HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
DECEMBER, 1959

Compiled by
Operation Managers

January 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

[redacted]

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PRELIMINARY REPORT

This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1)-1350. Any views or opinions expressed in the report are those of the author only.

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE December 31, 1959

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	131	102	233	128	101	229	4	2	1	1
Reactor & Fuels Research & Development	197	170	367	196	172	368	2	1	1	3
Physics & Instrument Research & Development	66	33	99	65	34	99	2	0	1	1
Biology Operation	35	45	80	35	45	80	1	0	1	0
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	34	100	134	34	101	135	1	1	1	2
Laboratory Auxiliaries	53	193	246	52	193	245	2	5	1	5
Financial	14	13	27	14	13	27	0	0	0	0
Prof. Plcmt. & R. P.	72	18	90	78	18	96	0	1	6	1
Programming	15	4	19	15	4	19	0	0	0	0
General	1	2	3	1	1	2	0	1	0	0
Totals	634	684	1318	634	686	1320	12*	11**	12**	13*
Totals Excluding Internal Transfers	634	684	1318	634	686	1320	8	7	9	8

* 2 Nonexempt to Exempt

** 1 Exempt to Nonexempt

Composite Separation Rate	1.8968
Separation Rate (based on separations leaving G. E.	.8345
Controllable Separations Rate	..3034

BUDGETS AND COSTS

Costs for December were $1,851,000, a decrease of $97,000 from November. Fiscal year-to-date costs are 49% of the amounts currently authorized to Hanford Laboratories. Hanford Laboratories programs at December 31, 1959 have the following cost-budget relationship:

	In Thousands		
	Cost	Budget	% Spent
2000 Program	$ 271	$ 616	44%
4000 Program	3 360	7 052	48
5000 Program	239	541	44
6000 Program	1 060	2 198	48

Research and development costs for the Hanford Product Departments were in line with the amounts authorized except for the IPD - New Production Reactor. Funds for FY 1960 were 66% spent at the end of December. An increased authorization in this category is expected from the Irradiation Processing Department.

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

The PRTR Phase III contract is 48.5% complete versus a scheduled 54% based on a contract completion date of May 20, 1960. A study of problems associated with cooling the PRTR in the event of a combined BPA outage and emergency generator failure was completed and issued as HW-63046. The report of comments by HLO on the engineering review of the PRTR by APED has been published as HW-62113.

The PRTR spare shaft-seal pump was disassembled after 2000 hours of operation. Excessive wear, approximately 1/4 inch, on the primary seal is attributed to helium coming out of solution as the pressure is reduced across the seal face. Injection of gas-free water into the seal chamber is being investigated as a possible solution to this problem.

Approximately half of the 85 PRTR process tubes have passed all tests and surface preparation steps and are ready for reactor installation. The balance of the tubes needed are expected to be ready when required by the Phase III construction contractor.

Design progress on loops and associated PRTR facilities was as follows: the design criteria for the High Pressure Loop were approved and issued as HW-61543, and an evaluation of the effects of the High Pressure Loop on PRP objectives has been issued as HW-62531. The scope description for the Fuel Element Rupture Facility was issued as HW-62878. The design criteria and project proposal for the Plutonium Recycle Critical Facility were completed and are being circulated for approval. The design of the in-reactor portion of the Pressurized Gas Cooled Loop has been completed.

Heat transfer experiments to define the thermal hydraulic behavior of the concentric tubular fuel element were completed to tube powers of 1530 kw. At these powers, which are 25% greater than the maximum proposed for PRTR operation, flow reductions to give outlet steam qualities of 16% by weight were accomplished with no adverse effects.

A 19-rod Al-Pu alloy fuel element was irradiated without incident to an average burnup of 43% of Pu atoms and a maximum of 60% in the ETR 6" x 9" loop. Heat fluxes, fuel temperatures and fuel design closely simulated expected PRTR conditions except for length of the element (33" core). Similar 7-rod clusters are operating successfully in the ETR 3" x 3" loop and in a KER loop.

Twenty-four Zircaloy-clad Al-Pu fuel capsules have been irradiated to date with heat fluxes up to 950,000 BTU/hr ft^2 and burnup as high as 100% of Pu atoms. No significant change in external dimensions of these capsules has been noted, and the fuel cores were readily removed from the cladding after irradiation.

Twenty-four UO_2-PuO_2 fuel capsules have been irradiation-tested with heat fluxes as high as 440,000 BTU/hr ft^2. No failures have occurred during the irradiation of any plutonium containing capsule or cluster to date.

Components have been assembled for a resumption of development work on the nested tubular fuel element. Redesign of end hangers and tube closures has radically reduced machining costs for this element.

Comparative room-temperature burst tests and flattening tests on sections of unirradiated and high-irradiated KER Zircaloy-2 pressure tubing indicated that the ductility of the Zircaloy was only partially destroyed by the irradiation. The two irradiated tube sections both burst with ductile fractures, rupturing at slightly higher internal pressures than comparable unirradiated tubes.

More abrasion-resistant autoclave films are produced on Zircaloy-2 by increasing either the autoclaving time or temperature. Increasing the time 10-fold doubled the film weight but increased its abrasion resistance 20-fold.

The first graphite samples removed from the GETR after prolonged irradiation at temperatures up to 1500 C showed small length increases rather than the expected contractions. However, the capsule contents showed that some of the aluminum structural components had melted, and the expansion observed in the graphite may have been caused by chemical reaction with aluminum vapor. Other high-temperature irradiation tests continue to show that the needle-coke graphites exhibit better irradiation stability than CSF graphite.

Autoclave tests in 400 C steam indicate that a 1500 psi autoclave proof test for NPR production fuel gives a far more rapid defect indication than 100 psi testing. Autoclave rupture tests of pre-defected NPR fuel samples in 300 C water at 1500 psi indicate that a 10-mil Zircaloy cladding ruptures sooner but then proceeds at a slower rupturing rate than 30-mil clad samples.

The limitations of fuel element failure testing in autoclaves or ex-reactor loops were pointed up by the appearance of a coextruded rod which failed under irradiation. Significant undercutting, presumably resulting from bond determination during irradiation, was observed.

The first deliberate rupture test with a coextruded Zircaloy-clad element was conducted in the HAPO 3x3 loop in the ETR. The element was irradiated at full reactor power and loop temperature for seven hours after defecting the element. Operability of the in-reactor rupturing device was confirmed and prototype NPR instrumentation given an evaluation test during this experiment.

Evaluation of a ruptured tubular fuel element has revealed as much as 500 ppm of hydrogen in the Zircaloy cladding. This element had incurred heavy crud deposits during irradiation, and high clad temperatures are, therefore, assumed to have existed during irradiation.

HW-63139 reports the results of a study to predict the events occurring in a production reactor process tube with no coolant flow during charge-discharge.

2. Chemical Research and Development

Recovery of neptunium in Redox was judged feasible by more than one method. Laboratory results, though not complete, confirm the methods proposed.

Close cooperation between CPD and HLO personnel has continually improved methods by which crude fission product concentrates can be removed from the limited head-end equipment in the Purex plant. Methods now exist for cesium, strontium, cerium, and promethium but yields are not high.

All components of the Fission Product Packaging Prototype except the filter were demonstrated in operational testing. Design expectations were achieved. Remote operation and maintenance awaits manipulator installation.

Inspection of the dismantled Radiant Heat Spray Calciner column after 200 hours of high temperature operation revealed no detrimental corrosion to column internals.

Successful shakedown of the prototype fluid-bed waste calciner was completed with a Redox-type waste feed.

Study of Purex Tank Farm condensate decontamination is planned in a pilot-scale mineral bed column completed in the 271-CR Facility.

Corrosion tests were initiated on twelve experimental Ni-Cr-Fe-Mo alloys prepared by Battelle Memorial Institute as potential dissolver materials. Significant differences in corrosion were observed over the range of alloy composition in various media.

First experiments with irradiated UO_2 feed for Salt Cycle tests showed satisfactory dissolution of the fuel wafer and electrodeposition of UO_2. Measurement indicated low gross decontamination as expected.

3. Physics and Instrument Research and Development

Reactor physics measurements continued on natural uranium fuel elements similar in size to N reactor elements. Enough data have been taken now to verify that the N reactor if fueled with natural uranium would lose reactivity upon loss of water. Enrichment of the uranium is not expected to alter this picture.

In the NPR Fuel Failure Monitor Program, laboratory tests demonstrated the validity of the concept of rapid mechanical scanning with one detector of gamma activity from a number of samples. These tests demonstrated the feasibility of scanning rates of twenty samples per second. Ten monitor stations monitoring 102 samples each would be required for the full NPR installation. The detailed mechanical design for the system is 50% complete.

Study of the reactor kinetic equations indicate that the solutions under some conditions are more unstable for a large reactor with non-uniform flux distribution than for a small reactor with uniform flux. The first approximate solutions obtainable analytically also indicate the possibility for spatial flux distributions different from those caused by xenon poisoning.

An experiment began in the PCTR to measure the "neutron temperature" of a graphite cylinder surrounded by graphite at a different temperature. The purpose of this work is to study the transfer of neutrons from the Maxwellian distribution characterized by the cylinder temperature to the distribution characterized by the temperature of the surrounding graphite. This experiment is an extension of similar work previously done in slab geometry.

In the Plutonium Recycle Program, satisfactory results were obtained from the evaluation of the Minneapolis-Honeywell Automatic Controller for the PRTR. The analog computer was used to simulate the reactor and the controller was connected to control the simulated reactor. Demonstrations and instrumentations were given to PRTR Operations personnel.

Work continued on the PRTR Wide Angle Viewer, Profilometer, and evaluation of the Rupture Monitor. Orderly progress was made in planning and preparation of the PRTR startup experiments.

In the Nuclear Safety Program, PCTR measurements in support of processing of nonproduction fuels showed that 3% enriched uranium solutions will always be safe when the ratio of hydrogen to total uranium atoms is greater than 44.

Major construction work on the Critical Mass Laboratory is nearing completion on schedule. The remaining work is primarily interior finishing and equipment installation.

Nuclear Safety experiments continued on heterogeneous and homogeneous systems in support of power reactor fuels processing. Advice was furnished CPD on the design of a fuel element mechanical disassembly cell and a fuel element dissolver.

Some difficulties are being experienced in the Nondestructive Testing Program in obtaining the desired sensitivity from the experimental broadband eddy current equipment being used to measure the Zr jacket thickness and air gap thickness in unbonded PuAl fuel elements. Work began on a new investigation of infrared and inductive thermometry methods of measuring the heat transfer characteristics of fuel elements.

Operation of the Shielded Personnel Monitoring Station was improved by installation of a thin lead lining on the inner walls of the iron room to reduce the background from low energy radiation.

Neutron dosimetry problems are being given increased attention on a plant-wide basis through cooperative technical meetings and experimental programs.

Reduction of data from the Atmospheric Physics experiments of last summer extended the previous Air Force data for an 800 meter grid to distances of 2, 8, and 16 miles in a logical and consistent manner. These results and a preliminary study of predicting initial arrival times for particles downwind from a source during inversion conditions were transmitted to the Air Force.

Orderly progress was made on the development of a number of radiological instruments in support of the Biology and Medicine program.

It was noted that radiation induced darkening of long glass fibers being investigated for use as light pipes for flexible probe scintillation detectors may be turned to advantage as a method for integrated gamma dosimetry.

4. Biology

Beta emitters in fish collected at Hanford were present in approximately one-third the concentration observed one year ago.

Concentration of Zn^{65} in oysters was higher than in any other mollusks sampled at Willapa Bay and ten times that in specimens from Dungeness.

P^{32} concentration in fish held in effluent treated with aluminum turnings was approximately half that of fish held in untreated effluent.

In five of a total of 14 weanling pigs from sows fed 25 μc/day Sr^{90}, there was a suggestion of microcytic anemia. Body burden is estimated at 5 to 10 μc Sr^{90}.

Increase of plutonium excretion from pigs was much greater than predicted from rat studies. Increase was largely in the feces and is presumed to reflect a higher level deposition in pigs as compared with rats.

Preliminary data suggest a slight advantage of tourniquets in decreasing transfer of plutonium from contaminated wounds.

No increase in polyvinylpyrrolidone excretion through the intestine was noted in dogs irradiated with 350 and 500 r X-rays.

Permeability studies on yeast suggest that increased permeability is a consequence of damage to transport systems rather than to a generalized permeability of the membrane.

5. Programming

A program of research and development was outlined for additional efforts on ionium recovery and preparation of uranium-232.

The report which was prepared supporting a request for about forty kilograms of high Pu-240 plutonium for PRTR was issued.

Initial planning and evaluation was begun on the possible approaches to the economic model for the plutonium value study.

Three speakers have now accepted our invitations to participate in the 1960 Hanford Science Colloquium. These speakers are: Dr. Sioma Kagan, staff economist for the Joint Council on Economic Education; Dr. Joseph Kaplan, U. S. Chairman of the International Geophysical Year; and Dr. George Gamow, physicist and noted thermonuclear scientist.

TECHNICAL AND OTHER SERVICES

Work on the GCL estimation program is essentially complete although extensive testing remains to be done.

A final report was issued upon an investigation of the effect of exposure angle on gamma film badge response.

Several approximating solutions were obtained to the mathematical model of the heat transfer process during the regenerative phase of a gas-catalytic reactor which clearly exhibit the travelling heat wave phenomenon that has been consistently observed in physical models.

Work on 7 operations analysis programs continued during the month. In addition, statistical and mathematical assistance on 18 problems was given within HLO and to other departments and operations.

Seven minor plutonium deposition cases were confirmed during the month. The total number of deposition cases that have occurred at HAPO is 244 and 177 are currently employed.

A Report to the Community - Radiation Protection at Hanford, was presented over KEPR-TV, Channel 19, on Thursday evening, December 17, 1959.

There were 22 authorized projects at month's end with total authorized funds of $6,735,000. The total estimated cost of these projects is $8,720,000. Two new projects were authorized and three were completed during the month. One new project is awaiting AEC approval. Four proposals for new projects are in preparation.

Project CA-749 - High Level Radiochemistry Facility, was announced as physically completed during the month. This project was performed on a design and construct contract with a total elapsed time of 17-1/2 months.

Beneficial use of the facility was achieved on November 3, 1959 and physical completion on November 30, 1959, with only minor exceptions remaining. Total project cost was $925,000 compared to an originally authorized amount of $1,200,000 and presently authorized $960,000.

During the month 21 CPFF work orders were issued to J. A. Jones Company amounting to $49,973.00. Six supplements to HL orders were issued amounting to $13,782.00. Total authorizations issued are $63,755.00. There were 46 existing HL orders at the beginning of the month with a total remaining unexpended balance of $139,172.00. Total J. A. Jones Company expenditures during the month were $89,934.00.

SUPPORTING FUNCTIONS

Beneficial use of Laboratory Equipment Pool Building 3718 was made during the month of December with receipt of three shipments of equipment. Preparations are being made by field personnel to transfer numerous items during the month of January.

The following three special requests were authorized by HOO-AEC and received by Hanford Laboratories during December.

(a) Fabrication of plutonium foils for ANPD - $2,000
(b) Fabrication of plutonium-aluminum pins for duPont - $5,000
(c) Procurement of surplus zirconium tubing by duPont - $25.00 (packaging)

As of December 31, 1959, the staff of Hanford Laboratories totalled 1318 employees, including 634 exempt and 684 nonexempt. There were 544 employees possessing technical degrees, including 331 B.S., 112 M.S., and 101 Ph.D.

The medical treatment frequency for December was 1.56 as compared with 1.46 last month. For calendar year 1959 the medical treatment frequency was 1.63. There were 4 security violations during December, bringing the total for the year to 46.

A Technical Shops employee suffered a permanent partial disability of his right hand as a result of an explosion which occurred while he was machining on an isostatic press.

A HAPO task force on Pressure Systems was organized with representatives from the Product Departments, CE & UO, and the Laboratories.

Three HAPO offers were extended to Ph. D. candidates during the month and acceptances were received from two, a chemist and a theoretical physicist, both for assignment to HLO. Three Ph. D. s reported on HLO rolls, including two chemists and one fisheries biologist. Fall recruiting for Ph. D. s was completed with visits to University of California, Stanford, Michigan, Washington and Washington State. Six new offers were extended to BS/MS candidates during the month and one acceptance was received for the Technical Graduate Program. Seven offers were extended to experienced BS/MS candidates and 10 acceptances were received from outstanding offers for the month. Three Technical Graduates accepted permanent placement; three went on military leave of absence; and one transferred to the Engineering and Science Program, leaving a total of 60 Technical Graduates assigned to HLO on December 31.

There are currently 8 openings for nonexempt personnel in the Laboratories, for which 4 candidates are in process, 3 transfers are pending, and one yet to be procured. Ten nonexempt vacancies were filled during December.

P P Bupp

for
Manager
Hanford Laboratories

HM Parker:pmg

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Comparison of Zircaloy-2 and Zircaloy-4 Alloys. Comparison tests of these two alloys have been conducted for several months using Zircaloy-4 stock from Bettis Ingot No. 28260. Test results reported in previous months indicated that this Zircaloy-4 stock was slightly more susceptible to the pick-up of molecular hydrogen than Zircaloy-2 control samples.

New data obtained this month show essentially identical corrosion rates for Zircaloy-2 versus the above Zircaloy-4 stock when exposed either (a) in 1500 psi steam at 400 C for 14 days, or (b) in 360 C water for 40 days. However, contrary to Bettis data, the pickup of corrosion-product hydrogen in these tests was approximately the same for both alloys, within the limits of experimental reliability for a small number of tests employing single heats of each alloy. The differences between HAPO and Bettis results are not in the amount of hydrogen picked up by the Zircaloy-4, but rather that Bettis data indicated approximately a two-fold greater hydrogen pick-up in Zircaloy-2 than the HAPO data. Data from the recent H HAPO tests are tabulated below:

Comparison of Zircaloy-2 vs. Zircaloy-4

Expt. No.	Alloy	Wt. Gain mg/dm^2	Ppm Hydrogen Found	Ppm Hydrogen Pick-up (increase over start)	% of Theoretical Hydrogen
		Test 1: 14 days; 400 C, 1500 psi steam			
L1	Zr-2	29	35	15	10
L2	Zr-2	30	35	15	9
L7	Zr-4	27	60	35	18
L8	Zr-4	27	45	20	10
		Test 2: 40 days; 360 C water			
H2	Zr-2	31	45	25	14
H12	Zr-4	31	50	25	11

Long-Term Zircaloy-2 Corrosion Tests. Recent examination of data from eight Zircaloy-2 coupons exposed for 5600 hours in 360 C deionized water appears to support the French claim that the corrosion rate of Zircaloy-2 after the "breakaway" point may not be as high as previously believed on

the basis of log-log plots of corrosion data. This experiment is being continued to longer exposure times.

Fuel Element Rupture Studies. Tests were conducted to determine the relative effectiveness of 400 C steam at 100, 500 and 1500 psig, for producing a rupture in a defective fuel element. These tests were made to investigate the optimum conditions for autoclaving coextruded Zircaloy-clad NPR fuel elements prior to reactor loading. The samples were two-inch lengths of NPR-size large tube elements with 20-mil cladding. They were defected with both 25- and 10-mil pinholes into the uranium core. The results are shown in the following table. A pressure of 1500 psig was far more effective for detecting the defects. Future tests will be conducted at 1000 psig with a 10-mil defect, and 1500 psig with a three-mil defect.

Autoclave Rupture Tests in 400 C Steam

Pressure, psig	Defect	Results
1500	25-mil	Ruptured after 27 minutes
100	25-mil	No visible change after 16 hours
1500	10-mil	Ruptured after 30 minutes
500	10-mil	No visible change after 7 hours
100	10-mil	Ruptured after 38 hours.

Visual Rupture Studies. Time lapse movies were made of two rupturing unirradiated fuel element samples in water at 300 C, 1500 psig. The samples were coextruded Zircaloy-clad, uranium core rod (0.6" OD) with 10-mil and 30-mil cladding. They had been pre-defected with a 25-mil pinhole through the Zircaloy cladding.

The samples ruptured by progressive blistering of the clad. With a 10-mil cladding, the blisters were much smaller than for the 30-mil clad. The 10-mil clad sample ruptured sooner and then proceeded more slowly than the 30-mil clad sample.

Clad Thickness	Induction Time	Wt. Loss 130 Minutes after induction
10-mil	21 minutes	20 grams
30-mil	45 minutes	50 grams

Radiometallurgy Laboratory Studies

The metallographic examination of the internal tube portion of a 36" long, 1.47% enriched tube-in-tube fuel element, which failed in low pH water after an exposure of 400 MWD/T, has shown that the temperature of the uranium was insufficient to produce any beta phase 3/4" downstream from the rupture, and that the hydrogen content of the Zircaloy-2 was approximately 500 ppm in the inner jacket and 200 ppm in the external jacket (RM-553).

The ruptured portion of the stainless steel process tube from the 6x9 ETR Loop was found to have three parallel, longitudinal cracks in an elliptically shaped, discolored area (RM-560).

Metallographic examination of the ruptured, 20-mil thick Zircaloy-clad, coextruded 1.6% enriched uranium rod from a 7-rod cluster showed undercutting of the Zircaloy-2 cladding without any gross uranium-water reaction (RM-555).

Visual examination and dimensional measurements were completed on the internal tube from a 36-inch long, natural uranium tube-in-tube fuel element which was irradiated to 300 MWD/T in KER Loop #1. Warp had occurred in several planes, with a measured maximum of 5/32 inch (RM-550).

PT-3 NA uranium tensile samples from the 0.075 a/o and the 0.10 a/o exposures were photographed and prepared for an anneal of ten cycles between the temperatures of 100 C and 625 C (RM-108-A).

Metallography, replication, and hardness were obtained on a thorium tensile sample that was irradiated to a calculated 1.0 a/o burnup (RM-213). Eight thorium tensile samples, including four irradiated to 0.03 a/o burnup and four irradiated to 0.10 a/o burnup, were tested at room temperature (RM-501).

Two sections of KER Loop #2, Zircaloy-2 process tubing, which had been in-reactor for 27 months, were sectioned to provide samples for burst testing and crush testing.

The results and conclusions from these tests will be reported in connection with the respective development programs of Fuels Design, Physical Metallurgy, and Structural Materials Development Operations.

Basic Metallurgy Studies

Radiation Effects in Fissionable Materials. A turbo-mechanism has been developed that will rotate an irradiation capsule so that the enclosed specimens will receive a radially uniform exposure to the neutron flux. Comparative irradiation tests using both rotating and stationary capsules are being performed at the MTR. The remaining two of four capsules reached their goal exposures and were discharged from the MTR during the month. These capsules, one rotating and one stationary, both contained uranium enriched to 1.732 percent U-235, and were irradiated to a total exposure of 0.05 a/o burnup of all atoms.

Testing of irradiated thorium, an isotropic cubic metal, should yield data that can be interpreted more simply than that for dimensionally unstable uranium, although both undergo damage from fast and thermal neutrons. One thorium specimen irradiated in the MTR to a total atomic burnup of 0.8 a/o was tested in tension at room temperature and measured for hardness. The properties were as follows: 0.2 per cent yield strength - 69,100 psi, tensile strength - 75,200 psi, percent elongation - 2.1, and

and R_A hardness - 53. These data for the unirradiated control specimens were (average) 18,300 psi, 26,700 psi, 37.7 percent, and 9.2, respectively. The specimen exhibited a brittle-type failure, and an extensive intergranular crack network was observed in the microsection of the specimen shoulder. Similar thorium specimens irradiated in a Hanford reactor to total atomic burnups of 0.03 and 0.10 a/o were tensile tested at room temperature. Average changes resulting from 0.03 a/o burnup were a 65 percent increase in both tensile and 0.2 percent yield strength and a 15 percent decrease in total elongation. Average changes resulting from 0.10 a/o burnup were a 85 percent increase in both tensile and 0.2 percent yield strength and a 70 percent decrease in total elongation. At 0.1 a/o burnup the thorium had a moderate elongation of approximately 13 percent compared to 2.1 percent measured after 0.8 a/o burnup.

Two characteristics of the stress strain curves for the irradiated thorium are of special interest. Whereas unirradiated thorium strain hardens slightly after initial yielding, the thorium irradiated to 0.03 a/o exhibited maximum strength at the yield point, and the thorium irradiated to 0.10 a/o yielded at constant stress nearly to the point of fracture. Most of the specimens exhibited a drop-in-load yield point. The stress difference between the upper and lower yield point was greater for the lower irradiation and for the fine-grained material.

Alloys of thorium containing 1 w/o oralloy (93 percent U-235), 4 w/o oralloy, and 5.4 w/o oralloy have been obtained for high temperature, high burnup irradiation tests of thorium. These tests are designed to determine the changes in mechanical properties in an isotropic fissionable material. The proposal for irradiating in the MTR nine NaK-filled Zircaloy-2 capsules containing tensile specimens of the three alloys was written. It is planned to irradiate the alloys at equal power levels (735 F maximum temperature) to total atom burnups of 0.2, 0.5, and 1.0 a/o.

Mechanical and Physical Properties of Materials. The creep properties of Zircaloy-2 are considerably improved by small amounts of residual cold work. The extent to which increasing amounts of cold work influence creep properties and the effects of recovery during testing are being determined on specimens cold worked in the range of 15 to 45 percent. The test conditions, as well as the amount of cold work in the specimens, were selected as limits of conditions that would be encountered in service in reactor process tubing or fuel element cladding. Tests in progress in the five vacuum creep units and their status during the month are:

A creep test of 25 percent cold worked Zircaloy-2 was completed after 5600 hours stressed to 17,800 psi at 400 C. A minimum creep rate of 2.69×10^{-6} in/in/hr was obtained.

A second creep test of 45 percent cold worked Zircaloy-2 was completed after 5000 hours stressed to 18,000 psi at 400 C. Minimum creep rate of 4.06×10^{-6} in/in/hr was obtained.

A third creep test of 25 percent cold worked Zircaloy-2 was completed after 5000 hours stressed to 21,000 psi at 400 C. A minimum creep rate 9.13×10^{-6} in/in/hr was obtained. These same test specimens are now being used to determine creep activation energies.

A creep test of 25 percent cold worked Zircaloy-2 was completed after 5200 hours stressed to 13,200 psi at 400 C. A minimum creep rate of 1.8×10^{-6} in/in/hr was obtained. The test specimen has been removed and an annealed specimen will be installed in the unit.

These tests made at 400 C show that residual cold work certainly does improve creep strength of Zircaloy-2. A marked reduction in initial deformation and first stage creep are produced by increasing amounts of cold work. However, the higher cold worked specimen (45 percent) have higher second stage creep rates than specimens with 25 percent cold work. Second stage creep is not obtained until after approximately 2000 hours test duration. An annealed specimen is being installed to provide a basis for comparison of these data with results of the BMI creep tests on annealed Zircaloy-2.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material is a direct way of detecting radiation damage in these materials. Thin film or foil specimens can be studied conveniently since radioactivity restrictions are minimized. The preparation, irradiation, and subsequent microscopic examination of films and foils are continuing. Thin evaporated films of carbon supported on 200 mesh copper grids have been irradiated to exposures as high as 2.9×10^{19} nvt (thermal) at macroscopic temperatures believed to be much less than 100 C. Diffraction lines identified as $CuAl_2$, Cu, and Cu_2O were obtained. The copper grid had become bonded to the aluminum support cylinder during the high exposure irradiation. Since the temperature necessary for copper-aluminum interdiffusion is much higher than the macroscopic temperature achieved by in-reactor gamma heating of the Cu-Al surface, the observed bonding or diffusion must be associated with high microscopic temperatures, a decrease in the activation energy for diffusion (increased number of vacancies) or cleanup of the copper and aluminum surfaces by the irradiation. X-ray diffraction identification of the diffusion products is in progress. Seven evacuated capsules containing thin evaporated and sputtered films of UO_2, ThO_2, ZrO_2, Al containing particles of UO_2, ZrO_2, and UO_2 sandwich films, amorphous carbon films, and cold worked foils of Al are currently being irradiated to various exposures to confirm and extend previous measurements.

In-Reactor Measurements. A knowledge of errors in temperature measurement due to the effect of irradiation on thermocouples in a reactor is essential for quantitative evaluation of the in-reactor studies of swelling, creep, corrosion, and other temperature dependent phenomena. For this reason, a program of in-reactor thermocouple stability testing is in progress. The in-reactor thermocouple stability capsule, containing an iron-constantan, a chromel-alumel, and a copper-constantan thermocouple has been irradiated 7400 hours. Helium-16 percent CO_2 thermocouple

environmental atmosphere flow to the capsule was stopped last month because of a plugged reactor test-hole vent. During this absence of flow, the atmosphere over the thermocouples was air. As in the past, the resistance between the copper-constantan couple and the bottom of the aluminum thermocouple well has remained at a high, erratic value. The iron-constantan couple-well resistance has varied between low and high erratic values, as it did last month. Large variations in resistance between the chromel-alumel couple and the thermocouple well occurred for the first time this month. In addition, the copper-constantan and iron-constantan thermocouples have been indicating temperatures 17 C and 8 C, respectively, lower than the chromel-alumel couples. Temperatures of the in-reactor couples, due to gamma heating, have slowly varied between approximately 250 and 300 C during this time.

An air atmosphere was also maintained over thermocouples in the duplicate ex-reactor control capsule being used in these studies. Resistances between the bottom of the aluminum thermocouple well and the iron-constantan and chromel-alumel couples have remained at low values. However, the copper-constantan couple-well resistance occasionally varied from low to high values.

The heater in the in-reactor capsule failed during normal operation at about 70 watts input. This capsule will be discharged as soon as possible.

X-Ray Diffraction Studies. Analysis of the data obtained in the preliminary phase of the texture studies of Zircaloy-2 tubing is nearly complete. Results show that a minor variation in certain fabrication variables (e.g., extrusion ratio, temperature and duration of annealing, amount of cold work, etc.) sometimes results in a major change in the texture of the metal. It has been noted that $\{10\bar{1}0\}\langle 11\bar{2}0\rangle$ is usually the favored slip system, but alterations in fabrication procedure will in certain cases result in a texture in which $\{10\bar{1}1\}\langle 11\bar{2}0\rangle$ is the predominant slip system. Deformation mechanisms observed thus far are essentially an interaction of prismatic with pyramidal slip, accompanied by $\{10\bar{1}2\}$ and $\{11\bar{2}1\}$ twinning. The amount of basal slip appears to be negligible.

Samples of Zircaloy-2 tubing coextruded with uranium at ratios 15:1, 20:1, 25:1, 30:1, and 35:1 have been obtained. Texture studies are completed for the tubes having ratios 15:1 and 30:1. The $[11\bar{2}0]$ direction is in the extrusion direction; the basal planes are parallel to the extrusion axis at 45° and 63° to the radius in the tubes having ratios 15:1 and 30:1, respectively.

Metallic Fuel Development

Cluster Fuel Elements. The ruptured 7-rod cluster fuel element which was discharged from KER Loop 2 on October 15, 1959, has been cut through the ruptured area and polished. The cladding was broken at a 45° angle to the surface as if it had failed as a brittle fracture in tension. The uranium was corroded away, principally along the bond layer, for about

60° around the circumference on either side of the split in the cladding. No cracks in the uranium were observed.

The first rupture test was run at the ETR. The reactor was operated for a total of seven hours after the fuel element was ruptured, and only a slight activity was observed in the loop water. The fuel elements have been returned here for examination and the irradiated fuel elements for the third rupture test have been shipped. Data from the operation of prototype instruments for NPR have been obtained from the experiment by the Irradiation Processing Department.

Tubular Fuel Elements. On September 30, 1959, a failure was incurred in a Zircaloy-2 clad tube-in-tube fuel element being irradiated in KER Loop 3. Only three weeks of exposure time had been accumulated on the element at the time of failure. Examination of the failed inner tube showed that a heavy "crud" film had deposited on the fuel element surface and that failure had occurred as a result of accelerated (pitting) corrosion due to "overheating" of the Zircaloy-2 clad.

Examination of a section of the failed element indicates that considerable hydriding of the inner clad occurred during irradiation. It is estimated, metallographically, that the inner clad contains approximately 200 ppm of hydrogen. The hydrogen in both the inner and outer clads is distributed uniformly throughout the Zircaloy-2.

Examination of the uranium showed no evidence of the uranium having operated in the beta phase. Since the calculated maximum metal temperature for a film-free element was 350 C, the maximum temperature drop through the "crud" film did not exceed 310 C (558 F). This limit would still permit Zircaloy-2 clad temperatures in excess of 500 C.

One 36-inch long tubular element operated for 250 MWD/T in KER Loop 1 was brought into Radiometallurgy. The element is one from a charge of four elements which gave a rupture indication. The surface of the inner tube is noticeably bumped, reflecting the large grain size seen in the piece before irradiation. A pronounced warp of about 0.280-inch single throw was measured optically. The clad surface is in good condition with no sign of crud film or corrosion.

Six tubular elements of 18-inch length are being assembled for KER Loop 4. Three are uranium-two percent zirconium alloy. To date there have been two rejects, one for thin clad at the weld, one for thin clad in the bore. The remaining four elements have passed ultrasonic testing and are ready for support welding and autoclave testing.

Six 18-inch long tube-and-tube fuel elements are being fabricated for irradiation to high exposure in a KER Loop. Three of these fuel elements are 1.6 percent enriched, U-2 w/o zirconium alloy, and the other three are 1.47 percent enriched uranium. In the past, the material which was received with the copper cladding still on it had the copper removed after heat treatment. The possibility exists that heat treating with

the copper in place might cause diffusion of the copper into the Zircaloy-2 cladding. Therefore, these elements had the copper stripped off before they were heat treated. At the present time these elements have been heat treated, the ends counter-bored and acid etched to receive end-caps, and are now in the shop having the end-caps machined and fitted.

Because of the small amount of activity observed during the first rupture test in the ETR, a fourth rupture test will be run. The fuel elements for this test will be KER-size tube-and-tube elements rather than KER-size 7-rod clusters which are being used for the first three tests. It is felt that use of tube-and-tube fuel elements in the fourth rupture test will give results more nearly approaching NPR conditions than will the 7-rod cluster elements. Fabrication of the tubular fuel elements for this test has begun.

Metallographic examination of the four 150-inch long KER outer tubes mentioned last month showed two of these to have defects that would make it unwise to use the material for irradiation. In all cases these defects were attributed to uranium quality.

Three additional 150-inch long KER inner tubes were examined and results show one of these to be poor, one fair, and one good. Again, the defects noted were those pertaining to uranium quality; this being dirt in the uranium occurring at or near the bond areas.

A series of tests to be applied to coextruded Zircaloy-2 clad fuel elements include the following:

(a) Wall thickness determination

It was found that much of the instability previously encountered in the use of the Vectorscope instrument was due to heat generated in the probe head by the increased current needed to make the instrument sufficiently sensitive to measure small thickness differences in Zircaloy-2. A new probe head is being made with heavier primary windings, which in preliminary trials appears to correct the difficulty.

(b) Fluoride films on Zircaloy-2 surfaces

Chemical tests have been developed to detect residual fluoride films which if left on the Zircaloy surface during autoclaving are reported to accelerate corrosion. Small concentrations of fluoride-ion cause the red lake of zirconium-alizarin to turn yellow. However, this test is not so sensitive as those for copper and uranium contamination previously reported, and whether it will detect harmful concentrations of fluorides on the surfaces of the fuel elements remains to be determined.

(c) The ID surface quality of tubular fuel elements heretofore has been estimated by the tedious process of scanning with a borescope. Efforts to improve this slow, inaccurate procedure have proceeded along the following line: The ID surface is given the standard Zyglo-pentrex treatment, following which it is scanned with a probe consisting of an ultraviolet light pipe, bearing a photocell on the end. Defective spots, containing the fluorescent Zyglo oil, are located by their brilliance as the ultraviolet illumination and photocell pass them.

Component Fabrication. Tooling has been designed for use in evaluation of the hot heading technique on KER coextruded outer tubes and construction should be complete in approximately six weeks. This tooling will be very similar to the equipment presently being used to hot head KER inner tubes, which consists of a grip device for holding the tube and a heated container and forming dies. The ends of the tubes will be preheated to 600 C by induction heating. The new tooling can be mounted in the 50-ton vertical draw press, the 400-ton vertical press, or the new 700-ton press and will be capable of being modified to head NPR outer tubes.

Twelve KER inner tubes have been successfully sized following the hot heading operation. The tubes were first plug drawn to expand the ID to a uniform 0.500 ± 0.001 inch, then a mandrel was inserted in the tube and the OD was reduced in two passes. These reductions in the die produce a tube that is 1.042 ± 0.002 inch in diameter over the full length. The inside diameter of the tube remains 0.500 ± 0.001 inch. As a result of the above reductions, the element length increases approximately 1/8 inch.

A tubular fuel element closure made by expanding the inner jacket until they can be joined with a single weld pass has certain advantages over some of the closure methods in use. A practical way to form this closure without wrinkling or tearing of the jacket has not been demonstrated as yet. An attempt to form this type of closure on scrap ends of K-size tube-and-tube element inner tubes was made using the Dynapak. Uranium is etched out of the ends, and the actual forming is done with rubber momentarily under high pressure when the punch of the Dynapak confines it in a closed die space. No satisfactory closures have been made by this method, but the results of tests are encouraging -- since there remain many avenues for improvement.

Fuel elements for NPR are to be charged into smooth-bore Zircaloy-2 process tubes. Therefore, supports must be attached to each fuel element to properly locate the element in the coolant channel. Initial tests on clip type supports indicate that the oxide film applied to the process tube by high temperature autoclave treatment is broken during charging and discharging of fuel elements. Some galling and roughing of the process tube occurs. The current criterion requires that no disturbance of the oxide film on the process tube occur during charging or discharging. Support development is being directed to producing a roller type support system or a support incorporating a ceramic coating to improve the friction coefficient.

The salt bath heat treatment of Zircaloy clad fuel elements is being investigated to define the conditions of treatment to produce optimum fuel element properties. Three-inch long sections of both KER outer and inner tubes have been treated in a range of quench conditions, range of beta temperatures, and a range of beta holding times. Examination has been completed of the uranium-Zircaloy bond structure and thickness, uranium grain size, and structure of the Zircaloy cladding. X-ray examination of as-extruded and heat treated specimens is being made for radial, circumferential, and transverse directions. These data have shown a tendency in the KER outer tubes for the (100) poles to become parallel to the radial direction, or direction of heat flow during quenching during some treatments. There is an accompanying columnar uranium grain structure at both the inner and outer surfaces. Lower temperature beta treatments (675-700 C) and oil quenching appears to yield the most stable crystallographic structures. The metallographic results for the inner tubes are comparable to the outer, but the x-ray examinations are not completed.

Allied Fuel Studies. Two coextruded fuel rods were operated at 30 kw/ft each by electric resistance heating in a 300 C, 1500 psi water loop while in contact with each other. The test was terminated after three hours and forty minutes when the rods failed at the rod-bus connection. Superficial and metallographic examination of the rods revealed no damage to the clad (such as caused by hydriding) or changes in the bond (such as caused by overheating).

NPR-size coextruded tube-and-tube specimens contained in NPR Zircaloy-2 process tube are being tested in a 300 C water loop with varying coolant annuli between the defect and adjacent component. With a full and half-size annulus, the fuel corrosion rate and damage to the fuel geometry are the same. With a zero clearance annulus at the site of the defect, the inception of failure at the defect is retarded, but once started, fuel corrosion and fuel shape damage are severe.

During a loop test of defected specimens the flow was altered by a factor of ten. At the high flow rate, fuel corrosion was accompanied by a minimum of fuel geometry distortion. At the reduced flow rate fuel corrosion was accompanied by increased distortion. This behavior demonstrates the effect of coolant flow on defect behavior and correlates with the observed behavior of static autoclave versus dynamic loop testing.

Fuel specimens with clad thicknesses in the range of 0.010" to 0.030" have been autoclave-tested at 300 C, 1500 psi. It does not appear that fuel corrosion rates are appreciably affected, but damage in terms of dimensional changes appear greater with the thicker clad. Blisters formed by the accumulating corrosion product under a thick clad grow to a larger size before they fail.

The appearance of a coextruded fuel rod failure incurred in a KER facility after attaining an exposure of ~2500 MWD/T appears significantly different from simulated failures produced in autoclaves or loops on unirradiated

specimens. The KER failed rod had been uranium beta-treated and air-cooled. Tests performed on unirradiated material of the same heat treatment indicate that it possesses a high bond strength and failure is not propagated along the bond line. Cursory examinations of the KER failure, however, indicate that failure has propagated readily along the bond line. The implication is that burnup of the fuel had damaged the bond, and the bond has lost mechanical strength. Test specimens of low bond strength produced by bond-thickening diffusion anneals behave in a manner similar to the KER rod failure.

An ex-reactor test simulating the charging of an NPR fuel element in a Zircaloy-2 process tube showed a problem of severe process tube scratching may occur if metal sliding contact fuel element supports are used. In addition to the loss of metal and thinning the process tube after a number of charge-discharge operations, these scratches may lead to localized corrosion or act as regions of stress concentration. A series of tests are being conducted in which flat autoclaved Zircaloy-2 samples of various contact areas are weighted and pulled across another larger autoclaved Zircaloy-2 plate. A flow of water is maintained on the plate during the test. Initial tests showed that with a contact area of approximately 0.1 in^2 and a load of ten pounds, scratching of the Zircaloy-2 plate occurred within a distance of ten feet. Larger cross-sectional area samples are being prepared and will be tested with loadings equivalent to NPR fuel element supports. These tests should show if it is possible, even under ideal conditions, to charge and discharge over a distance of at least sixty feet fuel elements with sliding contact supports without breaking down the oxide film and scratching the parent metal of the Zircaloy-2 process tube.

Reactor swelling experiments of Zircaloy-clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposures are being conducted. A metallographic section taken from GEH-3-59 which operated to an exposure of 2100 MWD/T at an estimated 825 C central uranium temperature shows a complete failure of the U-Zr bond. Separation of the uranium and cladding of up to 0.007 inch can be seen. Four swelling capsules are presently being irradiated in the MTR to extend the coverage of temperature, exposure, and cladding restraint. Measured uranium center temperatures in one capsule are in the 625-700 C range, while in the others the temperatures are in the range 300-400 C. Two capsules each containing one ingot and one dingot uranium rod clad in Zr-2 are being assembled for irradiation to compare swelling characteristics of the two types of uranium.

Six of nineteen swelling capsules in D Reactor were discharged because of a process tube failure. The remaining sixteen capsules are approximately four-fifths the goal exposure of 1500 MWD/T. The center uranium temperatures are in the range 400-500 C.

Metallurgical Development. A program has been initiated to determine the hydrogen pickup in uranium from various heat treating salts. The salts investigated were Houghton 980, NuSal and Liquid Heat 300. Uranium

washers were heated in these salts for times ranging from three to 30 minutes and in the temperature range of 690 to 750 C. Although hydrogen analyses have not been completed, the incomplete data indicate that hydrogen concentration increases with time and that NuSal, a binary chloride salt, has the least hydrogen pickup in uranium, and that Liquid Heat 300, a binary carbonate salt, has the greatest hydrogen pickup in uranium.

Metallurgical Evaluation. November 30, 1959, the pressure tube in the ETR 6x9 facility sustained a fracture at a position corresponding with the center of the core. Cause of failure must be determined in order to decide whether or not to charge the replacement tube now on hand at the ETR. A ring cut out of the tube about seven inches from the fracture, but still in a high flux level, was tested by crushing and found to be completely ductile. This work was done by Phillips Petroleum personnel. Examination of a fifteen-inch long tube section containing the fracture was started at HAPO. The diameter over the bulge at the fracture was only 0.020 inch greater than the remaining tube diameter. The diameter of the remainder of the tube showed no change over its original diameter. Absence of significant strain in the tube and the appearance of the fracture tend to rule out overstressing as a cause of failure.

Facilities and Equipment. Installation has been completed on both the 1500 cfm mechanical booster vacuum pump for the 306 Building Melting Furnace and the Variable Capacitance Bank for the 306 Building Tocco Induction Heating unit. The mechanical booster pump has reduced the furnace pump down time by a factor of two while providing a large degree of protection against gas bursts in the 10^{-3} to 1 mm pressure range. The variable capacitance bank installed in the Tocco Induction Unit provides essentially an unlimited selection of capacitance up to 100 microfarads. An auto-transformer, which operates in conjunction with the capacitance bank, provides three current to voltage ratio selections. This unit will operate to 50 kw with any size coil up to 15 turns and at 25 kw with any coil up to 20 turns.

A portable vacuum system, capable of pumping 1200 cfm at 10^{-3} mm of mercury with an ultimate blank off pressure of 4×10^{-7} mm of mercury, has been placed in operation. This unit is being used with a vacuum head and induction coil assembly, connected to the above induction system, for experimental closures of NPR type fuel elements.

A large box furnace has been installed in the 306 Building. This 40 kw furnace will operate at temperatures up to 1100 C and will accommodate material up to six feet in length.

2. REACTOR PROGRAM

Coolant Systems Development

Through-Reactor Decontamination of Present Reactors. Equipment was installed in 242 Building to test procedures for through-reactor decontamination. The equipment consisted of storage tanks, pumps, heaters, a Zircaloy tube and associated piping. A contaminated stainless steel D Reactor pigtail was connected to the Zircaloy tube. The decontaminant, a 10% solution of Wyandotte 1112 (inhibited bisulfate) was prepared, heated to 50 C in the storage tank, and pumped through the apparatus for a total time of 24 minutes. In the first test at a flow rate of 4 gal/min, the decontamination factor for the pigtail was about eight. In the second test at 8 gal/min, the decontamination factor was 40. Previous experiments had shown that under these conditions the corrosion of aluminum, Zircaloy, stainless steel, and carbon steel was negligible.

The effect of concentration on decontamination will be checked in engineering-scale equipment, inasmuch as laboratory data suggest that the concentration can be decreased to 2% without seriously affecting the decontamination effectiveness.

Once-Through Decontamination for NPR. The same apparatus was used to test procedures for decontaminating NPR on a once-through basis. Carbon steel and stainless steel coupons, previously exposed in the KER Mockup tubes were placed in the Zircaloy tube. In the first run, a 10% solution of Turco 4518 (inhibited oxalic acid) was used at a concentration of 10% at 70 C for 10 minutes. The average flow rate past the coupons was 0.9 ft/second. The decontamination factor for carbon steel was 9 to 11; but for stainless steel the d.f. was only about 1 to 1.5. In another test, a solution of 2.5% Turco 4518 was used under the same conditions. The decontamination factors were only slightly lower (7 to 8 for carbon steel and 1 to 1.5 for stainless steel). Other decontaminants are being tested to determine relative efficiencies.

Other Decontamination Studies. Work is progressing on use of a foaming agent from Dowell Company for suspension of the alkaline permanganate and acid treatment steps in decontamination. The use of stannous acetate to inhibit carbon steel corrosion by ammonium citrate solution proved unsatisfactory because the tin plated out and the decontamination factors were low (approximately 5). A proposed method of corrosion inhibition by neutralizing the pH (changing from "as-made" to 4.5 or some intermediate) appears unsatisfactory for the Wyandotte 1112. The reduction of corrosion was very good, but the decontamination was also reduced to a small factor.

A test was made in the IRP Loop employing peroxide-carbonate, alkaline permanganate and Turco 4512 (H_3PO_4). The decontamination of carbon steel was very good (d.f. $\sim$ 350), but the stainless steel loop did not clean up as well as with the ammonium citrate or bisulfates.

Effect of Repeated Decontamination on Corrosion Rates (Turco 4501 Process). Zircaloy-2 and 304 stainless steel crevice-stress coupons which were periodically discharged from CEP-1 were examined with a microscope for pitting in the crevices and cracking at the stressed areas. Neither type corrosion was found. The 304 stainless steel coupons were corroded at a rate of 0.2 mil/year. This high rate is due to the weekly removal of the protective corrosion product film by the decontaminating solutions.

Rupture Studies of NPR Candidate Fuel Elements. Plans are under way to install ELMO-4 in 1706 KE Addition next month. In the meantime, all out-of-reactor loop rupture testing is being conducted in the Heated Slug Rupture Prototype at 100-D. Four NPR size tube-in-tube coextruded fuel elements with annulus spacings from zero to 0.20 inch were tested for five one-hour exposures. The tubes were defected with 0.025-inch pinholes through the Zircaloy on the outside surface and were exposed at 300 C and 1650 psi.

Two large OD tubes with 0.12-inch and 0.06-inch annuli exhibited typical 3/8-inch diameter raised and torn mounds after the first hour. No change was noted during the next two hours, but during the fourth hour, when the velocity was reduced from 16 fps to 2 fps, each of the tubes developed several smaller mounds at the rupture zones. The other two large tubes with zero annuli above the defects had raised slightly (1 or 2 mils next to the defect) during the first three hours. One of the tubes exhibited a large break after the fourth hour, with the defect developing during the fifth hour to a size of about two inches by three inches on the outside of the tube plus a 1/4 inch high defect measuring about an inch in diameter on the inside of the tube. The rupture in the other zero annulus tube did not progress as extensively during the two additional hours.

The small diameter tubes exhibited typical 3/8-inch diameter breaks after the first hour for the 0.21-inch and 0.103-inch annuli spacings. Two other zero annuli pieces had small raised portions adjacent to the defect after the first hour.

Hydrogen Detector. Several tests using a palladium-platinum resistance detector for measurement of hydrogen concentration in water show that the instrument has a very fast response, 6-1/2 minutes at 500 F to reach 95% of equilibrium. Preliminary results also indicate the detector is capable of being used with hydrogen concentrations in the water up to 3000 cc/liter of water. This value corresponds to the solubility of hydrogen in water at 300 C and a hydrogen partial pressure of about 450 psi.

Titanium-Aluminum Galvanic Corrosion. The use of titanium thimbles to contain aluminum-jacketed control rods is planned for NPR. Consequently, titanium-aluminum couples are being tested at two different flow rates in 1706 KE single-pass mockup tube. Titanium and aluminum samples in contact were not severely corroded during a two-week exposure to Hanford process water at 80 C. Titanium corrosion rates were less than 0.01 mil per month, and aluminum corrosion rates were about 0.5 mil per month during this same period. Corrosion of both titanium and aluminum samples was

essentially the same at flow velocities of three feet per second and six feet per second. Discharges of additional samples are scheduled after exposures of six and 12 weeks.

Structural Materials Development

Zircaloy-Retubing Program. Two smooth-bore Zircaloy-2 tubes have been installed in C Reactor and an additional two have been received at White Bluffs for testing. Two vendors have now fabricated the first few ribbed Zircaloy-2 tubes for the production reactors and these tubes are ready for inspection by General Electric personnel.

NPR Process Tubes. Budd Company has completed welding on five tubes (15 extrusions) for Allegheny Ludlum. Twelve more extrusions are at Budd this week, with more to follow the next week. Tube Reducing Corporation expects to tube reduce the first lot of tubes the first week of January. Inspection of these should follow during the second week.

Chase Brass Company has drawn their first two NPR tubes. The operation went very smoothly with no evidence of scratching or chatter. Welding is proceeding on additional tubes. Drawing of the remainder of the first lot of 10 to 12 tubes is scheduled for the first week of January with inspection the following week.

Autoclave Film Tests. The possibility of scratching the inside surface of NPR Zircaloy process tubes in the charging and discharging operation has caused considerable interest in the abrasion resistance of oxide films produced by autoclave treatment at 400 C and 1500 psi in the range from 36 to 353 hours. The results showed improvements in durability of the films out of all proportion to the length of time in the autoclave or the thickness of the film. Increasing autoclave time by a factor of 10 doubled the film thickness but increased its abrasion resistance 20-fold. Longer autoclave exposure changes the nature of the film, apparently densifying it and/or increasing its hardness. The tests are described in detail in HW-62906.

Subsequent to the work described above, tests have been started exploring the effects of autoclave temperature on film characteristics. Samples have been autoclaved for 36 hours at 425 and 450 C to compare with the previous 400 C samples. The abrasion resistance of the 36-hour film at 425 C was slightly better than the 142-hour film at 400 C. The 36-hour film at 450 C was greatly superior to the 353-hour film at 400 C. Further evaluation is in progress.

Burst Test on Irradiated KER Process Tube. Two samples of Zircaloy-2 process tubing which had been irradiated for 27 months in the high-flux region of KER Loop #2 were burst under five feet of water at 60 F in Radiometallurgy, along with two similar, unirradiated control samples. Resulting data are as follows:

Sample	Burst Pressure
Irradiated about 2 years at up to 260 C	14,800 psi
	16,300 "
Similar, unirradiated tubing with 70% cold work	14,200 "
	14,200 "

In all cases the tubes bulged slightly prior to splitting from end to end of the sample. The fractures were irregular, following material discontinuities introduced during the heavy cold working. The fracture surfaces of the unirradiated samples were at 90 degrees to the tube surface, whereas approximately half of the fracture surfaces of the irradiated samples were at about 45 degrees to the tube surface. The irradiated tube specimens fractured in a ductile rather than a brittle manner and required slightly higher internal bursting pressures than the unirradiated control samples.

However, flattening tests performed on rings cut from these tubes yielded deflections prior to fracture of 0.75 inch for unirradiated tubing and 0.2 inch for the irradiated tubing, indicating some but not complete loss of ductility on irradiation.

In over-all evaluation, it is concluded that the fracture characteristics of the tubing in a burst test at room temperature were not adversely affected by the irradiation and that these results are favorable with respect to employment of Zircaloy pressure tubing in in-reactor service.

Nonmetallic Materials Development

MTR High Temperature Graphite Irradiations. The GEH-19-3 experiment in the L-48 shim rod is continuing into its fifth reactor cycle to accumulate a large exposure in an attempt to demonstrate length change saturation properties of needle coke graphites. At least one more cycle's irradiation will be attempted after this one. The decision to continue is based each time now on inspection of certain critical parts at each shutdown to determine further useability of the shim rod.

MTR Hot-Capsule Irradiations. The results of hot-capsule irradiations of candidate NPR graphite materials indicate the following approximate comparison, listing from "best" to "poorest": VC, GL-11, KC, SP-9, GL-10, SP-10, CSF. This comparison from the standpoint of contraction on irradiation is only qualitative since exposures of the various capsules varied nearly four-fold (up to 1.4×10^{20} nvt greater than 1 mev), and sample irradiation temperatures are known only approximately -- although generally greater than 600 C.

GETR Irradiations. The H-2 experiment in the E-7 position of the GETR was discharged December 5, after a calculated exposure of 1.2×10^{21} nvt ($E > 1$ mev). Upon disassembly, the experimental assembly was found to be

badly deteriorated with some graphite excessively reacted or shattered. In spite of this situation, length-change measurements were possible on many of the samples and showed small expansions (e.g., from 0 to about 0.2 percent), rather than contractions.

The mechanism responsible for the partial disruption of the capsule contents is as yet unknown. Upon discharge, the outside of the aluminum capsule appeared normal. Inside of the capsule the graphite samples in the most intense flux zone were highly eroded and others were cracked. Furthermore, thermocouple insulators made of vitreous alumina were shattered from the wires over a zone extending four sample positions, several aluminum spacers had been melted, and one alundum part was transported an inch from its normal locked position. A considerable amount of debris was scattered throughout the capsule, some of which appears to be graphite lumps and solidified molten metallic material. Laboratory studies of possible mechanisms, involving such factors as chemical or metallurgical reactions and thermal shock, are under way which will aid in the determination of the cause of the observed condition of the capsule. The graphite lumps in the capsule are being analyzed to determine whether a metal-graphite reaction occurred.

NPR Graphite. A shipment of samples of the first production scale run of graphite combining the factors which have been shown to lead to greater high temperature dimensional stability under irradiation, has been received from the Speer Carbon Company. All-flour mixes of Great Lakes needle coke and a graphitization temperature of 3200 C were utilized in producing the 4-1/2 x 4-1/5 x 50-inch bars.

Included in the shipment are samples of a No. 60 flour mix (60% through 200 mesh), a No. 50 flour mix, and a standard mix formulation. A large increase in surface area occurs between the No. 50 and No. 60 flours with a resulting increased pitch demand and difficulty in extrusion and baking.

After purity testing in the Hanford Test Reactor, physical property measurements and irradiation testing will be conducted.

Graphite Burnout Monitoring. One of the difficult problems in graphite oxidation monitoring in the Hanford reactors is obtaining exposure data of sufficient accuracy to permit correlation of power and burnout rates. A new foil holder has been devised which will permit easy inclusion of nickel and cobalt foils with each burnout sample. The device will be used in all future charges of burnout samples and is expected to greatly facilitate interpretation of the data.

Mattress Pad Materials. Adiprene urethane rubber mattress pads which were used to replace the original pads at the K Reactors failed prematurely due to increased radiation exposure and reactions of irradiated water with the rubber compounding ingredients. Results of an investigation to obtain better materials indicate that a nitrile rubber formulation developed at Hanford and a urethane plastic called Estane should be suitable for this application. To date these two materials have been

irradiated in water to a dose of 1 x 10^9 r. After this exposure the materials were not brittle and possessed good tear strength. Prototype mattress pads will be fabricated from these materials (as well as modifications of the materials) and compared with both the original materials and Adiprene by piling discharged fuel elements on the pads for various periods of time.

Thermal Hydraulics Studies

Studies Pertaining to Increased Power Levels Resulting from Larger Hydraulic Fittings. Increase of the size of outlet hydraulic connectors on "BDF" type reactor process tubes to permit increased flow and, consequently, power level, was further studied using the full-scale experimental heat transfer apparatus. Additional hydraulic stability curves relating pressures, temperatures, and flows were obtained under steady state conditions at tube powers up to 1750 kw. These data were obtained using a K Reactor nozzle barrel, slip joint Y fitting, a one-inch tubing pigtail, and a 0.650 inch ID rear header connector.

The additional data obtained at high heat generation rates confirm the results previously reported. That is, the larger sizes of outlet piping fittings result in a significant decrease in the amount of pressurization due to steam formation at low flows. As a result, the degree of protection offered by the Panellit systems to flow decreases is lessened and is about equal to that existing at the K Reactors.

During the above study additional data were also obtained concerning the effects of increasing the rear header pressure. It was found that an increase in rear header pressure quenched the amount of steam formation within the tube but had little influence on the eventual characteristics of hydraulic stability during flow reductions.

Hydraulic Studies. A study was completed to predict the events occurring in a process tube if there were no coolant flow while the front nozzle was removed for an extended length of time during charge-discharge activities. It was concluded that the boiling which would result would not be vigorous enough to eject heavy metal fuel elements out the front, but that it could possibly cause light metal elements or perf pieces to move. The results were reported in HW-63139.

Flow tests were conducted with three zone-5 secondary orifices (0.287-inch, 45° entrance taper) to determine the flow effects of having rough entrance sections. It was determined that these orifices which had roughnesses up to about 0.001 inch would not affect the normal tube flow rate over about 0.1 gpm for zone 5.

Incidental to these tests, it was determined that a variation in front header Parker fitting ID from 0.469 (specified) to 0.450 could be caused by tightening of the pigtails and flow meters. This decrease in fitting size would cause the experimental flow coefficient, K in $F = K \Delta P^{0.5}$,

to decrease about five percent. This indicates that if laboratory tests were run to determine a flow coefficient with a 0.469 fitting and the reactor fittings were actually 0.450, then the reactor flow might be as much as five percent below what it was calculated to be by use of the experimental coefficient.

Experiments were conducted in the Hydraulics Laboratory to determine the energy loss characteristics and check the leak sealing ability of a "Van Stone Seal Insert" which was developed by Materials Development Operation, IPD, for use in the BDF type reactors. The insert is to replace the two 8-inch perf pieces from the rear nozzle of the process tube outlet assembly. Water flow through the process tube will cause the insert to compress a silicone rubber seal mechanically against the Van Stone-nozzle junction, and stop any leakage which may occur due to a ruptured Van Stone flange or faulty flange gasket. Test results showed that energy loss characteristics were satisfactory and that the insert will adequately seal Van Stone leaks on initial installation.

Calculations were made of the flow loss to be expected from a possible rupture of an NPR instrument sensing line. It was found that for a 3/16 inch sensing line connected to a source of water at 1500 psia and 400 F, the flow rate would be 35 lb/min if a rupture occurred very close to the entrance. For a rupture located 50 feet from the entrance, the flow would be 15.5 lb/min while at 100 feet the flow would be 11 lb/min.

Heat Transfer Characteristics of 7-Rod Cluster Fuel Elements. Experimental heat transfer data were obtained from an electrically heated mockup of a 7-rod cluster fuel element. The mockup consisted of seven rods, 0.704 inch in diameter and 35 inches long, equally spaced in a 2.70-inch horizontal flow tube. The electrical resistance of the center rod in the cluster was greater than that of the six outer rods so that each of the outer rods had a 42% greater heat generation rate than the center rod. Thirty thermocouples were imbedded within the rods to measure surface temperatures and additional thermocouples were installed in the flow channels at the outlet end to measure water temperatures. Data were obtained at a variety of specific powers between 65 and 135 kw/ft for a flow rate of 110 gpm, an outlet pressure of 535 psig, and an inlet water temperature 20 F below the saturation temperature.

The flow channel thermocouple readings indicated that bulk boiling first commenced in the flow channels surrounding the center rod, next spread to the upper peripheral flow passages, and finally to the lower flow passages. The surface temperatures were found to occupy a relatively narrow span at any power level. Of these temperatures, it was found that the thermocouples at points of minimum spacing between surfaces exhibited temperature indications up to 20 F greater than those facing the flow passages. The center rod temperatures were not observed to exceed by an appreciable amount those obtained for the peripheral rods at any of the power levels.

There were no provisions in the test section to induce flow mixing by other than natural means.

Laboratory Equipment. An excessive amount of fuse failures has been experienced with the silicon rectifying equipment. It is believed that the ambient temperatures in the cabinets may be somewhat higher than that for which the fuses were designed. The vendor is planning on replacing the 336 individual 400 amp fuses with ones of a higher capacity.

Shielding Studies

Neutron and Gamma Attenuation. The data from the perforated ferrophosphorous concrete indicate that the attenuation of fast neutrons by the concrete part of the perforated shield can be predicted using removal cross sections and the composition of the concrete. There seems to be a large amount of radiation leakage through the ring and doughnut assembly due to resonance neutrons.

The data from the iron-serpentine (265 lb/ft^3) concrete test is being analyzed. The gamma attenuation through the as-cured iron-serpentine concrete (210 lb/ft^3) is about the same as for the as-cured magnetite-limonite (210 lb/ft^3) concrete. Iron-serpentine concrete should be a superior shield to any of the concretes tested thus far when baked at 320 C because of the large amount of water retained by the serpentine at high temperatures.

Masonite Thermal Damage. Because of apparent thermal damage to the masonite in the biological shield of the F Reactor, a limit has been adopted which prohibits exposure of the iron-masonite shields of the old reactors to an air atmosphere when shield temperatures exceed 100 C. Under certain conditions this limit could cause extended reactor shutdown time. At the request of IPD Operational Physics, a study of thermal damage to masonite has been initiated. Small samples of masonite which have been irradiated in the DR shield plug are being heated in air at temperatures ranging from 120 to 200 C. Weight loss measurements are being made in an attempt to define the relationship between thermal damage and temperature for irradiated material and to permit relaxing the above limit.

B. WEAPONS - 3000 PROGRAM

Research and development in the field of plutonium metallurgy continued in support of the Hanford 234-5 Building Operations and weapons development programs of the University of California Lawrence Radiation Laboratory (Project Whitney). Details of these activities are reported separately via distribution lists appropriate to weapons development work.

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

Basic Studies. To further investigate the stability of plutonium dioxide, a sample of PuO_2 which had been prepared by the calcination of the plutonium peroxide was heated in hydrogen for three hours at 1300 C. An x-ray diffraction pattern obtained with nickel filtered, copper radiation showed only a single face centered cubic PuO_2 phase. The data reported previously on the stability of PuO_2 was for material prepared by the calcination of plutonium oxalate. It appears that regardless of the route used in preparation of PuO_2, no reduction to a sub-oxide occurs during hydrogen sintering.

Investigations have begun to determine the reactions occurring between plutonium dioxide and various ceramics of inert fuel element matrice potential. The plutonium dioxide is being added to magnesium oxide, zirconium dioxide, zirconium dioxide stabilized with calcium oxide, aluminum oxide, and zirconium oxide with 10 w/o magnesium oxide. Pellets containing 2 and 8 w/o PuO_2 have been pressed from these materials and are being sintered at various temperatures to determine their sintering characteristics. The pellets will undergo x-ray diffraction to determine the compounds formed at the various sintering temperatures.

Fuel Fabrication. Zircaloy tubing evaluation is continuing and ultrasonic testing techniques are being developed for the determination of tube quality. The rods for the first loading of the PRTR will be categorized according to quality by ultrasonic testing techniques after assembly.

The Zircaloy tubes are being swage sized on a stainless steel mandrel to give an inside diameter on an eight-foot length of 0.505 ± 0.0005 inch. In excess of 200 tubes have been swaged and are now in the process of being gauged on the automatic air gauging machine which records inside and outside diameters simultaneously. Gauging is the most time consuming operation at present and requires about ten minutes per tube. Ten to twenty percent of the tubes must be rejected because of thin wall sections that do not reduce the same as the rest of the tube. This causes some areas to have excessive inside diameters. The tubes will now have the first end cap welded in place and prepared for assembly.

Enough billets for about 375 rods of the corrosion resistant alloy have been cast. One hundred and eleven cores have been extruded, corrosion tested satisfactorily, straightened, cut to length, weighed and are awaiting assembly. At first, about 50 percent of the cores were rejected in the corrosion test; however, about 100 percent are now acceptable. Some extrusions are now being rejected because of blistering. Two equipment failures on the extrusion press has slowed the fabrication. The

capability fabrication of a dummy 19-rod cluster element has been completed. It will be used for thermal cycling studies.

Fuel Evaluation. The three-foot long Zircaloy clad Al-Pu alloy 19-rod prototype cluster has now received a total of 17.5 days at full power and temperature in the ETR 6x9 loop. The element was discharged about three days short of goal exposure due to difficulties with the loop facility. It was successfully irradiated, however, to a maximum of 60 percent burnup of the Pu atoms in the highest flux region or an average burnup over its entire length of about 43 percent of the Pu atoms. During this time the element received about 15 thermal cycles. The irradiation conditions were very close to those expected in the PRTR.

A three-foot long Zircaloy clad Al-Pu alloy 7-rod cluster has also been discharged from the 3x3 loop of the ETR due to loop failure, after receiving about 18 days at full power and temperature. This amounts to a maximum burnup of about 14 percent. It is planned to recharge this cluster to complete the goal exposure of about 60 operating days. During irradiation the element was subjected to about 15 thermal cycles under conditions closely resembling those expected in the PRTR.

A two-foot long Zircaloy clad Al-1.8 w/o Pu alloy 7-rod cluster is under irradiation in the KER loop facility. Goal exposure is 2×10^{20} nvt.

A 10-inch long 4-rod cluster containing Al-8 w/o Pu and Al-Si-8 w/o Pu cores and irradiated to 2×10^{20} nvt in the KER loop facility has been examined. The following radiometallurgical results were obtained:

(1) Cladding on all rods decreased in diameter and increased in length.

(2) Cores in three rods increased in diameter and decreased in length. The core of one rod showed both increase and decrease in diameter and increased in length.

(3) Diffusion bonding occurred between ends of two Al-Pu alloy rods.

(4) No core-clad diffusion was visually detected.

A 3-rod Zircaloy clad 3.1 w/o Pu alloy cluster (GEH-4-46) which has graphite lubricated cores in cans which were swage sized onto the cores after assembly has been irradiated for 17.5 operating days in the GEH-4 loop at the MTR and is scheduled for discharge at a maximum burnup of about 50 percent of the Pu atoms. Another 3-rod cluster (GEH-4-43) containing Al-3.1 w/o Pu alloys cores which are a slip fit in as-received Zircaloy tubing is awaiting irradiation. These rods do not have any graphite lubricant and have diametral gaps between the core and cladding of as much as 0.0061 inch. Still another 3-rod cluster (GEH-4-48) which contains Al-Ni-Si-Pu corrosion resistant cores in swage sized tubing with diametral gaps in excess of 0.007 inch is completed and awaiting shipment to the MTR.

The fabrication of a three-foot long Zircaloy clad 7-rod cluster (GEH-11-4) containing Al-Ni-Si-Pu cores in swage sized tubing has been completed. This element which has gaps in excess of 0.007 inch will be irradiated and thermally cycled in the ETR 3x3 loop facility.

Of the 24 Zircaloy clad capsules containing Al-Pu or Al-Si-Pu alloy cores which have been irradiated to date, eight have been examined and sixteen are currently at the Radiometallurgy Laboratory for examination. Two-inch long Al-Pu and Al-12 w/o Si-Pu alloy fuel cores with 1.65, 5, 10, 15, and 20 weight percent plutonium were used. All cores were machined from cast rods. Jackets for the eight pieces examined were machined from solid Zircaloy-2 rod. Seamless extruded Zircaloy-2 and 3 tubing was used for cladding material on the remainder of the specimens. In all cases the fuel cores were about 0.504 inch in diameter and were 0.003-0.004 inch smaller in diameter than the jacket ID's. The non-lubricated cores were slipped into the jackets and end cap closures made by fusion welding in a helium or helium-argon atmosphere. All specimens were subjected to a helium leak test and steam autoclaved for 100 hours at a pressure of 100 psig.

No ruptures have been encountered to date. The specimens were irradiated in the MTR under the following conditions:

(a) Light water coolant (46 C)
(b) Specific power generation - about 30 kw/ft
(c) Heat flux - up to 950,000 Btu/hr-sq ft.
(d) Thermal neutron flux - up to 4×10^{14} nv
(e) Exposure - up to 15.26×10^{20} nvt
(f) Fuel core center temperature - up to 445 C (calculated)
(g) Fractional burnup of Pu atoms - up to 100%.

The following observations were made on capsules containing Al-1.65 w/o Pu and Al-12 w/o Si-1.65 w/o Pu alloy cores which have been examined to date:

(a) No significant change in the external dimensions of the capsules was noted.

(b) No significant microstructural change in the fuel cores was observed.

(c) For a given set of irradiation conditions the percentage increase in volume was higher for the Al-Si-Pu alloy cores than for the Al-Pu alloy.

(d) Unless the capsule core or cladding was damaged during handling operations subsequent to irradiation, the fuel cores were readily removed from the jackets.

Twenty-four UO_2-PuO_2 Zircaloy-clad capsules have been or are currently being irradiated at the MTR. Twelve of the specimens contain high density (90 percent of theoretical) sintered compacts. The remainder

have low density (65-70 percent of theoretical), non-sintered compacts. All capsules are 2-2.5 inches long, contain helium, and are clad with seamless extruded Zircaloy-2 tubing (honed ID, 0.030-inch wall). Both UO_2-PuO_2 mixed crystal oxides and mechanical mixtures were employed. Compacts were 0.5 inch in diameter and had the following compositions:

(a) High density compacts - 0.0259, 1.02, 2.57, 4.13, 5.67 a/o PuO_2,

(b) Low density compacts - 0.0259, 0.187, 1.46, 3.47, 5.46, 7.45 a/o PuO_2.

No ruptures have occurred to date. The capsules have been or are being irradiated in the MTR under the following conditions:

(a) Light water coolant (46 C)
(b) Specific power generation - high density compacts, 19 kw/ft
low density compacts, 12 kw/ft
(c) Heat flux - high density compacts, 440,000 Btu hr-sq ft
low density compacts, 275,000 Btu/hr-sq ft
(d) Thermal neutron flux - high density compacts, 0.2 to 1.7 x 10^{14} nv
low density compacts, 0.1 to 1.0 x 10^{14} nv
(e) Burnout - high density compacts, 0.18 a/o (total atoms)
low density compacts, 0.16 a/o (total atoms)
(f) Fuel core center temperature - high density compacts, about 2000 C
low density compacts, about 1400 C.

The one capsule examined to date contained high density, UO_2-0.0259 a/o PuO_2 mixed crystal oxide compacts. Results of the examination are:

(a) No significant changes in the external dimensions of the capsule.
(b) Microstructure is very similar to that of irradiated UO_2.
(c) No central void was formed.

Fabrication Development. Casting conditions were determined for the PRP fuel alloy, Al-1.8 w/o Pu-1.3 w/o nickel-1.0 w/o silicon, in which all samples passed the 350 C, 24-hour, static water corrosion test. The billets are cast at 700 to 735 C into an unheated mold. However, with the lower casting and mold temperatures, about 1/4 of the rods blistered in extrusion which was caused by entrapped air, gas, or moisture. Therefore, a 0.1 w/o Zr addition to the alloy was investigated to determine if increased casting and mold temperatures could be used without sacrificing corrosion resistance in the alloy. This investigation is incomplete. All other samples have passed the corrosion test thus far, but the blister reject rate has not improved. This month 120 billets were cast. Samples from 36 were corrosion tested, none were rejected. Duplicate specimens coated with alcohol dag also showed no visible signs of corrosion.

The drawbenches in the 308 Building are being activated and will be used to cold size plutonium alloy fuel rods to fit zirconium tubing of different inside diameters. Zirconium clad aluminum rods were also successfully drawn on the open hooded bench. Several drawing lubricants were evaluated. Of the lubricants tested, Oakite #12 was the most satisfactory

for drawing aluminum. Two tungsten carbide drawing dies were obtained for sizing extruded nickel-aluminum alloy rods. The tolerance which was required for this operation was 0.500 ± 0.0005. Twenty-five rods were successfully drawn to this tolerance through a 0.5002" diameter die with no rejects. If the rods are straightened before drawing, they maintain the same straightness after drawing; however, if rods are warped before drawing, the drawing operation does not appreciably straighten them with the slight reduction used.

Thermal cycling of dummy Zircaloy clad rods fabricated by various techniques is continuing. Rods were thermal cycled between 100 and 350 C at heating and cooling rates of about 3 C/min and at a pressure of 1400 psi. All rods were about three feet long and helically wrapped with a Zircaloy wire. Tubing was picked at random and it is known that 38 percent of the tubes have cracks emanating from the inside which are three mils or greater in depth. Fifty-one such rods have been cycled. Cracking and splitting of the tubing has been much more prevalent during recent thermal cycling tests which have been run with the latest batch of tubing. Some rods warp and distort quite badly without splitting the tubing whereas other rods split when very little distortion has occurred.

A simulated fuel rod that was injection cast and has been undergoing thermal cycle testing has successfully withstood 138 cycles. In fabricating this element the molten aluminum was forced into a zirconium tube which had 1/8" wide circumferential grooves rolled into the tube at six-inch intervals. The 0.050" reductions in the tube diameter apparently isolate the aluminum core in six-inch compartments, and this mechanical keying in conjunction with the metallurgical bond obtained in the pneumatic injection casting operation permits the cladding to expand and contract with the core as a unit. In making the end closures on the element the end caps were placed in contact with the aluminum core, leaving no space for thermal expansion.

UO_2 Fuel Development

PRTR Fuel Elements. The rate of fabricating rods for PRTR fuel elements dropped in December due to a shortage of acceptable tubing. The planned rate was 100 rods swaged each week but less than half that number were swaged. Problems in getting the tubes tested and high reject rates have caused the delay in delivery of good tubes.

A backlog of rods between swaging and machining was used to keep rods flowing through the process. The welding equipment has been used to capacity by two shift operations during part of the month. The extra shift was necessary to fabricate end hangers in addition to welding caps in rods. UO_2 being used now is fused oxide from Spencer Chemical Company which is crushed and screened to minus 20 mesh. Sufficient uranium oxide was processed this month for 14 fuel elements.

Rods are being autoclaved at the maximum capacity of the autoclave. The autoclaved rods are being inspected and assembled into 19-rod clusters as fast as hangers are available. The excess rods are being backlogged.

In addition to the swaged rods, there are about 40 rods in process in which the UO_2 was compacted by vibration. Half of these vibrational compacted rods have sintered UO_2 and the others contain fused UO_2.

A two-hour vacuum anneal at 750 C will allow Zircaloy-2 wires to be re-autoclaved when the original autoclave finish is unsatisfactory. This procedure was performed on 0.071-inch diameter Zircaloy-2 wire. The oxygen content of the wire increased from 900 ppm to 915 ppm. The ultimate tensile strength decreased from 75,400 psi to 72,200 psi. The diameter of the wire decreased 0.002 inch to 0.069 diameter during the heavy etch prior to the second autoclave cycle. A satisfactory black oxide finish was obtained during the second autoclave cycle.

End closure welding of PRTR swaged fuel rods with the one degree tapered caps has continued to be very satisfactory. Radiographs of 666 welds has revealed four welds with small defects. These welds have been repaired by rewelding.

Ten PRTR Zircaloy-2 fuel element end fittings have been completed in December. Sub-assemblies have been welded for the next 30 sets of end hangers.

Fabrication Development. Vibrational compaction studies reveal that particle size ranges for coarse and medium powder fractions can be broadened considerably. Densities are higher and more uniform with the broader size ranges than with discrete particle sizes generally believed to produce the highest densities. The use of broader particle size ranges results in more efficient use of crushed oxide. Handling and

characteristics. The Wolverine Tube showed several gross fluorescent penetrant indications of cracking or folding. Its ID surface was extremely rough and corrugated. The Accles and Pollack tube showed several fluorescent penetrant indications. Its inner surface was rough but was less severely marked than the Wolverine tube. The Heraeus tube passed the ID fluorescent penetrant test and its inner surface was smooth and unmarked.

End hangers and tube closures for the Mark II-C Nested Tubular Fuel Element have been redesigned to simplify closures, reduce cost, and to enable this fuel element to use the same reactor hanger rod attachment that will be used on the Mark I fuel element. The redesign eliminates the use of the expensive J-cup and utilizes the newly perfected technique of seam welding across two, thin, cladding tubes and a solid end cap. As before, a double closure will be used to insure fuel section integrity. The design simplification radically reduces cost of machining special contours by utilizing solid, straight sided, Zircaloy-2 rings machined from cast tubes for end caps. Readily available 9/16-inch diameter Zircaloy-2 rod and 1/8-inch thick Zircaloy-2 plate will be used for hanger fitting fabrication. This advanced design, in conjunction with newly developed fuel loading techniques, very encouraging flow data, and the probable availability of cladding tubes may make it desirable to include a Mark II-C fuel element in the first PRTR fuel loading.

Fuel Evaluation. The preliminary examination of the purposely defected, irradiated, swaged UO_2 fuel rod revealed no external dimensional changes. The outside diameter and surface appearance of the Zircaloy-2 cladding were unaffected by the irradiation. The examination of the UO_2 will continue.

Swaged UO_2 capsules have attained an estimated maximum exposure of 12,500 MWD/T during irradiations in MTR-ETR. The irradiation will continue to 25,000 MWD/T. No failures of capsules, or any other swaged fuel elements have occurred.

The swaged UO_2 19-rod cluster, PRTR fuel element remained unaffected after 20 weeks of operation in an ex-reactor, high temperature, high pressure flow loop. The element exhibits no warping, wire wrap loosening, or corrosion. This ex-reactor test will continue.

Basic Studies. The "plasma jet" high temperature source has been installed temporarily and successfully operated. Temperatures of 30,000 F will be used for material spraying, UO_2 fusion, and high temperature heat source, for better basic understanding of the ultra high temperature properties of UO_2.

Corrosion Studies

Autoclaving Cycles for Zircaloy-2 Clad UO_2 Fuel Elements. Tests have been completed on coupons which give the average autoclaving weight gains for etched Zircaloy-2 in superheated steam at 380, 400, and 420 C. Times of exposure varied from 13 hours to 72 hours. Pressures of

100 psi or 1500 psi were investigated at the various times and temperatures. The data indicate a significantly higher weight gain in 100 psi, 400 C steam than in 1500 psi, 400 C steam. However, the data for 100 psi steam exhibit more scatter, and the temperature distribution has shown a greater spread than at 1500 psi. It is also more difficult to heat the autoclave when operating at low pressure because of the less dense steam which has poorer heat transfer characteristics.

Aluminum Alloy Development. Tests in 290 C water on the high purity base aluminum alloys which show extremely low corrosion penetrations in 360 C water confirm the results obtained at the Argonne National Laboratory. At the end of one month, these alloys, without exception, show greater penetration at 290 C than at 360 C, in most cases by a factor of about three (0.2 to 0.3 mil at 360 C, 0.6 to 1.0 mil at 290 C). The reasons for this behavior and the temperature where this change occurs will be investigated.

To check the reproducibility of the high purity aluminum base alloys, four laboratory-scale melts of each of three formulations have been cast. Also, a set of the same formulations was cast using three different high purity aluminums (99.95%, 99.995%, and 99.999%). These castings are now being scalped and rolled prior to testing.

Thermal Treatment of Al-Ni-Fe Alloys. The first phase of an investigation has been completed after two months exposure of heat treated samples in 360 C water. The following preliminary conclusions can be drawn from this test:

(1) Prolonged heating at 550 C and 630 C is detrimental to the corrosion resistance of X-8001 aluminum, and consequently, heat treatment exceeding one hour in this temperature range is inadvisable.

(2) Heating at 450 C for 40 hours to 216 hours is also detrimental, but not to the degree that the higher temperatures are. However, the adverse effect of longer heat treatment at this lower temperature may well be the same as observed at the higher temperatures.

(3) Heating temperatures of 200 C and 350 C showed no effect on the corrosion resistance of X-8001 up to 216 hours. This test will be the subject of a report when the sample analyses and the desired metallography have been completed.

Corrosion of Materials in Low pH Water. The 300 C dynamic corrosion test studying the inhibition properties of HNO_3 in reducing aluminum corrosion has been completed. After 642 hours of testing, a difference in corrosion caused by velocity has been found. As the velocity was increased from 20 to 60 feet per second, the corrosion rate (after 642 hours) increased from 0.4 mil/month to 1.0 mil/month. These data contrast with the rate of 0.06 mil/month (with a penetration of 0.16 mil after 642 hours) obtained from previous H_3PO_4 tests. No velocity effects

were found in the H_3PO_4 test in the range 23-35 fps. This suggests a more protective film in the H_3PO_4 experiment. The final data will provide results for test times up to 1499 hours. Corrosion rates for 304 stainless steel at 300 C and pH 4.5 adjusted with HNO_3 appear comparable to rates obtained with H_3PO_4.

Testing PRTR Fuel Elements. Two PRTR fuel rods, one plain and one wire wrapped, were thermal cycled 100 times between 325 F and 550 F in ELMO-7 at a rate of 200 F/hr. At the conclusion of the test both rods had a residual bow of approximately 1-1/2 inch. This amount of bow is much larger than the slight bow existing in the horizontal test section itself, but may have been initiated by the test section bow. The bow was large enough to firmly press the fuel elements against the test section walls. Although an unrestricted single fuel rod may show considerable bowing, as in this case, the tests should be extended to include a complete PRTR cluster element suspended in a vertical tube. Radiographs and measurement of the rod lengths revealed both a shrinkage in the solid aluminum core and an elongation of the Zircaloy-2 jackets.

Structural Materials Development

PRTR Zircaloy Process Tubes. The month-end status of the 97 process tubes on hand is as follows:

No. of Tubes	Status
43	Ready for reactor installation. Inspected, etched, autoclaved, and straightened. Meet all specifications.
2	Same as above, except 1 mil and 3 mils under minimum wall thickness, respectively.
6	Held for further testing because of immerscope indications of possible flaws.
46	Questionable autoclave films on inside surface. Scheduled for vapor blasting, re-pickling, and re-autoclaving.
Total 97	

The 85 tubes for reactor installation are expected to be ready when needed by the Phase III contractor.

Process Tube Monitoring. Plans are being formulated for a program to monitor the integrity of the PRTR process tubes periodically, after reactor startup. Non-destructive inspection and measurement techniques based on ultrasonic and/or electromagnetic measurements appear to be the most promising approaches at present. Ultrasonic inspection appears to be applicable to detection or measurement of wall thickness, cracks, and possibly changes in crystalline structure. Eddy current techniques could

possibly be employed for measurement of the gap between the process tube and shroud tube giving an indirect measurement of bow. Visual inspection for bow should also be possible by transit.

Visual inspection with a borescope or by closed-circuit television should reveal gross scratching, corrosion or other obvious imperfections. The above non-destructive tests would be supplemented by periodic removal and destructive testing of selected tubes.

Radiometallurgy Laboratory Studies

Visual examination of a 23-1/2 inch long, 0.560 OD, swaged Zircaloy-2 clad, 2.42% enriched UO_2 fuel rod was completed (RM-603). A sample of uranium which had been irradiated to 3500 MWD/T and annealed at 600 C for 100 hours was polished, etched, and replicated for electron microscopy, as part of the 4000 Program uranium swelling studied (RM-321). The results and conclusions from these tests will be reported in connection with the respective programs of Ceramic Fuels and Physical Metallurgy Operations.

Thermal Hydraulics Studies

Heat Transfer Experiments Associated with the Mark II-B Fuel Elements. Additional heat transfer data were obtained from a full scale electrically heated mockup of the Mark II-B fuel elements. Particular emphasis was placed on obtaining pressure drop data across the heated section in each of the three flow channels for an evaluation of the hydraulic stability characteristics of the fuel element.

This series of experiments consisted of operating the test section at a constant heat generation rate and measuring surface temperatures and pressure drops throughout the section while the flow was reduced in a step-wise manner. The following table shows the power levels at which data were obtained and the condition of the exit coolant at the termination of each run.

Power to Test Section, kw	Steam Quality of Coolant at Exit of Test Section, % by weight
730	19.0
950	30.6
1200	27.9
1530	16.4

All of the experiments were performed at an exit pressure of 1100 psia.

Conditions of boiling burnout were not detected in any of these runs. Furthermore, a preliminary analysis of the results indicates that the hydraulic stability characteristics of the Mark II-B fuel element should not be a serious problem in the reactor.

Project Management and Design

Phase III PRTR Contract. The Phase III contract is 48.5% complete versus a scheduled 54% based on a contract completion date of May 20, 1960.

The contractor has completed fabrication of the biological shield liner and penetrations. He is currently performing the hydrostatic tests on the liquid carrying lines and the helium leak test on the inner liner. A considerable number of leaks were found in both systems. It appears that placing of heavy aggregate concrete in the biological shield will be started about the second week in January.

Heavy aggregate concrete placement for the fuel examination cell wall was completed. The cast iron shielding blocks on the "A" cell side and a portion of those on the "B" cell side were installed in the cell walls.

Installation of process cell piping and equipment is progressing slowly pending completion of the reactor shield.

PRTR Stack Addition. Contract work on the PRTR stack is estimated to be 97% complete. The completion date for the stack is December 27, 1959.

Procurement. The order for the electronic portion of the PRTR rupture monitor system was placed on December 3, 1959, with delivery scheduled for March 30, 1960. The design of the mechanical portion of the system was essentially complete at the end of the month.

A requisition has been issued for the new instruments and parts required to revise control room instrumentation to conform to the revised safety and containment systems.

The eight-inch special primary pump bypass check valve was received during the report period, and preparations were made for examination and brief testing before delivery to the Phase III contractor.

The shield-cooling heat exchanger, HX-2, and the spare reflector heat exchanger, HX-3A, were received from Struthers Wells Corporation. Bids were received from three vendors for the pressurizer safety relief valves, but because of the large number of exceptions taken to the specifications and the fact that no bids were received for high temperature testing, the specifications were modified and new bids are being evaluated.

Four prototype rebuilt process tube outlet nozzles were completed but did not pass inspection. The vendor continued to have considerable welding difficulty. Because it was clear that the vendor had not brought his welding up to acceptable standards, and that they would fail to meet the required delivery date, the contract was cancelled. Nozzles will be completed on-site by J. A. Jones. Partial shipment of the nozzle compartments has been received.

The calandria and top and bottom primary shields were completed except for cleanup of a few minor details. It appears that the Phase III contractor will not require the units until late January.

Because the helium gas system compressors received from the suppliers differed in the location of connection points and in the physical size and conformation to that expected, the piping drawings for the gas and water connections are being revised. Also, the testing program on the compressors indicated that additional equipment such as filters, condensate separators, unloading valves, etc., will be required for satisfactory operation.

The fuel handler has been received at Hanford and is being assembled. Parts to be delivered at a later date include the shroud and the exhaust air hose.

The Mosler Safe Company continued to have difficulties with the cast iron shielding for the Fuel Element Examination Facility. The repair procedure which they originally proposed for wall block #3 and one of the top blocks turned out to be impractical. The cracks were found to be of such a magnitude that the weld closure method could not be used. Therefore, the cracked area was removed and replaced by a steel plug insert. Other difficulties encountered were primarily in the machining of wall openings, which required about three times as long to machine as originally estimated. These difficulties have resulted in further delays in the shipping of wall blocks 1 and 2. They are now scheduled for shipment the week of December 28. The remaining blocks are tentatively scheduled for shipment during the second week in January. However, delivery was made on the filler blocks ahead of schedule on December 20, 1959.

Design and procurement difficulties have also resulted in a proposed change in the scheduled shipping date of the Fuel Element Examination Facility primary manipulator, which is being constructed by the W. F. & John Barnes Company. The design difficulties concern radiation effects and decontamination problems, and have, for the most part, been overcome. Procurement problems with certain critical items remain to be resolved. As a result of these difficulties, the proposed delivery date is April 1, 1961.

With the exception of the lens, the majority of the components of the FEEF wide angle viewer have been received and are being assembled for testing. Delivery of the lens, originally scheduled for October, is uncertain since the company from which they are ordered is presently on strike.

The design of the Load-Out Cask is behind schedule, although no known difficulties have been encountered. Expediting has been requested to contact the vendor.

Fuel Element Rupture Test Facility (Project CAH-867). The scope description of the Fuel Element Rupture Test Facility was issued December 8, 1959, as HW-62878. Preparation of the design criteria is in progress. Pump, heat exchanger, and filter vendors are being contacted to determine the sizes and types of equipment available for use in the facility. It is planned that the rupture inciting mechanism for the loop will be basically the same as that used on GE 3x3 ETR loop.

Two in-reactor test sections, which can incorporate NPR fuel elements, are being scoped. Test Section A uses a thin Zircaloy basket tube inside a Zircaloy pressure tube. Test Section B uses an NPR process tube inside a Hastelloy-X backup pressure tube.

One of the problems under consideration at this time is how to contain ruptured fuel elements during fuel transfer operations. The present approach uses a water filled transfer tube, but use of this tube may restrict the viewing of a ruptured fuel element in the Fuel Examination Facility.

High Pressure Loop (Project CAH-841). The design criteria document was approved by AEC and subsequently printed and issued. The special conditions for fabrication of the out-of-reactor portion of the loop by an off-site vendor are in rough draft form.

PRP Critical Facility (Project CAH-842). The design criteria for the Critical Facility was revised based on the comment issue and is being circulated. A project proposal requesting funds for construction is in preparation.

Design and Compenent Testing

PR-1 - Discharge Operation Mockup. The fueling vehicle was received on site and installation of the vehicle in 314 Building is approximately 60 percent complete.

All components of the fueling vehicle have been shipped by the vendor, except the shroud valves and the air system exhaust hose.

Two slots were milled in the bottom of the skirt and the bottom of lower cask section No. 1. The slots provide an air passage when the air cooling system is operated with the skirt down. A second air exhaust pipe was added to the lower cask section to reduce the pressure drop in the air cooling system. The pipe extends through the cask to the existing discharge air pipe. The additional pipe is calculated to reduce the power requirement of the positive displacement blower to within the rated motor capacity.

Drawings for the bridge position indicating system were completed. Work was begun on mounting devices for the positioning system, lengthening of the discharge hook assembly, and other vehicle modifications.

PR-10 - Primary Loop Mockup. The primary process pump was disassembled for seal inspection on December 1, 1959, after 1996 hours of operation with helium in the water at PRTR prototypical conditions. The short flywheel decay times and leakage fluctuations were determined to be due to rapid wearing of the primary seal faces, possibly caused by helium evolution from the leakage water during depressurization across the seal faces. The stationary graphite face was worn down approximately 1/4-inch, completely removing the raised portion of the face, and unbalancing the seal. A primary seal previously tested with no helium in the loop water operated for 1600 hours without noticeable seal wear.

The following changes were made in the testing procedure:

(1) Water is being injected into the primary seal chamber at approximately five gallons per hour. Injected water should, therefore, fill the seal chamber providing the necessary seal leakage with the remainder going through the breakdown rings to the loop.

(2) A thermocouple has been imbedded in the graphite face of the primary seal to detect when wearing with resultant overheating starts to occur.

(3) The primary seal leakage drain line from the low pressure seal chamber was enlarged from 1/4-inch to 7/16-inch to allow gases to be readily vented should they collect in the secondary seal chamber.

The pump has operated 450 hours since startup on December 4, with a maximum leakage of 0.3 gphr. Flywheel decay times on the pump increased from an average one minute, 40 seconds, before repair, to two minutes, five seconds with new seals.

A requisition of inquiry has been issued to increase the flywheel moment of inertia an additional 1200 lb-ft^2. This is the largest size practical consistent with space in the flywheel housing and the overload relay capacity during the motors accelerating time. This approximately doubles the flywheel effect and is calculated to increase the useful pumping time approximately 30 seconds.

The prototype process pump has operated 1400 hours with leakage rates consistently under 0.1 gallon per hour. This test is continuing without injecting water in the seal chamber to remove helium to see if the seal wear noted above will be duplicated or if there are other unexplained reasons for the primary pump seal damage.

PR-13 - Injection Pump Test. The R/M #1204, Vee-Flex, split ring packing failed when the rings became compacted together, causing overheating due to lack of leakage for lubrication. Universal Style #835 packing has been received for further testing.

PR-40 - Shim Control Mockup. Modification of the second prototype assembly, incorporating the changes made by GE-APED, was completed. Included in this assembly are chains and sprockets that have a baked-on coating of molybdenum disulfide. This coating has not been specified for the assemblies made by GE-APED. The drive system using the baked-on dry lubricant has less friction than the original assemblies. The unit was operated for about 800 full cycles (about 80 hours), then disassembled for inspection. No wear of the chains or sprockets was visible. The unit was reassembled and has now run a total of 1970 cycles. This is more than three times the average operating life of the original assemblies. This increased life is mainly attributed to elimination of the severe wear of chains and sprockets experienced on previous tests and longer motor life because of lighter loads. An inquiry has been made regarding the additional time and charges which an alteration to coat the chain and sprockets would require.

All the shim rods, which were fabricated in Tech Shops, were shipped to GE-APED on December 23. Fifteen thermocouples and the extension wire were sent the week of December 14. Six lead screws were received from Saginaw Steering Gear and forwarded to APED the week of December 14. Twenty-four additional screws were shipped the week of December 21, with the remainder promised early in January.

The AEC-procured drive motors have been delayed with promised shipments extending into February. Improvements in the shipping dates are being sought.

PR-52 - Process Tube Thermal Cycling and Pressure Testing. The process tube was operated 405 hours during the last month. Leakage rates for all high pressure seal closures were comparable to those reported last month.

Hold-down springs of 4130 steel have successfully undergone 600 thermal cycles. Springs will be fabricated at Tech Shops as no response was received from outside vendors. All hold-down devices for the reactor have been completed by J. A. Jones Construction Company.

PR-64 - Gas Sampling Technique. Experimentation with a prototype gas rotameter has shown that proper insulation and heating will eliminate the problem caused by condensation of water from the saturated helium passing through the rotameter.

PR-70 - Helium Compressor Test. Document HW-62734, "Interim Report, Design Test PR-70, PRTR Helium Compressor Test Program," dated November 25, 1959, was issued.

The aircraft type hydraulic pump purchased from Vickers is now being tested on the recently completed pump test stand. Initial operation has resulted in erratic pumping rates.

Additional testing of the Beach Sta-Dri units proved that they could not be operated at 300 to 400 F temperatures because of decomposition of the oil at these temperatures. It is, therefore, necessary to locate the filters after the cooler. In another test for filter efficiency, no oil was detected in the helium gas discharge of a 90% oil saturated filter. Infrared analysis was used for oil detection with a sensitivity of less than one ppm.

PR-80 - Air Cooling Duct Test. Fabrication of the small duct was delayed by higher priority items.

Special Tools. Chain driven prototype wrenches for removing the vertical and horizontal outlet jumper nuts have been fabricated and tested. These tools are being modified prior to the fabrication of the final reactor tools.

A tool for disconnecting the amphenol connector from the shim control has also been developed.

Silicone Foam Testing. One prototype structural opening with representative wire samples was filled with silicone foam. The Phase III contractor's personnel observed the direct pouring, which was successful. Considerable leakage through the wires prevented a thorough leak test. Further testing of the wire leak rates is planned.

PRTR Controller. Operational tests of the PRTR automatic controller in the power level range were completed. The tests consisted of connecting the controller to a reactor simulator (including the gas balance system and neutron kinetics of the PRTR) and introducing disturbances in reactivity and power level signals. Operation under conditions of changing demand power at various rates was also checked. The response of the controller appeared to be quite satisfactory. The tests have revealed that the power deviation trips units have an offset in output at high power levels, causing positive deviation trips at steady state when the trip point is set closer than five megawatts. This problem can be corrected by installing a trim potentiometer on one or more of the input resistors on the error former or deviation trip amplifiers. Operational testing of the automatic controller has not included period control startup tests to date because it has not been possible to get an acceptable period signal from the reactor simulator. It is planned to accomplish this phase of the testing prior to startup by building a logarithmic reactor simulator which can cover five or six decades of operation.

Temperature Probe. Specifications were prepared and bids solicited for two types of temperature probes for the Fuel Examination Facility. Preliminary tests using the 2 K thermistor probe show response time and output characteristics very similar to those of the 100 K probe. Further development here will be continued when new infrared transparent lenses arrive.

Design Analysis

PRTR Physics Analysis. Programming of the calculations for generating the PRTR xenon tables on the IBM-709 has been completed and debugging is under way. The tables have been designed to yield reactor poisoning based on tube powers with any combination of UO_2 and Pu-Al fuel. Tube powers between 100 and 1200 kw and time steps between 0.5 and 160 hours have been incorporated.

Outlines of critical experiments for the Critical Test phase of PRTR startup are about 75 percent complete. A detailed study of calibration of the shim system was undertaken to decide which of the many combinations of shim positions would yield meaningful results without redundancy. Calculations of the positive asymptotic reactor period as a function of increases in moderator level of 0.5, 1.0, and 1.5 inches with the moderator at half, three-fourths, and full level were also completed. It appears that sufficient accuracy in reactivity measurements can be obtained with minimum periods of 30 seconds.

Calculations have been started to determine the neutron flux distribution in highly self-shielded plutonium fuel. An attempt to use the available IBM-709 P-3 code for this purpose was unsuccessful due to the inherent numerical difficulty in solving the matrix for large arguments. It was determined that a functional fit of the exponential form $e^{-\Sigma r}$ for the flux in the plutonium rod agrees quite well with previous P-3 calculations made on the IBM-650. This analysis will be used to determine heat generation in a PuO_2 test specimen to be irradiated in the MTR.

An evaluation of the High Pressure Loop with respect to program objectives is presented in a report, HW-62531, which has now been distributed. It was concluded that the reactivity penalty associated with this loop would be about 3 milli-k, but could reach 5 mk for more highly absorbing test sections. Loss in attainable exposure resulting from insertion of the loop was estimated to be from 150 to 250 MWD/T. Other conclusions from an earlier study (HW-59691) were essentially unchanged. A similar study is now being carried out for the Rupture Facility.

PRP Critical Facility Loading Calculations. A wide variation of fuel types and lattice spacings are expected to be accommodated in the PRP Critical Facility. A continuing program of evaluation of the reactivity and accompanying flux and importance function distributions for combinations of arrays is under way.

Three-group neutron cross sections were calculated for several fuel and moderator types using the Maxwellian-averaged thermal values and the 18-group epithermal and fast cross sections reported in APEX-515. Multigroup and dimensional descriptions were prepared for cells fueled with uranium dioxide and alloys of aluminum with uranium-235 and plutonium-239; varying isotopic concentrations of uranium-238 were also included in some of the fuels. Each of these fuels is separately moderated with both light and heavy water and further was analyzed at several different lattice spacings.

Three-group diffusion theory calculations were then performed using the F-3 sub-program written for the IBM-709. Converged reactivity values and flux and power distributions were found for each of the 96 cell cases considered. Extra information was also calculated by a calling program, written in FORTRAN. Using the F-3 results, this code calculates the average three-group fluxes in each region, and the volume- and flux-weighted cross sections for composite cell or reactor cases. This option is most frequently needed in order to specify the nuclear parameters of a reactor region which is assumed to be composed of homogenized cells of a certain type. It can also be used to specify the infinite lattice properties of a core or the perturbed properties of a finite core.

High Pressure Loop Calculations. Preliminary calculations were performed in an effort to design a workable automatic control system. The calculations performed thus far have indicated that a single control system may not produce optimum control for different power transients. The cases examined were a reactor scram and a 25% step reduction in power. It was desired to maintain both the outlet temperature and the ΔT across the fuel element constant. The results have shown that a suitable set of controls can be designed to maintain the outlet temperature constant for times greater than four minutes following a scram. The ΔT across the fuel element cannot be held constant for the scram case because a minimum coolant flow of about 17% of normal has been specified.

For the case of a 25% step reduction in power, excellent control appears to be attainable using only the ΔT controller mentioned above. Use of the outlet temperature controller alone or the two controllers together appears to yield very poor control.

At present, these early results are being used to evaluate thermal stresses in the ex-reactor piping. Additional calculations may be made in the future depending on the results of the thermal stress analysis.

Engineering Review of PRTR. The report of comments by HLO on the engineering review of the PRTR by the GE Atomic Power Equipment Department has been published as HW-62413.

Safeguards Analysis. Analyses for use in the preliminary hazards report for the PRP Critical Facility were continued.

A list of proposed Process Specifications for the PRTR and a proposed format for these specifications were prepared and submitted for consideration by the PRTR Startup Council. Writing of the Process Specifications was begun.

A study of problems associated with cooling the PRTR in the event of a combined BPA outage and PRTR emergency generator failure was completed. In such an event it would be necessary to (1) maintain enough water in the steam generator to provide an adequate heat sink; (2) restrict loss

of primary coolant volume to prevent uncovering of the pressurizer inlet line; and (3) prevent evolution of helium in the reactor in quantities sufficient to "vapor bind" the system. A report (HW-63046) discussing methods of fulfilling these requirements has been issued.

PRTR Process Piping. The first interim PRTR piping flexibility analysis report has been received from Electric Boat Division of General Dynamics Corporation. Initial calculations indicate that the coolant piping at the pressurizer inlet elbow may be overstressed slightly by about 700 psi (~26,000 psi allowable). This result is based on allowable stresses incorporating a weld efficiency factor which has not been verified as applicable to fully radiographed pipe. Moreover, certain code refinements remain to be included, and it appears that these will be in the direction of eliminating the overstressed condition.

Plutonium Fabrication Pilot Plant

Routine progress was made toward completing the sintering furnace installation. The instrument panels were received from the vendor in an incomplete condition, having been shipped in advance of a strike. Shipment of the cross-push mechanisms now depends on settlement of the strike. These minor parts of the furnaces will seriously delay completion of the wiring of the control system. Present schedule for completion of the oxide line is February 1, but this is dependent upon receipt of the cross-push mechanisms no later than January 11, 1960.

Installation of the zirconium etch facility has been started. Installation of the remainder of the Group 5 equipment will be started early next month.

Liaison reports indicate that fabrication of the 20-inch rolling mill by Loma Manufacturing Company is on schedule. Physical completion of the project by April 1 thus appears to be possible.

PRTR Operations

All of the design tests have been reviewed by the PRTR Startup Council and are being revised as necessary. Tests covering the primary and moderator coolant systems have been submitted for final design and operational review prior to presentation for approval by the Startup Council. Preliminary scheduling of both engineering and maintenance manpower for the design test period was completed.

Work continued on the documentation of the PRTR Critical Tests. Rough drafts of the proposed tests will be presented to the PRTR Startup Council during January.

The classroom portion of the PRTR Engineering Assistant Training Program was completed on December 18, 1959. The second phase of training was started and will consist of: (1) formal submittal of answers to selected questions of the Qualification Test list, (2) study of installed reactor systems, (3) review of PRTR Design Tests, (4) review of PRTR Operating

Procedures and Practices, and (5) assignment to the Mechanical Equipment Development Operation in the 314 Building for additional training. The first group of six engineering assistants started their training in the 314 Building on December 28, 1959.

Standardized definitions for the PRTR coolant systems were issued during the month to interested parties.

Additional assistance was rendered FPD Maintenance in assembling basic data for instrument calibration work which will be started in March 1960.

Preparation of operating procedures for the reactor continued. A compilation of items to be included in the PRTR Operating Standards was begun.

Approximately 75 pieces of PRTR equipment were reviewed for spare parts requirements during the month.

Two meetings were held with representatives of the Analytical Laboratory Operation on the sample program. Discussions covered isotopic analysis of heavy water and possible laboratory layouts in the maintenance and mockup area. Future discussions will be held on the use of a refractometer versus an infrared analyzer for the isotopic purity analysis.

2. BASIC SWELLING STUDIES

Irradiation Program

Two types of capsules are currently being constructed: a metallographic specimen swelling capsule for MTR or ETR irradiation and a general swelling capsule for HAPO irradiation. Several of the latter, containing spherical specimens, have been assembled and bench tested. The first attempts to assemble the capsule that will be used to irradiate a precharacterized metallographic specimen are now in progress. The seals between the thermocouples and the heaters and the end of the NaK chamber have been completed and are being tested before incorporation in final assembly.

During the bench testing of the swelling capsule containing four natural uranium spheres, three of the four thermocouples reduced their output by a factor of about two. By heating various sections of the capsule with a torch, while water cooling the remaining portions, it was found that a "hot" junction had formed near the 1/16" Swagelok fittings used as seals on the inner, NaK filled chamber of the capsule. It was therefore decided that some other type of closure will be needed and that welding will be a more satisfactory method of sealing thermocouples into the inner chamber. Accordingly, a weld is being developed to join the thermocouple sheath to the end cap. Prototype fittings have been fabricated and short sections of thermocouples have been welded to a tube previously welded to the cap for the inner capsule chamber. Thermocouples from two sources were used for these experiments. Both types were sheathed with 1/16" 304 SS and contained #28 chromel-alumel wires insulated with Al_2O_3. Oddly enough,

it is possible to weld sleeves to the sheath of the thermocouples from one vendor but 308L SS plugs cannot be welded into the end to form a bead. The reverse situation occurs with the second vendor's thermocouples even though the materials of construction and the techniques of fabrication are apparently identical. Several other welding techniques are being examined in an effort to develop a compatible system. Meanwhile, additional tests on the feasibility of modifying the closure design to enable use of either vendors' thermocouple for this application are also being conducted. The various welds, both successful and unsuccessful, have been examined metallographically and chemical analysis of the sheath and insulation are being made in an attempt to explain the difference in the welding results between the two apparently identical thermocouples. The facts learned could have a very critical bearing on future thermometry.

Pore Size and Distribution. Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Swelling in two types of specimens, one with a burnup of 0.41 and the other with a burnup of 0.29 a/o, irradiated at temperatures below 550 C, is being studied as a function of post-irradiation annealing treatments.

Replicas of the 0.41 a/o burnup specimen that was annealed for 100 hours at 880 C have been studied. This specimen exhibited extensive swelling (density = 14.64), and large (100 microns) irregular pores but in spite of the fact that it was polished and etched three times, very few impurity inclusions were revealed. This is in sharp contrast to the large number of inclusions that have been observed in all of the other specimens of this series. This would indicate that the observation of the absence of inclusions is related to the prior history of the specimen: high burnup; high annealing temperature. Various explanations can be offered for the absence of the inclusions: (1) At the high temperature of annealing, 880 C, the impurity inclusions have gone into solution, such solution being dependent upon the high concentration of fission products; (2) the impurity inclusions are pulled out or fall from the specimen surface as a consequence of their being completely surrounded by fission gas pockets; or (3) the inclusions which are principally carbides and/or nitrides, reacted with the environment during the annealing treatment, similar to decarburization in steel.

Gas porosity in this specimen, from a quantitative standpoint, differs markedly from that in similar specimens annealed at lower temperatures in that relatively few small pores are disclosed, but many very large irregularly shaped pores are present. The size of the large pores are as great as 100 microns across their longest dimension. Careful study and intercomparison of the microstructure resulting from the various anneals may reveal whether the annealing treatment at 880 C has (1) caused all pores to expand in size, (2) caused coalescence of neighboring pores, or (3) caused a disappearance of small pores, due to gas mobility, and subsequent precipitation at the larger pores. Although the 880 C anneal of the specimen with a burnup of 0.41 a/o was performed under conditions

of slow heat and slow cool, cracking at grain boundaries has occurred. It is impossible to determine whether these cracks outline alpha grain boundaries resulting from the beta to alpha transformation, or whether they outline the prior beta or gamma boundaries.

In order to experimentally determine the distortion associated with replicating spherical pores exposed on an interface, the preparation of specimens with constant and known porosity has been investigated. The most promising results appear to arise from specimens of polystyrene spheres impregnated in a poly-vinyl alcohol matrix. An interface surface of this specimen is obtained by cutting with a biological microtome, and the porosity is achieved by selective solution of the polystyrene spheres in benzine. Statistical evaluation of the observed diameter and shadow lengths of the porosity revealed electron micrographs will be made.

Statistical analysis of pore diameters and ratios of observed pore shadow lengths to pore diameters on negative replicas is continuing. The object of the statistical analyses is to formulate a general functional relationship between these two parameters. If possible, such a relationship would automatically include the distortion introduced by replication etching of specimens and the subsequent replication.

Fission Product Mobility. A knowledge of the mobilities of rare gas fission products through uranium is important in understanding the mechanisms of pore formation. Diffusion of rare gases in uranium is therefore being studied. Rare gases are introduced into the uranium surface by electrical glow discharge (sputtering) and by ion bombardment. The amount deposited under various experimental conditions, as well as the mode of deposition and depth of penetration is presently being determined.

An additional segment of the uranium disk that was outgassed for three days at 620 C and then sputtered at 16 ma/cm^2 in 2 mm pressure of xenon for four days at this same temperature has been analyzed by vacuum fusion and found to contain 2×10^{15} xenon atoms per gram of uranium. This segment was carefully abraded under oil prior to analysis so as to remove a 1.5 to 2.5-mil layer from all surfaces. Results from the analysis corroborate the previous analysis on other segments of the same disk. There is still some uncertainty surrounding this disk due to the porosity observed in the light microscope in the segment submitted for metallography. This sample was repolished but failed to reveal any porosity. Other disks will be sputtered to examine this phenomenon in greater detail.

Solid Surface Tension Measurements

Investigation of the formation of fission gas pores in irradiated uranium has brought about a need for solid surface tension values of uranium in the presence of inert gases at swelling temperatures. The solid surface tension data are to be obtained experimentally by balancing the forces of surface tension pulling upward.

High purity, three percent enriched uranium was drawn to 0.00105-inch diameter wire. Short lengths of the wire (approximately one inch) have been suspended with weights attached in a furnace at 600 C in a purified Kr atmosphere. The weights were selected to bracket the point at which there will be no extension or contraction of the wires. The Zircaloy-2 sample holder contains five wires loaded with 0.010-inch uranium wire weights -- one sample loaded at the estimated balance point of surface tension versus weight; the other samples loaded at ± 10 and ± 20 percent of the value, respectively.

A knot in the fine wire constitutes the upper gauge mark and the "U" shaped uranium wire weights tied to the bottom of the sample wire forms the lower reference point.

The wire specimens and weights were vacuum annealed for 20 minutes at 600 C to remove any effects of cold work when knotting the wire. After cooling, the wires were carefully straightened. The annealed and straightened wires were then returned to the furnace which was evacuated to 5×10^{-5} mm Hg. The system was next backfilled with krypton gas that had been passed over a white hot zirconium wire to a pressure of approximately 0.05 atmospheres.

Initial gauge lengths were measured with an external X-Y micrometer telescope after two hours at 600 C. Daily checks on the extension or contraction of the gauge lengths will be made. Calculations indicate that measurable extensions or contractions of the gauge length should be obtained in about 280 hours.

In-Reactor Measurements of Mechanical Properties

This program has been recently initiated to establish the nature of changes caused in the properties of structural materials by reactor environment. Currently, the study of the in-reactor creep properties of Zircaloy-2 is in progress. It is not at all certain that the mechanical property changes measured after irradiation will be indicative of the changes induced during the period of irradiation. The retained defects associated with residual damage may have entirely different effects on the creep properties than will the instantaneous effect of a high neutron flux. The only appropriate method of testing to determine the property of interest, those of the structural material while under irradiation, is to make the measurements in the reactor.

The irradiation of an in-reactor creep capsule is in progress to determine the effects of neutron flux on the creep rates of an annealed Zircaloy-2 specimen. A prototype creep capsule was manufactured to Hanford specifications by an off-site vendor. The capsule is operating in a Hanford reactor. It was designed to provide continuous creep measurements while maintaining a constant temperature and stress on the specimen. The characteristics of the strain transducer were specified as: linear range, 0.4 inch; accuracy, 0.6 percent full scale maximum excursion from optimum straight line; and resolution, 0.15 percent full scale. Laboratory measurements on identical transducers show

that the accuracy can be increased to 0.21 percent full scale excursion and resolution improved to 0.05 percent full scale. The latter figures when translated into measurable creep rates show that a rate greater than 4×10^{-5} in/in/hr can be significantly measured. However, since a base line cannot be established due to transducer temperature changes the total elongation cannot be accurately measured. The limit of stress that can be applied to the specimen is 40,000 psi, and the maximum temperature is 400 C (752 F).

The creep capsule was charged into a flux of approximately 1×10^{11} nv (fast) to obtain operational creep data. The flux had to be kept at this low level to attain a specimen temperature at the desired minimum of 260 C (500 F). An exposure of 2×10^{17} nvt (fast) was given the specimen before the stress was applied so the test would begin on an irradiated sample. The initial test conditions of 22,000 psi stress and 290 C (550 F) specimen temperature gave no indications of creep either on the in-reactor specimen or on the ex-reactor specimen set up under identical conditions. The temperature was raised in increments of 25 F until the temperature of 315 C (600 F) was reached; no creep was measurable on either specimen. The stress was then raised to 25,600 psi and the temperature reduced to 260 C (500 F). As the temperature was increased to 274 C (525 F) the first creep was measured on the ex-reactor specimen at approximately 1×10^{-7} in/in/hr rate, but early indications show no creep on the in-reactor test. The specimen has now accumulated approximately 1×10^{18} nvt (fast) and after four months of operation all features of the capsule and associated instrumentation are operating satisfactorily.

A second creep capsule has been ordered. Certain changes were made in specifications to eliminate the shortcomings of the prototype capsule and increase the precision of the creep measurements. The efforts in the laboratories include the design of a third generation creep capsule for on-site fabrication and the testing of several types of strain transducers.

3. GAS COOLED POWER REACTOR PROGRAM

Gas Loop Project Management and Design (Project CAH-822)

Final drawings of the detail design for the in-reactor test section have been submitted for approval. All material and parts are now on order with the exception of the flexible connectors (top and bottom) which will be placed on order during January. Previous bids for these items were rejected on the basis of insufficiently stringent fabrication requirements. Based on conversations with Struthers Wells, it appears that the delivery date on the ex-reactor portion of the loop will be seriously affected by the steel strike; however, no official request for extension has been received. Indications are that a four-month extension of delivery date will be requested. Struthers-Wells has ordered the loop instrumentation and the motor control centers. Final piping calculations

were completed during the month with resultant forces computed to the top and bottom anchors.

Bristol-Siddeley Engines, Ltd., fabricator of the primary blowers for the PRTR Gas Loop, has indicated that a lack of available steel has forced a delay in delivery of the blowers. Under their revised schedule, testing of the first unit will begin January 19 instead of mid-December, and the three blowers will not be delivered until mid-April. Improvement of delivery by revising the test procedure and shipping air freight are under consideration.

Design and Component Testing

The dome seal nozzle closure has been successfully tested cold, both statically and during cycling. A test stand to provide temperature and pressure cycling is partially complete.

Material was received for performing welder qualification on Inconel and Hastelloy-X. Preliminary weld samples were completed by the FPD welder assigned to the 314 Building, who will do the welding on the in-reactor section.

Design Analysis

Gas Loop Transient Analysis. The heat transfer calculations which include startup and shutdown transient calculations have been completed. A formal report on this work is being prepared.

Irradiation Effects on Nickel-Base Alloys for Gas Cooled Loop Facility CAH-822

Nickel-base alloys are being considered for use as in-reactor structural materials for the gas cooled loop. Samples of the candidate materials will be irradiated in a side test hole at the C Reactor. Comparison of mechanical properties of the irradiated specimens with those of unirradiated control pieces will yield valuable data on the behavior of these alloys under anticipated loop operating conditions. A graphite capsule containing thin washer samples of various nickel-base alloys, low manganese steels, iron-chromium-aluminum alloys, and stainless steels was fabricated and assembled. This capsule will be exposed for approximately one month to reactor atmosphere at a high neutron flux. The effect of this exposure on chemical stability of the alloys will be measured after irradiation by changes in weight, hardness, and surface appearance. All pre-irradiation measurements and characterizations of the specimens were completed. Additional capsules for tensile specimens of Inconel, Inconel 702, Hastelloy-X, and Hastelloy R-235 are nearing completion. Specimen stock was fabricated and heat treated, and the machining of specimens started. The proposal to conduct the irradiations was written, and a production test request was routed for approval.

Gas-Graphite Studies

Graphite Oxidation Studies. Thermal oxidation studies were continued on GL-10 graphite, a needle-coke variety. Weight loss rates between 1.0 and 1.2 x 10^{-4} gm/gm/hr were observed at 750 C in flowing CO_2. These results combined with earlier data indicate that this needle-coke material oxidizes slightly slower than CSF graphite. CO graphite, a needle-coke material of lesser purity, was also studied at 750 C. The observed weight loss rates between 4.2 and 5.3 x 10^{-4} gm/mg/hr indicate an oxidation rate about four times as fast as that of CSF or GL-10. This is interpreted as evidence of the catalytic effect of trace impurities on the oxidation of reactor grade graphites.

Graphite Oxidation Prototype Unit. Design is approximately 80% complete on the Graphite Oxidation Prototype Unit. The purposes of this unit are to aid in the evaluation of: (1) the hazards resulting from an accident which permits air to replace the coolant gas in a high temperature gas cooled reactor, (2) a safety system to slow down the oxidation and thus avert destruction of the reactor in case of such an accident, and (3) the validity of extrapolating oxidation data from laboratory scale samples to full scale.

The experimental unit is to be full scale to an EGCR channel and will be six feet in length. Air flow will be equal to the flow in the annular region of an EGCR channel. It is expected that tests with this unit will simulate the promoting, controlling, and monitoring of a self-sustaining graphite oxidation reaction.

Glass Gamma Loop. A remote weighing device was installed on the recirculating glass gas loop to observe weight changes during oxidation of graphite samples exposed to gamma radiation. The device consists of a linear variable differential transformer attached to one arm of an analytical balance, a control unit, and a restoring coil and magnet attached to the other balance arm. A change in sample weight is detected by displacement of the transformer core. The current required by the restoring coil to return the balance to an equilibrium position is proportional to the weight change. Some non-linearity in the system has been traced to vibrations. A sample of GL-10 graphite was positioned in the gamma flux and room temperature calibrations are in progress.

ETR Irradiations. Several new or unusual graphites of the "less permeable" types were irradiated in the GEH-13-2 capsule which was removed from the ETR last month. These received an exposure of 1 x 10^{20} nvt (E > 1 mev) at temperatures between 400 and 600 C.

The samples were rods either 3/16 inch or 1/4 inch in diameter which were machined from larger pieces. The extrusion orientation and method of production are not known.

Sample Type and Manufacturer	%Δ L/L	%Δ W/W	Orig. C_o, Å	Δ C_o, Å	Orig. L_c, Å	Δ L_c, Å	Density	CTE* Ratio
GLC Type A, Gt. Lakes Carbon	-.0	-.08	6.734	+.001	420	-105	1.78	1.08
GEC-3, GE, Eng.	-.05	-.11	6.734	+.005	265	+5	1.74	2.75
HS-1, Hawker-Siddeley, Eng.	-.05	-.52	6.725	+.019	345	-95	1.79	3.67
GLC Type P, Gt. Lakes Carbon	-.10	-.27	6.727	+.013	380	-75	1.74	1.06
HS-4, Hawker-Siddeley, Eng.	-.12	-.30	6.728	+.014	300	-53	1.81	3.20
CEY, Natl. Carbon	-.40	-.99	6.719	+.012	470	-188	1.90	--

*Ratio of coefficient of thermal expansion values measured perpendicular and parallel to extrusion axis; pre-irradiated values supplied by General Atomics, the source of the graphite samples.

High Temperature Irradiation of Natural Flake Graphite. The influence of crystallite size and perfection on the behavior of graphite under high temperature irradiation was checked using x-ray parameters of powdered, natural flake graphite. For an irradiation of approximately 10^{20} nvt (E > 1 mev) at 525 C, the average C_o change was +0.37% and the line width increased from 0.135° to 0.20°, the latter figure corresponding to an apparent crystallite size of 1100 Å. The percentage change in reactor grade graphites for comparable exposure is 0.35%, indicating that the lattice expansion damage during high temperature irradiation is not highly dependent on the degree of crystalline perfection of the graphite.

Flux Calculations. A cooperative program has been initiated with ORNL for the theoretical computation of the magnitude and energy distribution of neutron fluxes in the Hanford and off-site test facilities. This 32-group calculation is specifically intended to yield information on fast neutrons with 20 groups in the range above 0.1 mev. Neutrons in this energy range cause the bulk of atomic displacements and by extension are believed to cause the bulk of irradiation damage phenomena.

The calculated energy distributions can be used to extend the foil measurements to regions below the activation threshold, and thus should greatly improve the accuracy of transposing damage rate data between various reactors.

PRTR Gas Loop Support Studies. Samples of alloys which may be exposed to carbon dioxide in the PRTR gas loop were heated in a laboratory furnace at 1500 F in a purified CO_2 atmosphere for 463 hours. The carbon dioxide was passed over heated copper turnings and silica gel to remove traces of oxygen and water vapor. The most oxidation resistant alloy was Hastelloy-X

which gained 0.27%. Other alloys and oxidation rates were: 406 SS (Carpenter), 0.74%; Fe-Cr-Y, 0.84%, Inconel-X, 1.30%; Inconel, 1.76% and Inconel-702, 1.87%.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals; namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Tensile properties, microhardness, electrical resistance, and x-ray diffraction spectra are being studied to determine the characteristics of recovery mechanisms.

One-hour isochronal annealing treatments at 25 C increments were extended to 300 C for irradiated and unirradiated specimens of molybdenum, zirconium, and nickel. The radiation exposures represented are approximately 4.5×10^{18} nvt for molybdenum and zirconium, and 1.5×10^{20} nvt for molybdenum, zirconium, and nickel.

The electrical resistance data for zirconium indicate a single recovery zone between room temperature and 300 C. A discontinuity in the recovery curves for molybdenum for both irradiation exposures occurs near 200 C. This appears to divide the over-all recovery zone into two sub zones. Significant recovery of the electrical resistance of irradiated nickel has not been measured up to 300 C. Radiation recovery begins at lower temperatures and is more extensive over the recovery range, for the lower-exposure specimens of molybdenum. An increase in microhardness occurs above 200 C for both the irradiated and unirradiated specimens of molybdenum. Between 200 and 300 C these increases amount to 12, 32, and 38 DPH numbers, respectively, for the unirradiated 4.5×10^{18} nvt and 1.5×10^{20} nvt specimens. Since the annealing treatments were conducted in silicone oil, the specimens were reground and measured again for hardness after the 300 C anneal. The agreement between these and the original measurements was good, indicating that the increase in hardness was significant and not due to an oil-metal reaction.

An increase in hardness with increasing annealing temperature was also observed for the irradiated nickel specimen. However, in this case the unirradiated specimen exhibits a slight decrease if any change with temperature. Both irradiated zirconium specimens show decreases in hardness with increasing annealing temperature; the unirradiated specimen showing no significant change.

A Zircaloy-2 tube which has been exposed to neutron radiation over a 25-month period and a similar unirradiated tube were removed from the KER facility. These tubes will be mechanically tested and examined metallographically to determine the effects of high neutron exposure at elevated temperatures on Zircaloy-2 and to establish testing methods for examining irradiated tubing. Strip-type specimens for room temperature and elevated temperature (300 C) tensile tests were machined from the unirradiated tube sections. A milling apparatus for machining similar specimens from the

irradiated tube sections at the radiometallurgy facility was designed and fabricated during the month. Preliminary tests of unirradiated specimens were started to evaluate special grips and fixtures fabricated to accommodate the curved cross section of the specimens.

E. CUSTOMER WORK

Radiometallurgical Examinations

Examination of Warped and Unwarped OIIN Natural Uranium Fuel Elements from 105-H (RM-296) Examination of both warped and unwarped, OIIN, natural uranium, I & E fuel elements continued this month. Metallographic examination was completed on one transverse sample from the unwarped fuel element. The photomicrographs revealed no unusual grain structure for irradiated uranium.

Rockwell "A" Scale Hardness tests, made on samples from both the warped and unwarped elements, produced the following results:

Warped		Unwarped
61.7	Minimum	65.7
67.9	Maximum	70.0
65.7	Average	68.4

Metallography Laboratories

A metallographic examination was performed on a section of Zircaloy-2 tubing which had been fabricated by Imperial Chemical Ltd. of England, and a comparison was made with the U.S.-fabricated tubing which was examined and reported last month. The British and American tubing samples were similar in many respects; e.g., good surface appearance, absence of cracks, and uniform grain size. However, the hydride content of this particular British tubing was slightly high. By comparing the samples with a previously-prepared chart on hydride concentration in Zircaloy-2, it was estimated that the British tubing contained 100 to 140 ppm of hydrogen, whereas the U.S. tubing contained, for the most part, less than 10 ppm except for some areas in the range of 40 ppm of hydrogen.

Samples Processed During the Month.

Total samples processed: 208

Photographs:

Micrographs	213
Macrographs	87
Electron Micrographs	136
	436

Special Al-Pu Alloy Pin Fabrication

Savannah River Plant has requested sixty plutonium-aluminum alloy pins. Pu-Al cores of approximately 15 w/o Pu will be fabricated to a diameter of 0.0325 inch and 0.470 inch long. They will be slipped into machined 1100 Al cans 0.0625 inch OD and half an inch long with a 0.015 inch wall thickness. A cap will be welded on one end to close the can.

[redacted]

An investigation and evaluation of techniques for fabricating the core material is now proceeding, and a method of welding the can is being investigated. Test welds made by the tungsten inert gas manual method look promising.

F. W. Albaugh

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

DECEMBER 1959

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety

Nuclear safety specifications for the offsite rail shipment of 3676 lbs. of 1.6% enriched uranium metal were issued. This shipment consisted of I and E fuel elements (443 lbs.), solid billets (1768 lbs.), and KER washers (1465 lbs.); all of which represented about three minimum critical masses. Part of the KER washers (285 lbs.) were in the form of aluminum clad fuel elements which required stripping in the 313 Building caustic tanks before boxing for shipment. One of the caustic tanks that was used contained about 500 lbs. of uranium sludge (natural and 0.96% enriched) from the processing of production line rejects. Nuclear safety in stripping the 1.6% enriched fuel elements was assured by processing in four batches and by maintaining a single layer (safe slab height) array. Standard shipping boxes were used for packaging this uranium for shipment. To assure nuclear safety in transit, the following conditions were specified:

1) The KER washers were secured tightly together onto several 8" iron bolts.

2) The shipping boxes were loaded with a single layer of uranium one diameter deep. The uranium thickness in the loaded boxes thus ranged from 1.4" to 1.7".

3) One railway car was used for the total shipment. Half the number of boxes were placed in one end of the car and half in the other. The boxes were all placed on the floor of the car in a one layer array.

4) No other fissile material was included in this shipment.

Nuclear safety specifications for the fabrication of 0.96% enriched fuel elements in the 313 Building were reviewed at the request of FPD. It was determined that certain limits could be safely revised upward with resultant improvements in plant operating efficiencies.

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Neutron Temperature Study

A traverse with lutetium foils was made across the TTR thermal column. The traverse ran parallel to the side of the thermal column through which the neutrons enter. It passed through the center of one side of the thermal column, the center of the thermal column, and the side opposite the first side. The ratios of the two lutetium activities show that the neutron temperature is constant along this traverse and at positions, inside the thermal column, which are greater than 4

inches from the sides.

Another ratio was obtained from a foil positioned in the center of the thermal column. For this measurement the graphite along the original traverse was replaced by a process tube. In the process tube was a graphite assembly which contained the foil. This arrangement is the same as was used for the calibration of the lutetium foils and for the plutonium and uranium foils. The ratio of the activities obtained from the lutetium foil in the process tube, when compared to the center foil of the traverse shows that within the experimental accuracy ($\sim 5^{\circ}C$) there is no difference in the neutron temperature for the two cases. Thus any effects due to the process tube and the assembly (e.g. effects due to neutron streaming and the addition of poison to the thermal column) were not observed.

Preliminary calculations of the resonance integrals for the lutetium isotopes have been completed. The results of the calculations are summarized in Table I.

TABLE I

	σ_{2200}	$RI^{\infty}_{0.55}$	$RI^{0.55}_{0.125}$	$RI^{\infty}_{0.125}$
Lu^{175}	16(22)	488	8	496
Lu^{176}	1950	875	4658	5533

The "σ_{2200}" and the "RI" are tabulated in barns. The subscripts and superscripts show the range of integration for the resonance integrals and the lower limits of the integrals are assumed to cut off sharply. The calculations were done using measured cadmium ratios of 1.45, 69, and 33 for Lu^{175}, Lu^{176}, and a 1/v detector, respectively. The epicadmium resonance integrals $RI^{\infty}_{0.55}$ were also calculated using resonance parameters. The values of the calculated $RI^{\infty}_{0.55}$ equal 667 barns and 840 barns for Lu^{175} and Lu^{176}, respectively. The poor agreement between the measured and calculated values for Lu^{175} could very possibly be due to an incorrect value of σ_{2200} for Lu^{175}. Since there is no measured value available for this quantity, the contributions to σ_{2200} from all of the observed resonances were added together to obtain the value of 16 barns. If $\sigma_{2200} = 22$ barns, the measured and calculated resonance integrals would agree.

The neutron temperature in the internal column of the TTR was measured using the lutetium "thermometer." The ratio of the thermal activities of lutetium corresponds to a neutron temperature of $69 \pm 6^{\circ}C$. When measured with a Pu^{239} and a U^{235} foil this temperature is $65 \pm 20^{\circ}C$. The errors which are indicated are those due to a 1 percent statistical error in a measured ratio. It is interesting to compare the magnitudes of the corrections to the activities because of the epithermal component of the flux. The correction factors are 1.110, 0.998, 1.062, and 3.255 for the Pu^{239}, U^{235}, Lu^{177}, and Lu^{176m} epithermal activities, respectively. The factor for Lu^{176m} is large but on the other hand it can be accurately determined with a cadmium-ratio measurement. Of the two activities, Pu^{239} and Lu^{177}, Lu^{177} is not only the more sensitive to changes of the neutron temperature, but it is also less sensitive to the epithermal components of the flux.

Neutron Temperature Coefficients

Programming of a subroutine to obtain cross sections from the nuclear data tape is completed. This subroutine will furnish either the average cross sections over lethargy ranges or the point cross sections at particular energies as specified by the calling program. It will also furnish Maxwellian averages. A program to check this subroutine is being written.

Debugging of the nuclear data tape program has been halted temporarily until it can be converted to the Monitor System. The compilation errors caused by the Fortran compiler do not seem to exist with the Monitor compiler.

A subroutine to calculate incomplete gamma functions has been written and tested. Three methods are used to calculate the function in order to give increased accuracy. The errors seem to be less than 1 unit in the sixth significant figure.

Absorbing Rod in a Maxwellian Flux

The parametric survey of the effect of an absorbing rod on the thermal neutron flux in a surrounding non-absorbing medium is continuing. It was decided to use the reaction weighting criterion in the remaining cases, and the ARMIE code was modified to include this. A renormalization of the flux at the rod surface was also included at this time. A more complete description of the work is being prepared.

Thermal Neutron Spectrum Near a Temperature Discontinuity

Evaluations of the analytic solutions to the temperature discontinuity problem in a heavy gas moderator in slab and cylindrical geometries are nearing completion. Analysis has been concentrated on the cases where the cylinder radius and the slab half width were two relaxation lengths, a size in which geometrical effects are quite evident. A variation of the relaxation lengths of the two media separately has produced interesting results. A slab or cylinder in which the relaxation length is made shorter than its surrounding medium, keeping the diffusion coefficient in each of the media the same, exhibits the properties of a region larger than two relaxation lengths. This is to be expected, since in effect we have made the region more dense and heavier. The effect is reversed for the opposite condition.

SYZYGY II, which was a modification of the 709 FORTRAN program SYZYGY including a net neutron current in the infinite plane discontinuity case, has been further modified to include a neutron current in slab and cylindrical geometries. It is now in the process of debugging.

An attempt will be made to correlate SYZYGY II results in the cylindrical case to those of ARMIE - a 709 FORTRAN program treating an absorbing rod in a non-absorbing medium. A relationship is sought connecting parameters of an absorbing rod with those of a non-absorbing rod with a neutron current in the temperature discontinuity problem. ARMIE does not treat the flux inside the cylinder, so by matching flux and total neutron density outside the rod, it is hoped that corresponding sets of parameters can be found.

Multimaxwellian Group Analysis

FIT-1 is still being debugged. The troubles mentioned last month have apparently been worked out of the program. The program was converted to the Monitor system recently installed by Data Processing Operation. A significant decrease in machine operating time is apparent with this system.

Neutron Rethermalization Experiments in Graphite

An experimental study of neutron rethermalization in graphite in cylindrical geometry has been started this month. This is an extension of work reported previously. The experimental techniques are quite similar to those used in the earlier work except that cylindrical geometry is being used rather than plane, simple lamp black insulation has replaced vacuum insulation, and lucite rods have been inserted in the fuel to help reduce the epithermal flux. In addition, measurements of the neutron temperatures are being made with lutetium foils.

These experiments have been designed to cover a temperature range of 200 to 900°K in four equal steps. To date, a low temperature and a room temperature irradiation have been made. The activated detectors have been counted for the room temperature irradiation and the data are being prepared for processing on the IBM 709 computer. The activated detectors for the 100°K experiments are being counted. Preparations are being made for three additional experiments at 300°K, 500°K and 200-900°K.

These experiments are being done in the core of the PCTR with a symmetric cylindrical array of fuel tubes. Since the entire system is cylindrical (except for the PCTR leveling slugs) an attempt will be made to analyze these data with a modified version of F-3 which will treat the entire reactor rather than just the core region as was done previously.

Multiregion Exponential Studies of Mixed Lattices

Consideration of multiregion exponential experiments has been dropped for the present. The feasibility of such studies was reviewed to see if effective bucklings of enriched uranium mixed with natural uranium could be measured in an exponential pile. The question arose because analyses of startup measurements of C metal used as slab enrichment gave a lower buckling than measured for a pure C metal exponential loading. When E metal came into use, which had been measured in an exponential pile but not at startup in a mixed load, the question of the actual effective buckling was unsettled.

An exponential experiment was postulated in which the central row of tubes would be part natural uranium, and part C or E metal, with natural uranium in the rest of the assembly. Then a multiregion, one or two group diffusion theory calculation would give the buckling of the mixed row in terms of the known natural uranium buckling and the measured relaxation length of the assembly. Only the one group analysis has been considered so far because of the complexity of 2 group methods. This method is feasible if the enriched buckling is large enough so that a small volume fraction would make a measurable change in the over-all relaxation length. The limit of detection requires that at least 25% of the central row of an assembly 7 tubes wide be enriched with a buckling of 300×10^{-6} or more. This would be reasonable considering the buckling and volume fraction of the enrichment normally used.

The proposed experiment was dropped when G. R. Parkos re-analyzed the startup experiments using the multiregion buckling approach and obtained results consistent with exponential data on uniform systems.

Although this specific application considered for the multiregion technique is no longer needed, the technique seems to be reasonable and could be applied wherever multiregion problems are involved. Limitations appear to be the need for a large buckling difference if a small fraction of the foreign material is to be used; errors inherent in 1 group analysis if large spectral differences are encountered; and the derivation of an effective, rather than absolute, buckling so that extrapolation to other systems may not be possible. Nevertheless the technique has an interesting possible application where spike or slab enrichment or poison is to be inserted into a lattice of other material and, 1) a critical facility using the desired lattice is not available, so that a single rod reactivity measurement is not possible, 2) a sufficient quantity of the foreign material is not available for uniform exponential experiments, and 3) the non-uniformity introduced is too large for a successful PCTR measurement.

Instrumentation and Systems Studies

The study of the reactor kinetic equations were extended to the case of a reactor large enough to have non-uniform flux distribution. Only a first approximation can be obtained analytically. This indicated that under some conditions the equation solutions are more unstable than for a small reactor with uniform flux. This conclusion has been verified by some solutions on the Litton Digital Differential Analyzer. The approximate solution also indicated that it may be possible to set up spatial oscillations of flux different from those caused by xenon poisoning. This has not yet been checked on the computer. A report on this work is under way.

An investigation of reactor characteristics relating to control was started with the consideration of methods of measuring transfer functions. It appears that some analytical methods can be used to determine the various relationships between control and measuring points in the reactor but ultimately actual tests with a production reactor will be necessary.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Measurements of Large Diameter Fuel Elements

Final values for the material buckling of three lattices are listed in the table below. The value of λ listed is the measured side-to-side extrapolation distance. The front-to-rear λ was assumed to be 1.03 inches. A preliminary value for one lattice is included using an assumed λ of 1.66 inches.

Fuel Element	Lattice Spacing (Inches)	B^2 $10^{-6}cm^{-2}$	λ Inches	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 2.0 with 1.66 x 1.1	7 3/16 dry	-259*	1.66	0.493	--	14.85
2.5 x 1.6	8 3/8 wet	-68	1.70	0.373	1.291	21.47
2.5 x 1.6 with 1.17	14 9/16 wet	-68	1.47	0.305	0.631	51.25

Fuel Element	Lattice Spacing (Inches)	B^2 $10^{-6}cm^{-2}$	λ Inches	Volume Ratios Al/U	H_2O/U	C/U
2.5 x 1.6 with 1.17	8 3/8 wet	-51	1.49	0.305	0.631	15.62
2.5 x 2.0 with 1.66 x 1.1	8 3/8 dry	-52**	--	0.493	--	21.12

* Remeasurement of a lattice reported last month which had a poor fit to the data.

** Preliminary value.

Correction of a small error in the vertical traverse for the tube-in-tube fuel element in the 8 3/8" lattice (wet) has changed the material buckling from -61 to -64 x $10^{-6}cm^{-2}$.

PCTR Measurements of Lattice Parameters of Large Diameter Fuel Elements

All material has been assembled for the 2.5" x 2.0" + 1.66" x 1.12" tube-in-tube experiment. The foil counter has been prepared and a preliminary counting routine and shift schedule have been formulated. The resonance escape probability, p, will be measured first for the above element in a 10 1/2" lattice. Measurements will be made in other lattices later. Some of the possible sources of errors in these experiments have been considered in detail. These include the effects of foil positioning, foil counting errors, the difference in U-238 and U-235 fission product gamma spectra, and thermal neutron leakage.

PCTR Measurements of k_∞ and f for Selected Cluster Elements

Some preliminary results are now available for the experiment with clusters of 0.925-inch diameter natural uranium rods, water cooled, in a 7-inch graphite lattice. The results afford useful comparisons between different experimental approaches in the PCTR and exponential measurements of essentially the same lattice as discussed in the last monthly report.

Preliminary values of results obtained are:

"1/v utilization	$f = 0.908$
Enriching with U^{235} - Aluminum Alloy	$k_\infty = 0.948$
Poisoning with Copper	$k_\infty = 0.943$

In the determination with enriched alloy, the flux spectra and adjoint were matched with both the center cell and the buffer cells enriched. In the copper poison method, the spectra were matched with center and buffer cells unpoisoned, inasmuch as it is not experimentally practicable to remove absorber from the lattice under investigation. The unpoisoned condition corresponds most closely to the "poison removed" condition.

Although the agreement of the two k_∞ results may be only fortuitous, the correspondence does encourage confidence in both methods. In addition, these values correlate reasonably well with the value $k_\infty = 1.063$ for PCTR measurements made previously with the same lattice using uranium of enrichment 1.007 percent U^{235}.

Using the IPD survey code to calculate the change in ηf upon enrichment, a value of $k_\infty = 1.070$ is predicted from the measured k_∞ of the natural cluster. However, none of the results agree with the value of $k_\infty = 0.905$ inferred from exponential measurements with essentially the same lattice assembly with natural uranium. Two possibilities for the 4 percent discrepancy are: (1) The material buckling is wrong; the validity of making exponential measurements with grossly negative bucklings ($-290 \times 10^{-6} cm^{-2}$) has been questioned for some time. The exponential assembly in this case had base dimensions 5 1/2 by 8 feet; (2) the calculation of the lattice age is incorrect. The calculation of this parameter is troublesome as the ratio of water to graphite increases.

Automatic Data Reduction System for PCTR

The bids for this equipment were received during the month. Both bids were rejected because they were too high. Datex Corporation bid approximately $89,000 and Epsco Corporation bid $110,000. The fair price estimate of $23,000 was arrived at in collaboration with a representative of one of the bidding companies. The systems proposed by both companies include more functions than the application requires. The original requisition was cancelled and the specifications are being reviewed to determine if they may be altered to gain a more acceptable bid cost.

Exponential Pile and PCTR Measurements for the NPR

Redesign of the graphite for exponential and PCTR studies for N Reactor has been completed to correspond to the recent design change by IPD. Graphite cooling tubes have been omitted, one of the vent spacers has been moved one inch in the exponential stack, and ball channels are not included; otherwise the assemblies will be duplicates of the N Reactor stack. The movement of the vent space in the exponential was necessary in order to use graphite which had already been extruded by the vendor at the time the design change was made. The order has not yet been authorized, pending receipt of cost figures for the large amount of additional machining required.

The condensed lattice is unchanged and will proceed as planned. Most of the graphite needed is in stock, and the rest which is needed to make up the odd lattice spacing has already been received.

Instrumentation and Systems Studies

Preliminary work was started this month to study various power transients in the NPR system. The immediate application of this simulation will be to observe the reactor power decay following a scram and also to investigate various start-up techniques. This simulation neglects the feedback effect of the heat exchangers; that is, it considers only the reactor and its internal reactivity feedback loops. This program can be used as a part of the simulation to study the entire NPR system under scram conditions if the need for such a program develops in the future. The programming is complete and should be ready for the computer soon.

The general basic design requirements for a prototype, linear, four-decade, scintillation, beta-gamma area monitor for the 105-N Building were changed during the month. The new design, agreed to by all interested parties, incorporates a two-range two-detector system. The detectors and associated circuitry will operate independently of each other. Each will incorporate a semi-linear, self-limiting, upper-range saturation operating mode. The sensitive system will cover the range from zero to about 500 mr/hr and the less sensitive unit will extend from zero to about five r/hr. Both units will be accurate over the initial 20 percent of the respective ranges but will then gradually saturate at the higher levels of each range. Such a method is arrived at by proper phototube dynode voltage-divider resistors and detector size selection. The two ranges tend to overlap to provide constant coverage. The more sensitive unit will alarm in a nonlatching fashion, and the less sensitive unit will be used for high-level, evacuation-type alarming.

Agreement was reached by all interested parties concerning final design criteria requirements for the prototype, scintillation, beta-gamma air monitor for NPR. The unit will be completely transistorized and will alarm on a continued level of 10^{-9} μc/cc of mixed fission products in 50 minutes.

The chopped gamma signal simulator was completed for initial tests of the detector portion of the fast-scan NPR Fuel Element Rupture Monitor. Data from this simulator demonstrate that a statistically usable signal can be obtained at a scanning rate of 102 samples per five seconds if there are about 300 or more counts per sample. A slip-ring assembly of 20 rings was ordered for the same project. The detailed mechanical design for both the fast and slow-scan systems is now 50 percent completed. The various scan-drive assemblies are being ordered. A light pipe and multiple NaI crystal detector was designed incorporating special shielding material. Because of space limitations, three parallel 1.25-inch diameter by 2.0-inch long NaI crystals will be used. Four RCA 6199 phototubes were chosen to be used in extended age, environmental, and resolution tests. Cost estimates are being compiled for various methods of data storage for the NPR fuel element rupture detection system. These cost figures will influence the selection of the devices which store and display the values of the individual process tube radiation levels.

Mechanism of Graphite Damage

Preparations were made for a beam sweeping device for the electron Van de Graaff. The deflection plates were ordered from the High Voltage Engineering Corporation. The electrical part of the system will be made here. When installed this system will make it possible to irradiate, uniformly, pieces up to one inch square.

The electron beam calorimeter was connected directly to the electron Van de Graaff to eliminate absorption in the exit window. The accelerator vacuum system carried the load satisfactorily although it required a day to de-gas the system.

STUDIES RELATED TO THE SEPARATIONS PLANTS

Plutonium Critical Mass Facility

The construction phase of the Plutonium Critical Mass Facility is proceeding on schedule. The total progress is judged to be ~ 56% complete as against a scheduled 52% for the end of December. It is noteworthy that the general contractors construction work is ~76% complete compared to a scheduled 55%. There are still indications of a probable delay in delivery of the control panel and instruments.

The control building is nearing completion. The interior painting and installation of cabinet work and laboratory benches is well under way. Most interior finishing is complete in the service building. The mixing hood has been delivered together with its associated fittings.

The reactor room is nearing completion. The large shielding door to the reactor room was filled with concrete (it weighs approximately 14 tons). This door is satisfactorily hung and freely operating.

The major construction work of the Plutonium Critical Mass Facility is thus nearly complete; subsequent work will primarily involve finishing operations and the installation of equipment.

Critical Hazards Specifications

Nuclear Safety in Plutonium Metallurgy Operation

The nuclear safety of operations involving the degreasing of plutonium turnings in Freon was evaluated.

NPF Fuel Handling

The nuclear safety of a mechanical processing cell which is now in the scoping stage was reviewed and comments forwarded to Facilities Engineering Operation. The purpose of this cell will be to remove the hardware from NPF fuel element assemblies and to shear these assemblies into small parts for dissolving. Both of these operations would be performed under water. The design basis calls for processing uranium metal and UO_2 fuels enriched up to 5% U-235. Since some of the fuels will be UO_2, the nuclear safety analysis required the evaluation not only of the reactivity of solid rods and fuel fragments in water, but also UO_2 fines suspended in the water. It is planned to circulate the water through a filter to remove these fines. It was concluded from this review that since the facility is not safe by geometry as presently designed, nuclear safety would be achieved through, 1) administrative controls to prevent more than one fuel element at a time from being loaded into the cell, and 2) by limiting the uranium concentration in the waterbasin.

Studies were continued this month to establish the safe dimensions of a fuel element dissolver for the reprocessing of NPF fuels. Eighteen designs were evaluated and all were found to be unsafe for the fuel element enrichments proposed, which ranged from 2-5% enriched uranium metal. A design, which has been tentatively accepted as nuclearly safe, consists of a canister in a barrel which

is over eight feet long. The canister is 8.4" x 8.4" (max.) inside with walls of 0.2" thickness (min.) fabricated from a neutron absorbing material equivalent to 0.020" of cadmium. The barrel is 10" x 10" (max.) inside.

For the fuel assemblies that are proposed, this dissolver design will be $\sim$ 80% of the critical size for 2.0% enriched metal rods, $\sim$ 90% of critical for 3.4% UO_2 rods, and 84% of critical for 3.4% UO_2 in solution.

Further studies are being made to more accurately evaluate the nuclear safety of the proposed system.

Experiments with Heterogeneous Systems

Critical approach and exponential experiments were continued with the small, 0.175-inch diameter rods of 3.063 percent enrichment. The uranium rods which were 23.5-inches in length were encased in 0.025-inch wall lucite tubes for insertion in the lattice assemblies. Fabrication of lattice assemblies with 0.300-inch, and 0.375-inch spacings was completed; a hexagonal pattern was used for the lattice assemblies. Since the minimum critical mass was previously determined for this fuel rod size these lattice spacings were chosen in order to evaluate the maximum buckling. Critical approach and exponential measurements were made with the 0.300-inch lattice. Because of the low H_2O/U volume ratio (less than optimum moderation) the material buckling of the 0.300-inch lattice was too small to permit an estimate of the critical mass by means of the critical approach technique with the quantity of uranium available.

The exponential measurement gave a buckling of 12,411 x $10^{-6}cm^{-2}$ for the 0.300-inch triangular lattice (H_2O/U volume ratio of 2.24); the extrapolation length was assumed to be 7.00 cm for the buckling calculation. The critical mass in spherical geometry for a water reflected system is calculated as 513 lbs. of U from the measured buckling.

Critical approach experiments are currently underway with the 0.375-inch lattice assembly.

Exponential measurements were continued with the 1.007 percent enriched uranium rods of 0.925-inch diameter to determine the quantity of neutron absorber which must be added to a water moderator in order to make safe a heterogeneous system (reduce buckling to zero). The buckling was measured for a 1.6-inch lattice (H_2O/U volume ratio of 2.15); the value of the buckling for the case of no boron in the moderator was, 3416 x $10^{-6}cm^{-2}$. Measurements will now be made after adding measured amounts of boric acid to the moderator in order to determine the amount of boron required to reduce the buckling to zero. Previous measurements were made in a 1.5-inch lattice with boron poisoned moderators.

Experiments with Homogeneous Systems

Further k_∞ measurements were made in the PCTR for homogeneous mixtures of 3 percent enriched UO_3 and polyethylene. Data were obtained for evaluating k_∞ at nominal H/U atomic ratios of 40, 44 and 48; the effect of the aluminum wall of the test cell on the measured values of k_∞ was also examined and found to be negligible. The purpose of the measurements was to determine the nuclearly safe concentration, or H/U ratio above which all values of k_∞ are $\leq$ unity.

The subsequent chemical analyses which were made of these mixtures following the measurements indicated that the material was not well mixed and that homogeneity had not been achieved.

From these analyses, the actual H/U atomic ratios were found to be approximately 42, 42 and 57. The error in these analyses was rather large due to loss of material in heating the sample, etc. The values of k_∞ based on these analyses were 1.038, 1.023 and 0.891 respectively. These values of k_∞ reflect the error in the chemical analyses; however, the points fall fairly close to the curve extrapolated from previous data.

The best value for the nuclearly safe concentration, or H/U ratio (cross over point) for which k_∞ becomes unity with 3 percent enriched UO_3-polyethylene systems, is the H/U atomic ratio of 44; all values of k_∞ with H/U ratios $\geq$ 44 will be less than unity.

Exponential experiments were being conducted in order to determine the buckling as a function of H/U atomic ratio for 3% enriched UO_3-polyethylene homogeneous systems in an effort to correlate theory and experiment.

One exponential measurement was conducted this month, at a nominal H/U atomic ratio of 4, in an effort to determine the maximum buckling for these systems as a function of H/U ratio. The size of the system (a 12-inch diameter by 24-inch high cylinder) was limited by the amount of UO_3 available. The neutron spectrum did not reach equilibrium throughout the region of the measurement as evidenced by the variable cadmium ratio in this region. Because of this the measured buckling should be considered as only an approximate value.

H/U	Total Density (gm/cm^3)	UO_3 Density (gm/cm^3)	λ (cm)	Buckling ($10^{-6} cm^{-2}$)
4.61	1.61	1.44	9.5 ± 1	5513

From the above measurement and prior measurements the material buckling would appear to have a maximum for H/U atomic ratios in the range 5-9.

Theoretical Critical Mass Studies

The reactor kinetics program and its associated subroutines have been converted to the Monitor system. Debugging of this program continues.

The subroutines written to calculate material and geometrical parameters for small, homogeneous reactors have been debugged. These subroutines are being used to debug a program which calculates fast and thermal neutron leakage from a bare homogeneous subcritical system.

A program has been written and debugged which converts data from chemical analyses to nuclei per unit volume. The program calculates quantities of interest in several different ways giving a cross check on the analysis.

A code for the reduction of chemical analyses has been written, debugged and is presently being used to reduce the P-11, Pu-solution experimental data. The code reduces the typical chemical analysis given in grams/liter to nuclei or molecules per cc. Cross checks are made to determine internal consistency.

Mass Spectrometry

No customer service was requested for isotopic analysis with this mass spectrometer during the month. The instrumentation of this spectrometer was continued in use to study and improve the ion pulse counting system of the mass spectrometers.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

Growth of Single Metal Crystals

One aluminum crystal, 3 1/2 inches in diameter, was grown in December. A larger temperature gradient than previously employed seems to have caused several differences in macroscopic properties of the crystal. The crystal has not been studied with neutrons as yet.

A "soft mold" technique of containing an aluminum ingot during the melt was tested and proved reliable. The soft mold is levigated alumina contained in a stainless steel can. A possible reduction in stresses during crystal growth is one of several possible advantages of the use of this technique.

Studies of Monochromating Crystals

The 105-KE crystal spectrometer was available for experimental work for four days during December. The first sixteen days of the month were lost because of the removal of a thermocouple stringer from behind the spectrometer shielding. Approximately ten of these days were lost in waiting for Operations to clean up the contamination of the X-2 level which resulted from their futile attempts to replace the stringer. Another long period of lost time is anticipated in the future when the stringer replacement is again attempted. Two other reactor outages were encountered during the month, the last resulting in another of the frequently occurring gas leaks in a thermocouple wire seal. The spectrometer area was inaccessible for several days until the leak was repaired.

During the four days which were available the neutron diffracting properties of an aluminum crystal were determined under three successively different conditions: (1) crystal as cast, (2) after rough sawing of flat surfaces, and (3) after sanding the sawed surfaces. No significant differences in diffracting properties were found indicating that the Bragg diffraction is not localized near the macroscopic crystal surface.

Slow Neutron Fission Cross Sections

The beam shutter mechanism at the 105-DR crystal spectrometer failed to operate for several days due to an as yet unexplained malfunction.

Measurements were continued on the 20 ev resonance fission cross section in Pu^{240}.

Measurements were made using single crystals of lead and of beryllium as filters [redacted]

Fast Neutron Spectra

The test of the cooled photomultiplier which was run in October has been analyzed. The analysis was complicated by the lack of a reliable monitor of initial neutron source strength. The lowest neutron threshold reached was about 30 kev.

Laboratory tests were made of the use of a fast coincidence unit to operate the scintillator neutron source strength monitor in coincidence with the pulsed neutron source in order to eliminate the large non-synchronous background in the monitor. The system appears usable and will be tested when the Van de Graaff becomes available for experimental work.

A remotely-operated, magnetically-actuated electrode system for an improved system of locating the position of the charged particle Van de Graaff beam for alignment purposes has been designed and laboratory tested.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

PRTR Startup Experiments

In addition to the subcritical experiments presented last month, a second two-zone loading is being considered. This loading contains 49 UO_2 elements surrounded by 36 Pu-Al elements and will probably be the initial full power loading.

A rough draft of the approach-to-critical experiments and required instrumentation for the two-zone and two three-zone loadings mentioned last month has been completed.

The Critical Facility of the PRP

The rough draft of the Design Criteria was reviewed and comments forwarded. A letter containing the concept and nomenclature of the various regions of the core was sent to the designers.

Instrumentation and Systems Studies

Evaluation tests continued on the 150 phototubes and 87 NaI crystal detectors for the PRTR Fuel Element Rupture Monitor. The rejection rate continues to run at about 25 percent on the phototubes and 10 to 15 percent on the detectors. The quality of the NaI detectors from this particular vendor leaves much to be desired with internal moisture and glass crystal separation apparent.

The GEDA runs for the controller evaluation were completed and actual operating instructions and demonstrations were given to concerned personnel. The study was started December 17, 1959. The analog computer (GEDA) was used to simulate the reactor and the controller was connected to control the simulated reactor. The characteristics of the controller and of the entire system were then analyzed.

The equations for the PRTR gas loop are being prepared to start a computer program in the middle of January.

Nearly all parts for the Wide Angle Viewer are on hand. Six stainless steel ball bearings are still needed but are expected to be on hand within a few days. Ten stainless steel gears are not expected for three weeks. The six non-darkening relay lenses are being held up by a strike at Simpson Optical Company. The company states that the lenses will be completed three weeks after the strike is settled. Various parts of this viewer are being assembled and tested at the Optical Shop.

Most profilometer parts are being fabricated offsite. These are expected to be completed by February 15. The optical components have been on hand for some time. These are being tested and have been found satisfactory. Two focus compensating lenses are of slightly shorter focal length than desired. Correction for this is being made by remounting two of the mirrors in the warp unit.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Further work on the analysis of the control rod experiment was completed during the month. The results obtained earlier for the 21.875-inch PCTR cell have been extrapolated to a 29-inch cell, the actual EGCR cell length. For a four-by-four array with the control rod in place, 29 inches in length, $k_\infty = 0.9888$. This represents a control rod worth of $\Delta k_\infty = -0.1662$. For a three-by-three array 29 inches long, the corresponding figures are $k_\infty = 0.8645$, and $\Delta k_\infty = -0.2905$. The values listed here were obtained by adjusting ρ and f for the difference in cell length. $\Delta\rho$ was calculated from the change in the graphite to uranium ratio, and $\Delta\rho$ was obtained by recalculating the absorption rates under the assumption that the cell had been lengthened in the center where the flux is relatively constant.

As a check on the consistency of the results obtained for the 21.875-inch control section, the control rod worth was calculated for the entire 37.5-inch PCTR four-by-four array. This includes the two end buffer regions and corresponds to a cell 18.75 inches long. The result was $\Delta k_\infty = -0.1528$, which is very close to the control rod worth quoted last month for a 21.875-inch array.

Most of the work on the error calculation has been completed, but a number is not yet available. The flux and adjoint mismatches cannot be measured directly, because the PCTR cavity is large enough to contain only one control rod supercell. The mismatches are being estimated by calculating the changes in flux and adjoint ratios which occur between the poisoned four-by-four loading without the control rod, and the unpoisoned loading with the control rod in place.

PCTR experiments were performed to determine the angular and radial flux dependence within a fuel tube, and to measure the perturbation caused by stainless steel spacers mounted on the fuel tubes.

Equipment is being fabricated for measurement of the reactivity effect of a stainless steel "through tube" in the EGCR lattice.

Rod Replacement Analysis

Methods of calculating the blackness of a thin cylindrical shell are being studied in anticipation of the stainless steel tube experiment (GCR lattice)

to be performed in the PCTR. The value of k_∞ for a 3 by 3 array with the central fuel cell replaced by a stainless steel cylindrical shell 0.1875" thick is calculated by the small source theory formulation as between 1.000 and 1.040 depending upon the value of the self-shielding factor, and consequently the blackness, of the shell.

NONDESTRUCTIVE TESTING RESEARCH

Tests of the broadband eddy current laboratory equipment being used to measure zirconium jacket thickness and air gap thickness in an unbonded fuel element show that additional compensation must be provided between readout channels. To facilitate this it is desired to obtain a greater difference in each of the two channels between readings due to zirconium thickness change and those due to air gap change.

A difference does exist, but it is small, and slight irregularities in the standards now being used give unsatisfactory results. A new set of thickness standards is being procured and changes are being made in the filter circuits to give better discrimination between jacket thickness and air gap thickness readings.

A transistor sawtooth driver circuit has been developed to replace the inefficient hydrogen thyratron, vacuum tube driver presently used. The transistor driver gives the same current amplitude, 0.7 ampere peak, through a 5 ohm load and with a rise time of 0.3 microseconds. The circuit comprises a 2N656 blocking grid oscillator stage, a 2N656 integrator reset stage, a parallel 2N43 driver stage, and a 2N1D46 power output stage.

An automatic gain control circuit was added to the receiver amplifier to reduce the effect of small changes of probe to surface spacing.

A prototype manual probe was constructed for use with the equipment. In this probe the test coils are supported on a cantilever spring, resulting in a design which has no sliding parts.

Two additional controls have been added to the input balance circuit, making it possible to operate nearer to a null input. This permits use of greater amplifier gain, resulting in increased sensitivity.

An investigation into the measurement of heat transfer properties of assembled fuel elements has been started. Methods to be evaluated include those using infrared and inductive thermometry techniques.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month on a two- and three-shift basis. There were five unscheduled shutdowns during the month; three were due to operator error and two due to faulty by-passing technique.

K_∞ measurements were completed on a 3 percent enriched UO_3 polyethylene system where k_∞ was approximately 1.000.

The neutron temperature in a graphite core experiment was completed.

K_∞ measurements were completed on the low 240 1.8 w/o Pu-Al alloy - 19 element cluster, dry, 8 3/8 inch lattice.

The neutron rethermalization experiment was started during the month.

A gas cooled reactor-power distribution experiment was completed. This work was handled primarily by Experimental Reactors personnel. The corrected data will be forwarded to Reactor Lattice Physics for interpretation after processing by the computer.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Reduction of the dispersion data, including quantitative assessment of ZnS loading collected on membrane filters and correction for natural dust loadings, was completed and delivered to AF Cambridge Research Center. The sample assay method used combined the phosphorescent technique developed by the Analytical Chemistry Operation and counter technique developed by the Nucleonic Instrumentation Operation. Analyses of these data for areas contained within critical isopleths of normalized dosages at 1.5 meters above ground level were completed by joint effort of AF and GE personnel. The analyses utilized only the data from 2, 8, and 16 miles. The results showed that these data form a logical and consistent extension of data obtained by the AF over an 800 m grid in Nebraska in 1956.

Re-analysis of all significant samples of ZnS dosages obtained during the past summer was begun. This analysis is being undertaken in order to reduce the uncertainty of these dosage measurements from the present 20% level to about 10% and to obviate the need for visual assessment of the dust loading.

A preliminary study to determine means of predicting the initial arrival time of the ZnS tracer at 8 and 16 miles downwind from the source during inversion conditions was completed and transmitted to the AF. The procedure was as follows: Streamlines for a given experiment were constructed for each 15-minute increment of travel time of the tracer material, utilizing the wind speed and direction data from the 410-foot Meteorology Tower, the two Texas A and M towers, the radiotelemetering network, and nonscheduled reports from personnel operating field equipment. Trajectories were then computed in 15-minute steps for the leading edge, midpoint, and trailing edge of the released material at heights of 20 feet and 100 feet above ground. The travel times obtained from these trajectories were compared with those determined directly from "drum" sampler data obtained at 8 and 16 miles. Results indicated that in a stable atmosphere the 100-foot wind speed would predict the minimum travel time to a distance of 8 miles for 10 of the 12 experiments used in the analysis. Further, travel times to 16 miles were best predicted by the 150-foot wind speed in the 4 cases studied.

DOSIMETRY

The SPMS was closed from November 16 to December 9 to permit installation of a 1/8 inch lining of lead on the inside of the iron room. The purpose of the

lead was to decrease the background for low energy gamma rays. Tests showed a reduction almost identical with that achieved in a similar facility at Argonne National Laboratory.

Results were received from Los Alamos on their results for potassium measurements of five individuals from Hanford who were also measured here. On the average their values were 14% higher than ours even after allowing for the correction developed last month. Our potassium calibration is being completely repeated.

Miscellaneous activities at the SPMS included the following: A false photopeak at about 4 Mev was eliminated by changing the output impedance of the preamplifier. With the altered preamplifier the high energy background was similar to that reported by other laboratories. The iron room was sealed off over the Christmas holiday to test for any effects of radon or its daughter products carried into the cell by the air conditioning system. No effect was seen. The low energy channels of the analyzer that are used as an index to indicate the presence of unsuspected gamma rays were found to vary from time to time due to small drifts in the analyzer itself. The channels used for this indexing will have to be changed. Experimental work was begun on a scanning counter that it is hoped will eventually replace our chair technique. A special holder is being fabricated to permit gamma ray source measurements.

The positive ion accelerator laboratory was shut down about one-half of the month to permit semiannual maintenance and building rearrangement subsequent to the construction activities that took place this summer. The accelerator was thoroughly cleaned and techniques employed to reduce the amount of carbon deposits formed during irradiation. It was found that during time-of-flight experiments the beam had struck parts inside the accelerator. These parts were removed or covered.

Hydrostatic checks were made of the pressurized parts of the accelerator and the safety valves were re-set.

To further continued cooperation among people at Hanford involved with neutron dosimetry problems a meeting of all such people was held to discuss the different types of work that are being done and the types of facilities that are available. Cooperative work was carried out in checking the response of the double moderator to thermal neutrons and in comparing gold foils and BF_3 tubes for measuring thermal neutrons.

Work began to set up a small facility for the construction and filling of tissue equivalent ionization chambers.

The Co^{60} source that was borrowed from the National Bureau of Standards is being calibrated in the Radiological Physics gamma ray calorimeter. Preliminary results indicate that the calibration will be very close to that provided by the Bureau.

INSTRUMENTATION

Development and test fabrication of transistorized circuitry continues for the experimental alpha air monitor using coincidence counting techniques to eliminate radon-thoron background effects. A gated-oscillator pulse circuit was designed to inject about 10 to 20 controlled pulses into the count-rate circuits

for each simulated Pu^{239}-caused pulse. Such a circuit permits easier balancing of the two count-rate meter circuits so that a net Pu^{239} alpha readout may be obtained.

Investigation of Purex background conditions was completed and the results analyzed. A comparison test was made using a scintillation detector with a recorder and pencil-size dosimeters. Data were obtained for one week at each of nine check points at Redox. The scintillation-obtained information checked closely with the pencil dosimeter information. Readings (average) ranged from a maximum of 1.85 mr/hr to a minimum of 0.02 mr/hr at the nine locations. Detailed information will be presented in a report.

Investigative work continues concerning a miniature detector and light pipe and low-level Pu^{239} detection in solution. The scintillation detector is one-eighth-inch in diameter as is the four-inch long light pipe. The present limit of detection is less than one millimicrocurie of Pu^{239} per milliliter of solution. A proposal was written to supply such a detector as an internal wound contamination probe plus a larger area NaI external wound probe and associated circuitry to 200-Area medical and monitoring personnel. Either probe method can detect less than one millimicrocurie of Pu^{239} in a wound.

An investigation of gamma field conditions was essentially completed at the 234-5 Building. The 200-Channel Analyzer and a large NaI crystal-phototube detector were used for the work. Qualitative gamma energy spectrum analysis information was obtained at requested points in the building. The large amount of data obtained are gradually being resolved into useful information. Some very interesting gamma-energy spectral information was obtained. Principal energy peaks noted were 0.06, 0.07, 0.1, 0.2, 0.38, 0.5, 0.75, 1.2, and 2.3 Mev. A point of desired information concerned the ratio of the 0.38 Mev peak to the 0.75 Mev peak under different conditions in varied locations. A second point of interest was the determination of the effectiveness of the water barrier radiation shield. A third point was the determination of gamma energy peaks at points in the spectrum which were not expected at various locations.

Fabrication continues on several newly-developed experimental alpha-detecting scintillation probes having no gamma response when used with proper discrimination circuitry in a five r/hr field and having effective detecting areas of eight square inches (2 x 4 inches) and 14 square inches (2 x 7 inches). Uniform 10 to 12 percent geometry (to ± two percent) is obtained over the total areas.

A prototype, experimental, transistorized, instrument using both air-proportional and scintillation probes for alpha detection and counting was completed and tested. Performance was excellent with only an addition of both a coarse and fine high-voltage adjustment for the air-proportional probe deemed necessary. The addition will permit easier monitor adjustment. All of the circuitry is transistorized and does not produce microphonic-type output speaker "pops" when used with air-proportional and scintillation probes respectively. The instrument is scheduled to be delivered to the 234-5 Building for field tests.

The completed prototype, transistorized, scintillation, aural and count-rate meter, alpha-beta-gamma monitor is performing satisfactorily in use-testing at the Calibrations (3745) Building. Combined alpha-beta-gamma scintillation detector methods and associated circuitry are being investigated to determine combinations

to give the best beta to alpha detecting ratios consistent with a good gamma-caused pulse rejection.

A miniature anthracene detector was designed which can easily detect point sources of C^{14} of a 400 d/m level.

Development work on the transistorized log count-rate meter has progressed to the point of the circuit now covering four decades from 10^2 to 10^6 c/m with errors of less than seven percent at any point. The experimental unit drives a 10-millivolt chart recorder.

The circuitry for the transistorized, developed, linear, count-rate meter covering three decades of 0-1,000, 0-10,000 and 0-100,000 c/m was modified to eliminate calibration range-to-range interference. Previously, slight calibration control interaction was noted but was compensated for by proper step-by-step calibration methods.

Fabrication continues on an experimental, portable prototype, scintillation, beta-gamma, dose-rate meter. The instrument uses a completely transistorized circuit with a solid-state chopper input. Full-scale first-range sensitivities of one mr/hr can be obtained with one-second response times.

In some investigations of the possible use of multiple glass fiber light pipes for flexible probe scintillation detectors, it was noted that the glass perceptibly darkened at lower radiation doses than expected. This is of interest as a potential difficulty in using these light pipes and as a possible means for measuring relatively small integrated doses by using long glass fibers to improve the ability to detect small amounts of darkening. Measurements of darkening were made by irradiating a four-inch-long multiple-fiber light pipe with the cobalt gamma source. A total dose of 3500 R was accumulated in 500 R steps. It was noted that the darkening faded after exposure. By correcting for this or by measuring immediately after exposure, the optical density was found to vary linearly with dose according to

$$\text{Density} = (1.28)(10^{-4})(\text{Dose in R}) + 0.32$$

over the range 200 to 2500 R. Density $= \log_{10} \frac{100}{T}$ where T is the percent transmission. It does not appear that this creates a difficult problem in any practical scintillation counter application. How far the lower limit of integrated dose detection could be extended by using longer glass fibers has not been determined as yet.

RESEARCH - 5000 PROGRAM

The mass spectrometer was operated 75 percent of the time during December furnishing isotopic analyses of program samples. One and a half days were lost due to instrument failure. The remainder of the time was spent on experimental studies of the occasional appearance of high oxide ion intensities in this mass spectrometer. It was determined that center filament temperature was not the only cause of seemingly poor ionization efficiency of the source at times. Measurements were made to constitute a basis for further experimental work on this phenomenon.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	83.2
24-Hour General	62	80.2
Special	120	90.0

Temperatures during December averaged near normal with no notable extremes. Although there was slightly more cloudiness than usual, precipitation totaled only 30% of normal. There were high winds on the 14th and 15th. However, the over-all monthly average speed was nearly 1 mph below normal.

Instrumentation

The low bid for the designed mechanical conveyor portion of the Laundry Monitor for 200-W Area Laundry Operation was accepted. Delivery is expected in February.

Fabrication continues (about 75 percent completed) on a scintillation detector Mask Monitor instrument for the Laundry Operation.

The following customer instrument fabrication work is presently being done to PIRDO specifications in the 328 Building Electronics Fabrication Shop.

1. Work is essentially completed on 12 scintillation gamma criticality alarm units. These will be delivered to 3745 Building for testing and calibrating by IRDO. After calibration, they will be installed in several 300-Area buildings.

2. Fabrication was completed on three G-M tube detector, transistorized, beta-gamma, alarming area monitors with alarm levels of 0.1 to 5.0 mr/hr available. These will be tested and calibrated and delivered to Redox for installation.

3. Fabrication of five alpha air monitors for Redox nears completion. These are of the scintillation detector fixed-filter type and will be tested and calibrated before delivery to Redox.

4. Fabrication continues on 10 three-decade log response scintillation area monitors ordered by Radiation Protection Operation. These units will cover three decades from ≥ one mr/hr to one r/hr and will have chart recording. They will be installed in various plant Regional Monitoring 614 Buildings.

5. Fabrication just started on three three-decade log response scintillation area monitors for use in the present reactor buildings on the elevators. These were ordered by IPD and will cover three decades from about 10 mr/hr to 10 r/hr with recorder information available and with both high and low-level alarms incorporated.

Acceptance tests were completed on five portable alpha detecting instruments and on three 110 VAC-operated, transistorized, SCINTRAN monitors. The SCINTRAN monitors were three test units of 18 ordered for PRTR use and being fabricated

to PIRDO specifications by a Seattle firm. Several electrical and mechanical changes were found to be necessary.

Acceptance tests were 50 percent completed on fifty, 0-200 mr, self-reading, pencil-size dosimeters.

Analog Computer

The simulation of the NPR Heat Exchangers, which was requested by Process Design Analysis - IPD, was started this month. This program is to study the behavior of the heat exchangers considering variable flow and heat transfer coefficients that are dependent on flow and temperature. Process Design is writing a 709 program which will afford a convenient check for results from the analog computer.

Utilization of the Goodyear (GEDA) computer was 62% for the month. Downtime early in the month was due almost entirely to power supply difficulties. An open circuit on a printed circuit board was isolated. Following its repair there was no further downtime.

The promised December shipping date for the new EASE computer was not met and it is now scheduled for delivery in late January.

Optics

Internal Diameter Micrometer for 105-C FEF - An estimate of $4,390 for fabrication was received from the Technical Shops. The design was modified slightly in accordance with the customer's suggestions.

Scratch Depth Illuminator for 105-C FEF - The design drawings are in the hands of the Technical Shop estimators.

Cave Periscope for Purex - The design is being revised to reduce the fabrication costs.

Infrared Radiation Ratio Pyrometer for HLO-FDO - Fabrication of the electronic unit has begun although two amplifiers have not as yet been received from the vendor.

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Chemical Research & Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATIONS PROCESSES

Decontamination of Reactor Components

Modifications of previously developed decontamination processes to decrease corrosion of carbon steel were studied. A commercial inhibited-citric-acid was tested for application in the APACE process. When used at pH 4.5 (normal for the APACE process) corrosion rates for carbon steel were a factor of two lower than obtained with uninhibited ammonium citrate. Fission product decontamination was as good as normally obtained without the inhibitor. In similar tests, stannous ion was found to reduce significantly the corrosion of carbon steel by ammonium citrate. However, the stannous ion caused a large reduction in fission product decontamination. Decreasing the acidity of Wyandotte 1112 (inhibited bisulfate cleaner) reduced its corrosiveness toward carbon steel markedly but also reduced its effectiveness in removing either fission products or activated corrosion products. Decontamination effectiveness was restored by adding ammonium citrate to the partially neutralized Wyandotte 1112; carbon steel corrosion was not increased. The best combination found was Wyandotte 1112 made 0.05 M in citric acid and adjusted to pH 4.5 with ammonia solution. The Dowell foamed cleaning procedure was applied to the APACE and the alkaline permanganate Wyandotte 1112 processes (with modifications to produce adequate foaming). Decontamination (activated corrosion products) of stainless steel was very poor. The method shows promise for decontaminating carbon steel and will be studied further.

Uranium Oxidation and Fission Product Volatilization Studies

Equipment shakedown tests of the high exposure meltdown facility were performed using cold uranium and induction heating. Difficulty was experienced in obtaining reproducible oxidation rate results. Initial runs were reproducible to ± 5 per cent but duplication of conditions in the low level work using radiant heating will require considerable experience.

A program for an additional meltdown study employing unirradiated uranium contained in a section of Zircaloy tubing was prepared at the request of the Irradiation Processing Department. Tests of this nature will provide temperature-time data relative to the penetration of Zircaloy process tubing by molten uranium.

Single Isotope Monitors

Analytical procedures for Zn^{65} and Np^{239} were investigated for application to recording of these isotopes independently in reactor effluent water. Complexing of zinc with chloride ion and subsequent retention on Dowex-1, an anion exchange resin, gave promise for application to a Zn^{65} recorder. Additional experiments are needed to determine optimum conditions for separation.

Excellent separation of Np^{239} from other isotopes present in reactor effluent was achieved using TTA in xylene. A relatively simple extractor was designed and a detector arrangement selected which will permit direct gamma measurement of Np^{239} in the organic phase after extraction.

Effluent Decontamination

Additional laboratory experiments confirmed the scavenging action of precipitates formed when used cleaning solutions from reactor decontamination are mixed. It was shown that the reduction of potassium permanganate results in the precipitate responsible for the scavenging action. This scavenging reduced both radiocobalt and radiobarium concentrations to 0.1 per cent of their original levels after standing for two days. The kind and concentration of cleaning solution mixed with the permanganate solution affected the rate of the scavenging reaction but did not materially affect the scavenging D.F. after two days standing.

Arrangements were made to obtain samples and information from a forthcoming decontamination of the primary loop of the Vallecitos Boiling Water Reactor. The data from the decontamination of this reactor after two years of operation should provide valuable information applicable to studies of the disposal of NPR decontaminating solution. The decontamination process planned at Vallecitos is similar to that proposed for the NPR.

Analytical Services

Disintegration rates of Co^{58} and Co^{60} in nickel and cobalt flux monitors were found by direct multichannel energy analysis. Results diverged only by 2 per cent from those by destructive analysis (monitor dissolution and direct plating).

Infrared spectrometry was used to confirm the effectiveness of a PRTR candidate Buxite type filter for removing oil vapor from a helium gas system.

Gamma energy analysis was made on a series of irradiated graphite samples of varying purity. The most probable isotope(s) was assigned to each of the ten energies of the gamma spectrum observed.

An emission spectrographic method was set up for rapid determination of the relative magnesium content of water. Speed of analysis was adequate to allow Irradiation Testing personnel's following progress of magnesium removal from loop water. Magnesium entered the loop from a broken thermocouple and made decontamination necessary.

SEPARATION PROCESSES

Solvent Extraction

Recovery of Neptunium in Redox. Three schemes prepared by personnel of the Redox Process Technology Operation for routine recovery of neptunium in the Redox plant were reviewed. The most promising entails operation of the first solvent extraction cycle on an acid flowsheet. Under these conditions, the dichromate in the

feed maintains neptunium in the hexavalent state and neptunium, plutonium, and uranium can be efficiently extracted. Neptunium is separated from uranium and plutonium in the acid-deficient second extraction column, neptunium remaining in the waste while uranium and plutonium are extracted into the organic phase. This waste then constitutes an attractive stream from which to recover neptunium. It is expected that routine neptunium recovery could be accomplished with only a nominal capital investment by freeing up the 1S and 10 columns for use in recovering neptunium from the second cycle waste. Further, application of intercycle ozonization and/or tail-end anion exchange on the plutonium should guarantee adequate decontamination of plutonium with three cycles of solvent extraction and thereby enable the equipment in one of the final plutonium cycles to be diverted to neptunium concentration and purification via a "spin" flowsheet. Operation of this equipment on a continuous or intermittent "spin" flowsheet with an acid, oxidizing first column should enable a relatively concentrated, partially purified neptunium product comparable to the Purex product to be loaded out.

The basic feasibility of these operations has been demonstrated by the earlier work of McKenzie and Richardson (HW-59526), with one exception. The degree of purification from residual plutonium and uranium which can be effected in the "spin" flowsheet is contingent on the efficiency with which neptunium can be converted to inextractable neptunium(V) and thereby selectively stripped from plutonium(VI) and uranium(VI). In the Purex system, excess nitrous acid could be used for this purpose. However, this is undesirable in the Redox system, and alternate reductants for neptunium(VI) were sought. Preliminary experiments indicate vanadyl ion may be suitable for this purpose. In a 1 M HNO_3 - 30 per cent TBP system a ten-fold excess of vanadyl ion reduced the extraction coefficient of neptunium (initially present as neptunium(VI)) from an initial value of 2.6 to 0.11 in two minutes and to 0.07 in five minutes. In a 1.3 M ANN, 0.2 M HNO_3 - hexone system a ten-fold excess of vanadyl ion reduced the neptunium distribution ratio from an initial value of 26 to 0.13 in two minutes and to 0.006 in five minutes. Although vanadyl ion is thermodynamically capable of reducing plutonium(VI), the rate in preliminary experiments appeared to be low.

Thus, although further tests are needed, it appears that vanadyl ion may constitute a useful (albeit somewhat expensive) tool for effecting selective stripping of neptunium away from plutonium or uranium in either the Purex or Redox systems. An alternative spin flowsheet in the Redox system entails an acid, ANN-salted extraction column and an acid-deficient, ANN-salted stripping column. However, it is felt this may pose difficult acidity control problems.

Purex Decontamination Studies. A sample of Purex 3WB taken on November 30, just prior to the most recent Palm recovery run, contained visible amounts of light, flocculent solids. Based on their centrifugation behavior in aqueous and mixed aqueous-organic systems, it appears that these solids are sufficiently light that they might follow the products in the HA-HS columns without necessarily being organic wet. A sample of these solids was submitted for spectrographic analysis, but results are not yet available.

Following removal of the visible solids by centrifugation, the "clarified" 3WB was filtered through packed glass wool. This treatment resulted in removal of

about 20 per cent of the zirconium-niobium activity but did not remove any ruthenium. Repetition of this experiment with a sample of centrifuged 3WB to which "mistron 25" (a very finely divided talc) had been added gave a nearly identical result, indicating no benefit from the talc addition.

Experience indicates that such "filterable" zirconium-niobium activity is frequently encountered at times when plant decontamination performance is poor. It is well possible that a routine filtration test on 3WB could provide a prior warning of decontamination difficulties stemming from accumulation of solids in 3WB.

HA Scrub Column Studies

Initial studies indicate that a substitute scrub cartridge can be designed for the Purex HA column without using plastic sieve plates. The first such cartridge tested in a four-inch-diameter glass column contained nine feet of one-inch-spaced stainless steel sieve plates with 0.08-inch holes, 21 per cent free area. Six-inch packed sections of 1 3/4-inch by 3/4-inch polyethylene Tellerettes were inserted at three-foot intervals. A stable capacity of 1040 gal/hr-sq ft, sum of phases, was obtained.

1C Column Studies

Flooding and efficiency studies of a high capacity "sandwich" cartridge for the Purex 1C column have been resumed. The "sandwich" cartridge consists of four linear polyethylene sieve plates (3/16-inch holes, 18 per cent free area, spaced 1/16-inch apart) with stainless steel nozzle plates (3/16-inch holes, 23 per cent free area) located 1/8-inch above and 3/4-inch below the plastic plates. The "sandwiches" are spaced six inches apart with a stainless steel sieve plate (1/8-inch holes, 23 per cent free area) placed at the midpoint.

Preliminary runs indicate that the column capacity is impaired by locating a "sandwich" at the bottom of the cartridge. Placing the stainless steel sieve plate at the bottom raised the column capacity from 800 gal/hr-sq ft to 1250 gal/hr-sq ft.

C Column Instrumentation and Programming Studies

The FORTRAN program to be used for reduction of the C Column data was completely revised to be compatible to the new MONITOR system which is to be incorporated at the data processing center next month. This system should reduce the cost of processing the C Column data substantially, in that set up time for each computer run will be reduced to a minimum.

The five Foxboro thermohms used to measure the mid-column temperatures have a resistance change to small to give good sensitivity with the Digital Voltmeter Scanning Programmer system. They will be replaced with Brown Type A resistance bulbs which have a resistance change five times greater than the thermohms.

Operating procedures for the traveling photometer have been established that will reduce the zero point drift of the calibration curve to < 1 g U/l per day. In addition, a simple standardization technique enables the zero point to be re-established at any time to within 1/2 g U/l of the original value.

Solvent Studies

A series of di-alkyl phenyl phosphonates have been prepared and purified for investigation as solvent extractants for the actinide elements. The series includes the ethyl, n-propyl, iso-propyl, n-butyl, sec-butyl, and iso-pentyl substituted compounds.

Analytical Services

Hanford ion exchange research (HW-60552) was used to separate neptunium from plutonium at trace levels.

X-Ray spectrometry was used to prove that a glass window for a plant in-line photometer lacked cerium, a vital component of radiation resistant glass.

Radiochemical analysis of plutonium in organic media has been hampered by the lack of a simple, sure way of separating the plutonium from the organic material. Relief is in sight. Two molar HNO_3 - one twentieth molar hydroquinone stripped >99 per cent of the plutonium from 30 per cent TBP in Shell Spray Base (after dissolving it in carbon tetrachloride).

The procedure for isolation and purification of thorium in ores was routinely applied. Eight more samples were prepared for isotopic analysis for ionium and protactinium. The mass spectra were free of any complicating interference. Fusion-extraction of thorium, with bisulfate and a mixture of potassium and aluminum chlorides, was as effective as the classical HNO_3-HF leaching method.

WASTE TREATMENT

Waste Solidification

Radiation induced decomposition of matrix materials is a matter of potentially serious concern to waste treatment. Thus (1) decomposition of nitric acid during acid-side interim storage, if sufficiently severe, could conceivably require an uneconomic continuous addition of make-up acid to prevent precipitation, and (2) decomposition of nitrate, sulfate, phosphate, or carbonate, etc., after calcination could, particularly if gases were produced, cause severe storage problems. Literature studies suggest that both solid (or molten) sodium nitrate and nitric acid solutions may suffer relatively extensive decomposition. An experimental program is accordingly being initiated to obtain definitive answers to these problems, both as affects the storage of solids and of nitric acid solutions.

Flow temperature measurements were made on some of the Purex-phosphate glass systems whose melting points were measured earlier by the differential thermal analysis technique. The flow temperature (temperature at which the melt would flow through a platinum capillary) was generally 30 to 70 C higher than the DTA

melting point. Most melts were quite fluid at a temperature 100 degrees above the melting point, i.e., at a temperature of about 950 C. The surface tension was also determined for several of the melts by the drop weight method and was in the range 275 to 375 dynes/cm. Work on the phosphate melts is being concluded and a report written.

Semiworks Waste Calciner Prototype

Operations of the fluid bed calciner using simulated ICPP waste as feed were completed with seven runs. Operations will be continued with simulated Purex high level waste as feed.

The last five runs were made with a modified fluidizing-gas distributor. The modification consisted of adding a 0.081-inch-diameter orifice at the air entry to each of the eighteen risers. The modified distributor provides good fluidization while reducing attrition from the jet-grinding effect of the gas flowing through the bubble-cap inlets. The product produced with this distributor at a 500 C bed temperature had a bulk density of 0.62 to 0.71 g/cc and a particle size distribution of 84 to 99 per cent greater than 48 mesh and 99.9+ per cent greater than 200 mesh. Product nitrate analyses ranged from 0.8 to 3.6 per cent (0.2 to 0.9 per cent of the feed nitrate).

Batch Waste Calcination Studies

Laboratory scale batch calcination studies with simulated Purex high-level wastes were continued. Two runs were made to better define the sulfate to salt nitrate ratios needed to form a melt at temperatures less than 900 C. At a ratio of 1.0, a melt formed, but was more viscous than the melt previously observed with a sulfate to salt nitrate ratio of 1.5 (reported November, 1959, HW-62899 C). Although no melt formed in a run at a ratio of 0.7, the solids were soft and sticky at 900 C.

Two runs were made with the same feed (sulfate to salt nitrate ratio of 1.4), but differed in operating technique. In one run, the feed was concentrated prior to calcination. The feed in the other run was added to the molten calcined solids. The final appearance of the cooled solids from both runs were similar indicating that the operating technique may have little effect on the properties of the calcined waste.

Observation Wells

Isotopic analyses of a ground water sample from well 699-50-53, located 0.6 mile north of 200 East Area, showed cobalt-60 present in the ground water at this location at a concentration of 1.5×10^{-5} uc/cc. This is about 10 per cent of the gross beta-particle emitter concentration in samples from the well. Other wells north of 200 East Area have shown no indication of large-scale waste migration. Contaminants in well 699-50-53 are probably the result of a local breakthrough of contaminated ground water through gaps, over or around the underground basalt ridge between the well and the 216-BY scavenged waste disposal site.

There have been no significant changes in contaminated ground water patterns under 200 West Area and only slight changes under 200 East Area this month. Wells south of the 216-BY cribsite have continued to show increases in total beta activity reflecting the southward movement of wastes from this disposal site. Slight increases in total beta concentration in the three wells defining the contaminated ground water zone southeast of 200 East Area were also noted. The size of this zone has apparently not increased as evidenced by analyses of samples from surrounding wells being below the total beta detection limit.

Disposal to Ground

A french drain which received waste water from a steam jet in the Purex plant became plugged and required replacement. Since this drain is located near the discharge line to the 216-A-3 crib a laboratory study was started to examine the feasibility of discharging this waste water to the A-3 crib. The crib now receives 8000 gal/month of oxalic acid wash from silica gel beds used in the final clean-up of UNH solution.

Special Geological Studies

GEH-24659, by F. Neumann, "Final Report on Seismological Investigations at the Hanford Works, 1958-1959," received in November, was reviewed in December. Mr. Neumann emphasized the importance of local geology in construction planning, because a 4-grade (8-fold) range in intensity can result from local conditions. Thus, although Hanford lies in zone 2 of the seismic probability map, the range is from 0 to 3. Both under and over-design of structures are therefore possible. More precise definition of the properties of the post-basalt sediments seems to be desirable, particularly by the use of geophysical methods which measure some of the in-place properties of the materials.

The report of Washington State University geophysicists summarizing the results of their seismic tests of October 13-16 was received and reviewed. The results obtained confirmed well the opinions expressed in HW-46050 ("The Feasibility of and Recommendation for an Exploratory Geophysical Program at the Hanford Works"). The Ringold surface was readily detected, although in several sites the Ringold formation appeared to grade into the Recent fluviatile sediments. This is the result of reworking of Ringold sediments prior to deposition of the fluviatile gravels. It is confirmed by samples of cuttings from wells during drilling. The ground water table was not detected where it lay in Ringold sediments.

A river channel in the top of the Ringold formation and believed to pass between wells 699-24-33 and 699-31-30 is either considerably narrower than earlier believed or is missing in that site. In the latter event it probably passes south of the wells 699-28-41 and 699-24-33 before passing north of wells 699-20-20 and 699-26-15. The difficulty in tracing sinuous water courses by means of wells is readily apparent. Definition of the channel is important here because of the influence it evidently exerts on the form of the 200 East Area ground water mound and on the movement of radioactive contaminants toward the Columbia River.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Interim Purex Cesium Recovery

A series of experiments are in progress aimed at firming up a process for a early plant test in the Purex head-end equipment for isolation of a crude cesium concentrate suitable for off-site shipment. The work to date involves "acid-side" precipitation from 1WW of cesium carrying ferri- or ferrocyanide followed by metathesis with silver carbonate to free the cesium, which would be shipped as an acidified aqueous solution in ORNL-type solution transfer casks.

In most of the runs, a sulfate strike was first carried out (with added sulfate and tartrate) to remove cerium, rare earths, and solids. The supernate was then diluted two-fold, cooled to room temperature, and zinc ferricyanide, zinc ferrocyanide, or nickel ferrocyanide precipitated. The precipitate was centrifuged (filtration characteristics were very poor), washed, and metathesized by heating with a slight stoichiometric excess of an aqueous suspension of silver carbonate. The supernate and water washes from the metathesis step were combined, acidified with hydrochloric acid, evaporated to dryness, and weighed to determine purity. With zinc ferricyanide scavenging, over-all cesium recovery exceeded 80 per cent, but the recovered cesium chloride averaged only four to eight cesium-137 curies/g, versus twenty-seven curies/g theoretical. Zinc ferrocyanide and nickel ferrocyanide (the latter precipitated from corrosion nickel by adding ferrocyanide alone) gave somewhat lower recovery (average about 60 per cent) but metathesized more easily and gave higher product purity (12 to 19 curies/g). Experiments are continuing aimed at improving purity and optimizing yield.

Strontium, Cerium, and Promethium Recovery

Intensive research has continued aimed at firming up an integrated process for the simultaneous recovery of strontium, cerium, and promethium in Purex head-end equipment.

Several successful laboratory-scale runs were made to test flowsheets based on the best current knowledge. These runs have demonstrated that it is possible to obtain over 90 per cent of the cerium and promethium and at least 80 per cent of the strontium as separate, concentrated, purified product fractions suitable for load-out from the Purex plant. Yields can doubtless be further increased by better optimizing conditions, and cesium can be recovered, if desired, from the supernate to the sulfate precipitation step. The more significant findings on which the above process is based include the following.

1. Use of lead carrier in the concentration range 0.01 to 0.03 molar assures co-precipitation of 85 to greater than 99 per cent of the strontium in the rare earth double-sulfate precipitation step at sulfate concentrations of only 1 to 1.5 molar.
2. Co-precipitation of traces of iron is effectively prevented by tartrate complexing, without adverse effect on recovery of the desired fission products. The use of tartrate has been successfully tested in the plant and found fully satisfactory.

3. Precipitated lead sulfate is readily removed from the strontium-rare earth sulfate precipitate by metathesis to soluble plumbite with hot 40 per cent caustic.

4. The strontium follows the trivalent rare earths quantitatively in the cerium peroxy-acetate precipitation. Strontium is subsequently separated from the trivalent rare earths by oxalate precipitation of the latter from hot, slightly acidic solution.

5. Strontium may be further purified and isolated from the oxalate supernate by cooling to room temperature and neutralizing to pH 11. Traces of iron are very completely removed by washing the strontium oxalate precipitate with buffered oxalate solution.

6. Conditions have been established for the metathesis of the rare earth and strontium oxalate precipitates to hydroxides for easy dissolution in nitric acid and load-out into shipping casks.

In other experiments, iron was found to interfere with the peroxy-acetate step. The presence of 0.001 to 0.008 M iron resulted in a precipitate which could not be filtered but which still centrifuged adequately. Cerium recovery was not affected, but promethium losses increased somewhat.

Analytical data are not complete on the last plant test; however, cerium recovery was essentially 100 per cent, again demonstrating the operability of the double sulfate process. Because of low sulfate concentration (and no carrier), strontium recovery was low at only about 30 per cent. The attempted peroxy-acetate step failed because of an operating error.

Solvent Extraction of Fission Products

Further experiments on the solvent extraction of strontium and rare earths with fatty acids (tall oil fractions) and Dimer Acid (a high molecular weight polly acid) in the presence of complexants (tartrate, Versene, or triethanolamine) which were intended to keep iron in solution were not particularly promising. At the pH's of six to ten required to insure fission product extraction, some iron still precipitated and carried down a substantial fraction of the strontium or rare earth. None of the extractants tried proved as effective as di-(2 ethyl hexyl)-phosphoric acid. This work is being suspended.

Fission Product Isolation and Packaging Prototype

All components of the Fission Product Packaging Prototype except the filter have been demonstrated in "cold" operational testing. Design expectations were achieved.

The hydrolyzer, after modifications, not only served to successfully convert an aqueous slurry of $Cs_2ZnFe(CN)_6$ into mixed metallic oxides, but also proved effective in later processing steps in converting a water solution of cesium chloride into a dry, free flowing product. Under proper operating conditions

entrainment is not significant at evaporation rates up to 24 pounds of water per hour. Thermal efficiencies in the order of 75 to 85 per cent (evaporative load/power input) were readily achieved. With the operating conditions explored to date, approximately 80 per cent of the cesium present as cesium zinc ferrocyanide is converted to leachable cesium oxide.

The filter was not demonstrated because of the varying nature of the solids discharged from the hydrolyzer during the hydrolyzer test program. The physical properties of the mixed oxides fed to the filter depend upon hydrolyzer operating conditions. A relatively long residence time in the hydrolyzer is required to assure a completely leachable product. However, a long residence time tends to produce an extremely fine product which is difficult to filter.

The crystallizer tank, salt filter screen and scraper, and the drying trough were eliminated from the prototype processing complex when the hydrolyzer proved to be an effective cesium chloride dryer.

The remaining equipment including such items as tanks, packaging and auxiliary equipment met design expectations. Some of these components were modified slightly to enhance their operation and to simplify design.

Remote maintenance features involving the use of the electromechanical manipulator have not been completely demonstrated because of manipulator manufacturing delays. However, the basic design elements appear to function satisfactorily. Use of the manipulator will serve to suggest improvements and make possible further developments in remote maintenance techniques.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Carrier-Free Isolation of Low-Level Cerium

A method for the carrier-free isolation of cerium from dissolver solution has been developed. Subsequent isotopic analysis of the separated cerium may prove a suitable means of "burn-up" determination. Trials on synthetic dissolver solution containing natural cerium have yielded uranium decontamination of approximately 10^4. Cerium recovery was better than 90 per cent on the samples for which recovery data were obtained. Fission product decontamination and interference have not been determined. Isotopic analyses of the separated cerium by mass spectrometry were in good agreement with the accepted isotopic composition of natural cerium, even for samples of less than 1 μg cerium.

EQUIPMENT AND MATERIALS

Hollow Shaft Agitator

The testing of a 10-horsepower, 300 rpm, hollow-shaft-motor agitator for use in either the Redox or Purex plants has been completed and test results have been presented in HW-63175. On the basis of smooth trouble-free operation at the various shaft lengths of interest, the agitator is recommended for both Redox and Purex canyon usage.

Tankage for Interim Storage of Acidic Purex 1WW

The effect of chromium(VI) on the corrosion of 304-L stainless steel and A-55 titanium by Purex 1WW is under study. Corrosion rates obtained, to date, in simulated concentrated 1WW at acidities from zero to three molar are from five to ten times lower in the absence of chromium(VI) (other than from corrosion of the test specimens) than when it is present.

Non-Metallic Materials

A preliminary screening of high temperature rubbers is being made to find a gasket material for use in phosgene at 500 F. Rubbers known to be useful at elevated temperatures are being screened in phosgene at room temperature. Those elastomers which successfully pass this test will then be tested at 500 F. After 19 days' exposure, Minnesota Mining's 1F4, duPont's Hypalon, and Dow-Corning's Silastic 7-170 show promise.

Samples cut from one of the plates bought for the present Purex HA column scrub section cartridge are being tested for tolerance to radiation in the presence of Purex HAX solvent. It is planned to also test the tolerance of this polyethylene to radiation in the presence of Purex HAW.

Slag and Crucible Dissolver, 234-5 Building

To test its suitability for service in the 234-5 Building, slag and crucible dissolver platinum samples were exposed (liquid, vapor, and interface) to boiling 13 M HNO_3 - 0.25 M HF solution. After exposure for nine 24-hour periods, corrosion rates were still less than 0.01 mils/mo. Teflon clad equipment is also suggested for use in this service.

234-5 Powder Transfer and Filtration

HW-63036, titled "234-5 Fluorinator and Powder Recycle Studies," was issued. The document summarizes the successful testing of 6-inch-long 1/2-inch-diameter porous carbon filter tubes selected for filtering plutonium fluoride powders from fluorinator off-gases. Also discussed is a pneumatic powder transfer system designed for returning off-standard plutonium fluoride powders back to the fluorinator for reworking. The transfer system uses a "reverse cyclone" for fluidizing powders.

PROCESS CONTROL DEVELOPMENT

UO_3 Plant Calciner Automation

During two automated shutdowns which were made on K calciner since the revision to the Programmer, as described in last month's report, an acceptable rate of shell temperature decrease was obtained after the feed was cut off. Section 3 of the Programmer Manual is complete and all of the drawings on the Programmer have been corrected and updated to account for revisions made since August.

Purex HSP Photometer

A new sensing unit was installed in the HSP sampler to replace the one damaged earlier in the year by excessive radiation from a column flush solution. The operation of the new instrument appears normal. However, the signal to noise level is low due to entrained air in the process stream. The noise level is being reduced by electrical and pneumatic filtering in the signal circuit. Analytical results over an extended time period are being examined to clearly establish the sensitivity and reliability of the unit.

Integrated Plutonium Output Redox 3BP Stream

A linear integrating system for the 3BP plutonium monitor was calibrated in the laboratory. The zero point of the integrator was offset 4 per cent of chart to automatically subtract the background count of the neutron monitor. The integrator exhibits an accuracy of better than 0.3 per cent. As presently installed at Redox the unit will integrate the plutonium count over a period of approximately 27 hours before exceeding the capacity of the register.

Resin Level Detector

A canned zirconate crystal for the resin level detector was tested this month. The electrical and acoustical characteristics of the canned unit were excellent, and allowed measurements to be made up to within two inches of the crystal face. An ultrasonic calibrating standard was fabricated for the resin level detector. This standardizing unit produces excellent multiple echoes and allows direct calibration on both the 0-2 and 0-10 feet ranges of the instrument.

A report jointly authored by FPD and HLO personnel titled, "An Ultrasonic Instrument for Measurement of Resin Depth," is in progress.

Effects of Co Gamma Radiation on Commerical Glass Electrodes

The type glass electrodes (Beckman 8990-80) most widely used in CPD applications appear to fail after an absorbed dose of about 2.5×10^8 rads. Failure is due to rupture of the glass envelope containing the reference solution. The rupture appears to be the results of: (1) excessive pressure of radiolysis products of the buffer solution, or (2) strains induced in the glass wax seals in the electrode assembly. Electrodes of different design are still functioning properly after an absorbed dose of 2.9×10^8 rads.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Hacksaw Testing - "Hardware" Removal. Hacksaw testing was essentially completed with final tests on the last of three types of saws. The saws had three different feed mechanisms: the mechanical feed of the Marvel saw, the spring feed of the Peerless saw, and the hydraulic feed of the Racine saw. Main results of the hacksaw tests are summarized as follows:

1. "Hardware" removal by hacksaw is feasible for all the fuels currently scheduled for HAPO processing if (a) the "weldedge" (two-piece) blade is used, and (b) if hardware is removed from multirod bundles (e.g., Yankee and Dresden) by cutting through thick endplates rather than rod ends. Unsupported rods bend in the cut so that chipped blades and ruptured cladding can result.

2. A minimum blade life of about one blade per ton of fuels can be expected, with some variation between saw types. Average blade life for cutting Hanford assigned fuels is estimated at three to five tons.

3. Any one of the three saw types can be used for "hardware" cutoff. Compared to the cheaper Peerless saw, the Racine saw cuts faster (2 sq in/min vs. 1/2 sq in/min for massive stainless steel) and gives longer blade life (factor of two or more). However, the Peerless saw's spring feed system is simpler and more easily remotable than the Racine saw's hydraulic feed. The Marvel has a relatively complex feed mechanism (compared to the Peerless) and its performance is intermediate between the Racine and Peerless saws.

The saw tests have provided basic information from which specifications for the NPF mechanical cell saw can be written.

Yankee Endplate Pulling. If endplate cuts are made in hardware cutoff (see "hacksaw testing" above) the "wafer" or remainder of the endplate must be stripped off to complete fuel disassembly. A portable puller, fabricated from a standard gear puller, was used to strip 1/2-inch thick wafers from a 36-rod bundle. A maximum torque of 300 in-pounds (1/2-ton pull) was applied to the puller screw for wafer stripping. Tests show that: (1) a manipulator-operated tool can be designed for wafer pulling, (2) pulling forces are not unusual, and (3) wafers should be thick enough so that bending will not occur.

Shear Basin Studies. Clad pellets of sintered UO_2 were sheared with the 321 Building hydraulic shear. When cut into one-inch pieces, approximately two per cent of the UO_2 sheared was dispersed and suspended in the basin water. This is identical to the amount suspended when shearing clad swaged UO_2 rods. Samples of the fuel element feed trough indicate very little back-mixing occurs in the trough eight inches from the shear blade.

Feed Preparation

Dissolution of Uranium-Molybdenum Alloy Fuels. During dissolution of U-3 w/o Mo - 0.2 w/o Si and U-3 w/o Mo - 0.2 w/o Al alloys in solutions initially 12-14 M HNO_3 to yield dissolver solutions 1.0-1.5 M UO_2^{++} and 4-8 M HNO_3 most (85-90 per cent) of the molybdenum precipitates as a white solid. X-ray diffraction analyses indicate the solid to be orthorhombic molybdenum(VI) oxide. About 90 per cent of the silicon from the U-Mo-Si alloy is also precipitated under these conditions. Precipitation of both molybdenum and silicon is more complete (ca. 95 per cent) if the slurries are digested at boiling after dissolution is complete.

The molybdenum oxide precipitate does not settle well but centrifuges to about ten volume per cent from solutions 1.5 M UO_2^{++}. Most of the uranium and plutonium associated with the solid can be removed by washing with water or dilute nitric acid. However, after exhaustive washing, the solids (washed and oven dried) contain about 0.06 weight per cent of both uranium and plutonium. This could represent a significant loss of plutonium depending on the irradiation history of the fuel.

The acidity of the dissolver solutions so produced can be reduced to about zero molar free nitric acid by treatment with formaldehyde or by boil-down with addition of water. A small amount of molybdenum oxide precipitates in the boil-down procedure. Solids are not formed during formaldehyde treatment unless the solution is concentrated about twofold. These low-acid solutions are stable at room temperature toward further solids formation. They can be subjected to the normal Redox process plutonium oxidation procedure without solids formation.

Solubility of Zirconium in NH_4F Solution. The solubility of zirconium in ammonium fluoride solutions at room temperature has been re-measured employing a different method for the determination of free fluoride concentration. Old (ca. two year) zirconium solubility solutions were re-analyzed, and a few new solutions were prepared and analyzed. In the free fluoride concentration range of most interest (0.3 to 1.3 molar) the data agree very well with the solubility product expression $(NH_4^+)^3(ZrF_6^=)(NH_4F) = 1.8$. The acidities of these solutions were high enough (ph"s in the range six to seven) the precipitation of hydrolyzed species was avoided.

During the dissolution of zirconium in ammonium fluoride-ammonium nitrate solutions, five moles of ammonium hydroxide are produced per mole of zirconium dissolved. Only if essentially all the ammonium hydroxide is expelled from the system is the amount of zirconium which is soluble in the cooled decladding solution governed by the solubility product expression given above. Experiments have been done recently to determine the effect of residual ammonium hydroxide on the amount of zirconium which will remain in the cooled decladding solution.

On mixing reagents to give 0.5 M $(NH_4)_2 ZrF_6$, 0.5 M NH_4F, and zero to 0.6 M NH_4OH, the differences between the zirconium concentrations before and after precipitation are represented fairly well by the expression.

$$(\triangle M\ Zr) = 0.65\ (M\ NH_4OH\ added - 0.05)$$

Zirflex Waste Loss. Recent work has shown the solubility of U(IV) in ammonium fluoride solutions at room temperature to be lower at low ammonium fluoride concentrations than was previously reported. In the recent experiments, greater care was taken to exclude air (which can oxidize U(IV) to the more highly soluble U(VI)), and the concentrations of U(IV) were determined spectrophotometrically. These data indicate the room temperature solubility of U(IV) to 1 M NH_4F is ca. 0.0004 M and ca. 0.0001 M in 0.5 M NH_4F. These values indicate that the loss of U(IV) to the cooled decladding solution will be less than 0.1 per cent (with reasonable flowsheet conditions).

Attempts to elucidate the mechanism of air oxidation of U(IV) to U(VI) have continued without much success. Suffice it to say the rate is sufficiently rapid that, unless air is excluded from the system, the loss of uranium to the terminal decladding solution will be governed not by the solubility of U(IV) but by the amount of U(VI) present. If sufficient U(VI) is formed to make its solubility the loss determining factor, losses in the range one to ten per cent will be encountered.

Recirculating Dissolver Studies. Two UO_2 dissolution runs were completed to compare dissolution rates under recirculating conditions with batch rates. Although laboratory analyses have not been completed, no significant difference was noted between batch and recirculating dissolution rates. In addition, dissolution rates were essentially the same whether the air lift sparge was located in the bed of UO_2 or above the bed of UO_2.

Flooded Tray Dissolver. Aluminum tubes were dissolved with mercuric nitrate catalyzed nitric acid in nineteen recirculator runs and in twelve laboratory batch runs. At average recirculation rates of only 0.2 gal/hr-sq ft of charge, the recirculator dissolution rates were about 1/5 of the batch rates. Peak dissolution rates were 500 mils/hr with 5.5 M HNO_3, 0.005 M $Hg(NO_3)_2$ in the batch runs and about 80 mils/hr with 7.0 M HNO_3, 0.005 M Hg $(NO_3)_2$ in recirculating runs.

Equipment and Materials

Jumbo Pogo Stick Pump. Initial testing of the jumbo-pogo-stick (a pneumatically actuated solution transfer device) designed for transferring boiling dissolver solution has proven encouraging. Although minor solenoid valve difficulties have been encountered during initial testing, the pump has delivered 35 gal/min using 40 psig air motivation, a 15-second fill-discharge cycle, and a 7-foot submergence.

Corrosion Testing of Experimental Alloys Prepared at Battelle Memorial Institute. Samples of the first twelve experimental Ni-Cr-Fe-Mo alloys prepared at Battelle Memorial Institute have been received, and corrosion testing of them is under way. Under Huey Test conditions (boiling 65 per cent nitric acid) all 12 corroded at less than two mils/mo when annealed. Alloys containing two per cent niobium, about nine per cent molybdenum, and in excess of one per cent copper showed excessive heat sensitization when heat treated for one hour at 1300 F and water quenched. Titanium stabilized alloys did not show heat sensitization with this heat treatment.

Tests in which these alloys were exposed to Sulfex dissolver solutions emphasized the marked differences in corrosion rates obtained as a function of the condenser system used. In boiling sulfuric acid-stainless steel solutions, corrosion rates obtained when using cold finger condensers were about tenfold higher than when Friedrichs condensers were used. All of the copper-bearing alloys corroded at rates of from one to three mils/mo in refluxing 4 M H_2SO_4 (Friedrichs condensers); all of the alloys corroded at rates about one mil/mo in 4 M H_2SO_4 - 20 g/l stainless steel solutions. Attack was general and uniform in all cases.

In boiling 6 M NH_4F - 0.5 M NH_4NO_3 corrosion rates for the twelve alloys varied from five to 17 mils/mo. In general, the corrosion resistance to this solution increased with increasing molybdenum content. The molybdenum content required to produce equivalent corrosion resistance was greater in niobium stabilized alloys than when titanium was the stabilizer. At the one per cent level, copper had no effect on the corrosion resistance; larger amounts decreased the corrosion resistance. Attack was, in all cases, general and intergranular.

Corrosion rates in boiling 1 M HNO_3 - 2 M HF varied from 35 to 85 mils/mo. Titanium stabilized alloys showed better corrosion resistance than niobium stabilized alloys. The effect of one per cent of copper in the alloys was negligible; larger amounts decreased the corrosion resistance. Preliminary data on corrosion of weldments in nitric acid-hydrofluoric acid solutions indicate no preferential attack of weld metal in titanium stabilized alloys.

Heat-Transfer Corrosion of 304-L Stainless Steel and Hastelloy F in the Nitric Acid-Ferric Nitrate System. Corrosion rates for under heat transfer conditions (bulk metal temperature 138 C) ranged from three to five mils/mo for Hastelloy F and from three to 13 mils/mo for 304-L stainless steel in nitric acid-ferric nitrate-uranyl nitrate-molybdate solutions anticipated in the dissolution of uranium-molybdenum alloys. These are weight-loss rates. Intergranular corrosion was severe. Penetration rates will be determined by sectioning test samples.

Dissolver Off-Gas Analyzer. The "Information for Application of Gas Analyzers for the HAPO Non-Production Fuels Program," (HW-63032) was issued December 10, 1959.

REACTOR DEVELOPMENT - 4000 PROGRAM

Uranium Dioxide by Electrolytic Reduction

Further evidence for an equilibrium reaction between uranyl chloride (dissolved in molten NaCl-KCl solution) and solid uranium dioxide has been obtained by the positive identification of uranium tetrachloride formed upon equilibration of these phases. Approximately one per cent of the uranium was shown to be present as UCl_4 in the UO_2Cl_2-KCl-NaCl salt phase following a four hour equilibration of 20 grams of the salt phase and two grams of electrolytic UO_2 at 750 C in the presence of air.

Salt Cycle Process

An experiment was completed to test salt cycle process steps using as feed a wafer cut from an irradiated uranium oxide capsule. Generally, satisfactory performance was observed for oxidative core removal, molten salt dissolution using chlorine, and electrodeposition of UO_2. Preliminary estimates of gamma decontamination factors, however, are only on the order of ten based on gamma scans of feed and recovered uranium dioxide samples. Indications are that contamination of the UO_2 product in the single stage process was more by occlusion than by the co-deposition of the fission product activities, Ce-Pr^{144}, Ru-Rh^{106}, Cs-Ba^{137}, and Zr-Nb^{95}. On the other hand, an apparent D.F. for the beta emitting Sr^{90} was calculated to be nearly 10^3. Disposition of plutonium in the process is not yet known. The activities preponderant in the sublimate collected throughout the experiment were Zr-Nb^{95} and Ru-Rh^{106}.

Continuous Ion Exchange Contactor Development

Jiggler Contactor. Development efforts have been directed toward the pairing of a simple packed bed elution column with the jigged bed absorption column for continuous recycling of the ion exchange resin. The errotic resin flow previously experienced has been overcome by placing the elution column directly above the absorption column (both four inches in diameter), introducing the eluant six inches above the bottom of the bed and using a two-foot length of 1/2-inch tubing to convey the resin from the elution to the absorption column.

Weiss Unit. A cartridge geometry has been developed for small-diameter (five inches or less) contactors. This cartridge gives good, stable countercurrent operation. It consists of screen-covered resin support plates spaced five inches apart with downcomers of 1/2-inch diameter stainless steel tubing extending four inches above and three inches below each plate. Uniform resin flow and holdup have been obtained under a variety of flow and pulsing conditions. In general, a low-amplitude (0.08 inch) high frequency pulse provides optimum operation. No plugging of the support screens (80 mesh) with resin particles (- 20 + 50 mesh) has been experienced. Imminent plans are to study the variables affecting the absorption efficiency. Thorium will be used as the transferring solute.

Salt Cycle Studies - Materials of Construction

Vicor, quartz, and fused silica were tested as possible crucible materials to contain fused NaCl-KCl at 800 C. None appears satisfactory for more than 48 hours' service at this temperature. All were attacked at the melt-vapor interface and appeared to devitrify. Cracking and chipping of the crucible where in contact with the melt occurred. In attempts to test pile-grade graphite, severe oxidation of the graphite occurred at temperature even in the absence of NaCl-KCl. This was attributed to impurities in the argon used as an inert atmosphere.

Waste Fixation

Mineral Reactions

The decontamination of Purex boiling tank condensate by beds of clinoptilolite as a function of solution pH is being studied. Small 5-gram columns of the zeolite are being charged with waste samples adjusted to pH five, seven, and nine. The experiments study the adsorption of radiocesium, radiostrontium, and lanthanide fission products on the beds at flow rates of 4 gal/ft^2/min through 22-cm columns. Analytical results on effluent samples from these beds are incomplete, however, the system operating at pH 9 was still maintaining a Cs decontamination factor of 10^4 after 5700 column volumes throughput. After receiving 15,000 column volumes at pH 5 and 13,000 column volumes at pH 7 a yellowish-brown deposit was observed in the zeolite columns which tended to retard the flow. After 25,000 column volumes of pH 5 solution had passed through the bed the flow was completely blocked. No deposit had appeared in the pH 9 system after passage of 18,000 column volumes. The plugging material was readily removed by backflushing. Experiments revealed that the suspended material in the condensate could be filtered from solution at a low pH with removal of up to 70 per cent of the beta activity from the solution.

Fixation of Radioactive Wastes

The first scaled-up mineral bed column and associated equipment for studying the decontamination of condensate wastes was installed in the 271-CR Facility. Cold runs are in progress to determine system reliability prior to using actual waste. Studies employing Purex Tank Farm condensate will begin early next month. A four-inch, glass pipe column was installed and provisions are being made to operate it with a simulated condensate waste to measure pressure drops across various bed materials of interest. In addition, it will be used to determine increases in pressure drop resulting from physical fouling of the bed by non-radioactive impurities present in the waste.

Radiant Heat Spray Calciner. No runs were made during the month due to alterations that are in progress to increase the capacity of the column. Inspection of the column with a boroscope while it was dismantled (after over 200 hours of high temperature operation) revealed no obvious indications of corrosion. The stainless steel top and bottom sections were in very good condition. The Inconel center section (the highest temperature portion of the column) was coated with some scale. However, it is not clear whether this is a corrosion product or simply calcined solids which have adhered to the wall. A chemical analysis of the scale is being made to determine this point.

Ruthenium analyses have been completed on the last column run (with neutralized, formaldehyde killed synthetic Purex 1WW). Most of the ruthenium was found in the calcined powder with less than two per cent passing the filters and less than one-half per cent reaching the condensate and scrubber.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Mechanism of Formation of Reactor Effluent Radioisotopes

The build-up data of As^{76} in effluent water obtained by adding sodium arsenate to water entering a reactor process tube have been compared with calculated kinetic rate curves for various proposed mechanisms of attachment and release of the adsorbed ions. The best fit is obtained when it is assumed that the As^{76} enters the water by recoil upon formation by the n, γ reaction. This finding correlates well with the observations that fission product radioisotope ratios indicate a similar immediate release upon formation.

Zn^{65} in Sea Foods

Twenty-one more commercial sea food samples were analyzed for Zn^{65}, making a total of 47 samples in all. Oysters were the only type of sea food to contain significant amounts. Of a total of 13 samples, eight contained over 0.1 d/m Zn^{65} per gram and three of these contained from 33 to 141 d/m Zn^{65} per gram. These were distributed from West Coast companies, and one was packed at North Bend, Washington. Three samples of Japanese oysters and three of East or Gulf Coast oysters were all less than 0.7 d/m Zn^{65} per gram. The highest value for a sea food other than oysters was tuna fish with 2.4 d/m Zn^{65} per gram.

ZnS Analytical Procedure

Further improvements in this procedure resulted in an increased sensitivity of 10^{-8} g ZnS and semi-automatic operation. The improvements resulted from modifying and adapting a commercial sample changer designed for liquid scintillation counting. The equipment is now undergoing tests by meteorology personnel.

Geology and Hydrology

Research on unsaturated flow in soils depends on point measurements of soil moisture content. Instruments available for determining soil moisture respond to the moisture in a volume of soil too large to be considered a point measurement on the scale of practical experiments. A method was developed for obtaining point values from the moisture content profile established by a scan across the soil volume of interest with one of the "averaging-type" instruments. However, this method required application of a series equation, which included the derivative of this scan at several points. The difficulty of determining these derivatives minimized the usefulness of the technique. Further development produced a formula for application to a soil moisture content scan which consists of a series of difference terms. This difference equation is much more readily applied to experimental data. Neither of these formulas has been tested. It is anticipated that they will be useful in designing laboratory flow models and in determining optimum distribution of measurement points in all unsaturated flow experiments.

Soil Chemistry and Geochemistry

Laboratory experiments were performed to measure the degree of selectivity of a series of zeolites for adsorbing strontium in the presence of calcium. These experiments consisted of measuring the strontium equilibrium distribution between samples of a zeolite and a 0.01 M solution of calcium on the one hand and a 0.01 M solution of strontium on the other each being traced with Sr^{85}. A strontium "selectivity factor" was calculated by determining the ratio of the K_d for Sr^{85} in the calcium solution to that in the strontium solution. Of the seven zeolites tested Linde-4A zeolite was the most strontium-selective with a selectivity factor of 5.37. This was measured with the powdered form; the commercial pelleted form was found to have a much reduced capacity for strontium in similar experiments. It was found possible to make a suitable granular bed of this zeolite by bonding the powder with sodium silicate and drying at 105 C. This treatment did not seriously affect the strontium capacity of the material. Heating the granular material to higher temperatures (200 - 400 C) destroyed the zeolite.

Laboratory experiments continued in a study of rare earths, typified by cerium. The effect of various anions on the precipitation of cerium and its adsorption by soil was determined. Data were obtained on the influence of phosphate and carbonate over the pH range from 1-13. In the range from 4 to 13 more than 99 per cent of 4×10^{-7} M cerium was removed from a phosphate solution. Adsorption was reduced in lower pH solutions. The cerium tended to be removed from the solution by simple precipitation with no soil present in the pH range 4 to 9.

The presence of carbonate ion inhibits the adsorption of cerium by soil in the pH range from 9-11, probably as a result of complex formation. Between pH 6 and 8 cerium precipitates from carbonate solutions, probably by hydrolysis. A cerium precipitate also forms above pH 12 in carbonate solutions. The study of the chemistry of cerium in dilute carbonate solutions is made difficult by the tendency for the precipitates to peptize.

Ground Waste Investigation

Further study of the influence of column length on the decontamination achieved by passing liquid waste through soils indicated that the shape of the breakthrough front changes with the square root of column length. The effect was found in analyzing experimental breakthrough curves and fitting them into the formulas derived by Hiester-Vermeulen. The calculated values of "k", the reaction rate constant, were found to be closely correlative with the reciprocal of the square root of the column length. In addition, calculated values of the column capacity parameter, "s", were correlative with the square root of column length. This relationship makes it possible to fit experimental soil column data to the Hiester-Vermeulen equations.

The experimental discharge of calcium nitrate solution spiked with Sr^{85} to a small field crib was continued. About 3430 gallons of solution have been added to the 6-inch x 6-inch crib. The concentration of nitrate ion in ground water samples from two nearby wells approached 100 per cent of the influent concentration. The Sr^{85} concentration in the ground water approached eight per cent of the influent concentration in the highest concentration sample obtained. The observation wells around the crib were probed with a neutron moisture detecting instrument. These measurements successfully defined the shape of the moist zone beneath the experimental crib. Four feet from the center line of the crib a distinct moisture content maximum was detected at a six to seven-foot depth. The non-uniform flow pattern inferred from the order of appearance of solution constituents in various monitoring wells was confirmed with the moisture content measurements.

Field Apparatus Development

Tests of thimble samplers in a wetted soil column were completed. In the range of 16 per cent moisture the thimble samplers permit the same precision achieved with direct moisture measurement, namely to about 1 per cent moisture. The moisture distribution in the column used varied from point to point to a degree which would account for virtually all the variation noted between the direct method and the thimble method.

Results of pumping tests in the test well site north of Gable Mountain were tabulated and processed for ultimate analysis. The data lead to the conclusion that aquifer boundaries exist at distances from the site which can be estimated. The boundaries define transitions from one permeability to another in the area from which water reaches the well site. For certain anticipated tests these boundaries may materially influence the interpretation of the results. Best value determined for aquifer transmissibility was about 1.5×10^6 g/d/ft.

Fission Product Monitoring

A paper study was completed of the merit of a detector for rupture debris which collects and then counts the daughters of noble gas fission isotopes. The conclusion was reached that there was little advantage of this method over scrubbing the noble gases from reactor effluent and counting them directly after a one-minute decay. The limiting consideration in the former method is the background from fission product present in the absence of ruptures. It was estimated that one gram/min. of uranium released in a rupture could probably be detected with a noble gas monitor sampling one-half of the reactor flow and utilizing a ten-minute decay. This sensitivity is likely not adequate for radiological purposes.

Micromeritics

Five additional runs were completed in the study of turbulent deposition of particles carried in a gas stream. The data continue to show the power function dependence of deposition velocity on particle diameter and stream velocity. The deposition velocity for 2 and 4 micron zinc sulfide particles moving in a one-inch line varies directly as the particle diameter to the 3.5 power and as the velocity to the 4.9 power. Reynolds numbers in the turbulent range to 25,000 were employed. For the particles studied, re-entrainment was found to be negligible at even higher velocities than those used in the initial deposition. The presence of larger particles in the stream greatly increased the re-entrainment of smaller particles.

L. P. Bupp

Manager,
Chemical Research & Development

LP Bupp:bp

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BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Roy Nakatani joined the Aquatic Biology Operation during the month of December.

Dr. R. C. Pendleton resigned his position as Biological Scientist with the Radioecology Operation to accept a position at the University of Utah, Salt Lake City.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

Concentrations of I^{131} in thyroid glands of jack rabbits were approximately two times those observed one year ago. Values follow:

Location	μc/g Wet Wt. Average	μc/g Wet Wt. Maximum	Trend Factor
4 Miles S. W. Redox	3×10^{-3}	6×10^{-3}	-
Prosser Barricade	2×10^{-3}	2×10^{-3}	+ 2
Wahluke Slope	2×10^{-3}	3×10^{-3}	+ 2

Columbia River Contamination

Concentrations of gross beta emitters in shiners collected at Hanford were slightly lower than those observed one year ago. The average radioactive contamination in whitefish flesh was approximately one-third of those observed one year ago.

Values follow:

Sample Type	Location	μc/g Wet Wt. Average	μc/g Wet Wt. Maximum	Trend Factor
Minnows (entire)	Hanford	3×10^{-3}	4×10^{-3}	-
Whitefish flesh	Priest Rapids	8×10^{-5}	3×10^{-4}	- 9
Whitefish flesh	F - 1	6×10^{-4}	1×10^{-3}	-
Whitefish flesh	Ringold	4×10^{-4}	6×10^{-4}	+ 2

Fallout Contamination

Fission products occurred in rabbits from Hanford Reservation in the following amounts:

Sample Type	μc/g Wet Materials Average	Trend Factor
Feces	3×10^{-5}	-
Bone	2×10^{-5}	+ 2
Muscle	9×10^{-6}	-
Liver	5×10^{-6}	-

Marine Investigation

Oysters collected from near the mouth of the Columbia River at Willapa Bay during 1959 contained 5×10^{-5} μc Zn^{65}/g, which was ten times as much Zn^{65} as in specimens from Dungeness, Washington. Values for oysters were higher than in other mollusks from the same sampling site.

Effect of Reactor Effluent on Aquatic Organisms

Routine monitoring of the effluent from the 100-KE reactor was continued with chinook salmon eggs which hatched early in the month. This life stage is comparatively insensitive to toxic materials present in the effluent and virtually no mortality was experienced either in the controls or in concentrations of reactor effluent which approximate present and predicted concentrations for the Columbia River.

Radiophosphorus concentration in small suckers held in a test facility which received reactor effluent passed through a bed of aluminum turnings was approximately half that of fish exposed to a like amount of effluent which had not been passed through the absorbing medium.

C. columnaris was tested for its sensitivity to dichromate. No inhibition of growth of the columnaris was observed when 3 ppm sodium dichromate was present in the nutrient. The dye malachite green was also tested and found to be marginally toxic at 1 ppm.

Chinook fry were more resistant to columnaris than were the salmon fingerlings previously tested. Death of a cichlid (spiney ray fish) was the result of columnaris infection although in general this species was less susceptible to the bacterium than were salmon.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Phosphorus

Exposure of cichlids to water containing radiophosphorus was continued throughout the month. A change from plastic to glass containers for the isotope solution

substantially reduced the loss of the isotope to the surfaces of the vessel and resulted in exposure conditions more closely approximating the intended level. The concentration of P^{32} in the highest level of fish is on the order of 5×10^{-2} μc/g. No adverse effects are yet evident.

Results of a preliminary study on P^{32} metabolism in the mouse showed the following:

1. The bremsstrahlung from P^{32} deposited in mice can be effectively monitored externally using a whole-body mouse counter equipped with thin sodium iodide crystals and aluminum shields.

2. Sixty per cent of orally administered P^{32} is absorbed.

3. With daily administration of P^{32} there appeared to be an initial rapid uptake but little increase in the body burden after the first week.

4. Organ and tissue concentrations following oral feeding (in decreasing order of percentage of retained dose): bone; brain, spleen and testicle; muscle; and kidney. The tissue concentration variations did not exceed a factor of three (from the highest to the lowest).

5. Two weeks following a single intraperitoneal administration the body burden was only 11 per cent of the administered dose.

Strontium

Preparations are under way for an experiment to test the detrimental effects of Sr^{90}-Y^{90} fed to rainbow trout. Three levels of radioisotope will be fed; 5×10^{-3}, 5×10^{-2}, and 5×10^{-1} μc Sr^{90}-Y^{90}/g of fish. Changes in growth rate and mortality will be used as criteria of damage. In addition, the gastrointestinal tract will be examined in all sacrificed animals as this is suspected as being the site of injury.

In five of a total of 14 weanling pigs (2 months old) from the sows fed 25 μc/day of Sr^{90}, there was a suggestion of microcytic anemia. The body burden of these young swine is estimated at 5 to 10 μc Sr^{90}.

Retention curves for Sr^{90} and Ca^{45} intraperitoneally administered to mature rats subsisting on various calcium level diets have been derived from detailed excretion data obtained over a period of 65 days' post injection. Similar curves obtained in previous experiments were based on analysis of animals sacrificed at rather infrequent intervals. This earlier data had been adequately represented by simple power functions of time, the exponent of time varying as a function of dietary calcium level. The more detailed data now available are not well represented by simple power functions of time. When resolved into two exponential components, the slope of the long-lived component appeared to be independent of dietary calcium over the range of .03 to .5%. Results from animals on 2% calcium diets are not yet available.

Ammonium phosphate additions to soils in concentrations up to the equivalent of 2000 lbs. phosphorus per acre depressed uptake of both calcium and strontium from basic soils. Mild increases in uptake were noted for both ions from acid soils. Concentration of both strontium and calcium in stems relative to leaves was clearly higher in the plants grown in the basic as compared with those grown in acid soils. This result suggests that the transport of strontium and calcium as well as its uptake may be a factor in the concentration of Sr^{90} in the leaves of plants grown on soils differing in their pH and cation content. There was no apparent difference in the action of the phosphate on calcium and strontium.

Iodine

No important changes were observed in any of our iodine studies with sheep. However, an unexplained rise in thyroid avidity for radioiodine appeared in the group of three-year-old swine fed 5 μc/day during their entire adult life.

A Ba^{133} source is being effectively utilized as a calibration source for the swine thyroid monitor.

Cesium

Results from a preliminary experiment growing plants in nutrient solutions containing varying concentrations of cesium suggest that Cs^{137} content of leaves is increased by greater concentration of carrier cesium in the root environment. This is of particular interest because the interpretation of increased Cs^{137} in leaves of plants grown on soil fortified with cesium has usually been based upon a supposition of a greater availability of the Cs^{137} when carrier was added.

Plutonium

Data are now complete from the experiment studying the effect of chronic X-irradiation on rats bearing plutonium burdens. These rats received 100 r of X-ray at weekly intervals. Median survival dose of the controls bearing no plutonium was 2600 r. For animals containing 5 μc/kg plutonium, the median survival dose was 1800 r; for 10 μc/kg plutonium, 1300 r; 27 μc/kg plutonium, 1200 r. Survival at the highest plutonium level did not appear to be significantly influenced by the X-irradiation.

Two pigs treated with a total of 9 g DTPA administered over a five-day period excreted between 10 and 20% of the plutonium which they had received by intravenous injection 60 days prior to the DTPA treatment. Present uncertainty in the actual amount excreted is due to incomplete analytical results. The rate of plutonium excretion in the urine was increased as much as 100-fold by the DTPA treatment. This is in accord with previous observations on rats and humans. Excretion of plutonium in the feces increased as much as 1000-fold. This is a much larger effect than would have been predicted from rat data and may in part reflect the heavier deposition of plutonium in the liver of pigs. Blood samples taken during the treatment period indicate no increase in plutonium blood levels suggesting that the effect of DTPA is primarily one of increasing the excretability of the plutonium normally present in the blood.

In the preliminary study to develop experimental techniques for testing the efficacy of tourniquets in preventing transfer from a plutonium-contaminated wound in the front limbs of swine, there were indications of slightly greater liver and lymph node concentrations when tourniquets were not utilized.

Application of suction at the site of injection failed to produce amounts of plutonium at the surface of the skin.

Radioactive Particles

Plutonium assay of tissues from 24 dogs killed at intervals after inhalation of $Pu^{239}O_2$ are now complete. There is little change from the first 12 dogs' data. Only two tentative conclusions can be drawn. First, there was little clearance of plutonium from the lungs during the first two weeks after inhalation, and secondly, during this period about half of the deposited plutonium was excreted in the feces.

A Selly resuscitator has been connected to a few rats with a phenolphthalein aerosol. Thus, enabling the equipment to be tested before radioactive work is initiated.

Gastrointestinal Radiation Injury

Studies were made of the effect of total body X-irradiation on the excretion of I^{131} labelled polyvinylpyrrolidone (PVP) via the intestine. As in earlier studies in which the exteriorized intestine was irradiated, there was a dose dependent response in the range from 250 to 1000 r. Data are now being obtained at higher dose levels. It was established that optimum effects are seen when the PVP is injected two days after the X-ray exposure. This time corresponds to the period of maximum depression of serum protein levels following irradiation of the intestinal tract. Studies with dogs irradiated at 350 and 500 r levels indicated no significant increase in PVP excretion. These studies will be extended to higher dose levels. Dogs excrete about the same proportion of the PVP in the feces as do rats, but excrete a smaller amount in the urine.

Microbiological Studies

Yeast cells were observed to show the greatest increase in permeability when irradiation was done under anaerobic conditions. In contrast, these cells were killed most readily when irradiated under aerobic conditions. This finding is another point indicating that cell death is largely unrelated to permeability changes.

The presence of the substrate glucose increased phosphorus leakage but decreased potassium leakage from irradiated yeast cells. Differential effects such as this suggest that radiation induced permeability is not merely a generalized opening up of the cell membrane, but rather a series of events to specific processes concerned with ion transport.

Successful autoradiograms were obtained from yeast cells grown on P^{32} and H^3 labelled water. This shows that the method of investigation was adequate and suggests that previous failures to obtain autoradiograms from tritium labelled thymidine were the result of either too low a dose of the thymidine or that thymidine is not utilized by this organism.

HA Kornberg

BIOLOGY OPERATION

HA Kornberg:es

D. Lectures

a. Papers presented at Meetings

None

b. Off-Site Seminars

L. A. George, December 10, "Radiation Biology at Hanford," Sunnyside Kiwanis Meeting.

c. Seminars (Biology)

[redacted]

b. HW Publications (published with internal distribution)

None

c. Open Literature

Palmer, R. F. and M. F. Sullivan, "Effect of intestinal tract irradiation on serum proteins of the rat", Proc. Soc. Exptl. Biol. and Med. 101, 326-328 (1959).

Kawin, B., "A portable radioactive solution container," J. Applied Radiation and Isotopes, V. 5, 305 (1959).

Sullivan, M. F., S. Marks, P. L. Hackett, and R. C. Thompson, "X-Irradiation of the exteriorized or in situ intestine of the rat," Radiation Research 11, 653-666 (1959).

Horstman, V. G., L. A. George, M. E. Kerr, and L. K. Bustad, "Miniature pig metabolism cage for radiobiological studies," Animal Care Panel 9 (4):181-2, 1959.

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT

December, 1959

ORGANIZATION AND PERSONNEL

There were no changes in personnel during the month of December.

OPERATIONS RESEARCH ACTIVITIES

Input-Output Simulation Model

While it has not yet been extensively tested, the GCL estimation program was essentially complete as of the end of the year. Plans for testing on both intermediate and large models during the month of January have been formulated.

Other

Computations on certain Hanford aggregate models have been completed and an extensive program of computation with respect to the Redox dissolver study will be carried out as soon as appropriate testing is complete.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Two experiments were conducted with C-Basin equipment in order to evaluate the precision and accuracy of certain measurements. One was concerned with the weigher, and was the second such experiment conducted since results from the first were inconclusive. In the second experiment the effect of weaseling slugs from a given tube over a period of some time was evaluated, and appropriate factors to correct for radioactive decay were found.

Fuel Element Failures

An analysis was made of partial data from a run to rupture test being conducted at B reactor in order to evaluate the self-support concept. The exposures which the test fuel elements must reach without rupture before given improvements can be claimed were found.

The exposure effect on rupture rates becomes very important when making long term plans for expansion. Although the model in current use to describe this effect is generally accepted, some concern is expressed over the adequacy of extrapolating the curve to higher exposures. Assistance is being given in the design of a possible test to determine this extrapolated exposure effect. It is being pointed out that a considerable number of ruptures will have to be taken before any incremental information is obtained. If the purpose is to demonstrate that the present model cannot be extrapolated, the exposure to which a fair-sized number of tubes would have to run is quite large.

Data were analyzed in order to determine whether there has been a reduction in the ratio of hole failures to total failures.

It has been noted that the total bond count for post-irradiated fuel elements with X8001 nickel alloy tend to be higher than those with C64 alloys. Data were analyzed to see whether the same situation prevails in pre-irradiated fuel elements but here it is impossible to separate out the effect of time, which appears to be the major source of variation in total bond count data.

Optimization of Reactor Operations

A first approximation to a model was derived which expresses reactor downtime as a function of reactor operating conditions. This was developed since concern was expressed over extrapolating the present optimization equation to conditions somewhat removed from experience. In this newly derived model, primary consideration was given the expected number of unscheduled outages as it affects total downtime, taking into account the lack of work to be performed when outages are close together, and the lack of manpower to perform charge-discharge work when several reactors are down simultaneously. This model is being circulated for comment before proceeding further.

Process Tube Leak Detection and Replacement

A report was issued summarizing the results of a fresh attempt to better predict which tubes will show severe attack with the probolog. Attention was directed only towards the pitting type of attack occurring at junctions with graphite blocks, since it was felt that one reason for lack of success in predictions thus far was the grouping together of several types of attack. The report was preliminary in nature, and further work is proceeding.

Z-Plant Information Study

Systems definition continued during December. In addition, specifications for the computing equipment to be used in the study were written in order to permit leasing of the equipment on a bid basis.

Radiation Protection Studies

Analysis of data from the experiment to investigate the effect of exposure angle upon gamma film badge response was completed and a formal report issued. (Unclassified document HW-63164, "Statistical Analysis Gamma Angular Dependence of HAPO Film Badge," by C. G. Hough and W. L. Nicholson, dated December 22, 1959.)

Preliminary analysis of data from the experiment to test the validity of the inverse square law as it applies to radium gamma film badge calibrations revealed an inadequacy in the response model. The model was reformulated and data are currently undergoing machine processing.

The statistical evaluation of the precision of bio-assay plutonium deposition estimation based on spike analyses was completed and a report issued to interested persons. (Unclassified letter to G. D. Brown, "Precision Study of Bio-assay Spike Analyses," dated December 3, 1959.)

Further calculations were done on data from several positive deposition cases in an attempt to determine the detection level of a spot sample bio-assay program as a function of 24 hour excretion rate and time since last void.

Reliability Studies

Work on the K reactor's system reliability study is nearing completion. Preparations are currently being made to write a document pertaining to the study.

Further work has been done on the NPR reliability study. A meeting with persons

responsible for the prosecution of the study was held for the purpose of deciding on preliminary values of the parameters which enter into the reliability calculations.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Analyses are in progress on data from several more co-extruded tubes in order to separate the effects on uniformity of dimensions of such variables as core length, processing batch, die number, and mandrel type.

A modification of an attribute sequential sampling plan based on the ratio of defects between a standard and an experimental process was made.

Quite extensive data have been gathered on the nickel concentration in baths in order to see whether more latitude in the control limits could be tolerated. A fairly extensive analysis has been made relating the nickel concentration to the various inspection characteristics such as non-mixing, voids, inclusions, etc. Additional work compares the bond strengths and bond porosity of fuel elements from baths with different nickel concentrations.

Formulae have been given for the voltage which may be given in an attenuation tester as a function of the initial gain setting reading, initial voltage, and present gain setting reading.

Irradiation Processing Department

The dimensional distortion data from PT 210A are being analyzed. The test was designed primarily to test for hot spot frequency as a function of extent of void area. The data are extensive enough to warrant an analysis of the various dimensional distortion effects also.

Mathematical assistance was given in obtaining approximating solutions to a large number of simultaneous reactor-control equations.

Assistance was given in the formulation and evaluation of the number of "magazines" needed for a mass charge-discharge program.

Estimates were made of the proportion of pig-tail fittings with corrosive attack exceeding specified amounts.

Chemical Processing Department

Conformance to specifications was demonstrated with data from production for the fourth quarter of 1959. These data were characterized by a decrease in measurement variation which more than accounted for the reduced number of titrations per part.

Calculations are being made to determine the characteristics of a sequential procedure for accepting parts on a part by part basis. Such a procedure will reduce the producer's risk to a tolerable level.

An analysis of the problem of combining component parts into finished assemblies in such a manner that the finished assemblies will fall within prescribed tolerance limits with respect to weight, while simultaneously maximizing the number of completed assemblies which can be manufactured from a given parts inventory was completed. It was desired that the method be automated, efficient, and requiring a minimum of human intervention. Such a scheme has been devised, coded for the IBM-709, and is presently being tested.

Relations Operation

Assistance was given in the evaluation of a psychological test program.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program - Reactor Studies

In cooperation with personnel of the Physics and Instrument Research and Development Operation, methods of studying the stability-instability characteristics of the solutions to a certain reactor control differential equation are under investigation.

2000 Program - Zirconium Corrosion

Statistical analysis continued on data from an autoclave calibration study being conducted by the Coating and Corrosion Operation. The goal of this study is to determine the functional relationship of zirconium corrosion within an autoclave environment on ambient variables such as pressure and temperature. The effect on corrosion rate of sample position within the autoclave is also being considered.

2000 Program - Chemical Development

Results from a digital computer multi-variate processing of sulfex data were unsatisfactory. Examination of the data revealed that a redefinition of the variables with deletion of nearly irrelevant ones might possibly improve the results of the processing. Revised variables are now being processed.

Further investigations were made of the properties of the solution to the mathematical model of the heat transfer process during the regenerative phase of a gas-catalytic reactor. Several approximating solutions were obtained which clearly exhibited the travelling heat wave phenomenon that has been consistently observed in physical models.

Additional analysis for the same customer was begun on a mathematical model which will explain certain observed effects noted in models of radiant heat spray calcinators.

4000 Program - Swelling Studies

A number of photomicrographs of uranium samples were read to obtain apparent diameter and shadow length data necessary for a quantitative analysis of the effect of varying anneal temperature on swelling. The data are being processed using both techniques developed by Experimental Statistics personnel and those classical to quantitative metallography so as to determine the applicability of classical methods to the three dimensional microscopy method currently in use by Physical Metallurgy Operation.

6000 Program - Biology and Medicine

Work continued on the development and application of multi-compartment models. An application was made to a three compartment model of plutonium inhalation and excretion in dogs.

1248472

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:kss

PROGRAMMING OPERATION
DECEMBER 1959

A. FISSIONABLE MATERIALS - 2000 PROGRAM

Special Radioisotopes

A status report on "Ionium (Thorium-230) For Radioisotope Preparation" was issued for comment. Although the survey of the sources of ionium from the U. S. uranium ore milling industry was not intended to be comprehensive, the preliminary analyses to determine the isotopic ratio of Th-230 to Th-232 was found to be encouragingly high (2.5 to 5.4%) in nearly 20% of the U.S. milling capacity. If this new information results in the development of additional interest, further work is required to establish the yield, actual availability, and an economical recovery process. A research and development program to cover such additional work was outlined.

B. REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. The Meleager A code was modified to facilitate investigation of fuel cycles at high (1000 C) neutron temperatures. The changes were made possible by a new compiler acquired by Data Processing Operation. These modifications were prompted by preliminary fuel cycle investigations of "Phoenix" burnup characteristics at high temperature.

The RBU Output Code was written during the month, and is now being compiled. The key punching of the RBU Cross Section Library continued, with an estimated month of work remaining. A trace of the Monte Carlo code was carried out, indicating operation as expected, and remaining preparations for carrying out a full scale test of the RBU system was completed.

PRTR Startup. A detailed preliminary schedule of critical tests has been established for PRTR startup next summer. A description of all tests was being prepared for publication as HW-61900 RD, Part B, by members of the Startup Council's committee on the critical tests. The following are typical of the type of tests being planned:

1. UO_2 Exponential and Instrument Check
2. Two-Zone Approach to Critical
3. Critical, Half Level, Two-Zone Loading
4. Level Sensitivity, Half Level, Two-Zone Loading
5. Shim Worth, Half Level, Two-Zone Loading
6. Critical, 3/4 Level, Two-Zone Loading

7. Level Sensitivity, 3/4 Level, Two-Zone Loading
8. Shim Worth, 3/4 Level, Two-Zone Loading
9. Critical, Full Level, Two-Zone Loading
10. Level Sensitivity, Full Level, Two-Zone Loading
11. Shim Worth, Full Level, Two-Zone Loading
12. Approach to Critical, Pu-Al
13. Poison Calibration of Level and Shims
14. Reflector Savings
15. Kinetics Measurements, Three-Zone
16. Cell Flux
17. High Spike Approach-to-Critical
18. Large Central Tube Coolant Replacement
19. Spike Enrichment Addition
20. Fuel-Coolant Temperature Coefficient and Hot Primary D_2O Design Test
21. CO_2 Loop
22. Reactor Checkout

Self-Sustaining Plutonium Recycle. Efforts to complete the consolidation of many discrete but coupled fuel cycle physics and economic IBM-650 programs with a single high speed IBM-709 code have continued under difficulty. A considerable number of bugs have been encountered, many of which have to do with the fact that the IBM-650 and IBM-709 perform certain basic operations such as number-round-off differently. In addition there are significant variations in the sine, cosine, and Bessl function sub-routines which give different answers and therefore complicate de-bugging. While the IBM-709 sub-routines are generally more accurate and a superior code will result, the data obtained from the IBM-650 will be applicable.

PRTR Plans and Schedules

Program schedules for the Plutonium Recycle Program were completed. These schedules extend into calendar year 1964 and identify target dates for the accomplishment of significant program tasks.

The report which was prepared supporting a request for about forty kilograms of high Pu-240 plutonium for PRTR was issued. Although earlier drafts of this report required revisions, the essential bases and conclusions were unchanged. When new funds and the value of plutonium displaced or consumed were considered along with assurance of production of the highest Pu-240 content, it was clear that the preparation of this material via Savannah River reactors from Hanford Laboratories fabricated plutonium-aluminum fuel elements was the preferred route. The major though somewhat intangible benefit of using high Pu-240 material in PRTR at an early date will be the nearly two year shortening of time for PRTR operation to achieve certain program objectives.

PLUTONIUM VALUE STUDY

Initial planning and evaluation is under way of the possible approaches to the economic model for this study. While the study must be limited to a

finite number of plutonium compositions it may well be possible to develop enough data to permit reasonable value estimates of other plutonium batches with simplified formulations. Many classical methods are being considered and several IBM-709 runs have been made to determine the possible spread of values that must be reconciled.

C. BIOLOGY AND MEDICINE - 6000 PROGRAM

Radiological Consultation

A brief review of the technical and political implications of the present limits recommended by the NCRP and the ICRP was prepared for use in a summary of environmental contamination.

A review was made of criteria for diagnosing radiation injury and comments forwarded to the chairman of the committee involved.

Sections of the report of the Inhalation Hazards Subcommittee of the NAS-NRC Committee on the Pathological Effects of Atomic Radiation were revised and sent to the chairman for compilation in the final report.

A fourth draft of the Subcommittee 6 report of the NCRP on Safe Handling of Radionuclides was completed. This draft incorporates the suggestions which have been submitted by members of the Subcommittee.

Meetings were attended on the subject of environmental monitoring with emphasis on the needs for ocean studies and on the possible effects of increased power levels on the environs. A rough draft of an environmental monitoring program was prepared for submission to the Manager, Hanford Laboratories.

At the end of the month, arrangements were being made for a meeting of the Advisory Committee to the Division of Biology and Medicine to be held on January 8. Materials for the booklet to be used during the program was submitted to Technical Publications for typing, the program was arranged, and arrangements were made for a dinner for the visitors.

D. OTHER ACTIVITIES

Three speakers have now accepted for the Hanford Science Colloquia in the 1960 season. They are: Dr. Sioma Kagan, staff economist for the Joint Council on Economic Education, who will speak February 5 on "The Worldwide Impact of Explosive Population Growth"; Dr. Joseph Kaplan, Professor of Physics at UCLA and United States Chairman of the International Geophysical Year, who will speak March 22 on "The Highlights of the IGY"; Dr. George Gamow, Professor of Physics at the University of Colorado and noted thermonuclear scientist, who will speak early in July on some phase of his research.

Preliminary plant improvement program reports describing current and authorized HLO capital expenditures were prepared.

Assistance was rendered in arranging for seven tours (involving 33 people) through HLO and HAPO facilities.

Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION MONTHLY REPORT - DECEMBER 1959

A. ORGANIZATION AND PERSONNEL

P. E. Bramson was assigned to the Radiological Development Operation from the Technical Graduate program on December 1, 1959. Arden C. Foy terminated on December 18, 1959. L. O. Campbell transferred to G.E. Vallecitos Atomic Laboratory on December 25, 1959. Mildred O. Wendland was reactivated on December 30, 1959. Two beneficial transfers were made within the Radiation Monitoring Operation. The force of the Radiation Protection Operation remained at a total of 133. One Technical Graduate, D. N. Brady, started a three-month rotation in the Radiation Monitoring Operation.

B. ACTIVITIES

Seven minor plutonium deposition cases were confirmed during the month. The total number of deposition cases that have occurred at HAPO is 244 and 177 are currently employed. Three of the seven cases were detected through the routine sampling program and four resulted from known incidents. In the incident cases, plutonium was also detected by body monitoring techniques for three involving injuries and in the other involving high-level skin contamination that could not be completely removed. It appears that internal deposition in all cases is less than 10 per cent of the MPL. In one of the cases involving an injury, a CPD Engineering Assistant received a plutonium-contaminated cut to a finger of his left hand while bagging waste out of a hood at 234-5 Building on December 28, 1959. After examination in the Whole Body Counter, a small piece of skin was excised and 0.0021 μc Pu removed. It was estimated that about 0.0034 μc of the Pu remained in the finger, which is less than 10 per cent of the permissible body burden.

The Whole Body Counter cell was out of operation for the majority of the month for the installation of the lead liner. Tests after completion of the work showed results achieved in reduction of background in lower energy range were comparable to those attained at Argonne.

Floor and equipment contamination to 4,000 c/m followed an explosion in the 328 Building of an isostatic pressure vessel used to compact enriched UO_2 powder. Personal surveys, including the injured lathe operator, revealed no skin contamination. Decontamination of floor and equipment was successful; four pairs of shoes with readings to 1,000 c/m were decontaminated to <200 c/m and released.

Approximately 180 contamination control signs were removed from the highway right-of-way in the vicinity of the 200 Areas. It was determined that the contamination status of this locale was not significantly different from other plant areas to warrant special designation.

Two cases of inadequate contamination control resulted from insufficiently marked or contained radioactive shipments from offsite. The first of these involved a parcel post shipment containing about a pound of uranium corrosion product samples. The second involved a 35-gallon barrel with smearable alpha contamination on the outer surface. AEC-HOO was notified in order to contact the other sites involved.

An emission of I^{131} from the separations area exceeded the control limit of ten curies per week on one occasion when Redox released 5.6 curies and Purex 1.7 curies for a total of 7.3 curies in one day and 13.4 curies for the week of December 20.

A defective fuel element, discharged from the 100-KW reactor, resulted in a stack emission of about 0.01 curie of particulates on December 20. Subsequent ground surveys indicated particle concentrations up to 10 per 1,000 square feet as far as Route 4N. The areas adjacent to the stack were highest with up to 14 particles per 1,000 square feet. For several days after the incident, personnel and vehicles were surveyed on exit from the 100-KW exclusion area. Both personnel and vehicles were found free of contamination.

Several samples from the Pasco Sewage Plant were taken during the past three months and analyzed for various radioisotopes. Solids from the plant are sold for use as a soil conditioner after passing through two stages of digestion. The time required for processing sewage is estimated to be about 45 days. The average concentrations observed in samples at this time were about 5×10^{-5} μc Zn^{65}/g solids and about 4×10^{-6} μc Cr^{51}/g solids. If the soil conditioner was used in a vegetable garden, the expected concentration in dry leaf would be about 5×10^{-12} μc Zn^{65}/g and about 8×10^{-12} μc Cr^{51}/g. Such usage of the sewage solids would not contribute significantly to human exposure.

Installation of additional safety devices at the Van de Graaff electron accelerator neared completion. Several switches were installed in the generator room that can be used to shut down the accelerator if someone is inadvertently there at startup. In addition, a warning horn will sound at startup. A switch was installed on the outside radiation zone fence that will shut down the accelerator if the chain is lowered for entry into the radiation zone. An accuracy check was made of the dose rate measuring device at the accelerator with a Victoreen R-meter. Runs were made at several different dose rates with a six per cent (6%) maximum variance observed between the accelerator dosage rate measuring equipment and the R-meter.

The actual installation of the automatic badge film processing machine was completed; however, certain additional studies associated with its performance are in progress. Processing solutions in use over the past one-month period did not show any deterioration. Studies are in progress to determine the optimum life of the developer and fixer solutions. The air exhaust system on the film dryer was installed. An additional hydraulic cylinder was inserted to lower the film trays into the developer solution at the start of the processing cycle.

Electronic work on the automatic densitometer was restarted with the arrival of the digital voltmeter. All electronic components have now been received and prototype assembly of the electronic and mechanical components is proceeding.

A study was completed to determine the feasibility of disposing Biology's low-level alpha animal waste in the 100-F burial ground. Adoption of the proposed procedure will save approximately $2,000 per year.

Operating costs for laboratory analytical work in July, August, and September gave an indication that the FY 1960 Environmental Monitoring budget for these costs would be exceeded by more than $50,000 if some action was not taken. An economy survey was undertaken in October and completed in November. Revisions to the entire sampling program, which includes deletion of samples no longer required for statistical purposes, revisions to the test well sampling program, canceling analysis of certain isotopes, and revised methods of reporting will streamline the entire program providing a saving of $65,000 per year.

C. EMPLOYEE RELATIONS

There were no medical treatment injuries during the month of December. The year-end total for all medical treatment injuries to Radiation Protection Operation personnel was 28. No security violations occurred during the month; however, two violations occurred during the year.

Three suggestions were received for evaluation. One suggestion evaluation was made during the month. There were two outstanding suggestions at month end. No awards were made. L. L. Crawford was appointed to succeed H. J. Paas as the Radiation Protection Operation representative on the Suggestion Board.

A 30-minute television program on Radiation Protection at Hanford was presented to the community over KEPR-TV, Channel 19, Pasco, Washington, on Thursday evening, December 17, 1959.

Radiation Protection training included: A one-hour lecture on Radiation Protection presented to 110 Central Stores employees on two occasions; four lectures presented to PRTR personnel on radiation theory and methods measurement, including demonstrations in the use of radiation instruments and a written quiz at the completion of the program; three information and orientation talks presented to Plutonium Metallurgy and Biology Research personnel; and two 300 Area monitors completing the IPD Radiation Monitoring Training Course.

Dr. Conant's course on "Understanding People" was completed by H. G. Ruppert.

D. SIGNIFICANT REPORTS

HW-63179 "Analysis of Radiological Data for the Month of November, 1959" by R. L. Junkins.

HW-61676 "Hanford Environmental Monitoring Annual Report, 1958" by B. V. Andersen.

HW-63308 "Monthly Report - December 1959, Radiation Monitoring Operation" by A. J. Stevens.

Report of Invention: "Radioactive Gas Dose Measurement Ionization Chamber" by F. L. Rising.

ENVIRONMENTAL MONITORING - RESULTS (November 23, 1959 - December 25, 1959)

Sample Type and Location	Activity Type	Monthly Average	Units*	Trend** Factor
Drinking Water				
100-F Area	Isotopic	1.7	% MPC_{GI}	--
Separations Areas	Gross Beta	1.1×10^{-7}	µc/cc	--
Pasco	Isotopic	0.3	% MPC_{GI}	--
Kennewick	Isotopic	0.09	% MPC_{GI}	--
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc	--
Columbia River Water				
Above 100-B Area	Gross Beta	***	µc/cc	
100-F Area	Isotopic	5.1	% MPC_{GI}	--
Hanford Ferry	Gross Beta	6.3×10^{-5}	µc/cc	--
Pasco	Isotopic	1.2	% MPC_{GI}	--
McNary Dam	Gross Beta	1.5×10^{-6}	µc/cc	--
Vancouver, Washington	Gross Beta	7.0×10^{-7}	µc/cc	--
Ground Water				
Outlying Test Wells	Gross Beta	9.8×10^{-6} (Max.)	µc/cc	-17
Atmosphere				
I-131 Separations Areas	I-131	2.7×10^{-13}	µc/cc	--
I-131 Separations Stacks	I-131	4.1	curies/week	--
Active Particles - Project	--	1.2	ptle/100 m^3	--
Active Particles - Environs	--	0.2	ptle/100 m^3	--
Vegetation				
Separations	I-131	2.1×10^{-5}	µc/gm	+4
Residential	I-131	$< 1.5 \times 10^{-6}$	µc/gm	--
Eastern Washington and Oregon	I-131	$< 1.5 \times 10^{-6}$	µc/gm	--
Fission Products less I-131 - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/gm	--

* The % MPC_{GI} is the percent of the maximum permissible limit for continuous occupational exposure to the gastrointestinal tract calculated from drinking water limits.

** The trend factor shows the n-fold increase (+) or decrease (-) from last month, where values of n less than 2 will not be noted.

*** Now sampled on a quarterly basis--no sample during this reporting period.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents Above Permissible Limits

	Whole Body	Localized
December	1	1
1959 to Date	8	10

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
December	17,470	173	13	1
1959 to Date	290,497	1,304	61	15

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	Average Dose Per Film Packet mr(s)
December	11,454	1,079	126	36	30	7.84	18.22
1959 to Date	128,131	10,397	1,033	263	469	7.38	15.65

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
December	1,859	0	0	0	4
1959 to Date	15,493	20	2	0	78
Fast Neutron					
December	116	18	3	0	4
1959 to Date	2,027	68	21	0	75

Bioassay	December	1959 to Date
Plutonium: Samples Assayed	718	9,011
Results above 2.2×10^{-8} μc/sample	33	425
Fission Products: Samples Assayed	745	8,985
Results above 3.1×10^{-5} μc FP/sample	0	34
Uranium: Samples Assayed	255	3,190
Confirmed Plutonium Deposition Cases	7	20*

*This brings the total number of plutonium deposition cases which have occurred at Hanford is 244.

Uranium Analyses

Sample Description	Following Exposure Units of 10-9 μc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10-9 μc U/cc Maximum	Average	Number Samples
Fuels Preparation	26	4.0	56	114	4.7	49
Hanford Laboratories	50	8.3	32	92	6.6	37
Chemical Processing	12	3.7	35	89	9.5	36
Chemical Processing*	20	11	2	-	-	-
Special Incidents	13	6.4	4	11	7.2	3
Random	3.1	-	1	-	-	-

* Samples taken prior to and after a specific job during work week.

Thyroid Checks	December	1959 to Date
Checks Taken	0	0
Checks Above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	30,295	416,578
- Beta-gamma	43,726	412,895
Skin Contamination		
Plutonium	22	294
Fission Products	19	434
Uranium	7	123

CALIBRATIONS

Portable Instruments	Number of Units Calibrated December	1959 to Date
CP Meter	862	11,492
Juno	279	3,585
GM	815	15,646
Other	150	2,336
Total	2,106	33,059
Personnel Meters		
Badge Film	2,022	13,457
Pencils	-	13,119
Other	539	5,118
Total	2,561	31,694
Miscellaneous Special Services	382	4,565
Total Number of Calibrations	5,049	69,318

A R Keene
Manager
Radiation Protection

AR Keene:AJS:kc

LABORATORY AUXILIARIES OPERATION MONTHLY REPORT - DECEMBER, 1959

GENERAL

Security performance for the Operation was satisfactory with no violations during the month. There were two violations in the Operation during the year.

There was one lost time injury incurred, the first since formation of Laboratory Auxiliaries Operation in 1956. The accident occurred in the Technical Shops.

TECHNICAL SHOPS OPERATION

Total productive time for the month was 16,018 hours. This includes 14,600 performed in the Technical Shops, 950 assigned to Minor Construction, 118 to other project shops, and 350 hours to off-site vendors. The total shop backlog is 24,110 hours of which 50% is required in the current month, with the remainder distributed over a three-month period. Overtime worked during the month was 2.2% (448 hours) of the total available hours.

Distribution of time was as follows:

	Man-hours	% of Total
Fuels Preparation Department	2,008	12.5
Irradiation Processing Department	698	4.4
Chemical Processing Department	491	3.1
Hanford Laboratories Operation	12,307	76.8
Construction Engineering & Utilities	476	3.0
Miscellaneous	38	.2

Customer requests for emergency service again declined resulting in a nominal amount of overtime being worked. Total shop backlog dropped approximately 5% and is near what is considered the optimum level for this shop.

One open requisition is on file to replace a glass technician who resigned.

Security performance was considered satisfactory with no violations. The first lost time injury in the Operation since reorganization in September, 1956 occurred on December 3. The injury which resulted in minor disfiguration of an employee's hand was a result of the rapid combustion of oil mist contained in a vessel and ignited by a friction generated spark. The pressure build-up caused an 18 lb. end plug to leave the vessel at high velocity striking the employee's hand. Three other employees in the immediate vicinity were struck by flying debris causing minor scratch type injuries.

RADIOGRAPHIC TESTING OPERATION

A total of 5,747 tests were made, of which 1,031 were radiographic (including x-ray and gamma-ray) and 4,716 were supplementary tests. Out of a total of 2,595 man-hours, 774 (29.8%) were in connection with radiographic tests, and 1,821 (70.2%) were used on supplementary tests. The supplementary test work included: autoclave, borescope, dimensional measurement (micrometric), eddy current, magnetic particle, penetrant (fluorescent O.D. and I.D.), surface treatment (pickling and alkaline cleaning), and ultrasonic (flaw detection and thickness measurements).

The number of pieces handled this month totaled 4,740 items. The feet of material represented by these items amounted to 42,239 feet. The large number of pieces handled and the corresponding high footage achieved is only possible with the tubular products currently being tested.

Work was done for 21 different organizational components representing most of the operating departments and service organizations. A total of 39 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 19 different occasions for advice and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

The testing and inspection of 45 PRTR process tubes is completed. Forty-three are ready for delivery to the contractor. Two of the completed tubes are being held since they are below the minimum specified wall thickness. Reprocessing of 46 autoclaved tubes with questionable autoclave films has been started on an expedited basis.

The first NPR process tube has been received and ultrasonic flaw detection and fluorescent penetrant testing will be demonstrated shortly. Inquiries have been made by NPR Project representatives to the tube fabricators for performance of the ultrasonic flaw test and the penetrant test at the mills. If the mills perform this inspection only a 10% check will be made on the plant site. The development lot of 50-70 tubes will be checked in their entirety here. Pickling and autoclaving of all tubes will be done at HAPO. It does not appear that the 60 ft. autoclave will be available for use before midyear. As the autoclave is essential to demonstrate satisfactory pickling and autoclaving a serious delay could be experienced in processing the reactor tubes. Another complicating factor is the recent decision to use a higher temperature and longer cycle. The latter will require an additional autoclave.

Zirconium sheath tube testing continues to be plagued by a lack of manpower. It has not been possible to maintain consistently a production of 100 good tubes per week. Fluorescent penetrant test I.D. and O.D. on 20% sample; eddy current evaluation of wall thickness indications and discontinuities, including radiographic examination, and ultrasonic testing are all required. In addition, rejects require additional examinations so that perhaps as high as 300 tubes are handled a number of times to produce the 100 acceptable tubes. Recent equipment acquisitions including a borescope stand, a second ultrasonic test station, and a new eddy current machine are expected to materially help this situation.

In the field work a sizeable job has been undertaken at F-area in implementing an IPD safety program on hoisting equipment. The work involves x-ray and gamma-ray examination of hooks, shackle blocks, and other accessory hoisting gear.

Testing Statistics

Component	No.of Tests	Ft. of Weld or Material	No.of Pieces	Description
CE & U	411	190	59	Radiographic welds on 347 S.S. to 106 C.S. weld coupons; Radiograph welds on 4-16" O.D. short radius ells; Radiograph welds pressurizer stand pope.
CPD	82	87	82	Radiograph welds on multipurpose dissolver assembly.
HLO	4,735	42,446	4,502	Radiographic thermocouple heater; Radiograph end welds on test fuel elements; Radiograph tips for weld integrity; Thermocycling Project; Radiograph fuel rods for core location; 9/16" O.D. x 8' long; Ceramic Fuel rods; 680" I.D. x 12' long, zr-2 tubes; Radiograph welds on PRTR Calandria; Palm Fabrication; 680" I.D. x .035" wall x 8' long, zr-2 tubes; Fluorescent penetrant test 14 I and E uel rods inspection of O.D. and I D.; Fluorescent penetrant test reactor pigtails; PRTR zirconium tubes.
IPD	519	15-1/2	97	Radiograph solder on 3 banks of instruments leads in 105-B and 3 banks of instrument leads in 105-DR; X-ray snatch blocks to determine integrity of castings; Radiograph elbows on the soot blow back lines on boilers in the 184-H Bldg.; Radiograph (3) neutron chambers to determine position of internal components; Magnetic particle inspection of six 24" O.D. x 40' long; Helium storage vessels at 110 KW Building.
Grand Total	5,747	42,739-1/2	4,740	

CONSTRUCTION OPERATION

During the month twenty-one CPFF work orders were issued to J. A. Jones Company amounting to $49,973.00. Six supplements to HL orders were issued amounting to $13,782.00. Total authorizations issued is $63,755.00.

There were forty-six existing HL orders at the beginning of the month with a total remaining unexpended balance of $139,172.00.

There were a total of seventeen old CE&U orders active at the beginning of the month and six of these were closed during the month. Total remaining unexpended balance of the eleven orders is $134,152.00. Two supplements were issued in the amount of $3,470.00 which is included in the aforementioned figure.

J. A. Jones Company expenditures on HL work during December were $89,934.00.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of Month	46	$ 139,172	17	$ 172,874
Adjustment (Closed out Unexpended Balance)		46,196		2,740
		$ 92,976		$ 170,134
Issued during the Month (Inc. Supplements)	21	$ 63,755		$ 3,470
J.A. Jones Expenditures during Month (Including C.O. costs)		52,433		39,452
Balance at Month End	29	$ 104,298	11	$ 134,152
Orders Closed during Month	38	33,067*	6	125,610*

J. A. Jones Expenditures	-	$ 89,934
Construction Operation Costs	-	1,951
HL Orders Issued	-	67,225
Total Orders Closed	-	158,677*
Total Backlog	-	238,450.

* Face Value of Orders Closed

Authorizations to the Jones' Company during the month were less than expenditures by $22,709.00 as was forecasted. It is expected that two jobs coming up in January will more than off-set this decrease in backlog. These jobs are Project CA-744 - Installation of equipment in 306 Building and the relocation and installation of equipment for PFPP in 308 Building.

During the month we completed and turned over to operations the installation of the 5,000 ton press and the installation of the Rolling Mill Vacuum System in 231-Z Building.

A major work order was received in this building for the fabrication of a hood and installation of a Monarch Lathe. Foundation and fabrication work started December 21.

Maintenance and modification of equipment continued at a high level in C-25 Building - WB during the month.

Two Heat Exchangers in Building 325 - 300 Area have been installed. Jones' forces are now held up pending repair of the main glycol lines before the third unit will be released to us. The autoclave installation in 306 Building has started. We have poured all the foundations, set the control panel and started electrical work.

Distribution of current work is as follows:

6 in 200 Areas.
6 in 100 Areas.
7 in C-25 Building - White Bluffs.
7 in WB shops.
14 in 300 Area.

FACILITIES ENGINEERING OPERATION

Projects

There were 22 authorized projects at month's end with total authorized funds of $6,735,000. The total estimated cost of these projects is $8,720,000. Two new projects were authorized and three were completed during the month. One new project is awaiting AEC approval. Four proposals for new projects are in preparation.

The following summarizes the status of HLO project activity:

Number of authorized projects at month end: 22

Number of new projects authorized during month: 2
- CGH-879 High Temperature, High Pressure Autoclave Facility - 306 Building.
- CGH-882 5000 Ton Hydraulic Press.

Projects completed during month: 3
- CA-749 High Level Radiochemistry Facility (Note: This project was completed with exceptions November 30, 1959, however this was not noted in last month's report.)
- CAH-828 Central Storage Facility - 300 Area.
- CGH-882 5000 Ton Hydraulic Press.

New project proposals submitted to AEC during month: 0

New projects awaiting Awaiting AEC approval: 1
CGH-874 Consolidation of Plutonium Metallurgy Facilities

New project proposals in preparation 4
Rattlesnake Springs Radioecology Research Area.
Uranium Scrap Burning Facility.
Physical Constants Test Reactor.
Biology Addition.

The attached project report details the status of individual projects.

Engineering Services

Title	Status
326 Building Retention Waste Sump Modifications	Work complete.
Additional Lab Hoods & Air Exhaust Modifications - 146-FR	Work essentially complete.
Glycol Heat Exchangers - 325-A	Field work essentially complete on two of four units.
329 Building Cooling Problem	Detail design is progressing.
Compressed Air System, 231-Z Building	Work essentially complete.
Air Conditioning Room 4 141-H Bldg.	Installation work in progress.
Ventilation - 314 Building	Estimates have been completed.
Fire Detection System - 146-FR	Work order issued for installation.
Electrical Modifications - Room 24-A 326 Building	Work order has been issued for field work. Materials on order.
Modifications, 3707-C Building	Computer section modifications essentially complete. Conversion of offices in lunch room not started.
Lead Lining, Shielded Personnel Monitoring Cell - 747-A Building	Work complete.
Space Rearrangement - 3706 Building	Field work complete.

Title	Status
108-F Building Solvent, Acid & Cylinder Storage, & Loading Dock	Arrangements have been made for field work to start in January.
Electric Hoist - Graphite Shop - 3730-C Building	No activity during the month.
Refrigerated Air Conditioning Room 130 - 146-FR Building	No activity during the month.
Reactor Room Exhaust Ventilation Control 326 Building Basement	Design continues for exhaust dampers to be controlled by alpha air sampling device.
Crib Waste System - Valves	Vendor information is being obtained.
Canopy Over Dog Pens - 141-H	Field work essentially complete.
Improve Ventilation for Exhaust Hood, Room 211-108-F Building	No activity during month.
Revision to Cell Door Mechanism 747-A Building	Design completed. Material on order. Installation to be performed in January.
Pressure Vessel Study	Audiogaging program is in progress as well as safety valve inspection.

Drafting and Design Services

The two remaining Kirk Contract personnel in the drafting operation were terminated as of December 31, 1959. The work will be performed by our employees, and it is not anticipated that Bovay personnel will be required in HLO.

Design and drafting work in progress includes the following:

1. PRTR prototype loop - "As-Built" - 314 Building.
2. Manipulator Model II "As-Builts" - 327 Building.
3. Calandria "As-Builts" - PRTR.
4. Miscellaneous equipment for high level radiochemistry cell - 325 Building.
5. PRTR Fuel Examination Ducts.
6. PRTR Gas Loop - In-Reactor.
7. Transfer Hood with Conveyor - to Transfer Pu Oxide - 308 Building.
8. Fuel Rod Wire Machine - 308 Building.
9. Vacuum Box for Welding of Fuel Elements.
10. Break away Corrosion Loop.

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Design and drafting work is being performed on layout and details of projects CGH-834 - Modifications and Additions to High Pressure Loop, 189-D Building; and CGH-877, Pyrochemical Test Facility - 321-A Building.

Maintenance and Building Engineering - Landlord Functions

Costs: October - $126,783
November - $161,651
FY thru November - $589,458

Analysis of Costs: The $589,458 expenditure through October represents 40.4% of the budget. This is within 5% of the forecast expenditure amount. Plant improvement costs were less than expected; however, building maintenance costs increased and steam consumption was lower than predicted.

Unusual Maintenance:

Item	November	FY Thru November
Heating & Ventilating Correction	$ 14,241	$ 18,884
Relocation & Alteration	-	9,368
Paint	7,807	11,570
Electrical Improvements	-	1,342
Lighting	-	392
Refilter	-	701
Miscellaneous	390	1,065
	$ 21,008	$ 43,322

Miscellaneous

Approximately 310 drawings including sketches, work sheets, and formal drawings were completed during the month of November by the Drafting Component.

Approximately 15,000 square feet of prints were reproduced during the month.

The total estimated value of the 16 requisitions issued during the month was $10,000.

TECHNICAL INFORMATION OPERATION

Early in the month the local AEC informed Technical Information, through GE Security, that it wished to monitor the offsite distribution of all classified documents prepared primarily for internal use at HAPO. Subsequent discussions with HOO, AEC indicate that most offsite distributions can be cleared using blanket approvals based on subject matter.

The report of the inter-Departmental Task Force on control of access to documents in the Classified Files was sent to Department representatives for comment.

The Industrial Information Branch of the AEC requested HAPO's help in "obtaining information on the technical literature reading and purchasing habits of scientists and engineers engaged in nuclear enterprise". A questionnaire prepared by the AEC was sent to 500 HAPO scientific and engineering personnel. At month's end, the questionnaires were being returned. The returns indicate that many HAPO engineers and scientists are unaware of the AEC's Technical Progress Reviews, four very useful journals for workers in atomic energy. Plant-wide publicity is planned to remedy this lack.

A representative of Arthur D. Little, Inc., visited the Operation during the month as part of a survey his firm is making of the "informational aspects of the Commission's Materials Research Program". The survey is concerned with the effectiveness of dissemination of such information and factors tending to limit effective dissemination. In addition to his discussions with Technical Information personnel, meetings were arranged for him with the Manager and Supervisors of the Fuels Development Operation and the Materials Development Operation, respectively.

The Commission program revising the Standard Distribution Lists for Classified Scientific and Technical Reports (M-3679) is underway. The revision will eliminate 22 categories in M-3679 on the basis that there need no longer be any classified reports in these categories. Some 5000 reports which still remain in these categories are being reviewed by the Commission for declassification. If the report cannot be declassified, the Commission is asking the sites to indicate a superseding unclassified report (if one exists) which can be substituted for the classified report in an access permittee's files. About 100 such requests have been received and are being processed.

As part of the change-over, all HAPO originated documents now in categories C-66, C-67 and C-68 (there are about 700 in the Commission's files) will be reviewed to determine (1) if they are obsolete, (2) if they have been superseded and (3) into which new categories they should be placed. The program is to be completed in three months. A letter was sent to all Departments summarizing the Commission request, giving details on forthcoming changes in the AEC's report distribution system, scope notes for new categories, and the procedures for the review. The Departments were asked to select reviewers.

Requests were submitted to AEC for approval to conduct the following work on an unclassified basis:

1. A specific fuel element closure development program.
2. Fuel element closure work development - general.
3. HAPO assistance to ANL studies on the pyrophoricity of plutonium.

The semi-annual notebook certification was prepared for the Chicago Patent Branch of the AEC.

Library Acquisitions and Circulation

	November	December	CY-1959	CY-1958
Books ordered (volumes)	260	242	4,275	3,979
Periodicals ordered	765	531	3,935	1,665
Books circulated (volumes)	1,578	1,614	20,617	22,455
Periodicals circulated (issues)	3,254	2,893	35,263	41,950
Inter-Library loans	96	70	949	879
Films borrowed or rented	19	9	206	299
Industrial film showings	38	44	680	707
Bound periodicals added to the collection	140	181	1,603	652

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	28,250	8,307	1,529	1,995	40,081
No. of bound periodicals	12,981	1	1,431	96	14,328
	41,231	8,308	2,960	2,091	54,409

Classification and Declassification

	November	December	CY-1959	CY-1958
Documents, including drawings and photographs reviewed for downgrading or declassification	5	10	635	1,213
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	11	25	407	390
Documents submitted to Declassification Branch, Oak Ridge	14	8	149	785

J. L. Boyd
Manager,
Laboratory Auxiliaries

JL Boyd:jcw

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE	OPERATING OR COMPL. DATE
CG-731	Critical Mass Laboratory	$1,000,000	$1,000,000 / 3-23-59	100 / 100	52 / 56	5-22-58 / 6-4-59	- - - / 6-30-60	2-24-59 / 6-30-60

USING COMPONENT: Physics & Instruments R & D
FED ENGINEER: D. S. Jackson

REMARKS: The reactor room roof was poured and the forms stripped. Concrete was placed in the large shielding door while the roof was being poured. The blocked out area around the shielding door will be poured early in January. The mixing and pump hoods were received. The reactor hoods were supposed to be shipped on December 31, 1959. Plastering of the interior of the of the service and control buildings was completed. The prime coat was painted on the interior of the control building and was initiated on the service building equipment room walls. Labor difficulties were experienced during the month. The pipefitters and sheetmetal workers are currently involved in a jurisdictional dispute over installation of cylindrical duct-work in the heating and ventilating system. This work was awarded by contract to the sheetmetal workers. As a result the pipefitters "went fishing" on December 9, 1959 and there is no indication of their early return. No appreciable project delay has resulted yet from this action, but if the fitters remain off the job in January the work schedule will definitely

USING COMPONENT
FED ENGINEER

REMARKS: (CG-731 Continued) be affected. The contractors are investigating what legal action can be taken against the pipefitters union to get men back on the job. Work on the ductwork in question cannot be performed until the reactor hoods are in place in the reactor room. No satisfactory solution has been attained regarding the late delivery of instrument panels by Minneapolis-Honeywell. We are presently investigating the advantages of having the panels shipped as is on January 15, 1960 and letting Minneapolis-Honeywell complete their work on the job site.

CA-744	Metallurgical Development Facility - 306 Building	$2,650,000	$2,685,000 / 11-5-58	100 / 100	18* 70** / 10* 55**	18*** 6-30-58 / 18*** 3-20-59	- - - / 9-1-60	9-30-59 / 9-1-60

USING COMPONENT: Reactor & Fuels R & D
FED ENGINEER: J. T. Lloyd

REMARKS: A new schedule is being prepared. The project completion date will remain as September 1, 1960. The chemical processing lump sum contract was awarded to Frank Lohse for $149,950. The Jensen-Rasmussen bid for for $150,000 as was the Fair Cost Estimate. The chemical processing tanks will be supplied by Portland Copper and Tank Works, Portland, Maine at a cost of $39,030, promised delivery will be in 5½ months. Notice to proceed with chemical processing construction has been given and work will probably start about January 8, 1960. Jensen-Rasmussen has completed the temporary closing in of the building structure and sufficient heating and lighting have been installed to permit pouring of concrete and interior construction. Equipment is being delivered to White Bluffs pending completion of floor slabs in rooms 170 and 171, except for the 700-ton hydraulic press which will be installed on its foundation when it arrives. The AEC has unofficially agreed to

AEC-[illegible] (8-60)

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 53-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63302
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.

USING COMPONENT

FEO ENGINEER

REMARKS: (CA-744 Continued) permit J. A. Jones Company to install the research and development equipment. The Jensen-Rasmussen Company has approved a schedule that calls for completion of rooms 170 and 171 by February 13, 1960 and completion of construction by April 1, 1960.

CA-749	High Level Radiochemistry Facility		$960,000	100	100**	6-15-58	- - -	11-21-58
		$950,000	10-3-58	100	100**	8-14-58	1-1-60	11-30-59**

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

A Physical Completion Notice with accruals, dated December 18, 1959, has been prepared. B. D. Bohna and Company still have to furnish five lock sets and parts for the emergency circuit breaker. Several items of plant force installation and fabrication work remain to be completed. This project will not again be reported as it is essentially complete.

*Depending upon claim review, total project cost may vary between $920,000 and $950,000.

** Project complete with exceptions; beneficial use was attained and project accepted by customer November 5, 1959.

CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building		$345,000	100	99	6-23-58	- - -	12-31-58
		$350,000	4-23-59	100	82	10-9-58	2-1-60	2-1-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: J. J. Peterson

REMARKS:

A project proposal requesting an extension of time is being routed for signatures. Siding and roof deck, which have been delaying completion of the job, arrived December 16, 1959. Acceptance Tests were run on the crane. A loose part in the trolley brake caused a coil and rectifier to go out. New parts have been ordered and are scheduled for installation the first week in January; crane tests can then be completed.

AM-7300-069 (5-58)

1248494

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 58-b-4

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN / CONST.
CGH-819	Increased Laboratory Waste Facilities - 300 Area	$193,765	$30,000 11-24-58	100 100	0 0	3-30-59 5-1-60	- - - - - -	4-1-60 3-1-61

USING COMPONENT: Chemical R & D
FEO ENGINEER: J. J. Peterson

REMARKS:

A revised project proposal requesting construction funds was transmitted to the Commission December 28, 1959.

General Plant Projects - FY 1959

CAH-827	Automatic Columbia River Monitoring Station	$39,000	$39,000 6-30-59	100 100	85 100	4-3-59 11-5-59	- - - 3-31-60	6-18-59 3-31-60

USING COMPONENT: Radiation Protection
FEO ENGINEER: D. S. Jackson

REMARKS:

The fixed price contractor completed his work during the month. Since there was some question regarding the legality of plant forces installing the equipment; a "Plant Forces Work Review" was submitted for review on December 9, 1959. After a lengthy review it was approved on December 29, 1959. The work will be started January 4, 1960.

CAH-828	Central Storage Facility - 300 Area	$38,000	$40,000 7-30-59	N.S. 100	100 100*	4-2-59 7-15-59	- - - 12-31-59	6-8-59 12-31-59*

USING COMPONENT: Finance
FEO ENGINEER: R. C. Ingersoll

REMARKS:

This project closed out December 31, 1959 with exceptions. Items to be completed are: Installation of lock cylinders (which are scheduled for shipment from Connecticut January 11, 1960) and installation of fire alarm supervision panel (scheduled for shipment from Massachusetts January 6, 1960). Beneficial use was attained November 25, 1959.

* Complete with exceptions as noted.

AM-7308-819 (5-58)

BUDGET CLASSIFICATION: General Plant Projects - FY 1959

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - [illegible]
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CAH-837	Animal Pens, Isolation and Examination Facilities	$80,000	$80,000 / 3-17-59	100 / 100	100 / 99	3-30-59 / 7-10-59	- / 4-1-60	6-5-59 / 1-15-60

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

Pharmacology had beneficial use of all the building, except for the mens' rest room, on December 18, 1959. Tile work and several other items in this room have yet to be completed. The roof has to be graveled. Some items not included in this fixed price contract will be done by others.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CGH-840	Sheet Metal Shop Addition - 328 Building	$40,000	$40,000 / 6-18-59	N.S. / 100	100 / 80	6-22-59 / 6-25-59	- - - / 5-1-60	9-1-59 / 2-1-60

USING COMPONENT: Laboratory Auxiliaries

FEO ENGINEER: J. J. Peterson

REMARKS:

Plant forces started installation of equipment from existing sheet metal shop on December 21, 1959.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION — AMOUNT / DATE	PROJECT PROGRESS IN PER CENT — DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT — CONST. SCHED. / ACTUAL	STARTING DATE — DESIGN / CONST.	DIRECTIVE COMP. DATE — DESIGN / CONST.	ESTIMATED OR ACTUAL COMP. DATE — DESIGN / CONST.
CAH-848	Geological and Hydrological Wells - FY 1959	$56,600	$56,600 / 6-18-59	N.S. / 100	77 / 77	5-12-59 / 7-16-59	- - - / 5-31-60	7-6-59 / 3-30-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: H. E. Ralph

REMARKS:

Thirteen of the sixteen wells have been developed; 2,700 feet of new hole has been completed. Three drilling rigs are working on the last three wells, numbers 14, 15 and 16.

BUDGET CLASSIFICATION: General Plant Projects - FY 1959

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED or Actual COMP. DATE DESIGN / CONST.
0084 (AEC-167)	Pickling and Autoclaving Facility for Zirconium Tubes - C-25 Building, White Bluffs	$140,000*	$140,000 / 5-25-59	100 / 100	100 / 100	3-2-59 / 3-10-59	- - - / - - -	5-15-59 / 10-15-59

USING COMPONENT: Laboratory Auxiliaries
FEO ENGINEER: H. Radow

REMARKS:

The last exception has been completed and acceptance signatures obtained. This job is now complete.

*Exclusive of general overhead costs which are charged directly to AEC-167.

General Plant Projects - FY 1960

CGH-860	Access for PRTR Fuel Elements - 327 Building	$81,000	$81,000 / 10-8-59	N.S. / 55	N.S. / 0	10-19-59 / N.S.	- - - / 8-15-60	1-15-60 / 4-30-60

USING COMPONENT: Reactor & Fuels R & D
FEO ENGINEER: J. J. Peterson

REMARKS:

A letter was written December 9, 1959 requesting return of the revised project proposal which requested a change in work performance method. The project proposal was returned by the Commission on December 23, 1959. Electrical design is essentially complete. Specifications are out for comment and work is progressing on architectural and structural design. A work release to HLO Construction was written December 21, 1959, for modifications to existing building framing and crane rail supports between column lines 2 and 5. A design schedule was transmitted to the Commission on December 28, 1959.

CAH-864	Shielded Animal Monitoring Station - 100-F	$46,000	$46,000 / 8-6-59	N.S. / 70	0 / 0	- - - / N.S.	- - - / 4-1-60	1-15-60 / 4-15-60

USING COMPONENT: Biology
FEO ENGINEER: J. T. Lloyd

REMARKS:

Drawings and specification are being reviewed for comment and "Special Conditions" is being prepared.

AM-7300-019 (5-58)

BUDGET CLASSIFICATION: General Plant Projects - FY 1960

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - [illegible] MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT CONST. SCHED.	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED COMP. DATE DESIGN	ESTIMATED COMP. DATE CONST.
CGH-874	Consolidation of Plutonium Metallurgy Facilities	$285,000	None	None	0	0	1 *	2 *		- - -	5 *	11 *

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: J. T. Lloyd

REMARKS:

Action on the project proposal has been deferred at each meeting held by the AEC Project Review Board. No tangible explanation for these deferments has been received.

* Months after authorization.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT CONST. SCHED.	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED COMP. DATE DESIGN	ESTIMATED COMP. DATE CONST.
CGH-877	Pyrochemical Test Facility - 321-A Building	$70,000	$70,000	11-17-59	N.S. 5	N.S. 0	12-8-59*	2-17-60	- - -	9-30-60	4-17-60	9-30-60

USING COMPONENT: Chemical R & D

FEO ENGINEER: R. C. Ingersoll

REMARKS:

Procurement specifications for three hoods and two induction heating units have been prepared. Bids are due January 5, 1960 on the hoods and January 6, 1960 on the induction heating units. Field Work Releases No. 56-CO and No. 56-CO, Revision 1, in the amount of $23,000 total, have been issued to HLO Construction for procurement of these items. Design on the Mg still hood is approximately 30% complete.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT CONST. SCHED.	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED COMP. DATE DESIGN	ESTIMATED COMP. DATE CONST.
CAH-878	Additional Facilities for Isotope Study on Animals - 141-C Building Addition	$61,000	$61,000	11-18-59	0	0	12-7-59	2-15-60	- - -	4-15-60	1-15-60	5-15-60

USING COMPONENT: Biology

FEO ENGINEER: J. T. Lloyd

REMARKS:

CE&UO (Bovay) design was started on December 7, 1959. Preliminary drawings are being reviewed for comment. The specifications for comment have not been completed.

BUDGET CLASSIFICATION Improvements to Production and Supporting Facilities - 60-a-1

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED COMP. DATE or Actual
			AMOUNT / DATE	DESIGN SCHED. / ACTUAL	CONST. SCHED. / ACTUAL	DESIGN / CONST.	DESIGN / CONST.	DESIGN / CONST.
CGH-832	Full Scale Physical Constants Testing Reactor	$915,000	None / None	0 / 0	0 / 0	- - - / - - -	- - - / - - -	- - - / - - -

USING COMPONENT: Physics & Instruments R & D
FEO ENGINEER: R. W. Dascenzo

REMARKS:

A project proposal for approval of preliminary engineering funds in the amount of $30,000 is being routed. It is presently in IPD for signatures. This proposal is similar to a previous one which was returned by AEC-HOO, in September, 1959, for lack of funds.

CAH-870	Facilities for Recovery of Radioactive Cerium - 325 Building	$490,000	$40,000 / 12-9-59	40 / 40	0 / 0	9-18-59 / N.S.	- - - / - - -	2-15-60 / 9-1-60

USING COMPONENT: Chemical R & D
FEO ENGINEER: R. W. Dascenzo

REMARKS:

Preliminary design was completed on November 30, 1959. Directive No. AEC-165, Modification No. 1 was issued December 9, 1959 authorizing an increase of $5,000 in funds to a total of $40,000. Title II work is proceeding on 25 structural, architectural, piping, mechanical, electrical, instrumentation, and ventilation drawings and 15 construction specifications. Five specifications and one drawing have been commented upon.

Equipment Not Included in Construction Projects - Program Class 2900

CG-661	Additional Heat Generation Facility - 189-D Building	$450,000	$664,000 / 9-18-57	100 / 100	100 / 99	12-6-56 / 12-3-58	- - - / 8-31-59*	10-15-58 / - - -

USING COMPONENT: Reactor & Fuels R & D
FEO ENGINEER: J. J. Peterson

REMARKS:

Work during the month was confined to study of temperature detection problem and adjustment of equipment.

* Beneficial use was attained.

AM-7300-019 (5-58)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CA-681	Hanford Equipment in the ETR	$1,044,000*	$1,140,000 4-1-59	100 100	100 100	9-17-56 4-1-58	- - - 3-1-60	9-30-59 10-30-59

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: H. Radow

REMARKS:

Portions of the ruptured 6 x 9 tube have been metallurgically inspected and analyzed to determine the probable cause of rupture. Conclusions have not yet been established and Phillips will not install the spare tube until more definite information is obtained. The first rupture detection experiment has been conducted successfully and the second is scheduled to be run early in January.

This project will not again be carried in this report.

*Includes accrual items listed as exceptions on the Physical Completion Notice.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CG-785	In-Reactor Studies Equipment - 105-KW Building	$276,000	$276,000 12-8-58	100 97*	0 0	1-5-59 N.S.	- - - 12-31-60	1-31-60 12-31-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: H. Radow

REMARKS:

Comment drawings of the capsule removal facility were reviewed at a meeting of all concerned, including IPD representatives. Modifications decided upon are now being incorporated on the drawings and procurement will then be processed. Procurement of all other major items of equipment is proceeding favorably, however delays are being encountered at some vendors and these are being expedited. The estimate for IPD's portion of the new monorail and hoist has been submitted and an Appropriation Request is being prepared.

*Remaining instrumentation and electrical design are held up, pending receipt of approval of vendor approval drawings on off-site procured instrumentation panels and valve rack.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE DESIGN / CONST.
CGH-801	X-Ray Diffraction Cell - 327 Building	$170,000	$170,000 10-1-59	40 40	0 0	6-10-58 10-1-60	- - - 10-31-60	- - - - - -

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

A revised project proposal cancelling this project is being circulated for approval.

AM-7300-919 (5-58)

BUDGET CLASSIFICATION: Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303

MONTH: December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION - AMOUNT / DATE	PROJECT PROGRESS IN PER CENT - DESIGN SCHED. / CONST. SCHED. / DESIGN ACTUAL / CONST. ACTUAL	STARTING DATE - DESIGN / CONST.	DIRECTIVE COMP. DATE - DESIGN / CONST.	ESTIMATED or Actual COMP. DATE - DESIGN / CONST.
CGH-805	High Temperature Tensile Testing Cell - 327 Building	$170,000	$150,000 2-25-59	100 100	0 0	8-26-58 3-1-60	- - - 3-1-60	6-15-59 2-1-61

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: R. W. Dascenzo

REMARKS:

After a review of budget funds the using operation requested that procurement of equipment for this project be reactivated on December 16, 1959. New invitations for bid are in process for the Meehanite cast iron cell structure and the viewing plugs.

A revised project proposal requesting $20,000 additional funds and an extension of time until February 1, 1961 is being routed in HLO for approval.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION - AMOUNT / DATE	PROJECT PROGRESS IN PER CENT - DESIGN SCHED. / CONST. SCHED. / DESIGN ACTUAL / CONST. ACTUAL	STARTING DATE - DESIGN / CONST.	DIRECTIVE COMP. DATE - DESIGN / CONST.	ESTIMATED or Actual COMP. DATE - DESIGN / CONST.
CGH-834	Modifications and Additions to High Pressure Heat Transfer Apparatus - 189-D Building	$700,000	$700,000 4-8-59	84 90	37 37	4-20-59 4-22-59	- - - 10-15-60	2-9-60 10-15-60

USING COMPONENT: Reactor & Fuels R & D

FEO ENGINEER: H. Radow

REMARKS: The order for the hi-speed valves has been placed with Hammel-Dahl and final price is now being negotiated. The order for the hi-pressure air receiver has been placed and negotiations with the low bidder for the hi-pressure water storage vessel are underway to resolve differences in his "Conditions of Order" form. Essentially all of the major procurement items are now on order or in requisition processing. Design is progressing favorably and a new issue of the drawing schedule is being submitted to reflect the current drawing status. Shipment of the first preheater is still being promised for the last week of December, however, liaison is skeptical of this. Expedited construction is being scheduled on the basis of receiving the preheater by mid-January. In order to factor in the known procurement costs and firm design, and allowing for operational changes such as direct Jones Company construction, per diem off-site inspection charges, etc., a cost-to-complete

USING COMPONENT

FEO ENGINEER

REMARKS: (CGH-834 Continued) estimate was requested. This has been completed and the authorized funds appear to be adequate with a reasonable contingency.

AM-7300-819 (9-58)

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT / DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED. / ACTUAL	PROJECT PROGRESS IN PER CENT CONST. SCHED. / ACTUAL	STARTING DATE DESIGN / CONST.	DIRECTIVE COMP. DATE DESIGN / CONST.	ESTIMATED COMP. DATE (Or Actual) DESIGN / CONST.
CGH-857	Physical and Mechanical Properties Testing Cell - 327 Building	$500,000	$75,000 / 10-1-59	0 / 1	0 / 0	10-20-59 / N.S.	- - - / - - -	4-1-61 / 1-1-62
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

As there are no available allocated funds, no work was done on this project this month. A revision to the project proposal is anticipated for this project.

CGH-858	High Level Utility Cell - 327 Building	$500,000	$70,000 / 10-1-59	0 / 0	0 / 0	10-20-59 / N.S.	- - - / - - -	1-1-61 / 11-1-61
		USING COMPONENT: Reactor & Fuels R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

A revised project proposal is being circulated for approval requesting a change in scope of work from a multi-purpose remotely operated lathe and milling machine to single-purpose plug-mounted tools. No design work was done pending acceptance of this change in scope work.

CGH-866	Shielded Analytical Laboratory - 325 Building	$750,000	$10,000 / 8-12-59	100 * / 100 *	0 / 0	9-5-59 / N.S.	- - - / - - -	12-15-59 * / 6-1-61
		USING COMPONENT: Chemical R & D				FEO ENGINEER: R. W. Dascenzo		

REMARKS:

Preliminary design, consisting of four drawings, was completed on December 4, 1959. A revised project proposal, requesting an additional $50,000 for detailed design and a change in cell location and project budget classification, was transmitted to AEC-HOO for approval on December 28, 1959.

* Preliminary Engineering.

BUDGET CLASSIFICATION Equipment Not Included in Construction Projects - Program Class 2900

MONTHLY PROJECT REPORT
HANFORD LABORATORIES OPERATION

HW - 63303
MONTH December, 1959

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT	AUTHORIZATION INFORMATION DATE	PROJECT PROGRESS IN PER CENT DESIGN SCHED.	PROJECT PROGRESS IN PER CENT CONST. SCHED.	STARTING DATE DESIGN	STARTING DATE CONST.	DIRECTIVE COMP. DATE DESIGN	DIRECTIVE COMP. DATE CONST.	ESTIMATED OR ACTUAL COMP. DATE DESIGN	ESTIMATED OR ACTUAL COMP. DATE CONST.
CGH-879	High Temperature, High Pressure Autoclave Facility - 306 Building	$46,400	$46,400	12-3-59	N.S.	N.S.	8-3-59	- - -	- - -	- - -	2-1-60	3-31-60
					75	5	12-3-59		3-31-60		3-31-60	

USING COMPONENT: Reactor & Fuels R & D

PEO ENGINEER: D. S. Jackson

REMARKS:

Requisitions were submitted for minor equipment items not previously ordered under the "Appropriation Request". Procurement of all major equipment pieces was performed under Appropriation Request AR-59-HL5-134. CPFF construction services contractor forces initiated work on December 18, 1959.

3000 Program - Account Class 3641

CGH-882	5000 Ton Hydraulic Press	$22,000	$30,000	12-7-59	N.S.	N.S.	100	- - -	8-5-59	- - -	12-31-59	- - -	12-21-59

USING COMPONENT: Reactor & Fuels R & D

PEO ENGINEER: J. T. Lloyd

REMARKS:

The project proposal was authorized on December 7, 1959. The work order was closed out on the date of Work Release Authorization, December 21, 1959. Accumulated costs and Physical Completion Notice are being prepared.

USING COMPONENT:

PEO ENGINEER:

REMARKS:

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of December 31, 1959, the staff of Hanford Laboratories totalled 1318 employees, including 634 exempt and 684 nonexempt. There were 544 employees possessing technical degrees, including 331 B.S., 112 M.S. and 101 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for December was 1.56 as compared with 1.46 last month. For calendar year 1959 the medical treatment frequency was 1.63. There were 4 security violations during December, bringing the total for the year to 46.

A Technical Shops employee suffered a permanent partial disability of his right hand as a result of an explosion which occurred while he was machining on an isostatic press.

A HAPO task force on Pressure Systems was organized with representatives from the Product Departments, CE &U, and the Laboratories.

PROFESSIONAL PLACEMENT

During December, 4 Ph.D. candidates visited for interviews; 3 offers were extended; and 2 acceptances were received, one from a chemist and one from a theoretical physicist, both for assignment within HLO. Three new Ph.D.s reported on HLO roll including 2 chemists and a fisheries biologist.

During December, HAPO personnel participated in Company-wide Ph.D. recruiting at the University of California, Stanford, Michigan, Washington, and Washington State.

Six new offers were extended to BS/MS candidates during the month and one acceptance was received for the Technical Graduate Program. Seven offers were extended to experienced BS/MS candidates and 10 acceptances were received from outstanding offers for the month.

Three Technical Graduates accepted permanent assignment; three were placed on military leave of absence and one transferred to the Engineering and Science Program, leaving 60 Technical Graduates on the Program on December 31. Permanent placement of Technical Graduates during calendar year 1959 was as follows:

HLO - 20
CE&U - 1
FPD - 3
IPD - 14
CPD - 7

TRAINING

Courses in Applied Creativity, Understanding People, and Program VIII of the Information and Orientation Series - The PRTR and the Plutonium Recycle Program -

were presented to Laboratories personnel during December.

EMPLOYMENT

Ten requisitions were filled during December. With the receipt of 14 requisitions and 3 cancellations, there were 8 openings at month's end for which 4 candidates are in process, 3 transfers are pending, and one candidate is yet to be procured.

COMMUNICATIONS

"Radiation Protection at Hanford", a half-hour television show on radiation protection and radiological sciences activities conducted by Hanford Laboratories, appeared on KEPR-TV on December 17. H. M. Parker discussed film sequences of these programs. Audience reaction appeared to be very favorable.

An employee information booklet entitled, "Hanford's Shielded Personnel Monitoring Station", was distributed to all Hanford people during the week of December 29. Appropriate advance publicity and a covering note were also disseminated.

EMPLOYEE COMPENSATION

L. W. Wright, a Laboratory Assistant in Chemical Research and Development, will retire under the normal provisions of the Pension Plan the first of next month.

Manager,
Professional Placement
and Relations Practices

TG Marshall:tr

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Nov.	Dec.
Requisitions		
At end of month	7	8
Cancelled	5	3
Received	8	14*
Filled	11	10

Nonexempt Transfer Request	Nov.	Dec
Transfers		
Active cases at end of mo.	80	73
Cancelled	4	6
New	5	5
Transfers effected	1	2

* Includes 1 off of hold.

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	397	77	14	13	9	4	3	7
Exp. BS/MS	213	55	38	4	40	26	1	27
Prog. BS/MS	169	-	-	-	9	3	6	5

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 6

**On the Roll totals include 1958/59 Carryover acceptances.

B. Technical Recruiting Activity - HLO - September 1, 1959 to Date

	Cases Considered	Visits to Richland			Offers*			On the Roll**
		Invited	Visited	To Visit	Extended	Accepted	Open	
Ph.D.	397	77	14	13	6	3	-	6
Exp. BS/MS	155	23	12	3	9	7	-	10

*Offer totals include offers open on 9/1/59
Ph.D. 3
Exp. BS/MS 3

**On the Roll totals include 1958/59 Carryover acceptances.

In addition to the above activity, 8 exempt employees have transferred into HLO from other HAPO departments and 6 technical graduates have accepted off-Program placement in HLO to date.

C - Technical Graduate and Technician Training Program
Month ending December 31, 1959

	TG Program	TT Program
Number of Personnel on Assignment	60	7
(HAPO Tech Grad Program.....52		
(Western District E. P. 8		
Distribution of Assignments by Departments		
HLO	17	2
CE&UO	3	0
FPD	0	0
IPD	29	5
CPD	10	0
C&AO	1	0
Distribution of Assignments by Function		
R&D or Engineering	41	7
Other	19	0

FINANCIAL OPERATION MONTHLY REPORT
DECEMBER 1959

Personnel

There were no personnel changes during December.

Activities

GENERAL ACCOUNTING

Suggestions for additions to the approved listing of Professional and Trade Societies were forwarded to Contract and Accounting Operation.

The General Manager's control budget relating to Inventory Spare Parts and Standby failed to provide for spare parts for the PRTR facility. This has been reported to Contract and Accounting and a request made to reinstate the funds.

Two significant changes in procedures for accounting for travel and living expenses will substantially reduce clerical effort and are expected to result in earlier and more current reporting of these costs. These changes are (a) until recently all travel expense reports have been forwarded to Traffic Operation for verification of travel costs. In the future only those having unusual charges for travel will be checked with Traffic. This will eliminate a significant delay in processing expense reports, (b) in the past it has been the practice to audit or recheck all expense reports processed. In the future, this will be limited to cover approximately 10% of all travel expense reports. Clerical effort saved by these changes will enable us to carry the heavy work load without resorting to excessive overtime, and should also help improve reporting dates.

Expenditures for equipment for December showed an increase over November expenditures. November expenditures were $100,672 and December expenditures rose to $234,088. Expenditures for the balance of FY 1960 should show a steady increase based on paperwork currently in process. Expenditures at December 31, 1959 were $773,338 which compares favorably with the original expenditure forecast for FY 1960.

Budget call letters were submitted to the Section Managers requesting data for the Automotive and Heavy Mobile Equipment Budget for FY 1962 and revision of budget for FY 1961.

The detailed review of EWIP by the Traveling Auditors showed no errors in our records and only $7,000 of closed items which should have been transferred to plant records. Of this total over $6,000 was available for transfer in the prior month but because of cut-off dates, was not journalized until December.

The annual physical inventory of precious metals and special materials directed by Contract and Accounting Operation was conducted on December 30, and 31, 1959. A report of results will be issued upon completion of the reconciliation by C&AO and reviewed by HLO Financial. To assist C&AO in preparing a detailed inventory schedule HLO is providing a listing of all HLO holders (80), their location, type of materials on hand, estimated quantities and counting time required.

All field work in connection with counting and reconciliation of the physical inventory of movable cataloged equipment in the custody of Biology Operation is

complete. The IBM listings and inventory sheets were forwarded to C&AO on 12-22-59 for their use in updating HLO records and to complete the inventory reconciliation of pick up items. Upon completion of the reconciliation by C&AO a report of results will be issued. One item valued at $105.00 was determined to be missing during the inventory.

The physical inventory of movable cataloged equipment in the custody of Physics and Instrument R&D Operation began on December 14, 1959 and is still in progress.

The $510,212 accumulated in Equipment Work In Progress and Construction Work In Progress on miscellaneous work orders and purchase orders was transferred to Plant records. Included in the transfer from EWIP was Project CG-682 - High Level Cut-Off and Examination Cell for $417,059.00.

SS Accountability advised us of the continuation of Survey 17 with a verification of HAPO inventories of enriched uranium, thorium, and U-233 as of the end of January 1960. All material custodians were advised of the survey and requested to submit inventory information to be compiled and forwarded to SS Accountability for use in preparing a detailed inventory schedule for the AEC.

Effective with December 1959 business HLO Property Accounting assumed the responsibility of reviewing all purchase requisitions and work orders for determination between taxable and non-taxable items subject to the Washington State Use Tax. In connection with this, all equipment received on the plant site during the months of April through November were reviewed for taxable and non-taxable determination. Of 389 items verified, 158 items required field checks, $283,22 was determined to be taxable and $37,765 was non-taxable.

Chapter 3 of the Property Management Manual was revised and distributed during the month to incorporate HAPO OPG 8.9, entitled "Control of Capital Plant and Equipment". No procedural changes affecting operating personnel in HLO are indicated.

Beneficial use of the Laboratory Equipment Pool Building 3718 was made during the month of December with receipt of three shipments of equipment. Preparations are being made by field personnel to transfer numerous items during the month of January.

COST ACCOUNTING

Instructions for preparing the Budget for FY 1962 and Revision of Budget for FY 1961 were issued by Contract Accounting. To provide adequate time for a thorough review of research and development proposals by the General Manager - HAPO, submission dates have been established which are considerably earlier than in past years. Proposals for new or expansion of existing programs are due to Contract Accounting by February 1, 1960 and proposals for continuing programs are due by March 1, 1960. HLO Section Managers were advised of the time schedule pertaining to the proposals. Detailed instructions concerning all phases of the budget preparation will be issued to HLO management early in January.

The FY 1960 Control Budget was adjusted in December to increase Reactor and Fuels R&D - Reactor Engineering Development Operation's budget for charges to construction projects by $211,000. The original control budget did not

anticipate this volume of direct participation by Reactor and Fuels R&D on the PRTR and PFPP projects.

Requests have been made to Contract Accounting to take the necessary action to revise the FY 1960 budget control points recently established by the General Manager - HAPO as follows:

1. Increase charges by $143,000 to other departments and gross budget to provide for the Technical Graduate assignments required by the Product Departments.

2. Increase HLO Research and Development and gross budget to provide for a transfer of funds from equipment to operating costs for
   (a) Plutonium Recycle Program $100,000
   (b) 5000 Program - Isotopic Analysis 13,000

3. Increase Spare Parts and Standby Inventory from $71,000 to $182,000 to provide for spare parts required for the PRTR.

A special report requested by HOO-AEC on "Distribution of Research and Development Effort" for FY 1959, FY 1960 and FY 1961 was completed and submitted to Contract Accounting for HAPO consolidation on December 23, 1959.

Data Processing charges for the Radiation Analysis (RAD) and Calibrations (CAL) have increased significantly due to conversion from the 702 to the 709 Computer. Agreement has been reached that both will be billed at the same rates as were charged for 702 processing, retroactive to July 1, 1959 and will continue until June 30, 1960. Data Processing will be formally requested to review the programming on these two jobs for possible economies and to estimate the billing rates to become effective July 1, 1960 so HLO can utilize in the budget preparation for FY 1961 and FY 1962.

To provide more efficient cost accounting services, procedural changes were instigated involving contacts between HLO management and the personnel of Contract and Accounting Operation on certain cost accounting matters. Effective December 14, 1959, C&AO personnel began making direct field contacts in the following areas:

1. Cost coding of time cards.
2. Completion and transmittal of Time Distribution Reports.
3. Clerical details involving HLO Work Order Servicing Components.
4. Correct coding of Store Orders.
5. Transmittal of Duplicating Tickets from Drafting Operation.
6. Project Whitney Equipment Tag numbers.
7. Determination of Washington State Use Tax.

HLO components were advised of these changes by letter. The above changes improved cost accounting services to HLO by eliminating extra steps and, therefore, time loss in relaying information to C&AO clerks. HLO Cost Accounting personnel will now be able to utilize their time more effectively in the counselling and analysis functions.

To more accurately distribute costs of the Radiographic Testing Operation, the following cost center codes and titles were established, effective January 1, 1960.

Code	Title
7350	Radiographic Testing - General
7351	Tubular Components Testing
7352	Testing Laboratories

The following three special requests were authorized by HOO-AEC and received by Hanford Laboratories during December.

1. Fabrication of plutonium foils for ANPD for the authorized amount of $2,000.

2. Fabrication of plutonium-aluminum alloy pins for duPont. There was no authorized amount specified for this request; although, the fabrication cost on this job has been estimated at $5,000. Costs will be billed to HOO-AEC.

3. Procurement of surplus zirconium tubing by duPont. There was no authorized amount specified on this request, but approximately $25.00 for packaging is involved.

New program codes established during the month were as follows:

.18 - UO_2 Fuels Research	- 4000 Program
.19 - Pu Ceramics Research	- 4000 Program
.20 - In-Reactor Measurements	- 4000 Program
.21 - Procurement of High Exposure Plutonium	- 4000 Program
.23 - Neutron Cross Section Measurements	- 4000 Program

A preliminary draft has been prepared describing the principles and procedures by which we propose to cost the PRTR Operation. In addition to covering the test reactor operation, the report also discusses proposed methods of calculating fuel fabrication costs, overall program costing and the philosophy supporting our conclusions.

The UO_2 Fuel Fabrication process has tentatively been subdivided into a series of specific steps by which it is intended to record manhours, machine time and unit production daily for use in calculating fuel element costs. Procedures for obtaining similar information with respect to the plutonium fuel fabrication are already in effect.

The test reactor facility has tentatively been subdivided into 30 component systems for accumulation of maintenance costs, and studies are currently underway to determine feasibility of further subdividing each system into specific pieces of equipment.

Action as indicated occurred on the following projects during the month: