in the water treatment process is proceeding satisfactorily. During examination of fuel elements which had been charged under this test, it was observed that the fuel elements which had been exposed to the nitrate treated water did not have the characteristic iron oxide film. Those from the control side of the reactor did have the characteristic discoloration. It is not known whether this absence of iron film resulted from the substitution of the nitrate ion for the sulfate ion in the water or to [illegible] by the water turbidity. Since the absence of this film could have a fundamental effect on effluent water activity and heat transfer, the test will be continued.

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Noise Abatement - C and K

Noise level in the C and K main pump house and K pump control building previously exceeded HAPO criteria for noise control, SDC-9.1. Noise abatement work is being done under a Maintenance Job Authorization. Installation of acoustical material has been completed at the 165-KE and 190-KE Buildings. Sound-level measurements show that a satisfactory reduction in noise level has been accomplished.

Reactor Confinement

The asphalt covering applied to the 117 Filter Building shielding berm for erosion control has been found to be unsatisfactory. A design change has been issued requesting the berm slopes be extended and covered with rock with the exception that a 60-foot section at 100-D and F areas will be covered with a two-inch concrete surface.

It has been decided to install self priming pumps in the operating gallery of all filter buildings. Since the present pump requires a positive suction head, replacement of the pump is less costly than installing foot valves on individual suction lines.

Shielding Studies

Shielding experiments are continuing in conjunction with overbored channels 1452, 1464, and 2488 in C Reactor. Variations have been made in ring and do-nut compositions, tolerance and deflections, and bayonet compositions. Before-and-after dosimetry measurements indicate that, in spite of increased gaps, an improvement of neutron shielding effectiveness has resulted from the hydrogenous material added to the rings and do-nuts.

A Masonite sample obtained from the second innermost circle of the top DR bulk shield shows the expected shrinkage and brittleness in that location. This sample was obtained from a horizontal core recently drilled adjacent to the DR test well to provide a shield sample exposure facility.

REACTOR MODIFICATION PROGRAM

C Reactor Overbore

During the C Reactor outage the week of November 7, two front thermal shields were overbored 550 mils with dual bore equipment. At the same time on one of the tubes, the rear centering flange was cut and the rear do-nuts extracted. These, unlike the front do-nuts, were found to be corroded in place, but not severely. The tubes were left as air tubes. During the operating period following the outage, one of the front gunbarrels was moved forward out of the thermal shield to determine the increase in radiation levels. This proved to be very moderate.

[redacted]

Process Tubes

Purchase orders have been placed for process tubes for the 20-tube overbore demonstration for C-Reactor. The particulars of the orders are shown below:

Vendor	Type of Tube	No. Ordered
Allegheny Ludlum	Smooth Bore Zircaloy-2	12
Bridgeport Brass	Smooth Bore Zircaloy-2	20
Alcoa	Ribbed Aluminum	20
	Smoothbore Aluminum	15

NEW PRODUCTION REACTOR

Process Tubes

In addition to the 67 tubes received from Harvey Aluminum on their N-Reactor pilot process tube order, 27 tubes have been received from Allegheny Ludlum. Chase Brass and Copper is behind schedule; to date 21 tubes have been received. The first 30 out of the total of 800 N-Reactor tubes in the Harvey production order have been shipped on schedule.

The initial lots of tubes from the pilot orders (21 Chase, 27 Allegheny, 10 Harvey) have all been inspected on-site by Vidigage, X-ray, ultrasonic and Cyglo tests. Harvey tubes were all acceptable. Chase and Allegheny tubes all had Cyglo indications and sixteen have been rejected. Thirteen of these were rejected on the basis of weld faults and two on the basis of thin walls.

Graphite Procurement

Reprocessing of graphite from Great Lakes Carbon Corporation to improve the purity to meet the +0.25 dih specification has been satisfactory. Sample bars from the last gas-purifying furnace heats were found to have acceptable dih purity values in the range of +0.7 to +0.8. Shipment of the bars in December will complete the order of top and bottom reflector graphite from Great Lakes.

Fuel Testing

KER-1 loop is temporarily empty due to the unsuccessful attempt in charging thermocouple and heater elements on November 11.

KER-2 loop was charged on November 11, with four single-tube elements with brazed end closures under PT-IP-363-A. These elements are designed

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to simulate the behavior of N-Reactor outer fuel tubes. The elements are enriched to 1.6 W/o U-235 and have iron supports.

An additional defectible element for the fuel failure-testing studies being carried on at the ETR facility was charged in KER-3 loop. The total number of this type of element in the tube is now seven. Elements at two different exposures will thus be provided for the ETR rupture tests.

Eight natural uranium tube-and-tube elements with hot-headed closures were discharged from KER-4 loop on November 11. Their exposure was 2030 MWD/T. Detailed examinations are being made. The KER-4 loop was recharged with identical charges as KER-2.

Ceramic Balls

The original specification of samarium content in the ceramic balls for the N-Reactor 3X system, was 0.345 gm/cm^3. Recent 305 tests of samples from the Electric Autolite Company and the Corning Glass Works indicate that the Sm content was ten to twenty percent lower than that claimed by the two companies for the particular samples. To reduce the possibility of the Sm content in the final ball product from falling below the 0.345 gm/cm^3 value, the minimum quantity has been increased ten percent to 0.380 gm/cm^3. This additional Sm will increase the cost of the balls by $[illegible],000.

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OUTAGES (Year) (   )

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	[illegible]	[illegible]	[illegible]	21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maintenance	[illegible]	[illegible]	25.3	67.6	11.5	[illegible]	[illegible]	[illegible]	[illegible]
Rupture Removal	[illegible]	[illegible]	11.5	10.1	[illegible]		16.8	1.4	[illegible]
Leak Testing	[illegible]		26.7	22.4	[illegible]	[illegible]			[illegible]
Tube Replacement	[illegible]		12.0		[illegible]	[illegible]			[illegible]
Project Work									
Production Tests		[illegible]	1.0	1.7		2.0	16.1	6.3	[illegible]
Instrument & Circuitry				1.6		[illegible]			[illegible]
Rupture Suspects									
Miscellaneous				[illegible]				1.6	[illegible]
Total	[illegible]	[illegible]	[illegible]	126.8	[illegible]	[illegible]	118.3	[illegible]	[illegible]
Scheduled Outages	[illegible]	[illegible]	[illegible]	87.6	[illegible]	[illegible]	101.5	[illegible]	[illegible]
Unscheduled Outages	[illegible]	[illegible]	[illegible]	39.2	[illegible]	[illegible]	16.8	[illegible]	[illegible]

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RUPTURED SLUG TABULATION FOR

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations	
1361-B	7-23-60	11-6-60	1115	662	705	18	I&E Reg.	Hot spot
2130-C	8-10-60	11-6-60	1123	551	1056	15	I&E Reg.	Hole failure
1559-KE	9-9-60	11-11-60	1473	532	1114	29	I&E Reg.	Unknown
3275-KW	9-6-60	11-11-60	1604	668	1083	20	I&E R.	Unknown
1366-D	8-7-60	11-12-60	1221	635	895	52	I&E Reg.	Side other
1166-F	8-27-60	11-14-60	1199	500	1207	72	I&E Reg.	Hot spot
1192-DR	7-30-60	11-20-60	841	457	984	63	Solid Reg.	Split
2455-DR	6-30-60	11-22-60	908	614	120	08	Solid Reg.	Split
1471-KE	9-9-60	11-27-60	1397	667	1786	47	I&E Reg.	Hole Failure
3566-B	8-27-60	11-30-60	1280	633	650	38	I&E Reg.	Side Other
1677-F	8-30-60	11-30-60	1208	599	230	22	I&E Reg.	

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TO : Process Engineering and Manufacturing Division

DATE: November 9, 1960

FROM : R. L. Plum, Chief Reactor Branch

This document consists of 12 pages

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SUBJECT: MONTHLY REPORT FOR OCTOBER, 1960

HAN-71591 - DEL
Rpt. No. 10

OR:GRG:GTO

Production

Reactor input production was 0.5 percent above forecast; 4.5 percent below at the six old reactors and 7.4 percent above at the K's.

Over-all time operated efficiency was 78.0 percent (81 percent forecast); 75.1 at the six old reactors and 86.5 at the K's. Efficiency was low at the six old reactors due to water leaks and a maintenance outage at DR for replacement of chute liners and Ball 3-X modification.

There was no increase in the combined reactor instantaneous power level or in the individual reactor record power levels.

Reactor Power Level Limits

The primary limit to reactor power levels during this report period has been rupture control considerations. D, DR, F, and H reactors were additionally restricted for a portion of the month by bulk outlet temperature limits.

Ruptures

Seven ruptures, five I&E enriched and two I&E normal, were removed from the reactors. The enriched ruptures were at C, DR, F, H and KW, the regulars at H and KW. Two of the enriched ruptures, at DR and KW, failed at only 18 percent of goal exposure. The regular metal rupture at H failed at 6 percent of goal exposure.

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Reactor Outages

Reactor outages for the month of October, 1960, are as follows:

Date Down	Date Up	Outage Hours	Remarks
B REACTOR			
10/4	10/7	76.8	Leak testing, tube replacement, and charge-discharge completed.
10/17	10/19	59.6	Leak testing and tube replacement.
10/22	10/23	44.7	Leak testing. A delay of about 5 hours was experienced when one hopper of 3-X balls was inadvertently dropped.
C REACTOR			
10/9	10/9	0.4	Panellit trip
10/9	10/11	39.9	Removal of an I&E-E metal rupture from tube 1656, charge-discharge and leak testing.
10/12	10/12	0.4	Panellit trip due to pressure increase on spline cap tube 0890.
10/17	10/22	106.6	Scheduled charge-discharge and miscellaneous maintenance.
D REACTOR			
10/19	10/22	62.1	Scheduled charge-discharge and tube replacement.
10/22	10/22	2.2	Panellit trip.
10/31	Still down		Water leak. Charge-discharge in progress.

[redacted]

[redacted]

DR REACTOR

10/3	10/5	38.4	Completed leak testing and maintenance work during a period for cooling over-heated bearings in gas loop compressor.
10/5	10/5	.5	Unexplained trip.
10/6	10/7	32.2	Removal of an I&E-E metal rupture from tube 0681.
10/24	Still down		Chute liner replacement and Ball 3-X modification. Five tubes were successfully over-bored.

F REACTOR

10/1	10/7	157.9	Scheduled charge-discharge and tube replacement and maintenance.
10/9	10/11	32.8	Panellit trip due to a ruptured rear pigtail. Miscellaneous maintenance performed.
10/23	10/25	51.4	Removal of an I&E-E metal rupture from tube 0778. Concluded rupture removal and charge-discharge and miscellaneous maintenance.

H REACTOR

10/10	10/16	164.6	Scheduled charge-discharge and tube replacement.
10/16	10/16	1.6	Repair of a broken wire which prevented the movement of two top rows of HCR's.
10/17	10/17	0.7	Correct rear cap leaks.
10/22	10/24	37.8	Removal of an I&E-E metal rupture from tube 3292 and an I&E regular metal from tube 1260.

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KE REACTOR

10/4	10/7	55.2	Scheduled charge-discharge.
10/26	10/28	47.8	Charge-discharge following a Panellit trip.
10/28	10/28	0.7	Unexplained Panellit trip.

KW REACTOR

10/13	10/15	3.5	Removal of an I&E-E metal rupture from tube 4585 and charge-discharge.
10/15	10/16	22.6	Removal of an I&E regular metal rupture from tube 2864.
10/19	10/20	39.3	Tripped by overload relay on #6 low lift pump motor.

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MAINTENANCE

Tube Replacement

One hundred thirty-seven process tubes were installed; 74 at F, 37 at H, 14 at B, 6 at DR, 5 at D and one at KW.

Four tube leaks (2 at B and 2 at H) and five Van Stone leaks (3 at B and 2 at DR) were encountered and corrected.

1904-H Outfall Structure

Efforts were made to repair the 1904-H effluent box. These repairs consisted of removing the anchor ring from the two outlet pipes, removing all broken and loose concrete, providing a leak-free sliding joint between the concrete walls and outlet pipes, pouring new lummite concrete, and filling voids underneath the outlet pipes and outfall box by pressure grouting. An additional two cubic yards of grout were pumped under the pipes and box.

Increased Process Water Flow, 100-K Area

At the present time the existing 900 HP low-lift pump motors are in the process of being rewound and upgraded to 1500 HP. One of the unmodified 900 HP motors in 190 KW burned out, and a rewound motor was installed by K maintenance forces due to the emergency nature of the job.

Shielding Studies

The high temperatures in the KW bottom thermal shield have been found to be caused by partial flow stoppage in the thermal cooling tubes. Following clearing of these channels, KW bottom thermal shield temperatures have been equivalent to those at KE.

PRESENT REACTOR TECHNOLOGY

Rear Parker Fitting Overbore

Eight Parker fittings were bored out on F reactor during the October 3 outage in a further demonstration of this approach toward a modest flow increase. The bumper slug charging machine has been revised and repaired. Equipment for broaching B-D-F front nozzles to accomodate bumper slugs was placed on order.

Expansion Hardware

Following the cast iron overboring test at C, a new gunbarrel of a design prototypical of that for major overboring in form but not size was installed in the bored-out channel. Installation involved welding a new insert to the centering flange with the programmed welding equipment.

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A new front nozzle, including the captive-venturi pigtail and check-valve concepts, and designed for size less than 200 mil overbore, was installed for test. It demonstrated a 6.9 gpm flow increase over standard equipment.

Remote Rear Tube Closures

Two dummy nozzles, to permit simulated remote operation of rear face valves with the roving actuator, were installed on KE reactor October 5. Just prior to startup on October 27, five channels were flush discharged with remote equipment, in a test for trajectory and equipment function. There are now 20 remotely operated valves installed (14 Mark V flapper valves and six ball valves) and two types of seals are under test with each type of valve.

Projection Fuel Testing

The irradiation of self-supported elements in 69 ribless zircaloy tubes in C Reactor and in ten tubes in B Reactor continued without incident during the month.

The phase of PT-262-A relating to relative rupture resistance of bumper slugs has been completed. The results of the test show a factor of 38 improvement in rupture resistance at a 95% confidence level, or a factor of 15 improvement at a 99% confidence level. Analysis of thermocouple data has led to the following conclusions:

1. A three-rail bumper element is superior to a four-rail model from the standpoints of heat transfer and hydraulics.
2. Top-of-tube corrosion can be reduced in comparison with regular I&E elements by bumper induced turbulence.
3. Mixer elements are important with the use of bumper elements to further reduce corrosion by improved mixing.
4. Additional thermocouple probe data are needed to better define the degree of temperature unbalances in the annulus with bumper slugs.

E-N Conversion Ratio

CPD reported this month that, in addition to the one column previously reported, the other two columns dissolved in June, 1960, had not been adequately sampled, and plutonium concentrations cannot be obtained.

At this time, only one column from the E-N conversion ratio test (a striped central zone column) has been dissolved and adequately sampled. It is undergoing analysis.

SPO completed tritium extraction on the 26 enriched Li-Al pieces in September and the results have been reported in DPSP 60-490. The

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results are given below for a striped column and a blanket column:

These values are higher than our previous assumed yields, which were based on extrapolations from natural lithium, solid Li-Al slugs. Careful theoretical analyses will be made to translate the single-column yields shown above, plus the Pu data being developed into values representative of the entire E-N pile's behavior.

Reduction of Reactor Effluent Activity

The effluent-sampling facilities at both B and H reactors were modified during the month to eliminate the release of solid material from the sample lines during sampling. The As^{76} and P^{32} concentrations in effluent samples from the test sides of the reactors were 40% and 85%, respectively, of that on the control sides. The tests are aimed at determining the effectiveness of reducing effluent radioactivity by the substitution of aluminum nitrate for aluminum sulfate in the water treatment process.

100-DR Process Pumps

A new prototype process pump was installed in 100-DR on October 28, 1960. This pump was purchased from Ingersoll Rand during the time De Laval was having trouble producing satisfactory process pumps, in order to develop a satisfactory alternate. This pump will be inspected periodically for one year for indication of damaging cavitation or other failure to determine if the purchase specifications are met.

Safety Control Studies

The operational test of the power-rate meter authorized by PT-IP-261-C was successfully carried out during the October 22 startup at D reactor.

Control Efficiency Studies

All six of the poison-displacement columns scheduled for the prototype system at KW reactor have been installed and are being used to some extent for operational control.

Reactor Confinement

Phase II-B - Filter and Sample Buildings

100-F - Acceptance testing has been completed. There are about thirty punch-list items to be cleaned up.

100-C - Acceptance testing has been completed. Completion of final punch-list items and general cleanup of the area is in progress.

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Phase III - Ventilation Modifications and Tie-Ins

The high-efficiency filters supplied by Mine Safety Appliance Company failed to pass the humidity test requirements. The vendor has been notified and requested to supply replacement filters for one area by November 14, 1960, and to complete the replacement for all areas by January, 1961.

100-F - Tie-in of confinement facilities has been completed. The exhaust air is now routed through the filter building, although no filters have been installed.

REACTOR MODIFICATION PROGRAM

Overboring Developments

An abortive attempt was made to overbore five F reactor channels 200 mils during the October 3 outage. The attempt failed when a carbide insert was broken loose and destroyed the cutters.

A second attempt was made to do the same thing at DR reactor on October 27, this time with marked success. Drilling times on the five channels ranged from eight minutes for the first two channels to 3.5 minutes for the last. This experience tends to confirm the hypothesis that previous difficulties in drilling reactor graphite occurred not because the graphite was harder than the gas-baked graphite used for laboratory work, but because insufficient pre-broaching of the reactor process tube channels caused the pilot to bind and overheat. The pilot is a fluted guide that is attached to and precedes the overboring cutter. For the DR test four of the five channels were broached in a separate operation to a nominal 1.745" diameter prior to boring (1.745" is the original i.d. of the channel, but the hole becomes slightly elliptical over the years of reactor operation). The fifth channel, which had passed a 1.715" plug gage but not a 1.720", was overbored with a 1.715" diameter pilot, and no prebroaching. It was on this channel that, in an attempt to determine how fast the boring might be done, the drilling time was 3.5 minutes. The five overbored channels were fitted with standard aluminum process tubes, as no oversized fuel if yet available. Uranium cores for this fuel are on hand, but the aluminum caps and cans have not yet been delivered.

On October 20 at C reactor the first on-pile overboring of the cast iron thermal shield was performed. The gunbarrel was removed, the centering flange bored out, the cast iron shielding do-nuts removed and the thermal blocks and inner cast iron do-nuts were overbored about 200 mils.

Materials and Fabrications

In support of the C-Reactor overbore demonstration, procurement actions have been initiated for tubes from Allegheny Ludlum Steel Company, Bridgeport Brass Company, Aluminum Company of America, and Reynolds

[redacted]

Metal Company. The orders include smooth-bore zircaloy tubes, smooth-bore aluminum tubes and ribbed aluminum tubes.

Nozzle Testing

Five reamed nozzles from D reactor have successfully undergone pressure, torque and impact tests. The end caps and welded lug rings failed upon application of a 100 ft.-lb. torque within 1-20 cycles, while the one coat, stainless steel lug tested withstood 50 applications of the above torque without failing.

NPR DEVELOPMENT

High-Temperature Irradiations

Six heavy-walled, zircaloy clad, single-tube elements being irradiated in KER-3 loop under PT-ID-309-A have reached an exposure of 1305 MWD/T. The elements should reach the scheduled exposure of 2500 MWD/T around February 1, 1961. The purpose of this test is twofold, to determine the behavior of an element similar in geometry to an NPR-sized inner tube, and to provide irradiated tubular fuel for in-reactor failure testing in the ETR.

The eight natural uranium tube-in-tube elements under irradiation in KER-4 loop to evaluate hot-headed end closures have reached 1925 MWD/T. The goal exposure of 2500 MWD/T is expected to be reached near January 1, 1961.

Tube Deliveries

Harvey Aluminum Company has delivered 57 more NPR tubes, making the on-site total 67 from the pilot order.

Cold-Clean Physics Measurements

PCTR measurements of "K infinity" and exponential pile measurements of D^2 have been completed and preliminary results have been obtained for the wet, cold, open lattice values. The "K infinity" measured for the open wet lattice is 1.075 ± .005. The wet buckling is 11[illegible] microbucks, which when combined with a "K infinity" of 1.07[illegible], yields a migration area of 650 ± 50 cm^2.

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(Year)

OUTAGES (   )

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	21.8	23.9	28.6	1.7	49.7	69.9	57.9	12.7	279.2
Maintenance	36.7	93.9	24.9	203.8	76.1	30.6	21.3	35.7	523.0
Rupture Removal	0.0	8.8	0.0	6.6	18.5	10.3	0.0	34.8	79.0
Leak Testing	76.8	9.9	2.5	22.0	0.0	14.1	0.0	0.0	125.3
Tube Replacement	36.0	0.0	11.6	0.0	69.0	77.4	0.0	0.0	194.0
Project Work	0.0	4.6	0.0	0.0	4.5	0.0	0.0	5.0	14.1
Production Tests	2.0	5.1	10.5	23.7	24.4	2.4	12.7	5.5	86.3
Instrument & Circuitry	0.0	0.8	0.0	0.0	0.0	0.0	0.7	0.0	1.5
Rupture Suspects									
Miscellaneous	4.8	0.0	0.0	0.6	0.0	0.0	1.0	3.5	9.9
Total	181.1	117.0	78.1	258.4	242.2	204.7	103.6	97.2	1312.3
Scheduled Outages	99.0	124.5	67.1	195.2	178.6	156.5	89.2	26.7	936.8
Unscheduled Outages	82.1	22.5	11.0	63.2	63.6	48.2	14.4	70.5	375.5

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Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss		Observations
					MWD	Days	
0581-DR	9-8-60	10-6-60	972	186	508	.31	I&E-E - Charging machine damage
1656-C	8-10-60	10-9-60	986	597	693	.37	I&E-E - Hole Failure
4585-KW	9-29-60	10-13-60	1368	134	2467	.72	I&E-E - Hole Failure
2364-KW	9-6-60	10-15-60	1309	285	3782	1.09	I&E Reg. Unknown
3292-H	8-11-60	10-22-60	1121	620	739*	.47*	I&E-E - Hot Spot
0778-F	8-30-60	10-23-60	1260	461	1394	.86	I&E-E - Hot Spot
1260-H	10-10-60	10-22-60	1027	42			I&E Reg. Unknown

* Includes both 3292 H and 1260 H

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[redacted]

October

OUTAGES (Year) (1960)

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	[illegible]	23.9	28.6	1.7	49.7	69.9	[illegible]	[illegible]	279.2
Maintenance	36.7	23.9	24.9	213.8	76.1	30.6	[illegible]	[illegible]	523.0
Rupture Removal	0.0	8.8	0.0	6.6	18.5	16.3	0.0	[illegible]	79.0
Leak Testing	76.8	9.9	2.5	22.0	0.0	14.1	0.0	0.0	125.3
Tube Replacement	36.0	0.0	11.6	0.0	69.0	77.4	0.0	0.0	194.0
Project Work	0.0	4.6	0.0	0.0	4.5	0.0	0.0	5.0	14.1
Production Tests	2.0	5.1	16.5	23.7	24.4	2.4	12.7	5.5	86.3
Instrument & Circuitry	0.0	0.8	0.0	0.0	0.0	0.0	0.7	0.0	1.5
Rupture Suspects									
Miscellaneous	4.8	0.0	0.0	0.6	0.0	0.0	1.0	3.5	9.9
Total	181.1	147.0	79.1	259.4	242.2	204.7	[illegible]	[illegible]	1312.3
Scheduled Outages	99.0	124.5	67.1	195.2	178.6	156.5	[illegible]	[illegible]	936.8
Unscheduled Outages	82.1	22.5	11.0	63.2	63.6	48.2	[illegible]	[illegible]	375.5

[redacted]

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TO : PE&M Files

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DATE: October 11, 1960

FROM : R. L. Plum, Chief
Reactor Branch

HAN-74591-DEL
Rpt. No. 9

SUBJECT: MONTHLY REPORT FOR SEPTEMBER, 1960

SYMBOL: OR:GTO:GRG

THIS DOCUMENT CONSISTS OF 11 PAGES
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PRODUCTION

Reactor input production was 8.2 percent above forecast (0.9 percent above at the six old reactors and 18.4 percent above at the K reactors). Forecast was exceeded due to high time operated efficiency and average power levels at the K reactors.

Overall time operated efficiency was 83.0 percent (80.2 at the six old reactors and 91.6 at the K reactors).

There was no increase in the combined reactor instantaneous power level or in the individual reactor record power levels.

Power Level Limitations

The primary power level limits at C, KE and KW reactors were based on fuel element failure control, and the power levels at B, D, DR, F and H reactors were primarily restricted by bulk outlet temperature limitations.

Ruptures

Three ruptures, two I&E regular metal and one I&E enriched were removed from the reactors. The regular metal ruptures were at C and D; the enriched at DR. The enriched rupture failed at 11 percent of goal concentration because of charging machine damage. This represents the best rupture experience since November, 1959, and 66 percent lower than the previous best month's experience during 1960.

Reactor Outages

Reactor outages for September are as follows:

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Date Down	Date Up	Outage Hours	Remarks
B REACTOR			
8/27	9/3	177.8	Charge-discharge, tube replacement, high tank flushing, rear face decontamination and downcomer modification.
9/4	9/4	1.2	Tripped due to insufficient control rod to achieve turnaround.
9/11	9/12	42.8	Water leak.
9/18	9/20	38.2	Water leak.
9/20	9/20	1.7	Replaced two front connectors leaking at fittings.
C REACTOR			
9/4	9/8	99.1	Scheduled charge-discharge, leak testing and miscellaneous maintenance.
9/23	9/25	48.6	Removal of an I&E regular metal rupture from tube 1486 and charge-discharge.
D REACTOR			
9/4	9/5	38.6	Water leak and charge-discharge.
9/12	9/18	157.7	Scheduled charge-discharge, tube replacement, ball 3X modifications and downcomer modification.
9/24	9/25	36.2	Removal of an I&E regular metal rupture from tube 1960 and charge-discharge.
DR REACTOR			
9/8	9/11	84.5	Charge-discharge and tube replacement
9/19	9/20	35.6	Water leak.
9/25	9/27	40.6	Removal of an I&E E-metal rupture from tube 0684, and charge-discharge.

[redacted]

[redacted]

F REACTOR

8/30	9/3	93.2	Charge-discharge, high tank flushing, and leak testing.

H REACTOR

9/6	9/9	57.3	Charge-discharge and high tank flushing.
9/13	9/14	35.8	Water leak.
9/15	9/15	0.2	Panellit trip.
9/29	9/29	0.2	Panellit trip.

KE REACTOR

9/9	9/11	39.7	Leak on front header of KER Loop 3, charge-discharge, and the installation of the foundation cooling system.

KW REACTOR

9/6	9/8	35.7	Panellit trip and charge-discharge.
9/29	9/30	45.6	Scheduled charge-discharge.

[redacted]

[redacted]

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Equipment

1. Eighty-eight process tubes were installed (74 at B, 7 at DR, 3 at B, 3 at H and one at KW).

2. Five water leaks were corrected (3 tube leaks at B, D, and H, and two Van Stone leaks at B, and DR.)

3. At F reactor the No. 5 process pump motor failed September 2 during motor startup. It was repaired by by-passing the failed coil and returned to service on September 7.

4. A block discharge was made at DR reactor on September 8.

5. Installation for reactor foundation cooling was completed at KE reactor on September 10.

6. The coil in No. 2 pump motor burned out at DR on September 11. This coil plus one each in the other two phases were by-passed and the motor returned to service on September 13.

CURRENT REACTOR TECHNOLOGY

Export Water System

A report has been received from G. R. Rich, Consulting Engineer, following his evaluation of the export water system. His recommendations are that (1) the use of existing surge suppressors continue but that their operation be modified for pressure actuation rather than electrical activation, (2) additional slow-closing air valves be installed near the pump discharge manifold, and (3) testing continue to determine the need for additional air relief valves. Additional detailed information has been requested from Mr. Rich, since his recommendations were not sufficiently detailed to permit design of the proposed modifications.

Reactor Control

At D reactor, with the use of a new spline coiler, a 60-spline startup was carried out with a net loss of only five effective hours. Spline coilers are targeted for the other old reactors by March 1, 1961.

[redacted]

[redacted]

Four poison displacement columns, out of the six-column prototype system, have now been placed in the KW reactor.

A study has been carried out to determine the incentives of using bumper slugs in the E-N program. The results indicated an appreciable gain in the use of bumpers for the E-N loading over and above the large gain predicted for use of bumpers with natural uranium, and GE has proposed delaying the E-N test until the H reactor is modified to use bumper fuel in early CY-1961.

Shielding Studies

A 50% reduction in neutron dosage rates was observed on the B pile front face following replacement of steel shielding in dry columns with high-density concrete. A similar study at C pile indicates a potential reduction of 30% in the front face neutron dose rates.

Process Tube Examination

Tube 3370-B, a ribless aluminum tube, was removed for inspection. The corrosion in the tube was very uniform. There was no evidence of ledging-type corrosion or hot spot areas caused by warp or misaligned slugs. No scratches caused by the supports on the slugs were noticied in the tube.

Reactor Effluent Water Investigations

The effluent treatment tests at the D retention basins, where the effluent water is being passed through a bed of aluminum turnings, have advanced from tests which largely duplicated laboratory work to tests at higher flow rates. The initial tests showed the same efficiencies for reduction of critical isotopes as did the laboratory tests. Dose rates from the sides of the tank increased from 300 mr/hr to 800 mr/hr when the flow rate was doubled. This indicates that the efficiency for detaining the shorter lived nuclides was not reduced by the change in flow.

A half-reactor test at 100 H substituting aluminum nitrate for aluminum sulfate in process water treatment was started September 16. This test was intended to demonstrate the amount of reduction in the output of phosphorus-32 that can be achieved by removing more than 90% of the phosphorus and half the sulfur from the

[redacted]

influent water. The feed rate was increased from 12 ppm at the start of the test to 25 ppm on September 21. Since that time the pH of the process water on the test side has been controlled by adjusting the aluminum nitrate feed. No difficulties in the water treatment plant or in reactor operation have been encountered. Therefore, it does not appear that addition of nitric acid for pH control will be required until spring.

Another half-reactor test was started at 100-B on September 16. Because of the uncertainty surrounding the importance of sulfur as a precursor to phosphorus-32, and in order to demonstrate the effectiveness of conventional and less costly aluminum sulfate to remove critical isotopes, this test duplicates the test at 100-H except that the sulfur in the influent water is not reduced. The feed rate of alum on the test side was increased to 10 ppm on September 16 and further increased until it reached 20 ppm on September 22. It will remain at that level for the duration of the test. No difficulties have been experienced and none are anticipated.

No results have been obtained on the two above mentioned water treatment tests. It is expected that approximately one month's operation will be required in order to reach equilibrium conditions in the process tubes.

ADVANCED REACTOR TECHNOLOGY

N Reactor Fast Flux

An estimate of the neutron flux above 1 mev in the NPR was made as a guide in programming experimental irradiations of Zr in test reactors. The figure being used is 1.35×10^{21} nvt/yr at 4000 MW.

NPR Physics Measurements

Physics measurements made in the PCTR in support of the NPR produced a value of the neutron diffusion length and a value of k_{oo}. The diffusion length of the NPR graphite was found to be 83.0 cm, a factor about 1.6 times the length one would obtain with the same graphite minus the void holes. The k_{oo} of the condensed NPR lattice (i.e. void holes removed) was measured to be 1.069. This result indicates that the NPR must be enriched above the anticipated level, but, subsequent experiments not yet reported, yield a higher and more encouraging value of k_{oo} for the mock-up lattice.

[redacted]

Exponential pile measurements were made on 1.0% enriched NPR fuel elements in light water. The results are useful in determining nuclear safety requirements on the handling of irradiated NPR fuels. The minimum critical mass was about four tons, occurring when the outer tubes alone were immersed in water. The minimum critical mass for complete tube-in-tube elements was measured to be 5.3 tons.

NPR Graphite

Observation of the processing of bars for the NPR core by National Carbon Company revealed that the product is of high structural quality. Chemical analysis and dih purity values of the first two shipments show that the material also meets the specification for nuclear purity.

Expansion Hardware

A number of front and rear nozzle assemblies designed for 200 mil overbore have been received and subjected to preliminary laboratory testing. One front assembly which incorporates a check valve was tested to obtain an indication of potential charging damage to be expected in charging fuel elements through the check; no damage was found in preliminary tests. The front assembly was also tested for pressure drop and found to exhibit less than half the pressure drop characteristic of the present hardware.

Horizontal Control Rod Overbore

The ceramic sleeves for one K reactor horizontal control rod received from the Coors Porcelain Company have been returned for additional machining. The feasibility study for overboring the horizontal control rod channels to accommodate an oversized sleeve has been completed, and overboring is considered feasible.

REACTOR FUELS

Projection Fuel Testing

Five columns of self-supported fuel elements (including spider support design) were charged into ribless aluminum tubes in B reactor, bringing the total to nine columns in reactor.

[redacted]

No additional installation of zirconium tubes was made in C reactor. The total number of ribless zirconium tubes in C reactor is 69.

Twenty columns of solid-rail bumper fuel elements were charged into D reactor during the September 11 outage. Ten of these columns contained four-rail slugs. Also charged were ten columns of three-rail slugs in which the rails between the tube ribs were omitted to permit the use of poison splines. Thermocouple probes were inserted in the downstream dummy patterns of six of the three-rail columns to determine the effect of this design on temperature uniformity in the coolant.

The irradiation of four tubes of 1.47% enriched bumper elements in D reactor was terminated September 24, 1960, without rupture. The material received an average exposure of 975 MWD/T. The factor of improvement over normal I&E geometry fuel was 38 with a 95% confidence level.

High Temperature Irradiations - KER Facilities

The heavy-wall, single-tube elements in KER Loop 3 continued under irradiation without incident to an exposure of 970 MWD/T. The test will provide information on the behavior of an element similar in geometry to the inner tube of an NPR fuel element, and it will in addition provide some irradiated fuel for in-reactor failure testing.

The eight natural uranium tube-in-tube elements in KER Loop 4 continued under irradiation without incident to an exposure of 1560 MWD/T.

Bumper Slug Charging Machine

The bumper slug charging machine was used in an attempt to charge bumper slugs in D reactor, but it failed because of greater-than-expected tube curvature. The machine stalled after charging 18 slugs in the last tube attempted, and it was broken in an abrupt stall with 130 lb. air pressure.

Nickel-Coated Fuel Elements

Aluminum-jacketed fuel elements coated with nickel continue to resist pitting attack or flaking of the nickel in ex-reactor mock-up tube tests. Exposure times for these elements total 11-1/2 weeks in 165-C process water or 12-1/2 weeks in 120 C process water. Defects made in the coating before exposure have not been enlarged.

PLANT IMPROVEMENT PROGRAM

The General Electric Company now considers that overboring is feasible in C and H reactors. Development of tools and machines capable of cutting steel and cast iron components within the reactor has been instrumental in the decision to attempt overboring these two reactors. This equipment development has likewise widened the range of overboring considered for all reactors.

The optimum overbore for C reactor is presently calculated to be approximately 0.5 inch on the tube diameter. A production test to overbore 20 tubes this amount is planned for C reactor for December or January.

Overboring

Several tests of a machine designed to bore out the cast iron thermal shield and in-board do-nut have been made which demonstrate weakness in the mechanical feed part of the equipment. The existing machine was designed to permit a 200 mil overbore at C reactor. Modifications are being designed for it to permit its use in a preliminary 550 mil overbore test. A contract has been negotiated with Norfin, Incorporated, of Seattle, to build two new dual boring machines as second generation prototypes to be used in a planned 550 mil overboring test at C.

The increase in fuel size to accommodate the larger process tube would involve some modifications of on-site and off-site fuel fabrication facilities. The project proposal to overbore C pile, install zircaloy tubes and self-supported fuel facilities with necessary supporting modifications is estimated to cost approximately $10 million.

The work proposed for the reactor areas toward increased production will henceforth be referred to as the Reactor Modification Program.

Sept. (Year)
OUTAGES (1960) [redacted]

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	37.8	53.3	45.4	68.8	22.6	8.6	23.4	52.6	312.5
Maintenance	48.3	63.7	43.1	38.6	25.1	18.1	3.7	14.2	254.8
Rupture Removal		11.3	14.7	6.2					32.2
Leak Testing	36.5	5.0	21.8	30.2	15.8	16.0			125.3
Tube Replacement	24.7		87.3	11.7	2.0				125.7
Project Work		8.3							8.3
Production Tests	5.3	6.1	16.8	5.2	2.2	50.3	12.6	2.6	101.1
Instrument & Circuitry						.5		9.8	10.3
Rupture Suspects									
Miscellaneous	1.2		3.4					2.0	6.6
Total	153.8	147.7	232.5	160.7	67.7	93.5	39.7	81.2	976.8
Scheduled Outages	105.2	122.9	188.1	115.1	45.6	67.2	25.0	63.0	732.1
Unscheduled Outages	48.6	24.8	44.4	45.6	22.1	26.3	14.7	18.2	244.7

[redacted]

RUPTURED SLUG TABULATION FOR September, 19__ [redacted]

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations	
1486 C	7/9/60	9/23/60	1084	577	987	.55	I&E Regular	Hot Spot
1960 D	6/9/60	9/24/60	1055	640	1088	.69	I&E Regular	Hot Spot
0684 DR	9/8/60	9/25/60	830	118	439	.28	I&E Enriched	Mechanical Damage
							[redacted]	

STANDARD FORM NO. 64

DE[redacted]D

Office Memorandum • UNITED STATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: September 12, 1960

FROM : R. L. Plum, Chief Reactor Branch *(signature)*

SUBJECT: MONTHLY REPORT FOR ~~MONTH OF~~ AUGUST, 1960

HAN-74591 — DEL
Rpt. No. 8

SYMBOL: OR:GRG:GTO:HAH

[redacted] THIS DOCUMENT CONSISTS OF 13 PAGES
[redacted] COPIES, [redacted]

Reactor Power Level Limitations

The power levels at C, F, KE, and KW reactors were limited by tube power, based on rupture control. Power levels at the B, D, DR, and H reactors were limited by bulk outlet water temperature.

Production

Reactor input production was 4.0 percent above forecast; 11.2 percent above forecast at the six old reactors and 5.9 percent below at the K reactors.

Overall time-operated efficiency was 84.5 percent (81 percent forecast); 86.5 at the six old reactors, and 78.7 at the K reactors. Efficiency was low at the K reactors due to ruptures, KER test facility trips and unusual maintenance. A new production record was achieved at C reacor, exceeding the previous C reactor record by 3.5 percent.

Twelve ruptures, six I&E enriched, two I&E regular, two solid regular and two KER were removed from the reactors. Three of the I&E enriched ruptures were at D (including two with 1.47% enrichment on a run-to-rupture production test) and one each at C, F, and KW. The two I&E regular ruptures were at H and KE, the two solid regular at KE. A failed thermocouple slug was removed from KER loop 1, and a suspected rupture, as yet unidentified, from KER loop 2.

Reactor Outages

Outages for the month of August are as follows:

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B REACTOR

Date Down	Date Up	Outage Hours	Remarks
8/6	8/8	42.7	Panellit trip due to a loose jumper on Row 35. Tube 3090 was replaced due to a water leak and charge-discharge work was performed.
8/27	Still Down		Scheduled charge-discharge, tube replacement and downcomer modification.

C REACTOR

Date Down	Date Up	Outage Hours	Remarks
8/10	8/12	42.2	Removal of an I&E E-metal rupture from tube 3578 and charge-discharge.
8/12	8/12	0.3	Unexplained Panellit trip.
8/13	8/13	0.5	Two unexplained Panellit trips.
8/24	8/24	0.2	Panellit trip on tube 3285, probably due to the spline cap insert working loose.

D REACTOR

Date Down	Date Up	Outage Hours	Remarks
8/1	8/1	0.7	Removal of an I&E E-metal rupture from tube 0770.
8/7	8/9	56.5	Removal of an I&E E-metal rupture from tube 2060.
8/9	8/10	18.8	Removal of an I&E E-metal rupture from tube 2262.
8/21	8/22	34.1	Tripped by power-supply loss while attempting to restore power to annunciator system. Charge-discharge work was performed.

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DR REACTOR

Date Down	Date Up	Outage Hours	
7/31	8/2	35.2	Concluded charge-discharge and maintenance following rupture removal.
8/7	8/7	0.7	Tripped by loop 1 when the building air compressor failed, dropping the air pressure below the loop trip point.
8/7	8/8	30.7	Concluded a small charge-discharge and maintenance during period of insufficient reactivity following loop trip.
8/11	8/12	18.0	Tube 2165 was replaced due to a rear Van Stone leak.
8/12	8/13	1.5	Manual trip for temperature control on tube 4055.
8/13	8/13	1.2	Repaired a leak in the front connector on tube 0677.
8/19	8/19	0.6	Unexplained flux monitor trip while flushing poison.
8/26	8/26	0.6	Leak in inlet hose connector on No. 8 HCR.

F REACTOR

8/12	8/14	68.4	Manual trip for temperature control, leak testing, and charge-discharge.
8/14	8/14	2.0	Unexplained Panellit trip.
8/30	Still Down		Scheduled charge-discharge and high-tank flushing.

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H REACTOR

8/11	8/15	95.5	Removal of an I&E regular metal rupture from tube 2558, charge-discharge and leak testing.
8/16	8/16	3.0	Changed Venturis on six tubes.
8/16	8/16	0.2	Tripped when PCCF tube 0886 was valved to low-flow prior to jumpering the Panellit gauge.

KE REACTOR

8/3	8/4	41.1	Removal of an I&E E-metal rupture from tube 1548 and charge-discharge.
8/4	8/4	0.3	Unexplained Panellit trip on tube 4291.
8/5	8/5	0.6	Tripped by low-flow on KER Loop 1 during a pump change.
8/5	8/5	0.4	Unexplained Panellit trip.
8/7	8/9	31.7	Removal of a rupture from KER Loop 2.
8/19	8/20	19.9	Removal of an I&E regular metal rupture from tube 3271.
8/21	8/22	28.9	Removal of a rupture from KER Loop 1.
8/23	8/23	2.1	Removal of a solid regular metal rupture from tube 4844.
8/24	8/25	30.8	Removal of a solid regular metal rupture from tube 4943 and charge-discharge.
8/27	8/28	31.4	Panellit trip on tube 5085 due to a ruptured spline cap seal.

KW REACTOR

8/9	8/11	80.0	Scheduled charge-discharge and installation of a new No. 1 low-lift pump motor and impeller of greater pumping capacity.
8/19	8/20	31.1	Removal of an I&E E-metal rupture from tube 0885,
8/23	8/24	31.6	Removal of a small bolt from No. 13 cross-header screen, detected by abnormal Panellit readings.

Equipment Experience

1. Seventy-four process tubes were installed; 66 at B, four at F, two at DR and one each at KE and KW..

2. Seven water leaks were corrected; five tube leaks (two each at H and F and one at B) and two Van Stone leaks (DR and F).

3. A new No. 1 low-lift pump motor and impeller of greater pump in capacity were installed at KW.

4. KW reactor was shut down on August 23 to investigate an abnormal Panellit pressure. A small bolt was found on the No. 13 cross-header screen.

PRESENT-REACTOR TECHNOLOGY

Effluent and Influent Water Treatment Studies

The aluminum turning test was initiated in early August at D Area. The test tank is located near the 107-D basin. The tank contains about 4 tons of aluminum turnings. Reactor effluent water is pumped from the 107-D basin into the test tank by a crib pump at a rate of 500 gpm. Preliminary results agree with the previous laboratory studies made by Silker. It is anticipated that there will be significant results by October or November.

The following influent water treatment tests are either in progress or in the late planning stage:

B Area - Increase alum to ~25 ppm to reduce the phosphate concentration in the water.

C Area - Reduce the amount of dichromate additive to one-half and observe the effects on the amount of radioactive chromium effluent.

H Area - Substitute aluminum nitrate and nitric acid for alum and sulfuric acid to reduce the sulfur content of the influent, which in turn should reduce the P-32 content of the effluent.

KER Loops - Single-pass addition tests. For example, add PO_4 to see if P-32 increases.

KE Single-Pass Test Tubes A test to determine whether quachrom glucosate will inhibit aluminum corrosion in filtered process water has been started in the Single-Pass Mockup Tubes, employing concentrations of 1.8 and 0.17 ppm quachrom glucosate. Concentration was chosen to be the same as the present process water sodium dichromate concentration and the 0.17 ppm concentration was chosen because this concentration results in a chemical cost competitive with 1.8 ppm sodium dichromate.

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It is planned to construct a miniature water treatment plant (including deionizers) at KE reactor for use in the single-pass KER tubes. It is hoped that this facility will be operational by the early part of CY-1961.

Projection Fuel Testing

Five columns of fuel elements with end-spider supports were charged into ribless aluminum tubes in B reactor this month. One column of fuel elements with welded rail supports was also charged.

A total of 69 zirconium tubes are now in place in C reactor, charged with self-supported elements.

Testing of bumper fuel elements continues in ribbed tubes in D reactor. Visual examination of the first natural-uranium bumper element discharged from D reactor at an exposure of 417 MWD/T revealed no corrosion film pattern (hot-spots). As a comparison, five hot-spot patterns were observed in a control column of I&E material discharged at 421 MWD/T.

Accelerated testing of the bumper geometry under production test PT-IP-262-A continued at D reactor. Two failures in the standard I&E geometry (1.47% enriched material) occurred as predicted at 20 and 21 operating days (tube exposure at failure was approximately 21 MWD). The remaining two enriched control columns were discharged. The four bumper columns remain under irradiation, demonstrating a steadily increasing factor of improvement in rupture resistance as the exposure increases.

Nickel Plated Fuel Irradiations

Two columns of nickel plated fuel elements were discharged from DR reactor on August 1 at an exposure of about 425 MWD/T. A cursory visual examination was encouraging in that no nickel spalling was observed.

High Temperature Irradiations - KER Facilities

A charge of fuel instrumented with thermocouples was charged on August 4 into KER loop 1. The charge consisted of a coextruded Zircaloy-2 jacketed rod with thermocouples imbedded in the uranium. The objective of the test was to measure the effect of film buildup on heat transfer and internal fuel temperatures. The loop operated normally through August 19, when the loop was subjected to an internal decontamination process. Following the startup on August 20, operation continued for approximately 24 hours. Two rupture indications were

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observed and a shutdown was necessary. Observation of the thermocouple element revealed water entry had occurred somewhere at the end of the rod where the thermocouple weld and the cap weld were located. The detailed point of entry and the cause of failure have not yet been determined.

Loop 2 of the KER facility was charged on August 4. On August 7, failure indications were observed and the fuel elements were discharged after three days of reactor operation. Location and nature of the failure have not been determined.

Six heavy-walled single-tube elements, two with capped jacket defects, are being irradiated in KER-3. The elements have attained an exposure of 540 MWD/T.

The eight natural uranium tube-in-tube elements being irradiated in KER-4 to evaluate hot-headed end closures have attained an exposure of 1210 MWD/T in 288°C coolant.

<u>High-Tank Investigations</u>

Production tests have been issued which provide for cleaning the B, F, and H high-tanks and lines.

Four significant changes have occurred recently in the D reactor high-tank cooling system, (a) descaling of the high-tank and associated piping produced a 36% increase in the high-tank flow, (b) a low-flow calibration test has removed some of the previous uncertainties in flow measurements in the range of 6,000 to 12,000 gpm, (c) a high-tank bleed system previously installed permitted periodic bleeding at a rate of about 40 gpm, (d) a high-tank liquid-level measuring system is now in operation. In conjunction with item (c) it allows control of the high-tank water temperature.

<u>DR reactor Bulk Coolant Program</u>

Work has continued to assess the effect of changes in water flow on temperatures in the effluent piping at the rear face of DR reactor. Test data were obtained on August 12 for various flow and power conditions. Strain gauge readings are, in the raw state at least, not consistent with previous data. A study of the internal consistency of model data and model prototype correlation methods indicate that the present model may not be adequate for predicting pressure conditions in the effluent piping.

Coolant and Heat Transfer

The effects of heat transfer tests of the eccentric positioned fuel element with a process tube with 75% eccentricity reduced the boiling burnout heat flux by 60%.

Non-Fissionable Charge Monitoring

Trip limits have been established for a direct reading pressure gauge to be used in flow monitoring of tubes containing non-fissionable charges. Use of these gauges is expected to reduce spurious scrams and the need for frequent pressure checks on these tubes.

Overboring

Tests of new overboring cutters finally indicate the possibility that a crooked channel can be straightened, or at least sharp changes in its direction smoothed. This conclusion follows a demonstration on a one-channel mockup of the F reactor distortion.

The reactor overboring program is being reoriented to demonstrate a 500-mil diametrical enlargement rather than 200 mils. A demonstration at F area indicated that a crooked channel can be successfully straightened by overboring.

Equipment Development

Seven flapper valves were installed on KE reactor August 8 but four of them leaked when pressure was raised, and three were subsequently removed. The leakage seemed to be caused by rough nozzles. A seal is being developed which will seal against a rough surface.

Norfin, Inc., was the successful bidder for 100 flapper valves at $96.00 per valve. It is estimated that the delivery will be completed about October 15.

The balanced hydraulic charging machine is being fabricated in the technical shops; it is about 85% complete. This machine is designed to feed one slug at a time from a K-type magazine, through a flapper check valve into the reactor during operation. Testing is scheduled around the middle of September.

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The charging machine for three-bumper slugs has been fabricated and assembled, and testing is under way in the 105-D building. Completion date of testing is September 2.

E-N Studies

Calculational methods now available are not sophisticated enough to compute the neutron multiplication ratio for a uranium-lithium striped charge. The principal difficulty lies in calculating the thermal flux distribution in the fuel target column. Experimental axial thermal flux traverses have been obtained along subject columns. Attempts to compute the radial distribution do not yield the proper poisoning effect on the lithium as required to match test pile measurements of reactivity. The computed flux in the target material is much lower than is indicated by experimental axial traverses. Further investigations of the physics of a striped uranium-lithium load are being carried on.

Control Efficiency Studies

Prototype displacement columns (short columns of fuel elements in a reactor tube which may be moved upstream or downstream from the control room) have now been installed in columns 1485, 4485, 3069 and 3079 of KW reactor. Two additional columns remain to be installed in the 6-column prototype system.

A justification and development study on automatic reactor control has been prepared in rough draft form. Quantitatively, this justification is based on a conservative estimate of increased operating efficiency. Qualitatively, it is based on the secondary benefits from more predictable control and on the need for doing the development for distributional control at Hanford, since the Hanford reactors are unique in geometry and size.

Shielding Studies

Maximum temperatures of the B, D, DR, F, and H side and top shields have been kept within the recommended range of less than 120 °C this summer. Decreases in these maximum shield temperatures from 1958 and 1959 are due in part to increased fringe poison use, and in part to the effect of increased helium concentrations.

Graphite Burnout Monitoring

Burnout samples were discharged from 3478-D on August 8 after 426 operating days. Samples near the rear gun barrel showed an average weight gain of 0.01% per 1000 operating days, while samples from the front and central sections showed average loss of 0.68% and 1.6% respectively. This is an example of graphite mass transfer within a process channel. Carbon suboxide decomposition was evidenced by dark deposits on some of the samples.

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Preliminary investigations of the use of enriched metal diamond loadings for increasing local graphite temperatures during oxidation testing are under way.

NEW PRODUCTION REACTOR TECHNOLOGY

Physics

Reactor physics work in support of NPR resumed following receipt of the uranium tubes (.94% U-235). PCTR experiments were completed in the dry condensed NPR lattice at room temperature.

NPR Reflector Graphite

The GEH 13-5 experimental capsule containing NPR reflector graphite has been completed and will be installed in the N-5 corner of the ETR during the Cycle 32 shutdown (about September 19). A holder was attached to the capsule so that flux monitors can be inserted and removed while the experiment is in the reactor. Flux measurements using bare and cadmium covered Ni and Co-Al wires are being made in N-5 and N-14 during Cycle 31 (August 8, 1960).

All of the NPR top and bottom reflector graphite to be made by National Carbon Co. has been received. Four heats of the material to be made by Great Lakes Carbon Corp. have been rejected on the basis of low nuclear purity (dih purity values below +0.25).

The first extrusions through a special 6" x 6" die have been made by Great Lakes. The process differs from the normal extrusions in that the normal reduction is made in only one direction and further that a streamlined vane is included in the reduction throat of the die perpendicular to the direction of the reduction. The internal surface of the bars showed a marked intensity of flow lines, which hopefully indicates that a high degree of preferred orientation has been achieved. It is hypothesized that such highly oriented bars will contract less in the two short dimensions under irradiation than do bars with a lower degree of orientation.

Fuel Design Analysis

Detailed results of the latest available data and theory on fuel performance has led to changes in the nominal cladding thicknesses of the NPR fuel elements. Improved performance will be obtained by increasing the cladding thickness on the outer surfaces of the inner tubes of the fuel element. The cladding at the surface is subject to strains estimated at twice that experienced by the next most critical surface. Theseresults lead to the following NPR fuel dimensions:

[redacted]

[redacted]

	Outer Tube	Inner Tube
Overall OD	2.404 inches	1.253 inches
Uranium OD	2.354 "	1.173 "
Uranium ID	1.808 "	.489 "
Overall ID	1.758 "	.439 "

Other results obtained from the IBM-709 program include (assuming the reactor operating at full design power):

Average Central Tube Inlet Coolant Temperature	366°F
Average Central Tube Outlet Coolant Temperature	543°F
Central Tube Flow	80,000 lbs/hr.
Maximum Heat Flux	490,000 btu/hr/sq.ft.
Peak Uranium Temperature	430°C
Cladding Surface Temperature	556°F
Active Zone Pressure Drop	97 psi

GAS COOLED REACTOR PROGRAM

Physics

Lattice physics work on the Gas-Cooled Reactor Program was concluded with the issuance of three final reports.

Gas Loop

The PRTR Gas Loop (Project CAH-822) piping fabrication by Struthers-Wells is estimated to be 98% complete. The preheater and several valves remain to be installed. The installation specifications for the gas loop have been forwarded to J. A. Jones Co.

EGCR Oxidation Prototype

Two preliminary runs have been made to determine if the prototype would ignite at about 600°C. In each case a heating element failure just prior to admittance of the air caused the runs to be made with the power off. In the first run the graphite temperature, T_G, was 570°C and the inlet air temperature, T_A, was 25°C. In the second run T_G was 625°C and T_A was 180°C. Combustion did not occur in either case. However, the normal heat losses in the system may exceed the heat evolved by oxidation. In order to eliminate this possibility, modifications have been completed which permit a low power to be maintained separately to the outer ring of heating elements. The temperature difference between the inside and outside of the block can thus be maintained at zero during burnout experiments so as to make the system entirely adiabatic.

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August OUTAGES (Year [illegible])

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	23.0	28.7	30.0	17.7	[illegible]	26.6	37.9	56.5	267.7
Maintenance	39.6	1.2	31.1	49.2	[illegible]	16.3	32.6	37.8	219.5
Rupture Removal		12.1	0.7	10.6		20.4	62.8	12.6	119.2
Leak Testing	2.5			14.7	15.5	24.5			57.2
Tube Replacement	74.0				11.2	10.9			96.1
Project Work			3.0					1.5	4.5
Production Tests	5.1		45.3	12.5			64.0	10.4	137.3
Instrument & Circuitry									
Rupture Suspects	6.3	1.0		0.6	0.2		0.7		8.8
Miscellaneous				1.5	8.2				9.7
Total	150.5	43.0	110.1	106.8	94.1	98.7	198.0	118.8	920.0
Scheduled Outages	140.4	29.0	95.7	66.3	57.0	39.0	48.7	71.4	547.5
Unscheduled Outages	10.1	14.0	14.4	40.5	[illegible]	59.7	149.3	47.4	372.5

RUPTURED SLUG TABULATION FOR [illegible]

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations
70-D	6/9/60	8/1/60	1031	463	65	.04	I&E E - Mechanical Damage
1548-KE	5/14/60	8/3/60	1418	790	2845	.90	I&E E Unknown
2060-D	7/9/60	8/7/60	1153	340	1584	1.00	I&E E 1.47%E- Side Other
2262-D	7/9/60	8/9/60	1127	379	1673	1.06	I&E E 1.47%E - Hot Spot
3578-C	5/20/60	8/10/60	1049	769	1104	.60	I&E E - Hot Spot
2558-H	5/11/60	8/11/60	898	547	1500	.92	I&E Reg. - Unknown
3271-KE	6/6/60	8/19/60	1333	542	3313	1.05	I&E Reg. - Unknown
0885-KW	7/4/60	8/19/60	1364	423	2003	.60	I&E E - Hot Spot
4844-KE	1/25/60	8/23/60	725	658	341	.11	Solid Reg. - Split
4943-KE	12/7/59	8/24/60	585	683	3459	1.09	Solid Reg. - Split
2864-KE							
KER-2	8/3/60	8/7/60			3709	1.17	Unknown
2160-KE							
KER-1	8/3/60	8/21/60	329	142	4696	1.48	Thermocouple Slug - Unknown

STANDARD FORM NO. 64

[redacted]

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Office Memorandum • UNITED STATES GOVERNMENT

TO : PE&M Files

DATE: August 8, 1960

FROM : R. L. Plum, Chief
Reactor Branch

HAN-74591 - DEL
Rept. #7

SUBJECT: MONTHLY REPORT FOR MONTH OF JULY, 1960

SYMBOL: OR:GTO:GRG:HAH

This document consists of 12 pages
N[redacted] of [redacted] copies, Ser[redacted]

PRODUCTION

Reactor input production was 0.4 percent above forecast; 1.1 percent below forecast at the six old reactors and 2.4 percent above at the K reactors.

Average overall time operated efficiency was 79.3 percent (82 percent forecast); 78.3 at the six old reactors and 82.4 at the K reactors. Efficiency was low at the old reactors due to the replacement of process tubes.

There was no increase in the combined reactor instantaneous power level or the individual reactor record power levels.

Ruptures

Eleven ruptures (four I&E regular, three I&E E, two solid regular, and two KER test elements) were removed from the reactors. Two of the I&E regular metal ruptures were at B and one each at D and KW. The three I&E E-metal ruptures were at C, D, and DR and the two solid regular metal ruptures were at C and H. A thermocouple slug failure was removed from KER Loop No. 1 and a tube-in-tube failure from KER Loop No. 2.

Reactor Outages

Reactor outages for the month of July are as follows:

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[redacted]

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Date Down	Date Up	Outage Hours	Remarks
B REACTOR			
7/10	7/13	55.8	Removal of a stuck I&E regular metal rupture in tube 1265, and charge-discharge.
7/23	7/25	46.4	Removal of a stuck I&E regular metal rupture in tube 1383.
7/26	7/28	35.1	Tripped when No. 8 pump was lost due to a burned-out motor coil.
C REACTOR			
7/9	7/11	59.4	Removal of an I&E E-metal rupture from tube 2072, charge-discharge, and raw-water export line tie-in.
7/24	7/28	98.0	Scheduled charge-discharge and installation of 50 zircaloy process tubes.
7/28	7/28	2.5	Removal of a solid regular metal rupture from tube 2252.
D REACTOR			
7/9	7/15	135.5	Scheduled charge-discharge and tube replacement.
7/21	7/21	0.2	Panellit trip due to a ruptured Bourdon tube on gauge 1779.
7/21	7/22	32.3	Temperature control following a Panellit trip.
7/22	7/22	0.5	Tripped by a 190 power failure while attempting to put a pump on the line.
7/29	7/29	0.2	Panellit trip due to a ruptured Bourdon tube on gauge 3695.
7/29	7/31	33.6	Removal of an I&E E-metal rupture from tube 3660, and miscellaneous maintenance.
7/31	7/31	0.3	Panellit trip due to a stuck toggle valve plunger.

[redacted]

[redacted]

DR REACTOR

6/30	7/2	33.6	Charge-discharge following a Panellit trip.
7/12	7/14	45.9	Panellit trip due to a stuck I&E E-metal rupture from tube 0677, and charge-discharge.
7/31	Still down		Removal of an I&E regular metal rupture from tube 2665, and charge-discharge.

F REACTOR

7/12	7/19	178.0	Scheduled charge-discharge, tube replacement, and maintenance.
7/20	7/22	45.6	Water leak.

H REACTOR

6/26	7/2	155.9	Concluded scheduled charge-discharge, tube replacement and Ball 3X work.
7/2	7/2	0.3	Unexplained Panellit trip.
7/14	7/17	76.6	Removal of a stuck solid regular metal rupture from tube 2352, charge-discharge, and leak testing.
7/17	7/17	1.0	Change Venturi on tube 2456.
7/20	7/23	48.4	Leak testing and charge-discharge.
7/26	7/26	0.4	Installation of a holding plate on the front face cap of tube 4371 when one of the three lugs was found to be missing.

KE REACTOR

7/3	7/6	71.9	Trip due to a rupture in KER Loop 2, and charge-discharge.
7/7	7/8	24.2	Tripped due to a rupture in KER Loop 1.
7/15	7/16	32.0	Temperature trip on KER Loop 4 heat exchanger.
7/16	7/16	4.6	Tripped by malfunction of water cross-tie by-pass switch.

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KE REACTOR (cont'd.)

7/17	7/18	26.5	Panellit trip caused by loss of No. 1 low-lift pump unit due to high temperature on the motor winding.

KW REACTOR

7/4	7/7	70.4	Panellit trip due to an I&E regular metal rupture from tube 2974.
7/17	7/19	32.1	Unexplained Panellit trip. Charge-discharge and miscellaneous maintenance were performed.

[redacted]

[redacted]

Equipment Experience

(1) 163 process tubes were installed; 76 at F, 50 at C, 30 at D, 5 at B, and one each at DR and KW. The tubes installed in C reactor were ribless zircaloy, raising the total number of tubes of this type in C reactor to 69.

(2) Three water leaks were corrected; two van stone leaks and one tube leak. The Van Stone leaks were at F, the tube leak was at H.

(3) The export water tie-in for N Area and the new central fire station was completed during a dual reactor outage at the B-C reactors on July 11.

(4) KE reactor was scrammed July 17 by the loss of No. 1 low-lift pump unit, which relayed out because of high temperature on the motor windings.

(5) At KW reactor foundation cooling was placed in service for the first time.

(6) B reactor was scrammed July 26 due to a grounded coil on the No. 8 pump motor. This coil was bypassed and the No. 8 pump unit returned to service for the startup.

REACTOR POWER LEVEL LIMITATIONS

The primary power level limit at C, F, KE, and KW reactors was based on fuel element failure control (tube-power limit). Power levels at B, D, DR, and H reactors were restricted by bulk outlet temperature restrictions.

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Files DECL[redacted] August 8, 1960

2000 PROGRAM SPECIAL NUCLEAR MATERIALS

Engineering

Coolant and Heat Transfer

Transient heat transfer experiments were run with a full scale mock-up of I&E fuel elments in a K process tube to investigate possibilities of cooling by boiling following a loss of pumping power. An initial analysis of the data indicates that such a cooling method might be quite successful.

Reactor Technology

Measurements of radiation dose rates at the front face of B reactor indicate that the principal neutron dose is coming from dry tubes which are currently shielded with steel plugs. It is estimated that the neutron dose would be reduced by a factor of two by using concrete-filled plugs in place of the steel plugs. A further reduction by a factor of about four could be obtained by shielding the front face with 1-$\frac{1}{4}$ inches of polyethylene. These conclusions apply to four of the present production reactors. A report (HW-66117) of the work is being prepared.

The first block discharge cycle at the DR reactor showed production roughly equivalent to that of the staggered discharge method. It would appear at this time that any disadvantages of the block method must be compensated for by improved maintenance utilization rather than increased production itself.

Mechanical Development

The operational Charge Discharge machine was removed from the C-reactor work area and stored in the 185-B building pending decision as to its disposal.

Overboring

Channel 1192-F was overbored 200 mils during the July 9 reactor outage. The experience in the graphite boring was similar to that in an earlier successful boring in DR reactor. The front of the graphite channel contains alternate hard and soft areas in an apparently random pattern, and considerable chattering of the drilling rig results. Downstream graphite is similar but less severe, whereas the graphite in the center of the pile cuts easily. The new equipment performed very well, but there are indications its power may be less than optimum. It is expected that the time required for the overboring operation will be between twelve to twenty minutes.

[redacted]

[redacted]

Reactor Fuels

Projection Fuel Testing

Two additional columns of end-spider supported fuel elements were charged into B reactor. Normal charging forces were used, tending to substantiate the suspicion that oversized fuel-element projections were the cause of high charging forces reported last month.

Dingot Uranium Testing

The final report of the analysis of the initial seven tubes of irradiated dingot uranium fuel elements will contain the conclusion that dingot is not inferior to ingot uranium with respect to dimensional instability.

Materials Development

Graphite

High Fast Flux - Calculations are underway to determine in a qualitative manner the fast flux obtainable on graphite samples located inside a highly enriched uranium oxide fuel element. Preliminary results are encouraging in that some gain in fast flux ($E > 1$ mev) can be achieved over that presently available in test holes. Further work will define better the upper limit.

Graphite Distortion at B and F Reactors - A traverse through the top center of F reactor indicated a further increase in elevation of the top of the inlet and outlet humps and the low point in the center depression. In total the depression has risen approximately 0.25 inch since the traverse taken in September, 1959. Power level increases at F during the last year have required increased helium concentrations to maintain graphite temperatures within process standards. Data onpower level, temperatures and helium concentrations are under examination to determine if low-temperature expansion of some of the tube-block graphite has occurred. Traverse data at both B and F reactors continue to indicate that the bend in the inlet hump for the top four rows of tubes will become sufficiently severe to require a change to four-inch fuel elements next year. Continued manometer traverse and probe length data will be gathered to permit orderly preparation for the use of four-inch elements.

Zirconium

Corrosion Studies

Zircaloy-2 Corrosion Hydrogen Pickup in 340°C Flowing Water. A number of samples were removed from the 340°C flowing water corrosion test

[redacted]

after six months of exposure in order to determine the effect of refreshed water on corrosion product hydrogen pickup. The percentage of corrosion product hydrogen pickup for the samples ranged from 1.4% to 9.1%. This is considerably less than values of 40 to 55% for corrosion by water or steam in static systems. The results indicate hydrogen pickup is less at the higher velocities and refreshment rates.

The annealing and pickling of the Bridgeport Zircaloy-2 C-reactor process tubes has proven successful and all treated tubes have been successfully installed in the reactor.

Physics

Operational Physics

Splines - Central spline caps were installed at F reactor and a single-spline operational test was carried out at B reactor; all reactors except DR and H are now making at least partial use of the poison spline system for operating control flexibility.

Control Efficiency Studies - The semi-annual summary of potential gains shows a 3-fold improvement in startup efficiency at the K reactors during the second quarter of CY-1960. As a result, the production efficiency was approximately 6% higher than previously. These improvements resulted largely from the use of poison splines.

Critical Mass Studies

E-Metal Storage - The limits on storage of unirridiated 0.947% U-235 uranium slugs were revised to allow 300-hole pallets to be stacked three high. The change is based on experimental data and the fact that both a flooding of the normally dry storage area plus redistribution of the E-metal into less-safe geometry would be required for a critical mass incident.

Theoretical Physics

A refinement was introduced into the interpretation of neutron rethermalization data by the use of a neutron diffusion coefficient which depends both on the neutron temperature and on the graphite temperature. This realistic model produces values of relaxation length which are up to one-third smaller than those produced by the constant diffusion coefficient model previously used. Likewise, the new model gives higher values for the rethermalization cross section than the old model.

[redacted]

New Production Reactor

NPR Process Tubes - A decision has been made to add silicon up to 250 ppm to the Columbia National Zirconium sponge used by Harvey Aluminum Company in fabricating the production order of NPR tubes. This addition is expected to improve the corrosion resistance of these tubes.

NPR High Pressure Tube Rupture Tests - Assistance was given Process Design for scheduling four additional tube rupture tests. The results of our study indicate that it will take approximately two months to perform these tests. During test performance other activities, particularly those concerned with loop operation, will be seriously curtailed. The Process Design section of GE will make the final determination of the test schedule.

KER Testing - The thermocouple train being irradiated in KER-1 to evaluate film effects was discharged on July 7, following indication of a fuel element failure. The enriched tubular elements providing heat to the loop had reached an exposure of 1,030 MWD/T, while a natural uranium thermocouple element had reached 435 MWD/T. The location, nature and cause of the failure have not yet been determined.

The four enriched tube-in-tube elements in KER-2 were discharged following failure indications at an exposure of 3,150 MWD/T (138 days operation, 272°C coolant). The failure was a longitudinal split in the Zr-2 jacket on the outer surface of the inner tube of the upstream fuel element in the charge.

Fuel Design Analysis - Studies of the effects produced by the various combinations of cladding thicknesses on the surfaces of NPR fuel elements have been carried out. Computer results indicate that, outside of added zirconium costs, no other losses of appreciable magnitude would result from increasing cladding thickness to 30 mils on any or all of the four surfaces of the 22 lb/ft NPR element. Slightly higher coolant pressure drops are offset by slightly higher conversion efficiencies, while increases in fuel temperature and heat fluxes are negligible.

Graphite for an exponential pile mockup of the NPR was received and assembled. Measurements are being delayed by lack of the outer uranium tube of the fuel element. Delivery of these elements is now six months behind schedule.

[redacted]

4000 PROGRAM REACTOR DEVELOPMENT

EGCR Oxidation Hazard Evaluation

Construction of the EGCR oxidation prototype has been completed. Testing and calibration is now in progress. Preliminary testing has demonstrated the unit will provide an adiabatic vessel. Temperature drops from $300^{\circ}C$ to $100^{\circ}C$ required $6\frac{1}{2}$ hours with 50 lbs/hr of air flowing through the annulus. With no forced convection this temperature drop was about $10^{\circ}C$/hr (at $300^{\circ}C$).

The gas loop (Project CAH-822) Phase A package remains 95% complete awaiting new heater tubing and a few valves. No significant improvement in blower test performance has been reported by Bristol-Siddeley. The in-reactor test section is essentially complete and it is being prepared for test.

[redacted]

RUPTURED SLUG TABULATION FOR JULY 1960

[redacted]

Tube No.	Date Charged	Date Ruptured	Tube Power (MW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations
2974-KW	5-17-60	7-4-60	[illegible]	377	3037	.88	I&E Regular - Hot Spot
2072-C	6-3-60	7-9-60	1225	387	630	.35	I&E E - Hot Spot
1265-B	5-30-60	7-10-60	1190	305	842	.53	I&E Regular - Hot Spot
0677-DR	5-28-60	7-12-60	1161	426	2338	1.44	I&E E - Hot Spot
2352-H	12-28-59	7-14-60	543	686	1048	.64	Solid REgular - Split
1383-B	5-10-60	7-23-60	1120	532	1113	.71	I&E Regular - Unknown
2252-C	2-10-60	7-28-60	590	616	343	.19	Solid REgular - Split
3660-D	6-9-60	7-29-60	1022	461	1201	.77	I&E E- Hot Spot
2665-DR	5-28-60	7-31-60	1006	473	770	.47	I&E Regular - Undetermined
2160-KE	5-14-60	7-7-60		856			Thermocouple Slug - Type Failure not Availal
2864-KE	1-11-60	7-3-60		3320			Tube-in-Tube - Jacket Split
					[redacted]		

[redacted]

1960 (Year)
OUTAGES (JULY)

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	37.2	30.4	28.3	20.5	31.0	54.6	52.5	52.6	307.6
Maintenance	63.2	27.4	79.2	2.1	56.7	42.0	13.6	16.4	300.6
Rupture Removal	24.8	10.0	17.3	31.8	0.0	14.4	0.0	18.6	116.9
Leak Testing	0.0	0.0	0.0	0.0	45.7	28.1	0.0	0.0	73.8
Tube Replacement	11.1	0.0	41.3	0.0	85.3	29.0	0.0	0.0	166.7
Project Work	0.0	25.7	0.0	18.0	0.0	0.0	0.0	0.0	43.7
Production Tests	1.0	66.5	34.8	0.0	5.0	0.7	63.4	1.4	172.8
Instrument & Circuitry	0.0	0.0	0.6	3.5	0.0	0.0	0.0	11.6	15.7
Rupture Suspects									
Miscellaneous			0.5				29.6	2.0	32.1
Total	137.3	160.0	202.5	75.9	223.7	168.3	159.1	102.6	1229.9
Scheduled Outages	108.9	146.6	152.8	38.5	169.7	99.3	62.8	64.9	843.5
Unscheduled Outages	28.4	13.4	49.7	37.4	54.0	69.5	96.3	37.7	386.4

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STANDARD FORM NO. 64

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*Office Memoran*DECLASSIFIED STATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: July 12, 1960

FROM : R. L. Plum, Chief Reactor Branch

HAN-74591 - DEL
Rpt. No. 6

SUBJECT: MONTHLY REPORT FOR MONTH OF JUNE, 1960

This document consists of 17 pages
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SYMBOL: OR:GTO:GRG:HAH

Production

Reactor input production was 12.9 percent above forecast; 4.1 percent above at the six old reactors and 25.7 percent above at the K reactors. Forecast was exceeded, particularly at the K reactors due to high time operated efficiency and average power levels. June production was essentially equal to the May record when adjusted for one less day.

Overall time operated efficiency was 84.4 percent (81 percent forecast); 81.5 at the six old reactors and 93.2 at the K reactors. The high efficiency at the K reactors is attributed to exceedingly good operating continuity. KE was down once during the month on schedule and KW once, continuing an outage which started late in May.

There was no increase in combined reactor instantaneous power level or the individual reactor record power levels. Record production was achieved at KW exceeding their previous record by 5.9 percent.

Nine ruptures, five I&E regular, two I&E enriched and two solid regular metal, were removed from the reactors. Two of the I&E regular metal ruptures were at H and one each at B, C, and F. The two solid regular metal ruptures were at DR and H and the two I&E enriched ruptures were at C and D.

Reactor Outages

Reactor outages for June, 1960 are as follows:

[redacted]

[redacted]

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[redacted]

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B REACTOR

Date Down	Date Up	Outage Hours	Remarks
5/30	6/2	72.5	Concluded rupture removal. Charge-discharge and tube replacement.
6/2	6/2	0.8	Panellit trip.
6/7	6/7	0.2	Panellit trip.
6/7	6/9	45.4	Panellit trip. Insufficient reactivity. Charge-discharge and miscellaneous maintenance.
6/26	6/27	29.6	Panellit trip. Insufficient reactivity. Charge-discharge and maintenance.

C REACTOR

Date Down	Date Up	Outage Hours	Remarks
6/3	6/5	43.8	Scheduled charge-discharge.
6/5	6/5	0.7	Panellit trip.
6/6	6/6	0.2	Panellit trip.
6/6	6/8	30.6	Panellit trip. Insufficient reactivity. Miscellaneous maintenance.
6/8	6/8	0.3	Panellit trip.
6/18	6/20	29.2	Removal of an I&E 94-metal rupture from tube 2456. Charge-discharge.
6/20	6/21	17.8	Removal of a stuck I&E regular metal rupture from tube 1889. Charge-discharge and tube replacement.
6/28	6/28	0.3	Power loss relay trip when a pump was being removed from service at 190 (due to the failure of a wear ring on the impeller assembly).
6/29	6/30	30.0	Temperature control and tube replacement.

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D Reactor

6/9	6/11	48.7	Removal of an I&E 94-metal rupture from tube 3964. Charge-discharge.
6/12	6/13	31.7	Temperature and pressure increase on tube 1074 when a spline cap insert became unscrewed and washed downstream.

DR Reactor

5/28	6/1	101.3	Concluded rupture removal. Charge-discharge and tube replacement
6/1	6/1	0.4	Tripped by low flow on the DR-1 loop.
6/2	6/2	0.2	Panellit trip when a jumper was inadvertently removed from gauge 2973.
6/17	6/19	38.0	Removal of a solid regular metal rupture from tube 2155. Charge-discharge and maintenance.
6/30	Still down		Tripped when a wire between Panellit gauges was inadvertently removed while attempting ~~to~~ to remove a leaking gauge. Insufficient reactivity.

F Reactor

6/2	6/3	35.3	Removal of an I&E regular metal rupture from tube 2471. Charge-discharge.
6/20	6/21	38.7	Scheduled charge-discharge and maintenance.
6/24	6/26	48.0	Leak testing. Tube and Venturi replacements.

[redacted]

[redacted]

H Reactor

5/30	6/1	30.2	Completed leak testing and tube replacement.
6/1	6/1	0.8	Loose rear cap on tube 4357.
6/1	6/2	17.8	Removal of an I&E regular metal rupture from tube 1583. Charge-discharge.
6/3	6/4	29.5	Removal of a stuck solid regular metal rupture from tube 3553.
6/7	6/8	35.6	Leak testing and charge-discharge.
6/16	6/18	34.4	Removal of a stuck I&E regular metal rupture from tube 2178. Charge-discharge.
6/18	6/19	26.4	Leak testing and tube replacement.
6/26	Still down		Scheduled charge-discharge, tube replacement, and Ball 3X work.

KE Reactor

6/6	6/8	58.5	Scheduled charge-discharge.

KW Reactor

5/31	6/2	46.7	Charge-discharge following Panellit trip.

Reactor Power Level Limitations

The primary power level limit at all reactors except H was based on fuel element failure control at present goal exposure. H reactor power level was restricted by bulk outlet temperature limitations.

Supplementary Control

Use of supplementary control systems (poison splines) reduced average startup losses at C, DR, H, KE and KW reactors to about 0.2 equilibrium days equivalent production, representing an improvement of about 0.4 days from the average 1959 startup efficiency for these reactors.

[redacted]

[redacted]

Present Reactor Technology

Projection Fuel Testing

The first three of the initial ten columns of end-spider supported fuel elements were charged into B reactor. Higher than normal charging forces were experienced and an investigation of the two columns remaining in storage from the same shipment revealed over-sized fuel elements; therefore, it was concluded the first three columns were also oversized and could have caused the higher charging forces.

Preliminary visual inspection of the first columns of self-supported fuel elements irradiated to 1200 MWD/T revealed no unusual corrosion patterns.

Dingot Uranium Testing

Analysis of the seven tubes of alloyed Dingot material discharged from D reactor at an average exposure of 795 MWD/T revealed:
(a) Dingot is not significantly higher in average warp than Ingot.
(b) Tube filling capacity for Dingot was not statistically different from Ingot.

KER Testing

The Zircaloy-2 jacketed natural uranium thermocouple element being irradiated in KER-1 under PT-IP-314-A to measure the temperature effect of curd film deposition in pH 10 coolant has shown neglibible filming at coolant temperatures up to 288°C with a surface heat flux of about 0.35×10^6 B/hr. ft.^{2}. No filming resulted from several temperature cycles.

The four eighteen-inch enriched tube-and-tube elements being irradiated in KER-2 under PT-IP-292-A to a goal of 3500 MWD/T have attained an exposure of 3085 MWD/T in 270°C coolant at an average specific power of 123 KW/ft.

The eight natural uranium Zircaloy-2 jacketed tube-and-tube elements being irradiated in KER-4 under PT-IP-300-A to evaluated hot-headed closures have attained an exposure of 805 MWD/T in 288°C coolant. The elements are scheduled to a goal of 2500 MWD/T.

Ceramic Ball Tests

HW-65547, "Development Test IP-330-A, Pile Testing of Ball 3X Candidate Materials," was issued on June 13. This DT will permit irradiating (for 30 operating days) samples of ball 3X candidates in the KW reactor and determining (1) rate of poison burnout under irradiation, and (2) post-irradiation activity of the samples.

[redacted]

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E-N Conversion Ratio

Twenty-six pieces of N material from the small-scale E-N test at 105-H were shipped to SRO about June 17.

Critical Mass Studies

A method has been devised which will permit the calculation of safe spacings for bundles of fuel elements. The answers should be conservative and will be used to replace the previous calculations.

Hazards Review

The analysis of the NPR cold water, startup, and flooding accidents was completed and issued. The latest revised values of control strengths for both the horizontal rods and ball 3X systems were included in HW-64755, "N Reactor Hazards Review of Cold Water, Flooding, and Startup Accidents."

NPR Transient Response

A preliminary analysis of the NPR has developed to the point that an analytical estimate of the transient response has been obtained. For a small step in reactivity the maximum power is reached in less than one second and quickly settles to within one percent of final power. A 50 percent over-shoot is obtained. Since the peak is reached so quickly and also due to good damping characteristics, the power response to reactivity changes is expected to be excellent.

Zirconium Tube Procurement

Bridgeport Brass Company has prepared 111 C reactor process tubes which are within specifications in all respects except possibly corrosion resistance. The corrosion test results have not yet been received. One additional tube has been prepared which is within specifications except that the wall is 1 mil below minimum specifications for 23 inches at one end of the process tube. This tube has been offered to us for $550 and will be shipped with the other tubes. It is technically acceptable for use in-reactor.

Harvey Aluminum Company has shipped 18-20 C reactor process tubes which are scheduled for delivery onsite on June 30.

[redacted]

[redacted]

Increased Graphite Temperature Limits at DR

The startup of DR reactor on June 1 and operation to the shut-down on June 17 was conducted under the provisions of Production Test IP-325-AC allowing a time-weighted increase of the graphite temperature limit to a maximum of 650°C even with a helium concentration in the reactor atmosphere as low as 20 percent. The higher temperature was allowed under test to gain reactivity through higher moderator temperature in place of a number of tubes of enriched fuel. The burnout of the graphite under startup of this sort is being monitored with inserted test pieces of graphite. The weight loss of these pieces will be measured after two startups.

Overbored Nozzles - C Reactor

Fluorescent-penetrant testing of the first of the overbored nozzles prepared for use with the 300 zircaloy tube facility in C reactor has indicated an unsuspected porosity. It has been concluded that the first ten tubes currently being installed in C reactor should be hand-charged with self-supported fuel elements and standard nozzles installed. This will provide perhaps two months' time for more complete evaluation of the suitability of the reamed nozzles for reactor use and for the evaluation of potential alternates.

Zr Thermal Fatigue Tests

An equipment failure in the testing equipment has resulted in a two-week delay in the steady-load thermal cycling program. Test results to date indicate no fatigue failures in more than 3000 thermal cycles between 200 and 800°F at stresses up to 35,000 psi.

Zr Sponge Specifications

Harvey Aluminum Company has been granted permission to increase the maximum limits of silicon in the sponge used for NPR process tubing from 100 parts per million to 190 ± 60 parts per million. The additional silicon was authorized on the basis of data which indicate that:

(1) The short term corrosion characteristics of the fabricated tubing would be improved somewhat.
(2) Metallographic examination of the fabricated material indicates that the additional silicon would result in more uniform distribution of alloying materials in the zirconium matrix.
(3) No data indicate unfavorable results from such silicon addition.

[redacted]

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NPR Graphite

The inquiry for bids for supplying about 300 tons of graphite for the front and rear reflectors and trunnion sleeves for the NPR has been sent out. The bid reply date is July 18. This is the last lot of graphite for the NPR for which an order is to be placed.

Shielding Studies

Film readings indicate that front face neutron leakage, which has reached an operating dose rate as high as 30 mrem per hour in some cases, passes through the iron rings and donuts around the gun barrels; no neutron moderating materials interrupt the travel of the neutrons through this region. Square polyethylene plates, which would moderate and scatter the escaping epithermal neutrons, are being considered as a short range relief; these plates would clip onto nozzle caps thus forming a transparent wall which should provide only negligible interference with normal front face personnel operation.

H-1 Loop

Naval Reactors cancelled the KAPL-120-8B list and all further testing in the H-1 loop. Determination of the ultimate disposition of the loop is in progress.

Equipment Experience

1) Eighty-four process tubes were installed; 67 at H, 10 at C (zirconium), 4 at B, 2 at D, and one at KW.

2) Five process water leaks were corrected, four tube and one Van Stone. Two of the tube leaks were at H and one each at B and C. The Van Stone leak was at H.

[redacted]

[redacted]

Heat Transfer and Temperature Effects

Transient heat transfer experiments were continued with a full-scale mockup of I&E fuel elements in a K process tube. Data concerning flow rates and fuel temperatures were obtained for conditions simulating a sudden decrease in front header pressure as would result from loss of high lift pumps, loss of line connecting pumps and reactor, or loss of a front riser.

Neutron attenuating measurements as a function of temperature have been completed for iron-serpentine concrete with a density of 265 lb/ft^3. The measured fast neutron removal cross section decreased by about 12 percent after prolonged baking at 320°C as compared with the as-cured material. The gamma dose rate through four feet of this concrete increased by a factor of three under the same conditions.

There is a period when the power level has not decayed to as low an equivalent heating value as the flow rate; hence, a period of inadequate cooling will result. The objective of the experiments was to determine the magnitude of front header pressure reductions which could occur without resulting in fuel element and process tube meltdown during the inadequate cooling period of the flow reduction-power decay transients. Nuclear heat generated and 5 percent of original power level for sensible heat removal from graphite stack are used for the calculations.

Preliminary analysis, for a tube power of 1000 KW and outlet temperature of 125°C, gave no excessive heater rod temperatures and complete recovery of adequate cooling was obtained when the header pressure was dropped down to 40 psig. For higher powered tubes, 1500 KW and 2000 KW, the header pressure required for adequate cooling was 80 psig and 150 psig, respectively.

Rear Tube Closure

Two prototype Mark V flapper valves were installed on the rear face of 105-KE on June 7 for observation. A requisition for 100 Mark V flapper valves and 100 ball valves has been issued.

Poison Spline System

The second K Area spline coiler was installed in KE and used June 8 startup. About 40 splines of 100 were removed from the reactor using a coiler.

Materials Development Operation

Ceramic Balls for 105 N Reactor

Ceramic balls poisoned with samarium oxide have been selected for NPR use.

[redacted]

[redacted]

Pile Gas Problem

Investigations of possible gas recovery and purification schemes is in progress. Efforts are now being centered on comparative economics of three different proposals:

1) Treatment of gas from startups and large purges only - including a 20,000 cubic foot gas holder capacity.
2) Treatment of entire circulating stream to remove O_2 and CO.
3) Additional treatment to keep N_2 within limits.

Preliminary spot estimates of recovered helium gas range from 1/2¢ to 1-1/2¢ per cubic foot with purification equipment cost of about 5,000 to 10,000 while prices of 10,000 cubic foot He-gas holders are quoted at $3,000 each.

Mechanical Development B

Basic test work is almost complete in Hydraulic Horizontal Control Rod.

Materials Development - 2000 Program

Metallurgy Programs

Corrosion Studies

Hydriding of Zircaloy-2 in Simulated NPR Stack Gas

Two groups of Zircaloy-2 coupons were exposed for 43 days in helium gas contaminated with 0.05 percent H_2 and 0.03 percent CO. This gas was prepared by passing tank helium over NPR graphite at 800°C where the traces of water in the gas were converted in part to hydrogen and carbon monoxide. The Zircaloy-2 samples were held at 350°C and 300°C while the gas flowed over them at a slow rate. Hydrogen analyses of the samples indicated no detectable hydrogen pickup in 43 days on either autoclaved or etched Zircaloy-2. From this test it was concluded that the system of 0.05 percent H_2, 800°C graphite and 350°C is a much safer operating zone than the 5% H_2, 1100°C graphite, and 400°C Zircaloy-2 system which resulted in hydriding failure in 53 days in earlier experiments. It is planned to continue the experiments for several more months to establish that the system is not hydriding at a rate undetectable for short exposure, but still unacceptably fast for the designed NPR tube life.

[redacted]

[redacted]

Zirconium-Hydrogen Reactors

Zircaloy-2 reacts with hydrogen rapidly at 500°C in the absence of any protective film on oxide-forming reagents. A chromium plate by a vapor deposition on Zircaloy-2 is being evaluated.

In one test, utilizing a ~~di-cumene~~ chromium vapor-deposition process, the very thin (0.005 mil) coating slowed down the hydrogen absorption rate in pure hydrogen at 500°C approximately 1000-fold. Evaluation and study of protective mechanism is continuing.

Reactor Program - Coolant Systems Development

Examination of KER Loop 1 Zircaloy Tube

Samples cut from three different locations along the tube have been examined metallographically. All three samples exhibited substantial recrystallization including one from the low-flux shield region which leads to the tentative conclusion that this was not irradiation-induced. Hydriding was estimated at less than 50 ppm.

One small pit approximately 10 mils in diameter and 3 mils deep was found which had not been reported previously.

Reactor Materials

Properties of NPR Reflector Graphite

The highest degree of preferred orientation yet observed in a production lot of reactor grade graphite as determined by coefficient of thermal expansion measurements is indicated by preliminary results on the Great Lakes graphite being supplied for the NPR reflector.

Sample Location and Orientation With Respect to Extrusion Axis	$\alpha \times 10^6$ 25 to 100	$\alpha \times 10^6$ 25 to 425	Ratio of Transverse to Parallel CTE's 25 to 100°C	25 to 425°C
Center of Bar Transverse	3.00	4.48	8.33	5.09
Center of Bar Parallel	0.36	0.88		
Edge of Bar Transverse	2.83	3.90	6.95	4.07
Edge of Bar Parallel	0.47	0.83		

[redacted]

[redacted]

The highest ratio previously observed was in KC graphite with a ratio of 4.05 for samples cut from the center of the bar measured between 25 and 425°C. Similar tests on AGOT-LS are in progress.

NPR Reflector Graphite Irradiation at ETR

Samples of NPR reflector graphite have been prepared and measured for the GEH-13-5 controlled temperature experimental capsule to be installed in the N-5 corner of the ETR. The capsule is designed for a sample temperature of 550°C and a fast neutron flux (E>1Mev) which varies by a factor of three along the length of the capsule. The experiment will consist of four sample positions with three wafer samples per position. Each sample cut will have two NPR graphite samples and one CSF graphite standard.

Annealing of Unirradiated Graphite

Unirradiated graphite which is annealed at temperatures above about 700°C undergoes some small growth. This length change is not associated with the much larger growth observed during relief of compression set, and may be related to the "freeing" of a graphite sample from a large bar. However, the mechanism of growth is not certain, and if full size bars also slightly expand this might explain the observed initial growth of graphite in reactors, such as C and K which have always run hot.

Cubes, 4" x 4" x 3-1/2", of CSF and GL-10 (needle-coke) graphite were heated in a hydrogen furnace to 900°C and held for two hours. The length changes measured varied from + .005 to + .01 percent and are believed to be the maximum effect attributable to annealing. Consequently, it is not now concluded that thermally induced expansion is important in initial reactor growth. A quantitative discussion of this experiment is found in HW-65815, "Thermally Induced Length Changes of Graphite Cubes."

Effects of Acid on Graphite

Dichromate-sulfuric acid solutions have been used to clean various aluminum reactor components. There has been recent interest in possible effects of this solution on graphite in connection with the cleaning of the Pneumatic and General Purpose Facilities. Four graphite samples were soaked in a weak dichromate-sulfuric acid solution for one hour then baked for one hour at 150°C and one hour at 250°C. X-ray examination showed a 0.1 to 0.2 percent increase in C_o for the four samples. There should be no serious consequences if a small amount of this mixture is spilled into the graphite.

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4000 PROGRAM - REACTOR DEVELOPMENT (GAS COOLED REACTOR POWER PROGRAM)

Graphite Studies

EGCR Graphite Irradiation

The experimental capsule, H-3, containing EGCR prototype graphite was successfully irradiated in the General Electric Test Reactor during cycle 13. All nine thermocouples operated satisfactorily during the cycle. Average sample temperatures along the capsule are: 350, 500, 650, 750, 750, 650°C.

During the cycle 14 shut-down now in progress the capsule and guide tube had to be removed from the reactor so a loop facility tube could be worked on. The capsule was reinstalled with no apparent damage.

Graphite Combustion Experiments

Experiments have been conducted on laboratory scale samples (cylinders up to 8" length and 7/8" diameter) to test the model proposed to evaluate graphite combustion conditions.

Agreement between observed and calculated temperatures has been good (±20°C). These tests will continue on several types of graphite to determine the effect of graphite reactivity on the ignition temperature.

Chlorine has proven very effective in control of runaway graphite oxidation. The addition of 2 percent (by volume) chlorine has elevated the graphite ignition temperature over 150°C and the successfully controlled combustion when the graphite temperature exceeded 1000°C.

Coatings Evaluation Studies

Several siliconized - SiC samples irradiated at 500°C to an exposure of several thousand MWD/AT are being tested. The samples are heated to 960 to 1000°C in flowing air until loss of weight indicates failure of the coating and attack of the graphite substrate. Two samples tested showed no attack.

[redacted]

[redacted]

Thermal Cycling Studies on Coatings

Three graphite rods coated with siliconized - SiC have been thermal cycled over a temperature range of 200°C to 1000°C in flowing air at 6 cycles per hour. Another rod is cycled three times per hour between 200°C and 1200°C. Coatings applied to selected graphites such as Great Lakes Carbon Company's "A" grade showed no significant change. Coatings on usual reactor grade graphite developed severe circumferential cracks with a resultant high weight loss in the graphite substrate.

Project CAH-822

The Phase "A" package remains at approximately 95 percent complete. Progress payment to this extent has been requested by Struthers-Wells and will be accomplished by the end of the month. The Hastelloy-X tubes for the electrical heater, the main delaying item, have been reordered from a new supplier after a history of rejected tubes from Carpenter Steel.

After experiencing repeated unsuccessful test runs of the blowers, Bristol-Siddeley reports the first blower has now been running at 6,000 rpm at 250 psi and 250 C. No new delivery date has been quoted.

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RUPTURED SLUG TABULATION FOR June, 1960

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	[redacted] Production Loss MWD	Days	Observations	
1583 H	3-31-60	6-1-60	1005	424	1134	.68	I&E Reg.	Side Other
2471 F	3-28-60	6-2-60	1237	466	268	.17	I&E Reg.	Mole end failure
3553 H	1-9-60	6-3-60	673	588	690	.41	Solid Reg.	Split
3964 D	3-21-60	6-9-60	1229	807	1125	.68	I&E E	Hot Spot
2178 H	3-31-60	6-16-60	969	468	720	.43	I&E Reg.	Hot Spot
2155 DR	2-11-60	6-17-60	873	554	583	.37	Solid Reg.	Side Hot Spot
2456 C	3-29-60	6-18-60	1074	697	695	.39	I&E E	Side Hot Spot
1889 C	4-9-60	6-20-60	1097	488	1695	.94	I&E Reg.	Side Hot Spot
[illegible] B	3-27-60	6-26-60	1245	[illegible]	207	.13	I&E Reg.	Unknown

[redacted]

[redacted]

June (Year)
OUTAGES (1960)

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	45.1	61.2	18.2	15.7	31.2	39.4	47.3	31.0	289.1
Maintenance	50.5	4.6	47.5	22.6	59.0	47.0	8.2	3.1	242.5
Rupture Removal	3.3	26.0	14.6	10.9	2.8	35.7	-	-	93.3
Leak Testing	0.8				22.1	40.7			63.6
Tube Replacement	7.5				6.8	91.8			106.1
Project Work		11.5						0.5	12.0
Production Tests	5.0	21.4		1.7		9.1	3.0		40.2
Instrument & Circuitry	15.6	20.3		2.7				3.9	42.5
Rupture Suspects									
Miscellaneous		7.9						0.8	8.7
Total	127.8	152.9	80.3	53.6	121.9	263.7	58.5	39.3	898.0
Scheduled Outages	98.6	97.0	49.9	33.7	92.2	172.0	56.1	34.5	634.0
Unscheduled Outages	29.2	55.9	30.4	19.9	29.7	91.7	2.4	4.8	264.0

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STANDARD FORM NO. 64

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Office Memorand DECLASSIFIED STATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: June 8, 1960

FROM : R. L. Plum, Chief
Reactor Branch

THIS DOCUMENT CONSISTS OF 11 PAGES
[redacted] COPIES, SER[redacted]

SUBJECT: MONTHLY REPORT FOR MONTH OF MAY 1960

HAN-74591-DEL
Rpt. No. 5

SYMBOL: OR:GTO:GRG

PRODUCTION

Record reactor input production was 5.4% above the previous maximum achieved during January, 1960. The production forecast was exceeded by 10.5%, with the six old reactors being 4.4% above and the K reactors 19.7% above. Forecast was exceeded due to high time operated efficiency and average operating level.

Overall-time-operated efficiency was 85.2% (82% forecast); 82.[illegible]% at the six old reactors and 91.8% at the K reactors.

There was no increase in the combined reactor instantaneous power level or in individual reactor record power levels. Individual reactor production records were achieved at B and KE, where previous highs were exceeded by 5.5 and 10.1%, respectively.

Ten ruptures (four I&E regular, five I&E enriched and one KER test element) were removed from the reactors. The four regular metal ruptures were at D, F, H, and KE. Three of the enriched pieces were at C and one each at B and DR. The number of ruptures during May was [illegible]% lower than the previous three-month average.

Reactor Outages

Reactor outages for the month of May are as follows:

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Reactor Outages

B Reactor

Date Down	Date Up	Outage Hours	Remarks
5/10	5/10		Trip due to faulty relay in emergency power circuit.
5/10	5/12		Maintenance completed after insufficient reactivity.
5/12	5/12	1.1	Repair of a faulty thermocouple in tube 2875.
5/12	5/12	0.3	Panellit trip due to an oscillating gauge on Row No. 17.
5/30	Still Down		Removal of a stuck I&E E-metal rupture in tube 0967.

C Reactor

5/3	5/4	32.0	Removal of an I&E E-metal rupture in tube 2287. Charge-discharge.
5/5	5/6	35.9	Removal of an I&E E-metal rupture in tube 2780.
5/14	5/14	0.4	High Panellit trip on gauge 3962.
5/20	5/21	31.8	Removal of an I&E E-metal rupture from tube 1792. Charge-discharge.

D Reactor

5/1	5/3	64.3	Removal of an I&E regular metal rupture in tube 1366. Charge-discharge.
5/13	5/14	38.3	Repairs of ruptured export water line.
5/28	5/30	36.0	Miscellaneous maintenance and charge-discharge.

[redacted]

[redacted]

DR Reactor

4/30	5/2	34.2	Removal of an I&E regular metal rupture from tube 0774. Charge-discharge.
5/13	5/14	41.7	Repairs on ruptured export water line.
5/20	5/21	35.8	Replacement of leaking tube 2672 and further leak testing.
5/22	5/22	0.6	Replacement of front face nozzle cap on 0764.
5/28	Still Down		Removal of an I&E E-metal rupture from tube 3858 and charge-discharge.

F Reactor

5/16	5/18	46.0	Removal of an I&E regular metal rupture from tube 2887 and charge-discharge.
5/20	5/21	36.0	Removal of tube 0977 which had a split rear Van Stone.
5/22	5/22	0.4	Tripped due to malfunction of No. [illegible] relay which caused a loss of No. 7 pump at the [illegible] Building.

H Reactor

5/11	5/11	0.2	Panellit trip.
5/11	5/13	46.5	Removal of an I&E regular metal rupture from tube 3171 and charge-discharge.
5/24	5/26	47.6	Leak testing and charge-discharge.
5/26	5/26	1.3	Panellit trip when a rear face cap came loose on 0963.
5/26	5/26	0.9	Tightened a loose rear cap on 2279.
5/28	5/28	0.2	Leaking rear pigtail on tube 0490.
5/28	5/30	34.5	Severed rear pigtail on tube 0490.
5/30	Still Down		Water leak.

[redacted]

[redacted]

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KE Reactor

5/14	5/16	48.0	Removal of a stuck I&E regular metal rupture from tube 1661 and charge-discharge.
5/16	5/16	2.2	High activity trip on Loop 3 due to a rupture in tube 3565.

KW Reactor

5/3	5/4	18.8	Beckman trip and insufficient reactivity Removal of a solid regular metal rupture from tube 0484.
5/17	5/18	33.3	Panellit trip due to rolling gauges and charge-discharge.
5/31	Still Down		Panellit trip on tube 0280.

[redacted]

[redacted]

EQUIPMENT EXPERIENCE

1. Sixteen process tubes were installed; 12 at DR, two at H and one each at D and KE.

2. Five tube leaks and three Van Stone leaks were corrected. Three of the tube leaks were at DR and one each at B and C. Two Van Stone leaks were at H and one at F.

3. On May 18th, the 2-C relay in the emergency electrical power system failed at B reactor. This caused the emergency alternator to come on, bucking the BPA voltage. The resulting voltage fluctuation in the instrument power supply caused a scram, and the overheating required replacement of the relay and considerable wiring. This relay was original equipment, and it failed primarily because of old age. The system has been restored to normal.

4. Both D and DR were shut down May 13 due to leaks in the raw water line.

5. On May 13 one of the 183-D pump motors failed during a motor start. The damaged motor is being shipped off-site for repair.

Charge Seaters

Equipment to take the place of the charging machine during the fuel piece seating portion of the cycle has been delivered to all areas. The seaters were operatdd during recent KE, KW, D, and DR outages.

Safety Control

The operational experience tests on the sub-critical monitor system have been successfully completed for all eight reactors.

Control Efficiency

As a result of nearly full spline usage, the average non-equilibrium loss for C and K reactors for April and May was 0.28 of an equilibrium day. This compares with one full day average loss per startup in the fourth quarter of CY-1959, a period representing pre-spline startups, and 0.7 of a day loss per startup for these three reactors during the first quarter of CY-1960, a period when spline usage was being expanded at the K reactors.

[redacted]

The average flattening efficiency during CY-1960 as measured by total ECT has averaged about 2 percent higher than the 1959 average; spline usage and the block discharge at DR have been major contributors.

Reactor Power Level Limitations

The primary power level limit at all reactors except H was tube power based on rupture control at the goal exposure permitted by the available metal supply. H reactor power level was restricted by bulk outlet temperature.

Reactor Fuels

Projection Fuel Testing

Twenty tubes of collapsible bumper elements and twenty tubes of control elements were charged in D reactor on May 13, under PT-IP-262-A. Each tube of bumper elements is paired with a tube of control elements to assess comparative behavior. One pair of tubes is scheduled for discharge at 400 MWD/T, two pairs at 800 MWD/T and the balance at 1,200 MWD/T.

An organization for scope design to convert one reactor for use of bumper fuel elements is being formed. Project representatives have been appointed.

Dingot Uranium Testing

The remaining monitor tubes of alloyed dingot material were discharged from D reactor at an exposure of 800 MWD/T. The elements are being examined. No results are available yet.

KER Testing

Eleven natural uranium Zircaloy-2 jacketed tubular elements 1.47 inch O.D., 0.40 inch I.D., with different beta heat treatments, one Zircaloy-2 jacketed seven-rod cluster element, and one 0.89 inch diameter natural uranium Zircaloy-2 jacketed rod in a Zircaloy-2 sleeve were charged in KER-3 on May 11, 1960. Shortly after the reactor started up on May 16, neutron activity was noted in the loop. The neutron monitor indications increased in severity until the reactor was shut down with a neutron monitor trip approximately ten hours after start-up. The elements were discharged and are awaiting examination to determine the cause of failure. The loop was not recharged.

E-N Load Analyses

Discussions have been held with Savannah River personnel regarding the separation of the mint material discharged from the recent small scale E-N test. Because of the short time since discharge, a calorimetric method of tritium determination appears not to be feasible.

[redacted]

Straight extraction on a laboratory scale will be required. Accuracy of the results of the tritium determination will probably not be better than 2%.

Metal Coefficient Measurements

An analysis has been made of scram transients for reactors with I&E loading, yielding an average metal coefficient of $-.075 \frac{ih}{MW}$ or $1.875 \times 10^{-6} \frac{\delta K}{MW}$ As a comparison the Giant program yielded a metal coefficient of $-.064 \frac{ih}{MW}$ Further investigations will be made including evaluating the effect of delayed neutrons on the analysis of scram transient tests. Ultimately the metal coefficient will be of use in refining miscellaneous safety and operational calculations.

Pu-238 Buildup

Calculations of the Pu-238 concentrations at various exposures were completed. Results are given below:

Exposure	Gms Pu-238/T Natural U	Gms Pu-238/T E-Metal
0	0	0
200	$1.45 \pm .22 \times 10^{-3}$	$1.47 \pm .22 \times 10^{-3}$
500	$14.6 \pm 2.5 \times 10^{-3}$	$15.0 \pm 2.5 \times 10^{-3}$
800	$43.9 \pm 7.3 \times 10^{-3}$	$46.0 \pm 7.5 \times 10^{-3}$
1000	$74.3 \pm 12.4 \times 10^{-3}$	$78.4 \pm 12.6 \times 10^{-3}$

Graphite Temperature Limits

PT-IP-312-A and PT-IP-325-AC providing for an increase in graphite temperatures at K and DR reactors, respectively, were prepared and approved during May. The K reactor change was of immediate advantage during startup and the increases are expected to be utilized in DR during the present outage.

[redacted]

Decontamination

C Reactor was decontaminated for the first time with an internal-external chemical flush. Using essentially the same system used successfully at the K reactors, the entire rear face of 105-C was decontaminated on April 20, 1960. The flush took approximately 18 hours to accomplish, but it saved almost half of an estimated five-shift maintenance sbhedule. Exposure to personnel was reduced to less than a quarter of normal,efficiency was improved 100%, and a number of comments by craftsmen and supervisors indicated a marked morale boost.

PHYSICS 2000 - 4000 PROGRAM

A new filament design has been used for the ion source of the heavy-element mass spectrometer to provide isotopic analyses in support of the Critical Mass Laboratory, Plutonium Recycle Program, and other programs of Nuclear Physics Research. The new filament design gives greatly improved yields of heavy metal ions and enhances the performance of this spectrometer for plutonium analyses.

For plutonium compounds in aqueous solution or other hydrogeneous mixtures, a quantity of special interest is the limiting concentration for which k_{oo} becomes unity. Providing the H/X ratio can be maintained at values for which $k_{oo} <$ unity, no other restrictions will be required to insure nuclear safety. Experiments were begun in the PCTR for determining the concentration at which k_{oo} = unity for a plutonium nitrate solution. The initial solution concentration of Pu in the buffer tank was 6.5 gm Pu/L, but this concentration appears to have been too low ($k_{oo} \simeq 0.86$) to properly analyze the experimental results. Further measurements are being made with higher Pu concentrations. The buffer tank has been refilled with Pu solution at a nominal concentration of 8.5 gm Pu/L, and with core tank concentrations in the range of 809 gm/L.

The digital computer code APDAC-I (a PCTR Data Analysis Code-I) has been placed in production use. This code provides a rapid and flexible means for analyzing the raw data obtained in flux traverse experiments by the foil activation technique. Theprincipal advantages to the customer of this code over usual data reduction codes are:

1. Data are recorded directly on special forms, from which input cards are punched, thus minimizing errors.

2. A complete statistical analysis of the data is made. Use of the code will permit a decrease in the amount of professional personnel time needed for data analysis and an increased efficiency of utilization of the experimental facilities.

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FISSIONABLE MATERIALS - 2000 PROGRAM

Coolant Systems Development

In-Reactor Single-Pass Testing

The six KE single-pass tubes were recharged. Two tubes are now testing the corrosion of standard aluminum-jacketed fuel in 7.0 pH process water with 1 ppm dichromate inhibitor, two in pH 6.5 2 ppm dicromate, and the other two tubes contain regular unweighed production elements.

Structural Material Development

C Reactor Zircaloy Tubing

Fabrication of 200 smooth-bore Zircaloy-2 tubes for C reactor is nearly on schedule. One hundred and seventy tubes are expected to be ready for shipment on the new delivery date of July 1, and the remaining 30 should be completed by July 15. Included in this group will be four to six tubes made an extra five feet long for corrosion tests in K reactor.

[redacted]

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[illegible] (Year) [redacted]
OUTAGES ( )

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	29.7	25.7	44.6	83.8	26.7	40.8	13.2	30.0	294.6
Maintenance	27.6	7.5	49.7	61.0	41.8	72.5	4.8	15.7	280.7
Rupture Removal	7.3	66.3	24.0	20.5	2.4	5.3	20.8	0.7	147.3
Leak Testing	1.2	0.0	0.0	11.2	4.8	33.2	0.0	0.0	50.4
Tube Replacement	11.0	0.0	8.9	23.0	5.3	4.5	0.0	0.0	52.7
Project Work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	5.5
Production Tests	0.2	0.0	12.4	0.7	0.0	0.0	10.8	0.0	24.1
Instrument & Circuitry	7.5	0.4	0.0	0.0	0.4	0.0	0.0	18.6	26.9
Rupture Suspects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.0	1.4
Total	94.5	99.9	139.6	200.2	81.4	156.3	50.2	71.5	883.6
Scheduled Outages	63.2	30.7	94.1	136.9	70.8	83.0	27.2	49.6	555.5
Unscheduled Outages	21.3	69.2	45.5	63.3	10.6	73.3	23.0	21.9	328.1

[redacted]

RUPTURED SLUG TABULATION FOR May, 1960

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations
[illegible]-D	3/21/60	5/1/60	1194	278	1960	1.22	I&E Regular - Unknown
2287-C	2/29/60	5/3/60	1199	543	810	.44	I&E E - Hot Spot
2780-C	2/29/60	5/5/60	1169	525	3388	1.83	I&E E - Hot Spot
3171-H	2/8/60	5/11/60	1158	645	440	.25	I&E Regular - Side Failure
1661-KE	3/10/60	5/14/60	1118	493	3339	.93	I&E Regular - Hot Spot
2887-F	2/1/60	5/16/60	1055	686	210	.13	I&E Regular - Side Other
1792-C	2/29/60	5/20/60	1005	675	1976	1.07	I&E E - Hot Spot
3858-DR	3/9/60	5/28/60	991	733	1097	.69	I&E E - Hot Spot
0967-B	3/13/60	5/30/60	1468	703	732	.45	I&E E - Unknown
3565-KER-B	5/15/60	5/16/60					Due to high contamination conditions in the KE reactor storage basin, it has not been possible to examine the fuel elements closely for visual rupture confirmation.

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STANDARD FORM NO. 64

[redacted]

Office Memorandum • UNITED STATES GOVERNMENT

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TO : Process Engineering and Manufacturing Division Files

DATE: May 9, 1960

FROM : R. L. Plum, Chief Reactor Branch

HAN-74591-DEL
Rpt. No. 4

This document consists of 17 pages
[redacted] of [redacted] copies, S [redacted]

SUBJECT: MONTHLY REPORT FOR MONTH OF APRIL, 1960

SYMBOL: OR:GTO:GRG:HAH

Production

Reactor input production was 7.0 percent above forecast; 3.1 percent above at the six old reactors and 13.2 percent above at the K's. Forecast was exceeded due to improved average power levels and nonequilibrium losses.

Overall time operated efficiency was 81.6 percent (82 percent forecast; 80.8 percent at the six old reactors and 84.1 percent at the K's).

The combined reactor instantaneous power level was not increased. The individual reactor power level was increased 5 megawatts at DR (1830 to 1835). New input production records were achieved at D and DR reactors, exceeding previous records by 5.4 and 3.7 percent, respectively.

Ruptures

Eleven ruptures, seven I&E regular, three I&E enriched and one tube-in-tube, were removed from the reactors.

Three of the I&E regular ruptures were at F, two at C and one each at B and KW. The three enriched ruptures were at C, DR and KW and the tube-in-tube element was in KER loop No. 4.

Reactor Outages

Reactor outages for April, 1960 are as follows:

[redacted]

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B REACTOR

Date Down	Date Up	Outage Hours	Remarks
4/4	4/9	125.3	Scheduled charge-discharge, tube replacement and Ball 3X work.
4/9	4/9	3.5	High temperature indicated on tube 2180. Investigation revealed a faulty thermocouple.
4/26	4/29	73.5	Removal of a stuck I&E regular metal rupture from tube 0668 and charge-discharge.

C REACTOR

Date Down	Date Up	Outage Hours	Remarks
4/1	4/1	0.6	Removal of an I&E regular metal rupture from tube 2588.
4/9	4/10	32.6	Removal of an I&E regular metal rupture from tube 1275 and charge-discharge.
4/11	4/11	0.3	Panellit trip.
4/11	4/13	32.1	Panellit trip; insufficient reactivity. Miscellaneous maintenance performed.
4/19	4/25	147.7	Removal of a stuck I&E E-metal rupture from tube 1380, charge-discharge and scheduled maintenance.

D REACTOR

Date Down	Date Up	Outage Hours	Remarks
4/10	4/13	61.1	Water leak and charge-discharge.

[redacted]

[redacted]

DR REACTOR

4/1	4/2	37.1	Water leak.
4/12	4/14	37.8	Charge-discharge and miscellaneous maintenance following a trip originating with a transformer failure at 190 Building.
4/30	Still Down		Removal of an I&E E-metal rupture from tube 0774.

F REACTOR

3/28	4/1	83.6	Removal of a stuck I&E regular metal rupture from tube 3873. Charge-discharge and tube replacement.
4/3	4/4	33.8	Removal of a stuck I&E regular metal rupture from tube 1169.
4/8	4/10	38.0	Removal of a stuck I&E regular metal rupture from tube 1569 and charge-discharge.
4/26	4/28	40.8	Removal of an I&E regular metal rupture from tube 3683 and charge-discharge.

H REACTOR

3/31	4/4	83.8	Removal of an I&E regular metal rupture from tube 1464 and charge-discharge.
4/4	4/4	0.8	High pressure Panellit trip.
4/4	4/4	0.2	Panellit trip due to poison only partially flushing from a ball valve tube.
4/18	4/20	54.6	Water leak and charge-discharge.
4/23	4/24	34.9	Leak testing.

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KE REACTOR

4/1	4/2	37.1	Tripped due to loss of No. 6 high-lift pump and charge-discharge.
4/8	4/9	31.5	Unexplained trip of HCR's and charge-discharge.
4/23	4/25	43.5	Tripped by a rupture in KER Loop 4, and charge-discharge.
4/26	4/26	0.6	Tripped due to a faulty thermocouple on Loop 4 heat exchanger.
4/27	4/29	29.8	Trip caused by a faulty grounding circuit in the Loop 3 heat exchanger temperature measuring system, and insufficient re-activity.

KW REACTOR

4/6	4/7	34.4	Removal of an I&E E-metal rupture from tube 2548 and charge-discharge.
4/28	4/30	56.9	Removal of a stuck I&E regular metal rupture from tube 1385 and charge-discharge.

[redacted]

Files [redacted] DECLASSIFIED May 9, 1960

Equipment Experience

(1) Sixty-three process tubes were installed; 48 at B, three at D, four at DR, two at F, five at H and one at KE.

(2) Three tube and three Van Stone leaks were corrected.

(3) One of the CG-600 pump impellers at 190-C (Byron Jackson pumps) incurred failure of a shaft interstage seal ring during operation, forcing shutdown of the unit.

(4) At C reactor the rear ball valves were removed from the 111 tube OCD facility and thermocouple leads were replaced on rows 68 through 75.

(5) An unscheduled outage at DR reactor was caused by the failure of a 13.8 KV/440V transformer which also caught fire.

(6) While attempting to replace No. 2 HCR at KW approximately three feet of the rod end broke off at the step plug. The rod was left out of service for later replacement.

(7) Class "A" overhauls on No. 3 and 4 KE river pumps and No. 2 and 6 KE high lift pumps and motors were completed.

Present Reactor Technology

Projection Fuel Testing

The first two columns of self-supported fuel irradiated in C reactor ribless zirconium process tubes were discharged during the outage of March 10, 1960. Exposure at discharge was approximately 775 MWD/T. Goal exposure for these columns was specified at approximately 200 MWD/T above the normal variable goal. A replacement charge of 20 tubes of bumper elements to be charged under PT-IP-262-A-FP is under preparation in FPD.

Dingot Uranium Testing

Four monitor columns of dingot uranium were discharged at about 400 MWD/T for special measurements. The examination of these monitor columns revealed no significant difference between the dingot and the control ingot material with respect to either warp or diameter change.

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KER Testing

The process tube in Loop No. 1 was replaced. Leak problems were solved and the loop is currently charged with dummies on a shake-down cycle prior to charging fuel elements.

On April 23, a failure occurred in the enriched tube-in-tube elements being irradiated in KER-4 at a coolant outlet temperature of 280°C. Exposure at the time of failure was 1070 MWD/T. Discharge of the elements was accomplished without difficulty and observations revealed no failure on the outer surfaces of any of the elements. Radiometallurgy exmaination will be carried out as early as possible.

SS Accountability

The program devised to predict isotopic concentrations as a function of exposure has been modified slightly. The expression for the effective resonance integral is now:

$$R.I. = [1 + \alpha (t - 20)] A + [1 + \beta (t - 20)] B \sqrt{S/M}$$

where

$A = 2.81$ barns $\qquad \alpha = 1.6 \times 10^{-4} / ^{\circ}C$

$B = 24.7$ barns $\qquad \beta = 3.18 \times 10^{-4} / ^{\circ}C$

The concentration of Pu 242 in natural and 0.946 precent enriched uranium was calculated for various exposures. The concentrations appearing below are for K reactor with a 38 piece natural I&E charge and a 46 piece enriched I&E charge. A Pu 241 capture cross section of 500 barns was used.

MWD/Ton of U	Pu 242 in Grams/Ton of U
Natural U	
100	0.001
200	0.001
300	0.004
400	0.015
500	0.030
600	0/056
700	0.100
800	0.166
900	0.253
1000	0.371
1100	0.512

[redacted]

Enriched U

700	0.040
800	0.068
900	0.183
1000	0.150
1100	0.217

Ceramic Ball Strength

Sufficient 305 pile tests have been completed to permit determining the concentrations of samarium and gadolinium required in a ceramic ball to provide the same control strength as the boronsteel - carbon steel mixture presently used at the K reactors.

.532 gms/cc of ball, gadolinium oxide
.445 gms/cc of ball, samarium oxide

Zircaloy Tubes

As reported last month, Bridgeport Brass Co. has completed the initial fifty smooth-bore C reactor Zircaloy-2 process tubes. Harvey Aluminum Co. has packaged for shipment 32 additional tubes. With the receipt of the Harvey tubes, a total of 95 smooth-bore C reactor tubes will have been received.

Earthquake Studies

Authorization has been received to continue the earthquake vulnerability studies with Lockheed Aircraft Corporation and the Holmes and Narver Company to a total level of $92,600, and the completion date has been extended to June 15, 1960.

Graphite

The first 18 dih purity sample bars from top and bottom reflector graphite were received from National Carbon Co. in April. The dih purity values ranged from +0.46 to +0.53, which compares with a minimum requirement of +0.25. Bulk density of the sample bars averaged 1.68 as compared to a specification requirement of 1.71 ±.03.

The first six dih purity sample bars from top and bottom reflector graphite were received from Great Lakes in mid-April. The dih purity values ranged from +0.38 to +0.46.

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Reactor Effluent Treatment

Design of a small scale test facility at 100-K Area in which the development study of effluent water treatment will be carried out was begun. The tank will be about 3 X 6 X 20 feet with facilities for sampling the bed medium and water at intervals along its length. Water from the 107-KW tank will be passed through the tank and dumped back into the KW effluent line.

Pile Physics Assistance

Startup efficiency at the K reactors continued to show a 50-70 percent improvement through use of splines. Both C and H reactors realized a 50-60 percent decrease in losses per startup, C reactor with initial spline application and H reactor with more aggressive procedures utilizing the PCCF system.

The new germinol graphite thermocouple stringers presently installed in B and F reactor, permit continuous observation of the front-to-rear flux distribution in good detail.

Equipment Development

The machine for charging self-supported fuel elements was delivered to 105-C reactor. Modifications to the machine mounting on the elevator are in progress to facilitate a quick exchange between this and the standard machine.

The analog-to-digital converter, with solid state circuitry, was installed in 105-B Area and is operating satisfactorily except for one minor exception which the vendor is correcting.

Two out of five in-core chambers ordered from Anton Electronics have been received.

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2000 PROGRAM

Experiments were run to investigate the conditions required to sweep out steam from a BDF process tube when boiling was initiated after temporary flow interruption during shutdown conditions. It was found that, depending on tube power, single phase flow could be recovered upon removal of the flow blockage. However, if the tube was boiled dry, flow could not be resumed without an increase in front header pressure.

A mathematical equation was derived to express the outlet water temperature limits for Hanford reactors as based on thermal hydraulic considerations. The equation is based on a considerable amount of experimental data, and it is expected to save time in determining limits as compared to the graphical method now in use.

The final formal report (HW-64774) on the shielding properties of ferrophosphorous concrete as a function of temperature has been written. The total dose rate (due to both neutrons and gamma) through four feet of this material in the as-cured condition was found to be due primarily to gamma leakage. After prolonged heating at 300°C, the principal contribution came from resonance neutrons, due to loss of water.

An interim report entitled "Effect of High Temperature on Masonite", (HW-64868) has been written. There was no appreciable damage to the masonite below 160°C. The kindling point in air was found to be 245 - 265°C.

Metallurgy Program

Sample Exchange With Harvey Aluminum

A cooperative test program to help resolve differences in the results of corrosion tests of Zircaloy-2 has been initiated with Harvey Aluminum. A series of 112 samples have been prepared consisting of 40 samples of sheet stock Zircaloy-2 and 72 samples cut from 9 NPR tubes recently received from Harvey Aluminum. The samples have been divided into four parts and will be handled as follows:

[redacted]

[redacted]

Part A - Etched and autoclaved at Hanford
B - Etched and autoclaved at Harvey Aluminum
C - Etched at Hanford; autoclaved at Harvey
D - Etched at Harvey Aluminum; autoclaved at Hanford

Weight gain data and visual appearance of these samples are expected to establish where Hanford and Harvey Aluminum testing methods differ.

Structural Materials Development

NPR Process Tubes

The Hanford position on interpretation of the corrosion test specifications for NPR process tubes has been clarified in a letter to vendors. Some confusion and difference of opinion has been apparent in sample preparation, particularly with respect to the amount of metal to be removed from the surface. The thin layer of disturbed metal at the surface normally does not react favorably in a corrosion test. For this reason about 0.002 inch of metal is normally removed from the tube surface before it is placed in service, and corrosion test samples from the tubes are similarly treated.

Zircaloy Retubing Program

Good progress is being made in the fabrication of the 200 Zircaloy-2 smooth bore tubes for C reactor scheduled for delivery by June 15. Proposals have been received from three vendors for the trial of a new fabrication process for producing these tubes on subsequent large orders. Development cost will be borne by the vendors.

Seventeen Zircaloy-2 BDF internally ribbed tubes meeting all specifications have been fabricated under a development contract. Due to a change in plans and designs, all further development and production on ribbed replacement tubes has been terminated.

KER Loop No. 1 Tube

The KER Loop No. 1 Zircaloy-2 process tube was discharged during the month. This tube contains four defect areas (two pits, and two small protrusions) and two areas of scratches. Examination of these defects

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in Radiometallurgy will be started in early May. Five samples of the tube from the front and rear edge of the moderator, and the 1/4, 1/2, and 3/4 positions in the moderator will be subjected to flattening tensile and burst tests, and metallographic examination for grain structure and hydride needles.

Radiometallurgical Examinations

1.47% Enriched I&E Fuel Elements (RM-404)

The self-supported elements that were irradiated under PT-IP-274-A for approximately 800 MWD/T were received for examination. The entire outside surface of both pieces was covered at the time of discharge with a heavy black scale that is usually found associated with hot-spot type corrosion.

The black scale had been largely removed by a chemical treatment after discharge, leaving a rough, orange-peel surface on the aluminum can wall. There was no evidence of any accelerated attack on the aluminum such as was found on the two non-supported elements examined previously.

The bond layer on both the outside can wall and the inner spire have been found to be cracked and separated in many places. Micro cracks in the uranium emanating radially from the inner bore were found.

Severely Corroded Process Tube from 105-DR (RM-401)

A sample from a 2S aluminum process tube which failed in channel 1265-B, seven months after it had replaced an original tube, was examined. The tube had been attacked on the upper side of the downstream end of the slug charge. Visual examination disclosed grave pitting attack which had penetrated the tube wall in two locations in the four-inch long sample. The attack included about two inches of the circumference of the tube. No heat effects were noted and the metal quality was consistent with commercial grade 2S aluminum.

MATERIALS DEVELOPMENT

Van Stone Inserts

Tests have established a satisfactory design and material for the Van Stone insert. The detailed drawings and specifications have been completed and forwarded to Plant and Industrial Engineering for a full-pile application.

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Decontamination

The 105-C reactor was decontaminated April 20, 1960, in an 18-hour period prior to the start of planned maintenance work (removal of OCD ball valves and replacement of thermocouple loadings. This was C's first decontamination. A decontamination factor of 3.2 was obtained, effectively doubling the utilization of the craftsmen. (Turco 4306-B was the flush, 5 gpm/tube at 60°C).

VSR Gas Seals

An effort to improve the service life of the K reactors vertical safety rod gas seals has been completed successfully. Improved materials and methods of holding the seals in place have yielded fourteen months of service, with good indication that they will provide adequate seal for another year. Previous seals became badly worn in a month or two.

Operational Leak Detection Via Condensation Nuclei Methods

A reactor as system mock-up is currently being constructed to evaluate the operation characteristics. Estimated completion date June 1.

Slug Position and Tube Marking System

A means is desired by which the irradiation and canning history can be quickly determined for any discharged slug picked up in the storage basin. Document HW-60468 covered the economics of the various proposals, the method adopted includes serial marking and dating of the pieces in the 300 Area Canning Operation, a photographic record of the charges as they go on the elevator, and IBM cards for a complete record of each piece.

Mechanical Development

Early development work for the expansion program was directed toward evolving a new concept for front-to-rear crossheader process tube fitting assemblies and related hardware. Currently GE is considering fastening the rear tube assembly solidly to the reactor and taking the small amount of zirconium tube expansion with the front assembly.

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The prototype charging machine for charging self-supported fuel elements into smooth bore zirconium process tubes at C reactor was delivered to the reactor.

A development design was 60% complete for a charging machine to charge bumper fuel elements into ribbed process tubes in support of a production test for this fuel element design. The difference between this charging machine design and the one for self-supported fuel is the requirement for orienting the bumper slug to bridge the tube ribs.

Measurements of the fission cross section in the lowest energy resonances of U-236 and U-238 gave values significantly lower than predicted by nuclear theory. The value for U-236 was low by a factor of 100.

Preliminary values of k_{oo} and f for two plutonium fueled graphite lattices were obtained from PCTR data. The plutonium was a 1.8 w/o alloy with aluminum.

PCTR measurements requested for the EGCR were completed on schedule. The last experiment done was a measurement of k_{oo} and f for uranium oxide rods enriched to 2.6 percent U-235. Analysis of the data obtained has not been completed.

2000 Program - Production of Fissionable Material

Reactor Materials

Hot Test Hole Irradiations

Two CSF graphite "do-nuts" have been irradiated in the 2C test-hole at KE to determine the contraction characteristics of graphite under stress. A graphite plug was inserted into the hole of one "do-nut" with the preferred orientation of the plug rotated 90° from that in the surrounding do-nut. The transverse thermal expansion is about twice the expansion parallel to the grain at the irradiation temperature, producing a compressive force on the plug in the transverse direction during irradiation. A do-nut without a plug inserted was also irradiated for comparison. After 1674 MWD/AT the unstressed do-nut had contracted .02% in the parallel direction, with no change measured in the transverse direction. The contractions measured on the stressed do-nut were .03%

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in both the transverse and parallel directions. The contractions measured for the plug were ~.05% in both the transverse and parallel directions. Because of the combined effects of thermal expansion, irradiation contraction, and probably initial irradiation expansion, the stresses are difficult to analyze; however, it is apparent that the contraction rates were altered by the stress-inducing do-nut arrangement.

4000 PROGRAM - REACTOR DEVELOPMENT (GAS COOLED REACTOR POWER PROGRAM)

Graphite Studies

Graphite Burning Experiments

Graphite burning experiments are being conducted to aid in evaluation of potential hazards to the EGCR. In the preliminary work 1/2 inch diameter graphite samples in a one inch I.D. quartz tube are being utilized. The graphite is not heated except by the gas and the combustion.

Graphite was found to ignite at 750°C in an oxygen stream of 2.0 cfh, burning with a blue flame. Oxygen flow and temperature were varied to determine the effect on the combustion. Combustion continued unless the oxygen flow dropped to 0.2 cfh. The reaction was very flow sensitive and insensitive to oxygen temperature variation.

O_2 Temperature (°C)	Flow cfh	Maximum Graphite Temperatu[illegible] At Center of Sample([illegible]
500	2.0	990
700	5.0	1300
700	2.0	990
700	0.5	825
750	2.0	990
800	2.0	990

EGCR Lattice Prototype

The full-scale prototype EGCR lattice unit in which the final burning experiments are to be conducted is nearing completion. Instrumentation has been installed, and essentially all equipment including the needle-coke graphite is on site.

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EGCR Graphite Irradiation

Construction of the EGCR graphite irradiation capsule has started. Mock-up tests for the assembly configuration, and calculation of predicted sample temperatures have been completed. These temperatures are estimated to vary between 300C and 700 C along the length of the capsule. The temperatures were confirmed within 10 percent by the mock-up tests.

Based on the mock-up test, a configuration similar to the GETR H-1 capsule will be used. Four quarter-cylinder samples, 1 inch in diameter and 3-7/8 inch long, fit into graphite sample holders which are screwed tightly into molybdenum centering discs attached to the aluminum cooling rings. The cooling rings are swaged into the aluminum can. A cooling tab has been added to the center of the support rods to prevent the rods from melting. Flux monitors of nickel, iron, and cobalt-aluminum are located in holes in the cooling rings. The capsule has been sealed and is being prepared for shipment.

It is estimated that the actual costs of $835,000 for loop construction in FY-1960 will underrun by approximately $50,000 to $100,000 because of a delay in delivering the Bristol Sidely primary loop blowers and PRTR construction completion date slippage of two months. A firm shipping date of the blowers depends upon blower tests in Conventry, England. The completion of the loop in FY-1960 at a cost of $835,000 can still be done. Every possible method of costing this money in FY-1960 will be used.

[redacted]

RUPTURED SLUG [redacted] 1960

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations	
-,38 C	1-24-60	4-1-60	1186	466	483	.28	I&E Reg	Hot Spot
1169 F	1-4-60	4-3-60	1133	546	2462	1.59	I&E Reg	Unknown
2548 KW	2-23-60	4-6-60	1518	222	1670	.47	I&E E	Hot Spot
1569 F	2-1-60	4-8-60	1131	392	2486	1.60	I&E Reg	Side Other
1275 C	2-10-60	4-9-60	1045	400	1207	.66	I&E Reg	Hot Spot
1380 C	2-29-60	4-19-60	1212	437	751	.41	I&E E	Hot Spot
0668 B	1-10-60	4-26-60	1041	607	2683	1.66	I&E Reg	Unknown
3688 F	2-1-60	4-26-60	1185	521	1286	.83	I&E Reg	Side Other
1385 KW	2-23-60	4-28-60	1103	514	2354	.66	I&E Reg	Unknown
0774 DR	2-1-60	4-30-60		774	1242	.71	I&E E	Side Other
4268 KER	2-21-60	4-23-60	725	1053	2455	.73	Tube in Tube	
					[redacted]			

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April (Year)
OUTAGES (196[illegible])

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	46.6	16.4	12.3	9.8	30.2	87.8	35.8	55.3	294.2
Maintenance	39.7	66.1	26.9	22.8	13.9	35.4	7.7	11.3	223.8
Rupture Removal	34.5	22.2	--	15.6	61.6	3.8	--	22.7	160.4
Leak Testing	1.8	--	15.6	23.8	--	34.6	--	--	75.8
Tube Replacement	79.7	--	6.4	--	7.0	2.0	--	--	95.1
Project Work		106.3							106.3
Production Tests		1.2					61.2	1.0	63.4
Instrument & Circuitry						1.0			1.0
Rupture Suspects									
Miscellaneous				3.9			32.8	1.0	37.7
Total	202.3	212.2	61.2	75.9	112.7	164.6	137.5	91.3	1057.7
Scheduled Outages	159.6	170.3	44.1	32.6	46.8	52.4	69.0	64.0	638.8
Unscheduled Outages	42.7	41.9	17.1	43.3	65.9	112.2	68.5	27.3	418.9

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STANDARD FORM NO. 64

Office Memorandu DECLASSIFIED ATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: April 12, 1960

FROM : R. L. Plum, Chief Reactor Branch

THIS DOCUMENT CONSISTS OF 2 PAGES NO [redacted] COPIES, SERIES [redacted]

SUBJECT: MONTHLY REPORT FOR MONTH OF MARCH 1960

HAN-74591-DEL
Rpt. No. 3

SYMBOL: OR:GTO:HAH

PRODUCTION

The reactor monthly production forecast was exceeded by 3.0 percent at the six old reactors and 10.3 percent at the K's for a combined average increase of 5.9 percent.

Overall-time-operated efficiency was 80.9 percent (81 percent forecast); 79.9 percent at the six old reactors and 83.8 percent at the K's.

Power Levels

The individual reactor record power level was increased 50 megawatts at DR (1780 to 1830).

Ruptures

Fourteen ruptures, eleven I&E regular, two I&E 94 metal and one solid regular, were removed from the reactors. Three of the I&E regular metal ruptures were at KW, two at D, two at F and one each at B, C, DR and H. The two I&E 94 metal failures were at C and DR and the solid regular at KE.

Reactor Outages

Reactor outages for the month of March are as follows:

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B Reactor

Date Down	Date Up	Outage Hours	Remarks
3/3	3/6	74.2	Leak testing.
3/13	3/14	37.7	Removal of a stuck I&E regular metal rupture in tube 2184. Charge-discharge.
3/22	3/23	36.0	Panellit trip when rear pigtail broke off of tube 3667. Charge-discharge and miscellaneous maintenance.

C Reactor

Date Down	Date Up	Outage Hours	Remarks
2/29	3/2	49.7	Removal of an I&E regular metal rupture in tube 3087, and charge-discharge.
3/2	3/2	0.5	Panellit trip due to an oscillating gage.
3/2	3/2	4.0	Poison discharge.
3/4	3/5	30.5	A heat imbalance caused by VSR #35 dropping. Charge-discharge.
3/17	3/19	35.5	Removal of an I&E 94 metal rupture from tube 0566. Charge-discharge and maintenance.
3/19	3/19	2.5	Repair of two faulty thermocouples.
3/29	3/31	33.5	Removal of a stuck I&E regular metal rupture from tube 2567. Charge-discharge.

D Reactor

Date Down	Date Up	Outage Hours	Remarks
3/3	3/5	34.3	Removal of a suspected I&E regular metal (mixer) rupture in tube 4187 and charge-discharge. The rupture was not confirmed.
3/21	3/25	85.5	Removal of an I&E regular metal rupture in tube 3563. Charge-discharge and maintenance.
3/25	3/27	35.4	Removal of an I&E regular metal rupture in tube 1463, and maintenance.

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DR Reactor

Date Down	Date Up	Outage Hours	Remarks
3/9	3/11	38.5	Leak testing.
3/22	3/23	44.1	Removal of an I&E regular metal rupture in tube 3877. Charge-discharge.
3/25	3/26	32.0	Removal of an I&E 94-metal rupture from tube 0859.

F Reactor

Date Down	Date Up	Outage Hours	Remarks
3/1	3/3	48.3	Removal of an I&E regular metal rupture in tube 2369 and charge-discharge.
3/3	3/3	3.7	Panellit trip due to a tubular dummy in the nozzle at the rear pigtail.
3/9	3/11	52.1	Leak testing and charge-discharge.
3/28	Still Down		Removal of an I&E regular metal rupture in tube 3873 and charge-discharge.

H Reactor

Date Down	Date Up	Outage Hours	Remarks
3/2	3/5	67.1	Leak testing and charge-discharge.
3/11	3/12	34.1	Power failure caused by the failure of No. 2 process pump at F. Charge-discharge and maintenance.
3/12	3/13	2.1	Panellit trip due to a Hoke valve being partially closed.
3/15	3/17	41.6	Leak testing and charge-discharge.
3/31	3/31	0.5	High pressure Panellit trip on tube 1464.
3/31	Still Down		Removal of an I&E regular metal rupture in tube 1464.

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[redacted]

KE Reactor

Date Down	Date Up	Outage Hours	Remarks
3/10	3/12	49.0	Panellit trip due to the failure of a pump servicing single pass tubes 4557 and 4863. Charge-discharge.
3/19	3/21	30.0	Power loss trip. Charge-discharge.
3/23	3/24	30.9	Removal of a solid regular metal rupture in tube 2044. Charge-discharge.

KW Reactor

Date Down	Date Up	Outage Hours	Remarks
3/11	3/13	66.2	Removal of an I&E regular metal rupture in tube 2060 and charge-discharge.
3/13	3/14	21.2	Removal of an I&E regular metal rupture in tube 2562.
3/15	3/15	6.0	Poison discharge.
3/17	3/18	38.0	Removal of an I&E regular metal rupture in tube 3557 and charge-discharge.

[redacted]

Limits

Except at DR reactor, the primary limit to all reactor power levels at the end of the report period was based on fuel element failure control at the goal exposure currently in effect. DR reactor power level was restricted by bulk outlet temperature limitations.

EQUIPMENT EXPERIMENT

Tube Replacement

Fifty-five process tubes were replaced, 35 at F, 11 at D, three at KW and two each at B, DR and H.

Water Leaks

Ten water leaks were corrected (5 tube leaks and 5 Van Stone leaks). Two tube leaks were at H and one each at B, DR and F. Four Van Stone leaks were at F and one at B.

4500 H.P. Primary Pump Drive Motor Failures - 100-F

Three 4500 H.P. motors at 100-F area failed during the month because of insulation breakdown. The reason for the insulation breakdown is not definitely known, but these failures were similar in nature to three previous failures that have occurred on CG-558 motors. The problem has been under study for some time, and a recommended solution to the General problem is expected to be received from the General Electric Company's Apparatus Department within a few weeks.

One of the above mentioned failures caused relay action on the 230 kv system between the 100-F and 100-H areas, resulting in the opening of a circuit breaker in the 100-H substation with interruption of B.P.A. service to that area. All emergency power equipment in 100-H area responded in a satisfactory manner.

Block Discharge at DR

The uniform low exposure of the central core loading following the block discharge at DR reactor resulted in a new high ECT of 1600 and the achievement of a new power level record; the previous twelve-month average ECT was 1520.

[redacted]

Reactor Fuels

Projection Fuel Testing

Irradiation of self-supported elements in B and C reactors continued without incident.

Twenty tubes of bumper elements prepared for charging under PT-IP-262-A-FP, "Evaluation of Projection Fuel Elements for Use in Ribbed Process Tubes," were rejected as a result of support attachment weld penetrations. These penetrations became apparent during examination after autoclaving, and upon metallographic examination this condition was found to be general.

Dingot Uranium Testing

Irradiation of fuel under PT-IP-280-A-FP, "Irradiation of Alloyed Dingot Uranium Fuel Elements," continued during March. Four of the 12 control columns were discharged at a goal exposure of 400 MWD/T for special measurement and to check for early stability effects. Results of these measurements will form a basis for the goal exposure of the remainder of the 30 tons still under irradiation. The only measurement performed to date on this metal is for warp, and these results indicate no significant difference between ingot and dingot.

A rupture was sustained in one of the lots of alloyed dingots charged under PT-IP-280-A. Examination of the failure, classed as a "side other" did not indicate a failure mechanism related to the dingot core.

Alternate Component Vendor Evaluation

Fuel elements fabricated using aluminum components provided by Hunter-Douglas Division of Bridgeport Brass Company were charged under authorization of PT-IP-171-A-FP, "Evaluation of Aluminum Caps and Cans From New Vendor." Successful irradiation of this material will include Hunter-Douglas in the list of "qualified" component vendors currently limited to ALCOA and Harvey Aluminum Company.

Advanced Reactor Fuel

IBM Design Analysis

A revised and rewritten IBM program for calculating flux skewing and step by step analyses of fuel operating conditions in the process

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tube has been completed. Results for a 22 lb./ft. NPR fuel element show that, in the absence of corrective action taken by the appropriate use of horizontal control rods, the fuel power density tends to peak upstream from center approximately 4 to 5 feet at a level insignificantly higher than for the usual symmetrical cosine distribution.

Reactor Physics

Reactor Dynamics

Preliminary results of a dynamic analysis of the NPR indicate that the present design possesses satisfactory dynamic stability. The estimated amplitudes of power over-shoots associated with small sudden rod movement are within satisfabtory limits.

Reactor Engineering

Flow Protection

Analyses of the possibility of boiling burnout in K reactor process tubes for various transient conditions were completed. The conclusions reached were that no burnout will result from B.P.A. power loss or from loss of a single low- or high-lift pump. The analyses also showed that significant power surges could be tolerated on either 5-or 6-pump operation without encountering film boiling in the process tubes.

Corrosion

Data on the effects of up to 0.20 ppm turbidity on fuel jacket corrosion rates obtained from PT-IP-233-I have been analyzed. The data show that turbidity levels up to 0.2 ppm do not effect corrosion rates.

Two charges of fuel elements which had been coated with a water soluble silicate coating were irradiated in C reactor for 10 days under the terms of PT-IP-308-F. The coating caused no detectable ill effects and did reduce the degree of rib galling. The main part of the test will now be changed to determine long-term corrosion effects.

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FISSIONABLE MATERIALS - 2000

Thermal Hydraulic Studies

K Reactor Cross-Tie Limit

The K reactors are provided with a complex coolant cross-tie system through which a reactor that has lost its coolant supply may be provided coolant from the other reactor. A problem of concern is the case where a BPA outage to both reactors is followed by the failure of the emergency electrical system of one of the reactors. In this case the emergency coolant from one reactor is small and the coolant supplied to the other reactor may be insufficient to prevent fuel element and process tube melting even though the reactor is scrammed almost immediately after the outage. It is desired to provide a reactor power level limit to provide adequate cooling for the above condition.

For a postulated case of any emergency shutdown of a K reactor, the following may be said:

1. If flow and heat generation rates are such that bulk steam generation occurs for any length of time after the reactor is shut down it is likely that excessive fuel element temperatures will result. One of the main factors contributing to excessive temperatures with bulk steam generation is the likelihood that most of the cooling water will pass through the lower tubes and leave the upper tubes deprived of coolant. Calculation of the certainty and the extent, if any damage, are very complicated and the results are subject to considerable error.

2. The analysis of shutdown cooling conditions can be performed with considerable confidence if flow and heat generation rates are such that no bulk steam generation occurs after the reactor is shut down. For such cases, initial operating levels for the reactor can be accurately established to provide any degree of protection desired.

Shielding Studies

Neutron Attenuation Measurements

The following table summarizes the measured removal cross-sections obtained recently in the Shield Facility:

[redacted]

Bake Temp. °C	Ferrophosphorus 300 lb./ft^3	Ordinary 150 lb/ft^3	Iron-Serpentine 265 lb./ft^3	Iron-Serpentine 210 lb./ft^3
	Measured Fast Neutron Attenuation (cm^{-1})			
As Cured	0.131	0.0780	0.124	0.110
100	0.121	0.0735	0.113	
200	0.117	0.0724		
300	-	0.702		
320	0.114			

The Argonne Laboratories neutron recoil counter is expected to be used to evaluate several different resonance energy neutron fluxes at Hanford.

Gamma response calibrations up to 80,000 R/hr. on nine aluminum shell ion chambers for use in the shielding program have been completed.

Design and Component Testing

NPR Charging Machine

Development of a quick disconnect magazine end cap has been started.

Metallurgy Program

Corrosion Studies

Hydriding of Zircaloy-2

Significant concentrations of hydrogen will be formed in the NPR stack gas if water leaks into the stack and contacts the hot graphite, and even the normal steady-state concentration of hydrogen in the stack gas may be on the order of 0.1 percent. Consequently, the rate of hydriding of Zircaloy-2 by molecular hydrogen is being studied.

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Copper Removal From Extruded Zircaloy Surfaces

A test was run to determine whether Zircaloy would pick up hydrogen during removal of the copper coating with nitric acid. None of the tested samples exhibited any signs of hydriding.

Etching Process for NPR Tubes

A continuous etching process is being developed for possible application to NPR process tubes.

Reactor Program

Coolant System Development

NPR Decontamination Studies

A section of carbon steel piping from KER Loop 1 was decontaminated with 10% Turco 4512 (inhibited phosphoric acid) using a single-pass technique. After 19 minutes, the activity was reduced essentially to zero.

For decontamination of the NPR primary loop system after a rupture, it appears that the last procedure is one using three steps:

a. Peroxide - carbonate - bicarbonate.
b. Alkaline permanganate
c. Some inhibiged acid.

Structural Materials Development

Burst Tests on KER Tubing

Three unirradiated samples, with about 70% cold work, were burst tested at 300°C. The primary purpose of these tests was to evaluate at elevated temperature, the mechanical end-closures designed for room temperature testing of irradiated tubing. The burst data are listed below. These tube samples are nearly equivalent in size and fabrication histroy to the Zr-2 tube now in KER loop.

Test No.	Temperature $^\circ$C	Bursting Pressure, psi	% Elongation
1	300°	8300	6.6
2	275°	8350	5.8
3	300°	8350	5.8

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NPR Process Tubes

Pilot quantities of NPR pressure tubes have been inspected by Zyglo fluorescent penetrant dye and ultrasonics with test results as follows:

Test	No. of Tubes Tested	No. of Tubes With Indications
Ultrasonic (0.003" Scratch Standard)	19	11
Ultrasonic (.005" Scratch Standard)	17	1
Fluorescent Penetrant (Outside)	18	13
Fluorescent Penetrant (Inside)	18	9
Weld Radiography	12	5

Further testing showed that surface conditioning to about 0.002" of metal would eliminate most defects and 0.005" would eliminate all surface-defect indications.

Retubing Program

A total of 63 smooth Zr-2 tubes for C reactor have been delivered. Of these tubes yet to be delivered, 36 are awaiting final inspection and two are in the final processing steps. Two additional 100-tube orders have been placed for June 15 delivery.

PHYSICS - 2000

Exponential pile experiments continued on a rod-and-tube fuel element and a tube-in-tube element. The tube-in-tube element was measured in an 8-3/8" lattice in a 6 x 8 foot pile. The same lattice had been measured previously in a 6 x 4 foot pile. The 6 x 8 foot pile gave an extrapolation length of about one inch as compared to a 1.7 inch value obtained in the 4 foot pile. The preliminary buckling value appears to be about ten microbucks less than measured in the 4 foot pile.

A preliminary value of $k_{oo} = 0.985$ has been obtained via the PCTR for the lattice discussed above (8-3/8" lattice spacing, 2.5" x 2.0", 1.66" x 1.1" tube-in-tube element).

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Analyses have been completed on PCTR experiments designed to develop a technique for measuring k_{oo} for lattices where k_{oo} is less than unity. Three techniques were tried. They resulted in k_{oo} values for a particular lattice of 0.949, 0.941, and 0.939 with an uncertainty of ± 0.002. The reasons for the spread between the top and bottom values are not understood.

Instrumentation for the Critical Mass Laboratory was finally shipped by the vendor on March 30.

A paper by D. G. Foster, "Age of Na-BE Neutrons in Water and Kerosene" has been rewritten at the suggestion of a reviewer for Nuclear Science and Engineering. The results were re-analyzed using a better theoretical model for the asymptotic flux. Final experimental values are in excellent agreement with theory.

Subthreshold fission measurements have been completed on the 5.2 ev resonance in U-234. The peak fission cross section value is 49 ± 9 barns. The fission width is $(2.0 \, ^{+2.2}_{-1.0}) \times 10^{-5}$ ev.

The mass spectrometer used in the Iotopic Analysis R and D Program operated at about 90 percent efficiency during the month.

2000 Program - Production of Fissionable Material

Fast Flux Monitoring

The results of Ni activation in 1573 DR indicated that the integrated fast neutron flux per MWD/AT in an annulus tube facility is approximately one-half that in a cold test hole. No accurate absolute value can be reported since the fast flux spectrum in the annulus tube is not known. An estimate which is probably good to within 50 percent is 2×10^{16} nvt (1 Mev)/(MWD/AT). Net thermal flux values were $1.34 \times 10^{17} \pm 0.2$ nvt/(MWD/AT) using Co activation, and the Cobalt cadmium ratio was 13.0 ± 0.5, where the limits of error are the experimental deviations from the mean value. These fast flux measurements show that the temperature coefficient of the rate of radiation damage in graphite below 300°C is actually less than reported in HW-47776 and other Hanford documents presenting the work of annulus tube irradiations.

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Flux Computations

Fast neutron flux calculations for C, K and N reactors have been completed using a multi-group, one dimensional, diffusion type code. The results may be summarized as follows:

1. The ratio of the integrated fast flux/(MWD/AT) at K to that at C is 1.3.

2. The ratio of the integrated fast flux/(MWD/AT) in the NPR to that in K is 2.2.

3. The theoretically derived, absolute value for the integrated fast neutron flux/(MWD/AT) at the Y test hole in C is 4.6×10^{16} nvt (1 Mev).

A document, HW-64393, is in preparation which will include the results of these calculations in greater detail.

Conversion Factor for Y Test Hole, C Reactor

Since most of Hanford hot test hole data have been obtained at the Y test hole in C reactor, the knowledge of the fast flux in that facility is necessary to intercompare rates of damage in off-site irradiations with the old Hanford results. The final, best estimate for that conversion factor is 5.0×10^{16} nvt (1 MEV)/(MWD/AT). This result was obtained using the shape of the fast flux spectrum from the computations cited above and a theoretically derived energy dependence of the activation cross section for the Ni^{58} (n,p) Co^{58} reaction.

Graphite Burnout Monitoring

Samples discharged on January 25, 1960, from the center of channel 1960-C were hightly pitted and showed a burnout rate of 35 percent per 1000 operating days. Emission spectroscopy analysis of scrappings of the pitted areas indicated the presence of trace to moderate amounts of iron, vanadium, and silicon, while gamma spectroscopy showed the presence of iron. The high concentration of impurities in the pitted areas was confirmed by auto-radiographs.

The catalytic effect of impurities was demonstrated in the laboratory, where the burnout rate of treated samples (soaked overnight

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.001 M solution of ferric chloride and vanadium sulfate) was three times greater than that of control samples (3.8×10^{-3} gm/gm hr. at 600 C in dry air). The treated sample showed development of pitted areas, while the control sample was oxidized evenly.

Samples from 3066-KE were discharged on March 20, 1960 after thirteen months exposure.

<u>4000 Program - Reactor Development (Gas-Cooled Reactor Power Program</u>

<u>Gas Loop Project (CAH-822)</u>

Fabrication of the in-reactor section is 20 percent complete. About 55 percent of the required material has been received.

<u>Graphite Studies</u>

<u>EGCR Graphite Irradiation</u>

Designs for three possible EGCR graphite sample configurations have been completed which incorporate four quarter-cylinder, 4-inch long samples held together as a unit. Mockup tests of these designs have been initiated to aid in confirming heat transfer calculations made for the three configurations.

<u>Radiation Damage Annealing</u>

Very recent work shows that the contraction of graphite which occurs during high temperature irradiation can be altered by annealing at higher temperatures. The dimensional changes during annealing seem to be associated with a removal of interstitials from between the lattice planes with a resulting further contraction in the C^o lattice direction but a growth (recovery) in the A_o direction.

<u>Thermal Oxidation</u>

Samples of British nuclear grade graphite have been oxidized in flowing CO_2. At 750°C, the specimens lost weight at a rate twice that of CSF graphite. It was noted that the material was coarse in structure, evidently with large coke particles.

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Metallograph Studies

Typical samples of each available raw coke have been polished after impregnating with epoxy resin. Pictures at 50 x and 250x are being made on the metallograph with bright field, polarized light and sensitive tint plates to reveal characteristic details. Samples of CSF, TSGBF and GL-10 (needle coke) graphite have been prepared with polished surfaces parallel and transverse to the whole bar extrusion axis. No outstanding characteristics have been found which might distinguish between areas related to coke particles and areas of graphitized binder. Samples of calcined coke have been prepared for comparison with the raw cokes and graphites.

[redacted]

RUPTURED SLUG TABULATION FOR

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations
59-F	1-4-60	3-1-60	1230	376	1977	1.24	I&E Regular - Hot Spot
2060-KW	12-19-59	3-11-60	1461	661	6316	1.78	I&E Regular K-III - Unknown
2184-E	12-14-59	3-13-60	1201	571	1660	1.07	I&E Regular - Unknown
2562-KW	1-22-60	3-13-60	1397	373	2357	.66	I&E Regular - Unknown
3557-KW	1-22-60	3-16-60	1398	387	4290	1.21	I&E Regular - Unknown
0566-C	1-21-60	3-17-60	1174	442	582	.33	I&E 94 Metal - Hot Spot
3563-D	1-4-60	3-21-60	1187	548	2075	1.27	I&E Regular - Side Other
3877-DR	2-18-60	3-22-60	1120	212	1932	1.11	I&E Regular - Side Other
2044-KE	12-7-59	3-23-60	784	402	4599	1.40	Solid REgular - Split
0859-DR	2-1-60	3-25-60	902	377	1415	.82	I&E 94 - Hot Spot
1463-D	1-4-60	3-25-60	1135	557	2651	1.62	I&E Regular - Unclassified
3873-F	1-4-60	3-28-60	-	553	1010	.64	I&E Regular - Side Other
2567-C	1-24-60	3-29-60	1106	429	1460	.82	I&E Regular - Hot Spot
1464-H	12-28-59	3-31-60	1133	659	659	.37	I&E Regular - Unclassified
					[redacted]		

[redacted]

[illegible] OUTAGES (Year) (1950)

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	26.9	41.4	[illegible]	26.8	4.8	23.0	37.4	32.8	265.8
Maintenance	32.4	55.2	35.7	20.6	25.1	50.9	2.4	15.7	235.0
Rupture Removal	23.9	21.3	55.0	40.0	39.6	3.6	25.7	79.4	289.4
Leak Testing	64.7	3.0		25.5	34.8	66.1			195.1
Tube Replacement			18.4		42.7				61.1
Project Work							5.4		5.4
Production Tests		15.8	4.5	0.8	1.0	2.7	14.3		39.1
Instrument & Circuitry		.5	6.5		3.6				10.6
Rupture Suspects									
Miscellaneous						7.8	24.8	3.5	36.1
Total	147.9	137.2	154.8	114.7	187.6	155.0	110.0	131.4	1138.6
Scheduled Outages	49.3	88.3	88.4	42.0	91.4	61.8	51.6	33.1	505.9
Unscheduled Outages	98.6	48.9	66.4	72.7	96.2	93.2	58.4	98.3	632.7

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STANDARD FORM NO. 64

Office Memorandum [redacted] DECLASSIFIED STATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: March 9, 1960

FROM : R. L. Plum, Chief
Reactor Branch

HAN-64521 - DEL
Rpt. #2

SUBJECT: MONTHLY REPORT FOR MONTH OF FEBRUARY 1960

SYMBOL: OR:GTO:GRG:HAH

THIS DOCUMENT CONSISTS OF 20 PAGES
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PRODUCTION

Reactor input production was 0.7 percent above forecast; 4.3 percent below at the six old reactors and 8.2 percent above at the K reactors.

Overall-time-operated efficiency was 76.5 percent (82 percent forecast); 75.3 percent at the six old reactors and 80.4 percent at the K reactors. Efficiency was low due largely to the large number of ruptures and small increases in outage time for water leak correction and production tests.

The combined reactor instantaneous power level was not increased. Record power levels at the individual reactors were increased at B reactor (1685 to 1730MW), D (1710 to 1765), DR (1710 to 1780), F (1815 to 1825), H (1825 to 1890), KE (3730 to 3800), and KW (3810 to 3840).

Ruptures

Twenty-one ruptures, seventeen I&E regular, three solid regular, and one I&E E, were removed from the reactors. Five of the I&E regular metal ruptures were at C, 5 at H, 3 at KW, 2 at B, one at KE and one at F. Two of the solid regular metal ruptures were at KE and one at H. The I&E E rupture was at KE. A failed cluster fuel element was removed from No. 1 KER Loop on February 7.

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Reactor Outages

B REACTOR

Date Down	Date Up	Outage Hours	Remarks
1/31	2/2	38.8	Removal of an I&E regular metal rupture from tube 1575 and miscellaneous maintenance.
2/2	2/2	3.1	Investigated the high water exit on tube 1564.
2/9	2/11	40.1	Panellit trip and charge-discharge.
2/11	2/11	21.6	Removal of an I&E regular metal rupture from tube 3880.
2/26	2/29	73.9	Removal of a stuck I&E regular metal rupture from tube 3284 and charge-discharge.

C REACTOR

2/4	2/5	39.9	Removal of a stuck I&E regular metal rupture from tube 2875. Seven zirconium tubes were installed.
2/6	2/7	29.2	Removal of a stuck I&E regular metal rupture from tube 2276.
2/7	2/7	4.0	Poison discharge.
2/10	2/12	63.5	Removal of a stuck I&E regular metal rupture from tube 1478 and charge-discharge.
2/13	2/13	3.1	Poison discharge.
2/14	2/15	28.5	Removal of a stuck I&E regular metal rupture from tube 0765. Retubed three channels.
2/15	2/15	.9	Panellit trip.
2/29	Still Down		Removal of an I&E regular metal rupture from tube 3087. Charge-discharge is in progress.

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D REACTOR

1/31	2/2	45.2	Temperature control due to a faulty ball valve on a PCCF tube. Miscellaneous maintenance work performed.
2/21	2/24	65.9	Scheduled charge-discharge, tube replacement and trip-out tests.

DR REACTOR

2/1	2/1	.4	Panellit trip due to a faulty light socket in the PCCF control system.
2/1	2/3	45.4	PCCF charging machine hung up while attempting to discharge ball valve tube 2173. Completed leak testing.
2/3	2/3	1.4	High pressure Panellit trip.
2/4	2/4	.7	Unexplained trip on No. 1 safety circuit.
2/11	2/13	37.3	Charge-discharge following the correction of a loose Venturi assembly.
2/13	2/13	.3	Panellit trip, probably due to solid aluminum charge seating in the tube.
2/18	2/23	127.6	Loose Venturi on tube 3467. Charge-discharge and leak testing.
2/24	2/24	1.5	Continuation of trip-out testing.

F REACTOR

2/1	2/6	134.9	Scheduled charge-discharge and maintenance.
2/6	2/7	29.2	Manual trip due to insufficient control rods.
2/25	2/29	80.7	Removal of a stuck I&E regular metal rupture from tube 1985. Charge-discharge.

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H REACTOR

2/8	2/10	36.4	Removal of a solid regular metal rupture from tube 0755 and an I&E regular metal rupture from tube 0770. Charge-discharge.
2/10	2/10	1.0	Investigation of by-pass indications in the safety circuit.
2/11	2/11	.2	Unexplained Panellit trip.
2/11	2/12	33.0	Removal of an I&E regular metal rupture from tube 3661.
2/13	2/13	3.8	Removal of a stuck I&E regular metal rupture from tube 0884.
2/13	2/13	.3	Panellit trip due to a rear pigtail failure.
2/16	2/17	32.6	Removal of an I&E regular metal rupture from tube 2978. Charge-discharge. (Further inspection of the metal discharged from tube 0770 (due to a suspected rupture) on 2/8/60 confirmed the presence of an I&E regular metal rupture.
2/17	2/17	1.6	Low pressure Panellit trip due to a rear cap leak on tube 2370.
2/17	2/17	2.8	Low pressure Panellit trip due to a rear cap leak on tube 2675.
2/22	2/24	34.3	Removal of a stuck I&E regular metal rupture from tube 2673. Charge-discharge.

KE REACTOR

1/31	2/2	35.3	Tripped due to a faulty dump valve on KER Loop 2, and miscellaneous maintenance.
2/7	2/9	32.7	Tripped due to a suspected cluster fuel element failure in Loop 1. Charge-discharge.

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KE REACTOR (cont.)

2/21	2/22	33.1	Removal of a solid regular metal rupture from tube 5556. Charge-discharge.
2/22	2/23	7.1	Removal of a solid regular metal rupture from tube 4645.
2/23	2/25	37.9	Water leak testing.
2/25	2/25	10.9	Indications of a water leak on the near side. Tube 4651 was found to be leaking and was replaced.
2/25	2/25	.7	Unexplained Panellit trip.
2/26	2/26	.7	Removal of an I&E E-metal rupture from tube 1151.

KW REACTOR

2/5	2/6	34.5	Removal of an I&E regular metal rupture from tube 3890 and charge-discharge.
2/23	2/25	60.2	Removal of an I&E regular metal rupture from tube 2459 and charge-discharge.
2/26	2/26	22.6	Removal of a stuck I&E regular metal rupture from channel 2483.
2/27	2/27	4.7	Poison discharge.

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Equipment Experience

1. Seventy-nine aluminum process tubes were replaced.

2. Eleven tube leaks and two Van Stone leaks were corrected.

3. Vertical rod channels 41 and 58 at C reactor were boroscoped and found blocked by displaced graphite at 12 and 19 feet from the top of the unit.

4. Dual area trip-out tests (PT-IP-301-1) were successfully completed at D-DR reactors.

Reactor Fuels

Projection Fuel Testing

PT-IP-274-A charged into B reactor at the end of November, was designed to demonstrate the relative performance of rib-supported and self-supported fuel under identical irradiation conditions. The fuel used was 1.47 percent enriched uranium. On December 23 and 30, control column failures were sustained, and on December 30, the remaining two control columns were discharged. The test material remained in reactor until its discharge on February 9, without a failure. Statistical evaluation of the test indicated that a factor of improvement in rupture resistance of 30 had been demonstrated at a confidence level of 95 percent. Visual examination of the elements showed no hot spot corrosion patterns as compared with 13 observed (in addition to the two failures) on the control elements. Operating conditions for both test and control material included specific power above 100 kw/ft., calculated surface temperatures up to 150°C and for the test material exposures above 850 MWD/T.

E-N Irradiation

The 20 remaining central zone striped columns under irradiation at H reactor are scheduled for discharge during the next outage.

KER Loop Irradiations

On February 7, 1960, a failure occurred in the 1.6 percent enriched Zircaloy-2 jacketed cluster elements being irradiated at a coolant temperature of about 230°C in KER Loop 1. The exposure at failure was 2520 MWD/T. Cause of failure has not yet been determined.

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Reactor Physics

Zirconium Tube Hazards Review

A review of the possible hazards associated with the use of zirconium tubes in the old reactors has been completed. The results of the study, which will be documented immediately, are that the zirconium process tubes in themselves will not worsen the safety status of the Hanford reactors. In some cases, instead, improvement can result. Higher melting point process tubing will contain fuel elements subjected to inadequate cooling for a longer period of time. Also the thinner process tube wall allows a greater latitude in fuel element sizing and in some cases results in a lattice configuration less overmoderated than at present.

Reactor Engineering

Zirconium Process Tubing

Three of the four contracts for Zr-2 ribbed process tubes in BDF geometry have been cancelled.

A total of nine ribless zirconium process tubes are now in place in C reactor, including seven installed during February. Thirteen more are in storage at Hanford and 24 are enroute from Bridgeport Brass Co.

Graphite Distortion

Traverses of the top center process tubes at B and F reactors have indicated an increase of .15 to .3 inches in the elevation of inlet and outlet humps and of the center depression since readings taken approximately three months ago. The behavior expected would have included little or no change in the elevation of the humps and decreases of about 0.1 inches in the elevation of the center depressions. A repeat traverse was made at B reactor and indicated that the measurements were not in error. Recent traverses of center tubes in D and DR reactors showed the expected behavior. The reasons for the unusual behavior in B and F reactors are being sought. Traverses of the top center tubes will be repeated at about one month intervals (rather than the usual three months) to monitor the course of graphite distortion.

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File Physics

Non-equilibrium loss reductions in excess of 50 percent were achieved during several startups at the two K reactors through large-scale use of poison splines for transient control. Significant startup efficiency improvement at DR and H reactors were made following additions to and relocation of FCCF columns. The average flattening efficiency as measured by the total ECT reached a record high of nearly 77.5 percent of all reactor tubes with most reactors at a relatively high point in flattening. KE reactor achieved an ECT value of 80.5 percent of total reactor tubes.

Flattened Zone Discharge

The first full flattened zone discharge was carried out at DR reactor during an extended outage February 18 to 24. Initial operation following the startup was promisingly consistent with reactivity and flattening predictions.

Rear Face Improvements 105-KE - KW

An improved handling system for rear face nozzle caps incorporates the use of a gravity roll conveyor, nozzle cap tracks and cap trays used in connection with an engineered system of removing, servicing, and replacing nozzle caps for charge-discharge activities. The installation of the new equipment at KE and KW are complete and similar equipment has been programmed for the remaining reactors.

Inspection of Rear Risers

The 105-B rear risers were inspected on February 1, 1960. The near risers had one suspect area which may be cracked and a sample line that should be secured. The far risers appeared sound.

1904-F

During the last F reactor outage, approximately 25 cubic yards of grout were pumped underneath and around the outlet end of the 1904-F outfall box, and the holes in the walls of the box around the outfall lines were caulked with lead, wool, and grout to repair a serious water leak.

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Overboring

A successful attempt was made to overbore a process channel in D reactor. Approximately twenty feet of the channel was bored out in a thirteen minute operation with a carbide tipped cutter, using slow speed and heavy feed. The tool was not visibly dulled.

Spline Coiler Machine

The use of a poison-spline coiler machine was demonstrated at 105-KW reactor and except for deficiencies in the reel design, the machine performed satisfactorily. An improved reel prototype was designed and preliminarily tested with no problems.

FISSIONABLE MATERIALS -2000 PROGRAM

Thermal Hudraulic Studies

Fourteen different combinations of rear fittings were examined in the hydraulics laboratory as part of the feasibility study for increased flow rates in the BDF type reactors by use of larger rear hydraulic fittings. Most of the fourteen cases examined consisted of reaming the existing header fittings (Parker fitting) and using larger J-type connectors. The data indicated that normal single tube flow rates could be increased up to 15 percent above present rates. The maximum flow rate corresponds to that attainable by using a complete K reactor-type rear assembly on a BDF tube. Attainment of such flow rate increases is based on an assumption of constant front header pressure; since reactor hydraulic supply curves probably show a decrease in front header pressure with flow increase, the total reactor flow increase would be less than the single tube analysis would indicate. Mechanical problems may also limit the use of the largest reamed fittings which were tested (0.650" ID header fitting). The results are reported in HW-63756.

Heat Transfer Experiments Pertaining to Present Production Reactors

Three sets of experimental data concerning thermal hydraulic characteristics of BDF-type reactor process tubes under various conditions were completed. These data, obtained from the full-scale electrically heated low pressure heat transfer apparatus, were as follows:

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1. Steady state hydraulic demand curves for enlarged rear fitting at standard rear header pressure.

2. Similar data with the same test section at rear header pressures at 150 psig.

3. Steady state hydraulic demand curves at very low tube powers with standard rear fittings.

For data set No. 1, flow instability would not occur due to plugging for tube powers less than about 1,100 KW if the tube were supplied with flow from a front header at a pressure of 550 psi. Double protection for upstream plugging by a high trip would not be realized with tube powers less than 600 KW, with initial Panellit pressures equal to 180 psi.

For data set No. 2, the hydraulic demand curves align with similar curves for low rear header pressures in the boiling region. This is significant in that studies of hydraulic stability for reactor operation at high rear header pressures can be conducted with existing data.

For data set No. 3, the hydraulic demand curves obtained for tube powers of 50, 100, 200 and 300 KW were carried to flows sufficiently small that the pressure drop had reached a maximum and was decreasing with decreasing flow. This factor makes this data of particular value in analysis of shutdown cooling conditions.

Laboratory Equipment

The high pressure heat transfer apparatus remained shutdown for modifications to allow greater flow and heat transfer rates as provided by Project CGH-834. Progress was generally on schedule and operation of the apparatus was still planned for the second week in March 1960.

Considerable difficulty has been encountered in recording thermocouple readings from electrically heated test sections when using the new silicon rectifiers as a heat generating source. The a-c ripple imposed on the d-c output of the rectifiers induces an undesirable current in the thermocouples used to measure surface temperature in the heat transfer test sections. Suitable filters for the recording instruments were developed that would filter out the a-c components in the thermocouple signals without greatly affecting the response time of the instruments.

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Shielding Studies

Neutron and Gamma Attenuation

The iron-serpentine concrete (265 lb/ft^3) test slabs were removed from the oven, where they were baked at 320°C, and placed in the shield facility for irradiation. The data indicated there was a 7.1 lb/ft^3 water loss after the concrete was baked at 100°C and 8.1 lb/ft^3 after the 320°C bake. This leaves a total of 6.4 lb/ft^3 of water retained in the concrete after the 320°C bake.

The lighter non-serpentine concrete (210 lb/ft^3) test slabs were removed from the shield facility and placed in the oven where they will be baked at 320°C. After the foils have been counted and analyzed this will complete the testing of this concrete in the "as-cured" condition.

An interim report on the results of the boron-steel thermal shield test has been issued as HW-63981, "NPR Design Test DT-1037, Boron Steel Thermal Shield Test." In this test the neutron attenuation of a one-inch plate of boron-loaded mild steel (approximately 1.0% boron by weight) has been studied experimentally using the 36" Shield Test Facility. Measurements to date indicate attenuation factors of 225 and 4.5 for thermal and resonance neutrons, respectively.

Structural Materials Development

Zircaloy Retubing Program

A total of 26 ribless Zircaloy-2 tubes for C reactor have been received from Bridgeport Brass and Harvey Aluminum. Delivery of the remaining 74 tubes on order should be nearly complete by mid-March. Two-hundred additional C reactor tubes are being ordered for complete delivery by June 15. Due to a change in plans and fuel design, contracts for development work and production of ribbed Zircaloy-2 tubes for the production reactors are being terminated, although an estimated twenty to thirty ribbed tubes should be delivered in the next few months from tubes already in process on these orders.

NPR Zircaloy Process Tubes

A three-day information meeting with workshop on fluorescent dye penetrant and ultrasonic testing was conducted during February for representatives of the four contractors for NPR Zircaloy process tubes. The theory and operation of the two test methods were explained in an

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illustrated lecture session. The actual testing operations were then demonstrated at the White Bluffs testing site of Radiographic Testing Operation, using short lengths (up to 15 feet) of experimental NPR tubing. In a final discussion session, results on testing and reclaiming other types of Zircaloy tubing were presented, and testing equipment costs were discussed. The fluorescent penetrant and other test results on these pilot tubes are of interest to the vendors as a measure of the problems they may face in application of these tests at their sites. With the inclusion of Harvey Aluminum, capability has been developed on the part of each of three vendors to produce NPR process tubes to present HAPO specifications. Work will continue to improve these capabilities in line with the new more rigorous specifications.

Chase Brass and Copper Co. has shipped eleven full length NPR tubes which are now at Hanford for final testing. Ten completed NPR process tubes produced by Allegheny Ludlum Steel Corp. have also been shipped.

Nonmetallic Materials Development

Hanford Irradiation of NPR Candidate Graphites

Samples have been discharged from the 2C test hole at KE reactor with an accumulated exposure of 2500 MWD/AT at 550 to 600°C. These samples were thermally annealed at 650°C prior to irradiation. The results of length charge measurements are tabulated below:

HANFORD IRRADIATIONS OF NPR CANDIDATE GRAPHITES

2500 MWD/AT at 550 to 600°C

Graphite Type	Percent Length Change	
	Transverse	Parallel
GL-10	+0.022	-
GL-11	+0.015	+0.003
VC	+0.006	-0.019
KC	+0.025	-0.017
CSF	-0.005	-0.022
TSGBF	-0.008	-0.012

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The measurements show that all of the graphites made with needle cokes (GL-10, GL-11, VC and KC) exhibited expansion in the transverse direction, while those from other cokes (CSF and TSGBF) contracted.

Several high density graphites prepared by pressure forming and baking processes were included in this irradiation. Exceptionally large contractions were noted as follows:

HANFORD IRRADIATIONS AS HIGH DENSITY GRAPHITES

2500 MWD/AT at 550 to 600°C

Graphite Type	Apparent Density	Percent Length Change	
		Transverse	Parallel
NC-1 (unimpregnated)	1.81	-0.085	-0.091
NC-2 (impregnated)	1.90	-0.128	-0.12[illegible]
NC-3 (unimpregnated)	1.83	-0.095	[illegible]
NC-5 (impregnated)	1.92	-0.0[illegible]7	[illegible]7

These samples will be re-irradiated to determine whether the high initial contraction rates continue at higher exposures.

Flux Monitoring

Preliminary results from calculations of the fast neutron flux spectrum in the Y test hole at C reactor were obtained from ORNL. The calculations were performed using a thirty-two group diffusion-type code, the GNU-II, which had been modified to include twenty groups in the range 0.183 mev to 10 mev. The ratio of the flux above one mev to the flux above 5 mev, the reported Ni activation threshold, was calculated to be 21.2 compared to a value of 12.9 for a Watt fission spectrum, a change by a factor of 1.65. Thus, it appears that considerable modification occurs in the flux spectrum in the test position even in the region above 1 mev.

KER Loop

Rupture of a 7-rod Zircaloy coextrusion clad uranium fuel element in KER Loop 1 on February 7 produced a characteristic chain of warnings, a high delayed neutron activity (which scrammed the reactor), strong responses in the monitors of the other three KER loops, and high

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radiation levels at the rear nozzle and at other points in the loop. Water analyses confirmed the rupture, showing abnormally high I-131, total I, Cs-137, and Np-239 concentrations. Examination of the rupture in the discharge basin revealed a longitudinal split about 3/4 inch long in the cladding of an outer rod in the cluster. The fuel surfaces appeared clean and free of crud deposits.

Reactor Materials

GETR Irradiation of NPR Candidate Graphites

Collecting of information from the H-1 experiment irradiated in the GETR has been completed and the data are presented in the following table. The table supersedes a similar but preliminary table in last month's report and represents the best rationalized values of both mechanical/optical gauging of the samples. Also, new exposure values based on foil measurement are available in the place of estimates obtained from Vallecitos three-group calculations. For values intermediate to the monitors, data of J. Moteff, Trans. American Nuclear Society, Vol. 2, No. 1, were used to determine longitudinal variation.

It is seen that VC and GL-10 are the least contracting graphites, followed by GL-11. All three needle cokes contract less than CSF. Of the RX series, RX-3, graphitized at the highest temperature, 3140°C, is the least contracting. This is following in turn by RX-1, graphitized at 2900°C, and by RX-2, graphitized at 2900°C with pitch impregnation. It is now possible to directly compare the GL, VC series with the RX series since the former are production produced 4" x 4" extrusions and the latter are laboratory produced 2" diameter extrusions.

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GETR Experiment, H-1

Temp. °C	Integrated Flux 1 mev nvtx10^{-20}	Exposure MWD/AT (1)	CSF	GL-10-	GL-11	VC	RC	RX-1	RX-2	RX-3
					Transverse Samples Length Changes, % L + .01% 90% Cl					
800	1.42	3600	-.05	-.03	-.04	-.03				
[illegible]50	1.79	4500					-.10	-.05	-.06	-.04
950	3.30 FOIL	8300	-.06	-.02	-.06	-.03				
1000	2.73	6900					-.16	-.08	-.08 (3)	-.[illegible]7
11[illegible]	3.84 FOIL	9700	-.14	-.12	-.14	-.10				
1150	3.93	9900					-.31 (3)	-.26 (2)	-.34 (3)	-.21
1200	4.52	11400	-.35	-.24	-.29	-.22 (4)				
1200	4.89	12400					-.45 (2)	-.37 (2)	-.37 (2)	-.20 [illegible]
115[illegible]	5.12	1300	-.29	-.22	-.26 (2)	-.05 (3)				
1100	5.15	13000					-.43	-.32	-.37	-.27
1050	3.56 FOIL	9000	-.13	-.12 (2)	-.13	-.06				
1000	3.78 FOIL	9600					-.15	-.12	-.16	-.11

(1) Conversion of 3.95×10^{16} nvt per MWD/AT.

(2) ± .02 percent

( ) ± .[illegible] percent

± .0[illegible] percent

Summary

VC	GL-10	GL-11	CSF
RX-3	RX-1	RX-2	RC

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Graphite Burnout Monitoring

Samples discharged from tube 1960-C in January after twenty-two months exposure to pile atmosphere in an empty process channel showed the following weight changes:

GRAPHITE BURNOUT, 1960-C

Boat Number	Distance from Front of Graphite, ft.	Average % Weight Loss Per 1000 Operating Days
1	4.3	1.6
2	14.0	35
3	23.8	.11

The highly oxidized samples were badly pitted on one side, giving the appearance of Swiss cheese. The pits probably developed on the upper side of the sample, as the top of the boat was also very highly oxidized, and it collapsed when tongs were placed around it. In addition, the top of the channel appeared to be more heavily attacked when it was inspetted in February. The borescope revealed that 50% of the channel area between 13'5" and 24'10" had been attacked. No estimate of the depth of penetration of the oxidation could be made. The channel will be borescoped again in April, and at that time photographs will be taken.

The cause of oxidation has not been determined yet. One guess is that leaking water deposited dissolved minerals in the graphite, catalyzing the oxidation of the graphite. Radiographs will be taken on the samples to determine whether the pitted areas are higher in radioactivity than the nonpitted areas. Also, scrapings of the pits will be analyzed by emission and gamma spectroscopy.

4000 PROGRAM - REACTOR DEVELOPMENT (GAS COOLED REACTOR POWER PROGRAM

Graphite Studies

Hot Capsule Experiments

Results from twenty-two capsules irradiated up to 5000 MWD at 500 to 800°C in the MTR were recently evaluated. The results are consistent with previous irradiations, demonstrating that the needle-coke graphites contract less in the transverse and parallel directions than CSF. For all graphites tested, the parallel contraction was greater than the transverse.

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Several capsules contained samples cut from a slab extrusion from Great Lakes Carbon Corp. The slab dimensions were 2.4 x 14.5 x 16 inches. With respect to dimensional stability, samples from the 2.4 inch direction (transvers to the direction of extrusion) were the most stable, followed by the 14.5 inch direction and the longitudinal 16-inch extrusion direction. Samples from the center of the slab contracted less than periphial samples.

PRTR Startup Experiments - LC Schmid

The final draft of the approach-to-critical experiment which contains the high spike enrichment of Pu-Al fuel elements has been written and distributed to the members of the Startup Council for approval. All of the approach-to-critical experiments have been written and will eventually appear in document HW-61900 along with other physics experiments to be done at startup of the PRTR.

PRTR Gas Loop (CAH-822)

The delivery date for the Phase A package has been re-established as June 1, 1960, following a meeting with the vendor. This date is taken as sixty days following the revised delivery date of the main gas blowers. Considerable difficulty is being experienced in the fabrication of the gas blowers.

Final prints have been received and approved for fabrication of the top and bottom flexible connectors for the in-reactor test section. Additional requisitions were issued to fabricate these connectors from stainless steel (1200°F rather than 1500°F), to assure having connectors available at the time of loop installation.

Due to the complexity and number of factors affecting temperature transients of gas loop piping, transient analysis of the loop will be programmed on the new Berkeley annalogue computer as soon as the instrument has been checked out.

Gas Cooled Power Reactor Program - In-Reactor Section

The nozzle closure assembly made of stainless steel which was tested at 1050°F and 500 psig was removed from the test furnace and disassembly of the unit was attempted. During disassembly, the tensioning nut galled the main stud and it had to be machined out. During machining the pin which prevents rotation of the dome with respect to the rest of the assembly was sheared and the dome rotated, destroying the sealing faces.

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Fabrication of a new nozzle closure assembly made of Hastelloy X was started. Leakage of the assembly will be determined under full pressure and temperature conditions.

The mechanical device which will be used to flex components in the furnace was completed. Operation of the device was started. Testing of the flexible hoses was continued. During the month, the flexible hose was subjected to long-term hydrostatic test at 2000 psig at room temperature without leakage. Hot tests on this unit at 1200°F and 500 psig (was) started.

Additional Hastelloy X material for use as the pressure tube was ordered.

Material received for the in-reactor section is now 45% complete.

Fabrication of equipment to test the outlet helium bellows for the bottom face of the lower shield was completed. Testing of the bellows was started.

PRP Critical Facility (Project CAH-842)

The PP, HW-63069, was approved by General Electric Company and transmitted to the AEC February 12, 1960.

The Design Criteria, HW-62117, has been revised to include a reactor moderator system capable of changing and controlling the reactor tank level at any point in the top four feet of the vessel. Additional equipment required for this change includes an 850 gallon storage tank, an adjustable weir overflow system, an addition pump, and associated piping and valving. The reactor cell was deepened from 26 to 32 feet to house the additional equipment.

Detailed design of the building addition has been completed. The fuel transfer lock design was withdrawn from the building design package and will be procured on a "design and build" basis. Rough draft specifications were completed during the report period.

[redacted]

(Year)
[illegible]ruary - OUTAGES ([illegible]) [redacted]

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	[illegible]	[illegible]	19.2	[illegible]	48.2	35.4	24.6	[illegible]	[illegible]
Maintenance	[illegible]	[illegible]	37.6	52.6	84.5	61.6	3.9	7.2	306.4
Rupture Removal	72.1	114.5	0	0	7.8	47.7	25.0	65.9	333.0
Leak Testing	0	0	0	20.0	14.9	0	48.8	[illegible]	[illegible]
Tube Replacement	0	0	18.6	15.8	52.7	0	0	0	87.1
Project Work	0	0	0	0	7.5	0	3.7	0	11.2
Production Tests	6.3	38.7	17.4	24.9	0	0.8	40.3	3.3	131.7
Instrument & Circuitry	6.8	0.9	0	2.8	0.	0.2	0.7	0	11.4
Rupture Suspects									
Miscellaneous	0	0	0	0	1.4	0	3.9	2.8	8.1
Total	175.5	188.0	92.8	214.4	217.0	145.7	150.9	122.0	1306.3
Scheduled Outages	91.2	72.0	87.1	134.6	172.0	83.3	35.6	43.6	719.4
Unscheduled Outages	84.3	116.0	5.7	79.8	45.0	62.4	115.3	78.4	586.9

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RUPTURED SLUG TABULATION [redacted]

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concentration MWD/Ton	Assigned Production Loss MWD	Assigned Production Loss Days	Observations
2[illegible]75-C	12-14-59	2-4-60	1149	316	931	.50	I&E Regular - Hot Spot
3[illegible]9[illegible]-KW	12-19-59	2-5-60	1490	394	4671	1.30	I&E regular KII - Hot Spot
[illegible]76-C	12-9-59	2-6-60	1175	344	3706	2.08	I&E regular - Side Other
0755-H	11-4-59	2-8-60	800	427	782	.46	Solid Regular - Side Hot Spot
1478-C	12-14-59	2-10-60	1071	343	3793	2.13	I&E regular - Unknown
3880-B	11-27-59	2-11-60	1140	423	1753	1.10	I&E regular - Hot Spot
3661-H	11-28-59	2-11-60	1121	519	1204	.70	I&E Regular - Side Hot Spot
0770-H	12-28-59	2-8-60	1125	275	31	.02	I&E Regular - Side Other
0834-H	11-28-59	2-13-60	1131	532	1657	.97	I&E Regular - Hot Spot
0765-C	12-9-59	2-14-60	1218	416	1988	1.12	I&E Regular - Hot Spot
2978-H	11-28-59	2-15-60	1049	561	813	.48	I&E Regular - Hot Spot
5556-KE	11-16-59	2-21-60	970	478	1486	.44	Solid Regular - Split
2673-H	11-28-59	2-22-60	1063	569	1084	.63	I&E Regular - Hot Spot
4645-KE	10-30-59	2-22-60	1002	500	1590	.47	Solid Regular - Split
4651-KE	12-7-59	2-23-60		563 [1]			I&E Regular - Hot Spot
2459-KW	11-29-59	2-23-60	1513	689 [2]	3260	.91	I&E Regular -
[illegible]85-F	12-8-59	2-25-60	1209	529	633	.37	I&E Regular - Hot Spot
[illegible]33-KW	12-19-59	2-26-60	1473	531	5050	1.40	I&E Regular - Hot Spot
3284-B	11-27-59	2-26-60	1162	728	3704	2.32	I&E Regular - Unknown
[illegible]1-KE	1-11-60	2-26-60	1443	363	2055	.61	I&E-E - Hot Spot
3087-C	11-7-59	2-29-60	1140	715	1133	.64	I&E Regular - Hot Spot
2160-KE	8-24-59	2-7-60	900	2520	3022	.90	Cluster Fuel Element - Jacket Split

1 Was not discovered until investigation after months end

2 Reported as 27[illegible] in weekly [redacted]

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STANDARD FORM NO. 64

[redacted]

Office Memorandu DECLASSIFIED TATES GOVERNMENT

TO : Process Engineering and Manufacturing Division Files

DATE: February 9, 1960

FROM : R. L. Plum, Chief Reactor Branch

SUBJECT: MONTHLY REPORT FOR MONTH OF JANUARY 1960

HAN-74591-DEL
Rpt. #1

SYMBOL: OR:GTO:GRG:HAH

THIS DOCUMENT CONSISTS OF 45 PAGES
[redacted] IES, S [redacted]

PRODUCTION

Reactor input production (1.7 percent above the November 1959 maximum) established a new record and was 7.7 percent above forecast; 1.8 percent above at the six old reactors and 16.4 percent above at the K's. Forecast was exceeded due to high time-operated-efficiency at the K reactors and high average power levels at all reactors.

OPERATING EXPERIENCE

Power Levels

The combined eight-reactor instantaneous power level was increased 895 megawatts (17,360 to 18,255). Record levels at the individual reactors were increased 45 megawatts at B reactor (1640 to 1685), 80 at C (2000 to 2080), 80 at F (1735 to 1815), 55 at H (1770 to 1825), 20 at KE (3710 to 3730), and 100 at KW (3710 to 3810).

Ruptures

Fifteen ruptures, 14 I&E and one solid regular, were removed from the reactors. Four of the I&E ruptures were at B reactor, 4 at C, two at KW and one each at DR, F, H and KE. The solid rupture was at KE. Seven of these ruptures were stuck and one caused a process tube leak.

Reactor Outages

Reactor outages for the month of January are as follows:

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B REACTOR

Date Down	Date Up	Outage Hours	Remarks
12/30	1/1	42.6	Removal of a stuck I&E 94 metal production test rupture from tube 1764.
1/10	1/11	35.8	Removal of an I&E regular metal rupture from tube 3268 and charge-discharge.
1/21	1/24	77.0	Removal of a stuck I&E regular metal rupture from tube 1686 and charge-discharge.
1/24	1/25	19.8	Removal of a stuck I&E regular metal rupture from tube 2676.
1/31	Still Down		Removal of an I&E regular metal rupture from tube 1575.

C REACTOR

1/3	1/4	33.7	Removal of an I&E regular metal rupture from tube 2168.
1/14	1/16	40.6	Removal of an I&E regular metal rupture from tube 2171. Thermocouples were installed on vertical rows 51 thru 57.
1/21	1/23	37.4	Removal of an I&E regular metal rupture from tube 2576 and charge-discharge.
1/24	1/26	38.1	Removal of a stuck I&E regular metal rupture from tube 3861 and charge-discharge.

D REACTOR

1/4	1/9	117.9	Completed scheduled charge-discharge and tube replacement.
1/9	1/9	1.9	Venturi change in tubes 1991 and 2491.

[redacted]

D REACTOR (cont.)

1/25	1/27	52.3	Removal of pump shaft fragment (from No. 7 pump at 190 Bldg.) from crossheader screens and front face fittings and charge-discharge.*
1/31	Still Down		Temperature control due to a faulty ball valve on a PCCF Tube.

DR REACTOR

1/10	1/11	37.3	Removal of an I&E regular metal rupture from tube 1570. Completed charge-discharge and maintenance.
1/21	1/22	44.9	Leak testing. Tube 2185 was replaced.
1/24	1/24	0.3	Panellit trip.
1/24	1/24	0.2	Panellit trip.

F REACTOR

1/4	1/9	115.3	Water leak. Charge-discharge and tube replacement. Installation of crossheader differential gauges.
1/23	1/25	39.1	Removal of a stuck I&E regular metal rupture from tube 1182 and charge-discharge.
1/25	1/25	1.4	Manually tripped due to insufficient rods for control.

H REACTOR

1/9	1/10	32.7	Charge-discharge following maintenance on front face cap. Replaced ten leaking rear pigtails.

* Shaft fragments were dislodged on 1/15 at the time No. 7 pump was being started up following impeller replacement. Cause of failure has not yet been determined.

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H REACTOR (cont.)

1/20	1/22	52.7	Removal of a stuck I&E regular metal rupture from tube 2981. Charge-discharge and tube replacement.
1/23	1/23	3.8	Adjustment of gas composition.
1/23	1/23	0.7	Panellit trip.
1/26	1/28	40.5	Leak testing and replacement of tube 1960. Removal of a stuck I&E regular metal rupture from tube 3183.
1/28	1/28	0.6	Panellit trip.

KE REACTOR

1/11	1/13	44.9	Removal of a solid regular metal rupture from tube 4345. Charge-discharge and tube replacement.
1/13	1/13	6.0	Poison discharge. A delay of about 2.5 hours was experienced due to the malfunction of a "C" elevator relay.
1/25	1/27	46.9	Removal of a stuck I&E regular metal rupture from tube 2052. Charge-discharge.
1/27	1/27	0.9	Beckman trip due to a surge on instrument power supply.
1/27	1/28	3.3	Poison discharge.
1/31	Still Down		Trip due to a faulty dump valve on KER Loop 2.

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KW REACTOR

1/4	1/5	38.9	Panellit trip due to an I&E regular metal rupture from tube 3075 and charge-discharge.
1/6	1/6	2.9	Poison discharge.
1/22	1/24	6.4	Removal of an I&E regular metal rupture from tube 3866 and charge-discharge.
1/25	1/25	4.4	Poison discharge.

Tube Replacement

One-hundred-five process tubes were replaced; 67 at D, 19 at H, 14 at F, two at B, and one each at C, DR and KE.

Water Leaks

Five tube leaks and two Van Stone leaks were corrected; (two tube leaks at F and one each at B, DR and H). The Van Stone leaks were at F and H.

PRESENT REACTOR TECHNOLOGY

Self-Supported Fuel Testing

Irradiation of four columns of 1.47 percent enriched self-supported fuel elements in ribless tubes continued under PT-IP-247-A. Irradiation will continue until a factor of 20 improvement in relative rupture performance is demonstrated with 95 percent confidence unless terminated earlier by failure.

E-N Irradiation

Test columns from the fringe blanket loading have been discharged; final discharge of the central block loading is expected during the next outage at H reactor.

KER Loop Irradiation

Four 18" enriched tube-in-tube elements, two alloyed with 2.8 percent Zr and two un-alloyed, were charged in KER Loop 2 on January 11 under PT-IP-192-A.

[redacted]

Graphite Purity

Analysis of dih (delta in-hour) variations for core graphite of the NPR indicate that a ± 115 dih spread in graphite purity will result in only ± .5 mk variations in NPR reactivity. This requirement for dih variation is twice the standard variation for AGOT purity quoted by National Carbon Company.

Fuel Element Measurements

Four foot exponential pile buckling measurements on tube-in-tube fuel elements have been concluded, and the results are as follows:

Lattice Spacing	Buckling (μB) Wet	Buckling (μB) Dry
7-3/16"	-123	-25[illegible]
8-3/8"	- 64	- 50
10-3/8"	- 45	+ 76
12-3/8"	- 72	+104
14-9/16"	-127	+ 55

Comparison of the graphite to uranium and water to uranium ratios for this fuel element at crossover with the corresponding ratios for the NPR fuel element indicate that the NPR lattice is below the crossover point, as expected.

Ribless Zr-2 Production

Bridgeport Brass Co. has approximately 40 smooth-bore C reactor tubes in the process of final inspection. Eleven of these tubes were shipped to HAPO on January 1. In addition, six C reactor ribless tubes have been processed by Harvey Aluminum Co. and two of these have been completely inspected.

Graphite Irradiation

The second test capsule containing samples of various graphite types was discharged from the GETR on December 28. Length measurements on the graphite samples indicated length decreases of several tenths of one percent.

Exposure levels on these samples were too low to give any evidence of saturation or slowing down of the rate of contraction. Consistent with all other test data to date, the graphite made from "needle" coke contracted somewhat less than the CSF reference graphite. In addition, there is an indication that graphite made with finer coke particles and exposed to higher temperatures in graphitizing furnaces contracted at a slightly lower rate than more conventional graphites. There seems to be a significant increase in contraction rate above a temperature of about 100°C.

Splines

D and KE reactors used splines for startups during January. Forty and 35 splines were successfully used on startups at these respective reactors with an estimated gain of five effective hours per startup. It is expected to use splines for startups again at KW reactor as soon as the removal reel is operational.

Spline Coiler

A spline coiler, to replace the troublesome spline choppers, has been built and tested in the laboratory. This device, withdraws the spline from the process tube and coils it up on a small reel inside a shielded container, then drops reel and container into a disposal chute.

EQUIPMENT DEVELOPMENT

Cap Remover Prototype

The cap remover prototype has been assembled and mounted on a temporary carriage in 108-D Building, connected to a program simulator and operated functionally. Work is continuing to remove minor bugs, but the assembly now performs the intended function of removing the cap and replacing it.

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MATERIAL DEVELOPMENT - 2000 Program

Metallurgy Program

Corrosion Studies

Hydriding of Zircaloy in Simulated NPR Gas Atmosphere

Three sets of Zircaloy-2 and Zircaloy-4 samples were exposed to gas having 93 percent He, 3 percent H_2, 3 percent CO and less than 0.01 percent O_2 or H_2O. The samples were exposed for 21 days at 400°C. The etched but unautoclaved samples of both alloys were severely hydrided and very brittle. The autoclaved samples show some hydrogen pickup, but about 20- to 70-fold less than the etched samples.

Autoclaving Studies of Zircaloy-2

Some preliminary conclusions are as follows:

1. At a given temperature the weight gain is $\approx$ 2 mg/dm^2 higher at 100 psi than it is at 1500 psi, time being 72 hrs.
2. The allowable temperature variation from the specified value during autoclaving is in the range 10 to 20°C.
3. Formation of a visually acceptable black film is rarely harmed by two pieces of Zircaloy-2 touching each other during autoclaving. This is of significance for hardware assemblies.

Reactor Program

Effect of Irradiation or Corrosion in High-Temperature High-Purity Water indicate there is very little (e.g., less than about 20 percent) corrosion of several alloys of aluminum, 304 stainless steel, Zircaloy-2 and Zircaloy-3.

Structural Materials Development

NPR Zircaloy Process Tubes

Chase Brass and Copper Co. has completed the fabrication of 13 NPR process tubes. The final drawing operation proceeded smootly, and the tubes emerged with no apparent scratches but with varying

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amounts of bow. The bow was removed by a press straightening operation. Three of the tubes had been stripped of drawing lubricant and one had been inspected as of January 22. This one tube had two small galled areas inside, which were successfully removed by localized grinding.

The first tube produced by Allegheny Ludlum Steel Corp. went through the rocking process at Tube Reducing Corp. on January 19. This tube passed through the tube reducer uneventfully, emerging with less than the usual bow or spiral and a better than normal outside surface. Seven more tubes were processed during the next two days, and four more are nearly ready for tube reducing.

Reactor Engineering - 2000 Program

Data from heat transfer experiments with a 7-rod cluster fuel element show negligible inter-channel mixing and higher water temperatures in those areas where the distance between rods is small. There was significant phase separation even under local boiling conditions.

Production of Fissionable Material

Reactor Materials

The H-1 experiment in the GETR was discharged January 6 after an 2267 MWD(reactor thermal) exposure. In general, the experiment was found to be in better condition than the previously discharged H-2 experiment although the predicted irradiation conditions were much more severe. The flux values however were confirmed to be 1/7 of the expected flux.

There is an apparent superiority of needle coke graphite at the lower temperature and there seems to be a temperature coefficient of contraction, since all samples at high temperature contracted more than a difference proportional to exposure. There is a difference between VC and RC graphites which is believed to be caused by the extrusion technique. For that reason the RX series material should probably not be directly compared to the GL and VC graphites.

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The appearance of the experimental assembly, with the exception of a substantial carbon deposit on the internal wall, was good. In contrast to the significant melting observed in the H-2 experiment, only one strut in this test melted. All ceramic spacers were intact and no fracturing of thermocouple insulators was observed.

A series of experiments designed to clarify some of the behavior observed in the H-2 capsule was performed in an induction furnace at 1500°C. The loss of the molybdenum parts in the H-2 experiment now appears to be caused by the dissolving action of aluminum vapor. Aluminum and graphite systems at about 1400°C rapidly form Al_4C_3. The Al_4C_3 in or on graphite is very detrimental to the graphite body if moist air is present. Some samples thus treated have completely disintegrated in a few weeks at room temperature. The Al_4C_3 in the presence of water forms aluminum oxide and methane. Reactions of molybdenum, graphite, Al_2O_3 insulators, alundum, and chromel alumel in various combinations do not appear to behave differently than would be predicted from material considerations alone, and apparently such reactions had little to do with the observed condition of the H-2 capsule.

Graphite Burnout Monitoring

Samples were discharged from tube 1960-C after 22 months exposure. Weight changes will be measured after samples have been desiccated. Oxidation rates are expected to be high because the center graphite sample carrier crumbled easily during the discharge operation. In order to correlate power and burnout rates, nickel and aluminum-cobalt alloy flux monitors were included with the graphite samples when the channel was recharged.

Effect of Filler on the Radiation Resistance of Neoprene

A comprehensive study of the effect fillers have on the radiation resistance of Neoprenes is currently under way. This is a portion of an overall program designed to study the effects of compounding ingredients on elastomers and their radiation stability.

Preliminary results show that tensile strength is the physical property most affected by variations in type and quantity of filler. At high doses many of the specimens were covered on the surface with

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fluid droplets. It is postulated that chlorine evolved from the irradiation of the neoprene polymer has reacted with atmospheric moisture and filler to produce chloride salts. Further work is under way to determine the composition of the fluids.

Physics 2000 Program

Summary

An excellent demonstration of the versatility of the PCTR was given this month. Three distinctly different types of experiments were done. (1) A core made up of solid graphite was used to study the effect of graphite temperature on neutron temperature, (2) a homogeneous core of UO_3 enriched to three percent U-235 was used to determine the amount of hydrogen which must be added to assure no criticality problems with this material, and (3) tube-in-tube fuel elements in a graphite lattice were used to determine reactor physics properties of a core similar to the N reactor core. During a portion of the month, the PCTR was run three shifts per day.

First criticality experiments were started on Pu-Al rods in light water. The rods contained five percent Pu in aluminum. A near serious contamination incident occurred when a plutonium compound was removed from one of the rods by corrosive action.

Nuclear safety problems associated with the dissolving of spent power reactor fuels were studied. Safe dimensions were determined for such a dissolver.

A "soft mold" technique was applied to grow single crystals of aluminum to be used for neutron interaction studies. This new technique produced better crystals than have been obtained before.

4000 PROGRAM - REACTOR DEVELOPMENT (GAS COOLED POWER REACTOR PROGRAM)

Air Oxidation Studies

Experiments are in progress to evaluate the effect of variables of manufacture on the oxidation rate of the graphite. The rate of oxidation of various types of graphite could be very important in determining the life of a reactor. One variable which appears to

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have a great influence on the rate of oxidation is the amount of graphite impurities. An index of graphite purity is the dih value. Seven samples varying in density, dih, purity, particle size and type of coke were oxidized at 600°C with an air flow of 25 cfh, with the following results:

Graphite	Oxidation Rate x 10^{-2} g/g hr	dih
SP-21	2.52	+0.027
TS-AGOT	1.92	+0.180
SP-23	1.87	+0.317
CO	1.60	+0.360
SP-10	1.47	+0.671
CSF	1.19	+0.854
SP-7	0.429	+1.10

The dependence of oxidation rate upon dih purity is best illustrated by comparing SP-7 and SP-10 graphites. Both graphites have the same coke source, particle size and density. Both were processed identically except that trace Fe_2O_3 was added to SP-10. This caused the dih purity to drop from 1.1 to .671 and the oxidation rate to rise by a factor of 3.4

Project CAH-822 Gas-Cooled Loop

The Struthers-Wells Corp. has submitted a request for extension of the April 15 completion date. A revised completion date is June 1, 1960.

Approximately 30 percent of the in-reactor material has been received.

Hastelloy-X, on the basis of preliminary data, appears to be superior for the gas loop service to any of the high-temperature alloys now under test. It is now planned to provide a pressure tube and shroud tube of Hastelloy-X in addition to inconel pressure tube and inconel 702 shroud tube previously planned.

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Plutonium Contamination Incident - 305 B (TTR and PCTR)
January 20, 1960 - V. I. Neeley

During the loading of the 1.1 inch lattice, there was detected the escape of some Pu from the canned fuel elements. The monitoring procedures provided rapid detection (within 4 minutes) and prevented the inadvertent spread of contamination to other nearby areas. The contamination was contained wholly in the TTR reactor room. The events leading to the contamination are, apparently:

a. The rod end-cap was machined too thin.

b. The rod was numbered on the wrong and (thin end) with a vibrating tool.

c. The rods were etched with a solution of hydrofluoric and nitric acids prior to shipping.

d. The etching solution apparently leaked into the element through holes opened during the machining and/or numbering causing corrosion which then escaped.

e. The rod was placed in a plastic bag which accidentally, but fortunately, sealed itself, and the bag remained sealed for the approximately 2 months of storage prior to the rods use in the experiments.

f. The physicist conducting the experiment removed one glove to tear the plastic at the point where it had sealed itself and his bare hand became contaminated; also his clothing and other material and equipment handled subsequently.

g. The contamination was detected in a routine hand check when that loading operation was completed.

h. The second physicist present received minor contamination from equipment handled after the first physicist.

i. Two days were required to decontaminate the TTR reactor room and equipment.

j. The rods are now being monitored individually as they are removed.

[redacted]

RUPTURED [illegible] FOR JANUARY, 19[illegible]

Tube No.	Date Charged	Date Ruptured	Tube Power (KW)	Concen-tration MWD/Ton	Assigned Production Loss [illegible]	Days	Observations	
2168-C	11/7/59	1/3/60	955	361	1973	1.13	I&E Regular	Hot Spot
[illegible]75-KW	10/30/59	1/4/60	1318	512	2383	.68	I&E Regular	Hot Spot
3268-B	10/20/59	1/10/60	1176	563	630	.41	I&E Regular	Hot Spot
1570-DR	10/12/59	1/10/60	1062	564	1078	.69	I&E Regular	Hot Spot
4345-KE	8/24/59	1/11/60	1018	651	4906	1.38	Solid Regular	[illegible]
2171-C	11/17/59	1/14/60	1160	446	1661	.95	I&E Regular	Hot Spot
2981-H	11/4/59	1/20/60	1095	552	915	.54	I&E Regular	Hot Spot
1686-B	10/4/59	1/21/60	1115	709	3024	1.96	I&E Regular	Hot Spot
2576-C	11/7/59	1/21/60	1235	498	1987	1.14	I&E Regular	Hot Spot
3866-KW	11/29/59	1/22/60	1507	424	4022	1.15	I&E Regular	Hot Spot
1182-F	10/23/59	1/23/60	1176	558	1293	.80	I&E Regular	Side Other
2676-B	11/27/59	1/24/60	1109	365	1683	1.09	I&E Regular	Hot Spot
[illegible]961-C	11/7/59	1/24/60	1225	545	2453	1.41	I&E Regular	Unknown
2052-KE	11/16/59	1/25/60	1316	537	34[illegible]	.[illegible]	I&E Regular	
~~3183-F~~	~~11/4/59~~	~~1/27/60~~	~~NA~~	~~602~~	~~[illegible]~~	~~[illegible]~~	~~I&E Regular~~	~~Pin Hole~~
1575-B	11/27/59	1/31/60	1197	417	821	.[illegible]	I&E Regular	Hot Spot

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(Year)
OUTAGES (1960) January

Reason	B	C	D	DR	F	H	KE	KW	Total
Charge-Discharge	34.3	19.8	37.3	11.0	19.0	33.8	32.9	46.8	234.9
Maintenance	27.3	47.5	58.6	30.8	35.3	36.3	13.2	12.1	261.1
Rupture Removal	66.8	68.1	0	13.1	10.8	12.6	45.0	30.6	247.0
Leak Testing				26.2	31.6	16.6			74.4
Tube Replacement	0.7		84.4		25.4	21.2			131.7
Project Work		12.5	0.3		32.2	0.7		11.5	57.2
Production Tests	4.4	1.9	9.8	1.0		4.7	16.4		38.2
Instrument & Circuitry				.5		1.4	0.9		2.8
Rupture Suspects									
Miscellaneous	2.6				1.4	3.7	1.1	5.4	14.2
Total	136.1	149.8	190.4	82.6	155.7	131.0	109.5	106.4	1061.5
Scheduled Outages	59.8	79.7	170.2	37.8	103.1	81.4	44.9	67.1	644.0
Unscheduled Outages	76.3	70.1	20.2	44.8	52.6	49.6	64.6	39.3	417.5

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END

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